APPENDIX 8-1: CARIBOU MITIGATION AND MONITORING PLAN

REPORT

Mount Polley Springer Pit Expansion

Caribou Mitigation and Monitoring Plan

Submitted to:

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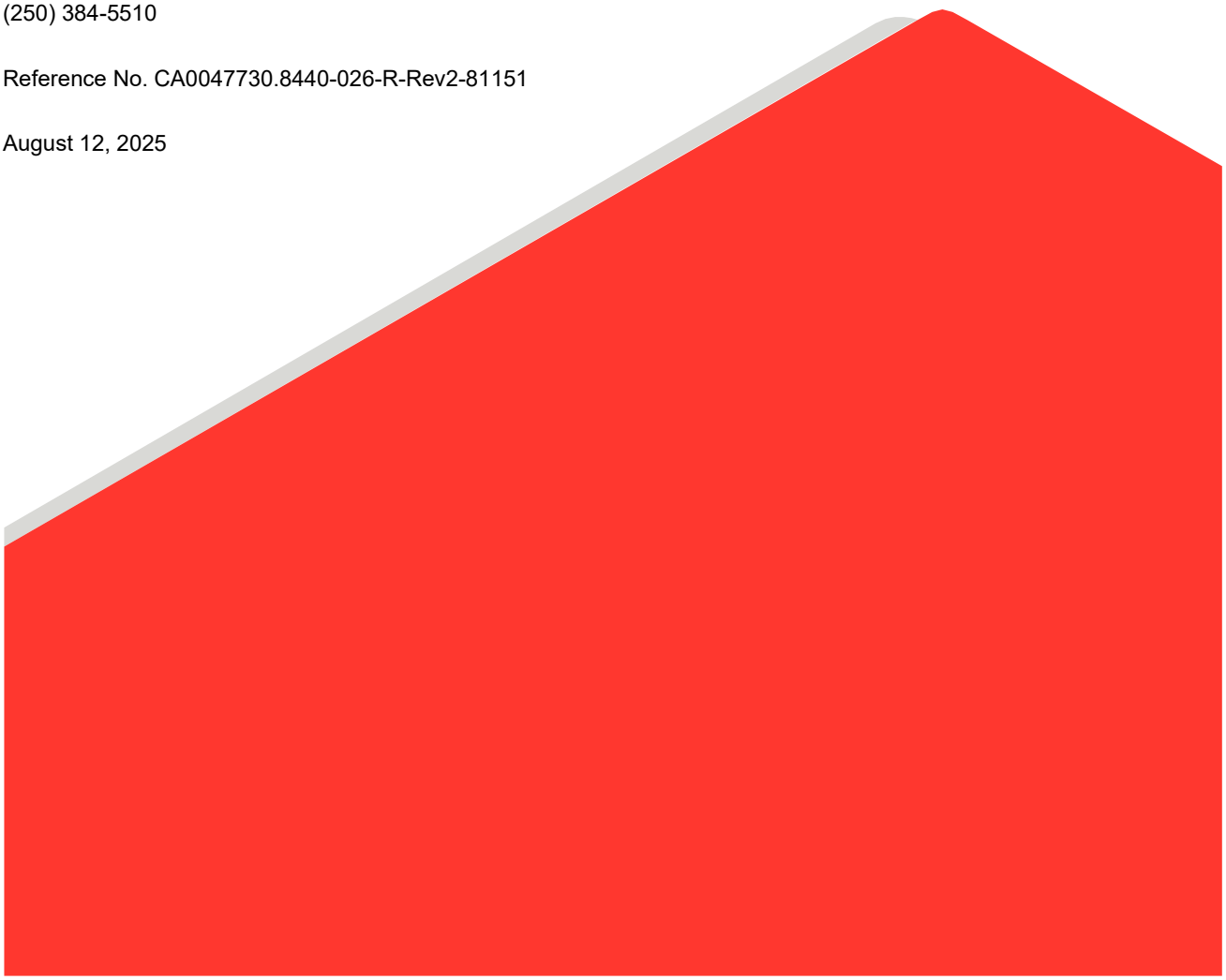

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Executive Summary

Mount Polley Mining Corporation (MPMC) is proposing to expand components (the Project) of the existing Mount Polley Mine (the Mine), a copper gold mine located approximately 80 km southeast of Quesnel, BC, adjacent to Polley Lake and Hazeltine Creek. The Project overlaps federal unmapped habitat and an updated provincial range boundary of southern mountain caribou (*Rangifer tarandus*, population 1), the Wells Gray North sub-population. The Wells Gray North herd is a part of Designable Unit 9, which is listed as Threatened on Schedule 1 of the *Species at Risk Act*. This Caribou Mitigation and Monitoring Plan (CMMP) has been prepared as a program framework to avoid and reduce Project-related effects to caribou.

This document provides an overview of baseline conditions for caribou and their habitat in the Project area and the Caribou Assessment Area (CAA), describes mitigation measures to reduce adverse effects to caribou, identifies potential residual effects to caribou and their habitat, and outlines monitoring and reporting commitments to measure the success of mitigation measures.

Baseline conditions for the CAA are described using two mountain caribou components: habitat condition and population structure and dynamics. Each of the components has two indicators or metrics that are used to measure and report upon the condition and trend of the component. The Project effects assessment was based on context, magnitude, extent, duration, reversibility, frequency, risk, and confidence. Potential project-related effects include habitat alteration, sensory disturbance, disturbance to movement, and indirect mortality, with anticipated residual effects on mountain caribou habitat availability.

The Project footprint is sited within federal critical habitat of unmapped range, as well as provincial matrix range, that at baseline conditions is considered 100% disturbed; with a breakdown of directly (28.1%) or indirectly (71.9%) disturbed. A variable Zone of Influence (ZOI) was applied to the Project based on information provided by the BC Ministry of Water, Lands and Resource Stewardship (WLRS) to account for different types of anthropogenic disturbance having variable impacts to caribou from sensory disturbance. A review of disturbance of caribou habitat within the ZOI for the Project identified that 23.2% of the Project ZOI is located in habitat that is already directly disturbed at baseline conditions and 73.8% is located in areas considered indirectly disturbed at baseline conditions, with no undisturbed habitat present.

Mitigation measures for the Project follow the mitigation hierarchy (avoid, minimize, restore on-site) outlined in the provincial *Procedures for Mitigating Impacts on Environmental Values*. For each mitigation level, the type of mitigation approach, the results and discussion of the effectiveness of the mitigation measures, and the rationale for moving to the next mitigation level are described. The monitoring and reporting section provides guidance on two types of recommended monitoring (implementation and effectiveness) to assess whether applicable mitigation measures were implemented as planned and to determine whether the caribou habitat restoration program is meeting conservation targets.

This CMMP has been prepared as a strategy for addressing residual impacts to caribou.

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APPENDICES

Appendix A
Declaration of Competency

ABBREVIATIONS

Terminology used in his document has been defined where it is first used, while the following list has been presented to assist readers that choose to review only portions of the document.

Abbreviation	Description
BC	British Columbia
CAA	Caribou Assessment Area
CMMP	Caribou Mitigation and Monitoring Plan
DST	Decision Support Tool
EAC	Environmental Assessment Certificate
ha	hectare
km	kilometre
m	metre
MPMC	Mount Polley Mine Corporation
SARA	Species at Risk Act
WHA	Wildlife Habitat Area
WLRS	BC Ministry of Water, Lands, and Resource Stewardship
ZOI	Zone of Influence

1.0 INTRODUCTION

This Caribou Mitigation and Monitoring Plan (CMMP or the Plan) was prepared to satisfy requirements laid out in the Mount Polley Mine Province of British Columbia (BC) Ministry of Mining and Critical Minerals (MMCM) Amended Permit M-200, specifically Section C Protection of Land and Watercourses, subsection 11(b). Mount Polley Mining Corporation (MPMC) is a wholly owned subsidiary of Imperial Metals.

The CMMP was prepared by WSP Canada Inc. (WSP). A Declaration of Competency Form for Paula Bentham, RPBio, for preparation of the CMMP is provided as Appendix A.

This CMMP is organized as follows:

- Section 1.0 provides an overview of the Project, the CMMP objectives, and the regulatory framework for caribou management in BC.
- Section 2.0 describes the roles and responsibilities for the CMMP implementation.
- Section 3.0 describes the boundaries of the assessment.
- Section 4.0 characterizes the existing baseline condition of caribou habitat and population status.
- Section 5.0 describes the assessment methods of pathways of effects and to evaluate residual effects.
- Section 6.0 provides the Project effects assessment.
- Section 7.0 outlines proposed mitigation following the mitigation hierarchy.
- Section 8.0 quantifies residual impacts to caribou following application of mitigation.
- Section 9.0 outlines an offsetting strategy.
- Section 10.0 summarizes the monitoring and reporting program.
- Section 11.0 describes the consultation strategy.
- Section 12.0 provides a summary of the next steps of the CMMP.

1.1 Project Description

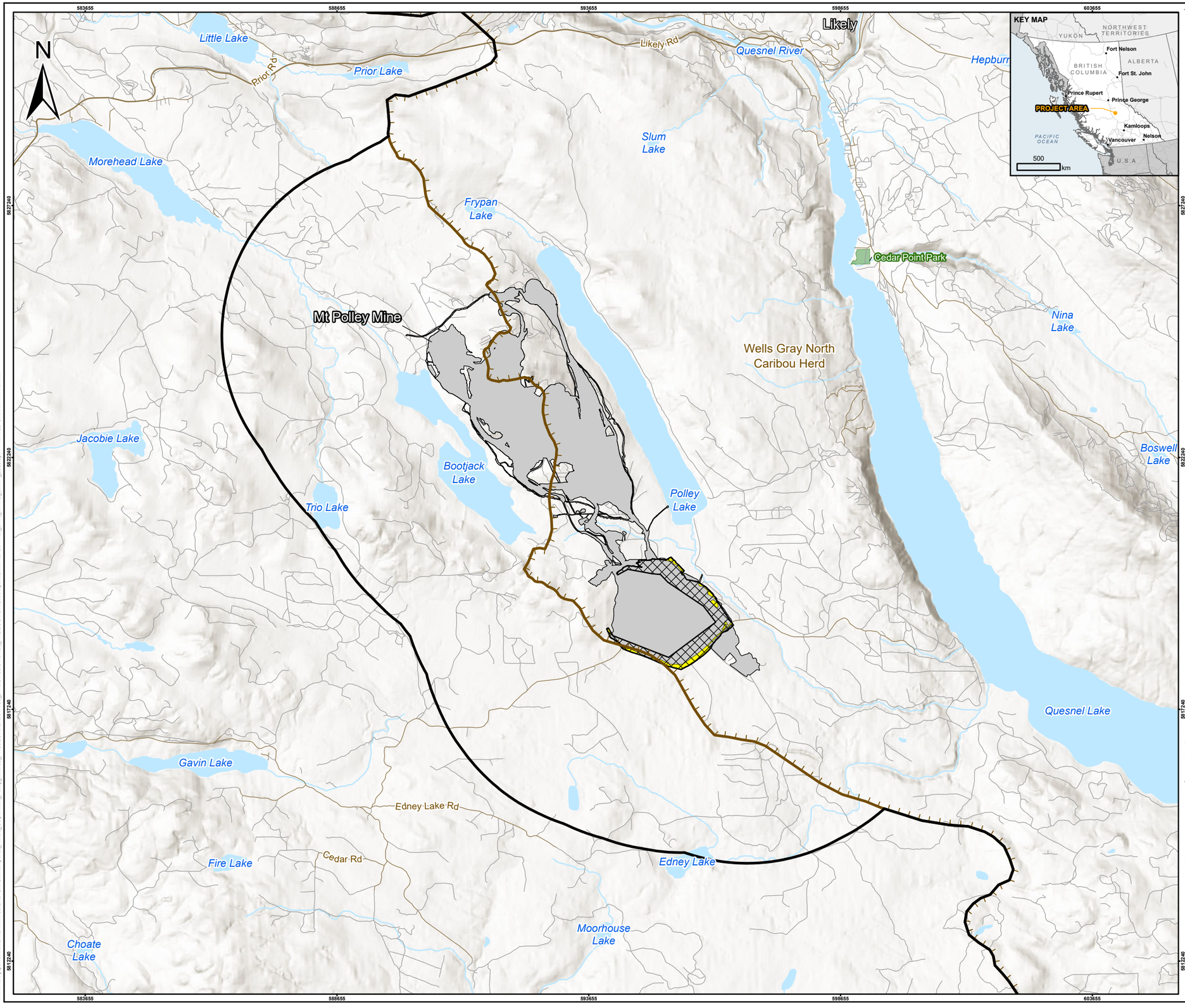
Mount Polley Mine (the Mine) is a copper gold mine operating in central British Columbia (BC), approximately 80 km southeast of Quesnel, BC, adjacent to Polley Lake and Hazeltine Creek, which flows into Quesnel Lake and then the Quesnel River.

MPMC has prepared a joint *Mines Act* and *Environmental Management Act* Permit M-200 Amendment Application to support the Springer Expansion Project that will extend the life of the Mine until 2031. Mining of Phase 4 is anticipated to finish in 2025; this represents the end of the permitted operational mining activities under permit M-200. However, the opportunity exists to extend the Mine's life with the development of the "Springer Expansion" project (the Project). This proposed Project falls within the existing mine boundary and would support an additional approximately eight years of operation, depending on market conditions.

The full scope of the Project includes the following (Figure 1):

- an expansion of the Springer Pit by mining the saddle between Cariboo and Springer pits, deepening both pits and creating two starter pits CX and W2,
- an extension of the Southeast Rock Disposal Site (SERDS),
- an extension to the duration of treated water discharge to Quesnel Lake to be throughout mining operations in 2031,
- interim raise in the elevation of the tailing storage facility (TSF) to 974 m from 970 m,
- raise in the elevation of the TSF to 987 m from 974 m,
- an extension of the Northwest Potentially Acid Generating (PAG) Stockpile disposal date,
- and a modernization of the Neutralizing Potential Ratio (NPR) to lower the ratio from 2 to 1.5.

The M-200 authorizes construction of the embankment to an elevation of 970 m. Construction to raise the embankment to 970 m was started in July 2022 and completed in 2023. The Springer Expansion will require an additional raise of the TSF. The TSF will be raised in a series of lifts over the course of several years, the first of which would include the interim increase to 974 m to avoid potential impacts to operations and support the full implementation of Phase 4, as well as future mining Phases 5 and 6, which includes the deepening of several existing pits for the purpose of supplementing ore production into the year 2031 (Section 3.2). Of these components of the Project, the TSF elevation raise is the only component that will result in disturbance to habitats that are currently not directly disturbed, while the other components will occur within the existing disturbance footprint of the Mine.



LEGEND

- PROJECT FOOTPRINT
- PROPOSED RAISED EMBANKMENT
- EXISTING MINE FOOTPRINT
- CARIBOU ASSESSMENT AREA
- CARIBOU HERD BOUNDARY

BASE DATA

- TOWN
- MAJOR ROAD
- ROAD - LOCAL
- ROAD - RESOURCE / RECREATION / UNCLASSIFIED
- WATERCOURSE
- PARK / PROTECTED AREA
- WATERBODY

0 1.5 3
1:75,000 KILOMETRES

REFERENCES

1. MINE FOOTPRINT AND PROJECT DATA PROVIDED BY CLIENT, 2025.
2. BASE DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – BRITISH COLUMBIA.

COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N

CLIENT
MOUNT POLLEY MINING CORPORATION

PROJECT
CARIBOU MITIGATION AND MONITORING PLAN

TITLE
PROJECT OVERVIEW

CONSULTANT

YYYY-MM-DD	2025-07-23
DESIGNED	NM
PREPARED	CD | JG
REVIEWED	NM
APPROVED	PB

PROJECT NO.	PHASE	REV.	FIGURE
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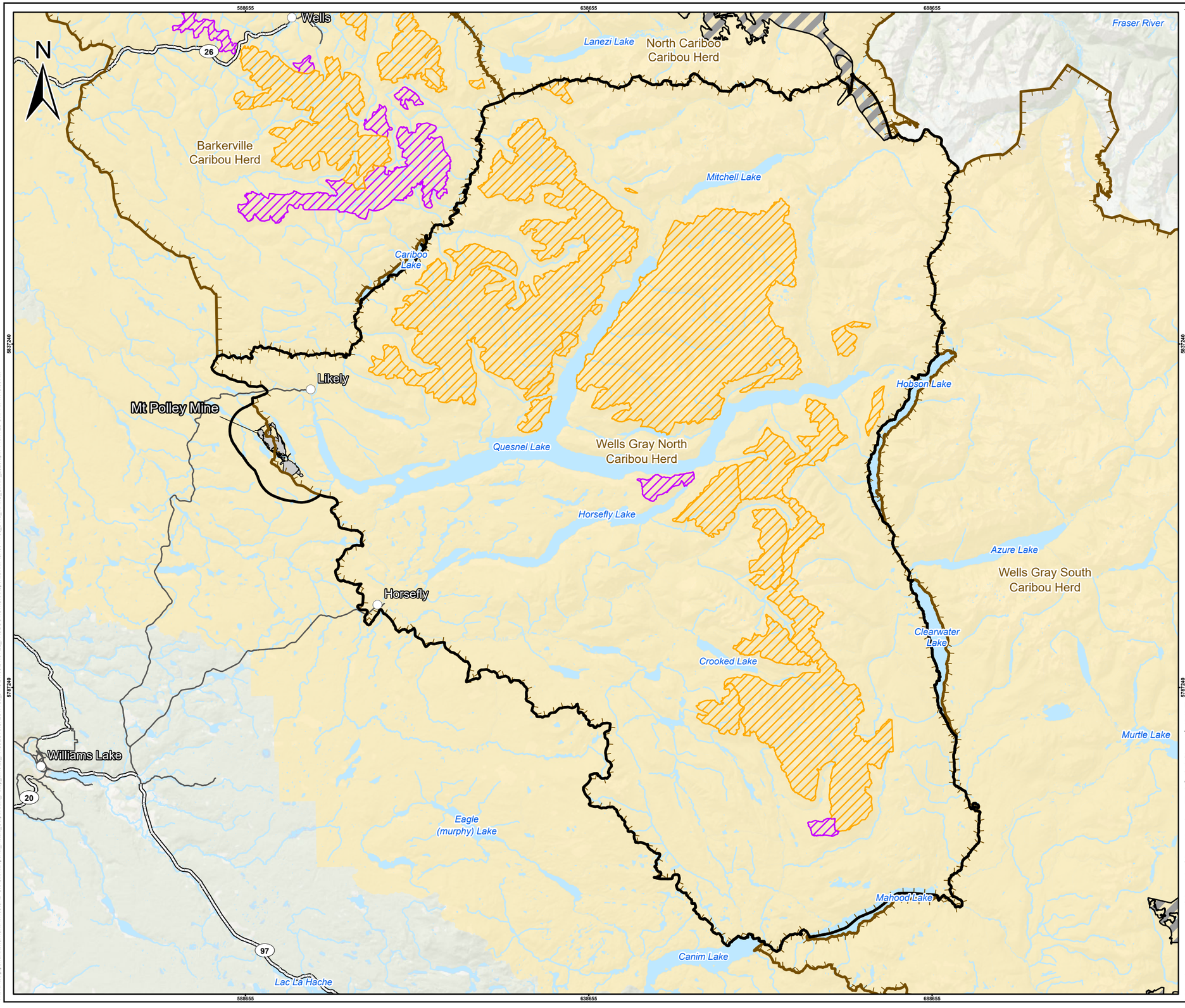
1.2 Purpose, Objectives, and Scope

The purpose of this CMMP is to provide a program framework to avoid and reduce Project-related effects to southern mountain caribou (*Rangifer tarandus*, population 1), hereafter referred to as mountain caribou, and their habitat. This CMMP applies to Project activities during the Construction, Operations, and Closure Phases taking place within the Wells Gray North herd boundary and a Caribou Assessment Area (CAA; Figure 2).

The objective of this CMMP is to provide an overview of baseline conditions for caribou and their habitat in the vicinity of the Project and proposed mitigation measures in accordance with the mitigation hierarchy guidance outlined in the Environmental Mitigation Policy (MOE 2014a). The structure and content of this CMMP generally follows the provincial *Procedures for Mitigation Impacts on Environmental Values* (MOE 2014b) and considers currently available information and management actions identified in the provincial caribou recovery program (Government of BC 2025a), the *Guidance for the Development of Caribou Mitigation and Monitoring Plans for the South Peace Northern Caribou* (MOE 2013), *Operation Restoration Framework for Woodland Caribou Habitat Restoration in British Columbia* (FLNORD 2021), and the *Draft Woodland Caribou Plan for the Wells Gray North Subpopulation* (Government of BC [date unknown]a).

Commitments made in this CMMP consider those outlined in MPMC's 2022 Mine Plan and Reclamation Program (MPRP; MPMC 2023), which outlines the objectives for the End Land Use Plan. The overarching objective of this plan is to return all areas that have been disturbed by mining operations, except pit walls, to equivalent or greater land capability than existed prior to mining, with a focus on ecosystem rehabilitation.



LEGEND

- EXISTING MINE FOOTPRINT
- CARIBOU ASSESSMENT AREA
- CARIBOU HERD BOUNDARY
- MOUNTAIN CARIBOU WILDLIFE HABITAT AREA - MODIFIED HARVEST ZONE
- MOUNTAIN CARIBOU WILDLIFE HABITAT AREA - NO HARVEST ZONE
- UNGULATE WINTER RANGE
- CRITICAL HABITAT

BASE DATA

- TOWN
- HIGHWAY
- MAJOR ROAD
- WATERCOURSE
- WATERBODY

0 12.5 25

1:550,000 KILOMETRES

NOTES

1. UPDATED MATRIX AND CORE HABITAT BOUNDARIES HAVE BEEN CREATED BUT ARE NOT YET PUBLICLY AVAILABLE SO CANNOT BE DISPLAYED ON THIS FIGURE. INSTEAD, THE ENTIRE CRITICAL HABITAT POLYGON IS DISPLAYED, WHICH CONTAINS MATRIX RANGE, CORE ALL-SEASON HABITAT, AND UNMAPPED HABITAT.

REFERENCES

1. MINE FOOTPRINT AND PROJECT DATA PROVIDED BY CLIENT, 2025.
2. BASE DATA AND CARIBOU DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – BRITISH COLUMBIA.
COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N

CLIENT
MOUNT POLLEY MINING CORPORATION

PROJECT
CARIBOU MITIGATION AND MONITORING PLAN

TITLE
CARIBOU ASSESSMENT AREA

CONSULTANT

wsp

YYYY-MM-DD	2025-07-23
DESIGNED	NM
PREPARED	CD | JG
REVIEWED	NM
APPROVED	PB

PROJECT NO.	PHASE	REV.	FIGURE
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1.3 Regulatory Context

Woodland caribou in BC occur in 54 populations that have been classified into three ecotypes – mountain, northern, and boreal – based primarily on feeding behaviour and habitat associations (Government of BC 2021a). The range of the arboreal lichen–winter feeding mountain ecotype (mountain caribou) corresponds closely with the distribution of the Interior Wet Belt in southeastern and east-central BC (Cichowski et al. 2004). Mountain caribou in the vicinity of the Project belong to the Wells Gray North subpopulation, which, along with the Barkerville subpopulation, make up the Quesnel Highland Mountain Caribou Planning Unit Boundary (Unit 5B [Government of BC [date unknown]a]). Population estimates from 2023 for the Wells Gray North sub-population were reported at 202 individuals, which is considered to be stable both currently and historically (Government of BC 2025a). Large portions of this herd's range overlaps with the Wells Gray Park, a provincial park that is protected from various development and recreational activities, which likely contributes to these population trends (Government of BC 2025a).

The Wells Gray North sub-population is part of Designatable Unit (DU) 9 of the Southern Mountain population (EC 2014), which is recommended as Endangered by the Committee on the Status of Endangered Wildlife in Canada and is listed as Threatened on Schedule 1 of the *Species at Risk Act* (SARA) (Government of Canada 2025). In BC, the Southern Mountain Caribou population is ranked S1 (critically imperilled) by the BC Conservation Data Centre and is on the provincial Red List (BC CDC 2025).

The Government of BC prepared implementation plans to meet its commitment to manage and/or recover species at risk under the *Accord for the Protection of Species at Risk in Canada* and the Canada-British Columbia Agreement on Species at Risk (Government of Canada and Government of BC 2005; WLRS 2023). An implementation plan outlines the response of the provincial government to the need to manage species at risk for which management and/or recovery in BC may have significant socio-economic implications (WLRS 2023). Implementation plans guide and prioritize management actions that are required to meet objectives and goals identified through government decisions (WLRS 2023). To facilitate the implementation of government commitments for mountain caribou management, the Province of BC developed the *Mountain Caribou Recovery Implementation Plan* (MCRIP), which was informed by the Mountain Caribou Science Team (MCST). The goal of the MCRIP is to recover the mountain caribou population to the pre-1995 level of 2,500 animals within 20 years. As such, the MCRIP identifies management options and associated actions and targets that are deemed necessary for mountain caribou management. Initially, the MCST recommended no timber harvest within 'core' habitat, and habitat management, as appropriate actions for self-sustaining recovery in Quesnel Highland Unit 5B (MCST 2006). In 2009, the MCST updated the recommended actions for mountain caribou recovery and identified predator management, prey management (i.e., moose), population census, recreation management, and habitat management as priority actions for Quesnel Highland Unit 5B (MOE 2009a).

In 2018, the Province of BC committed to the Caribou Recovery Program led at the time by the BC Ministry of Environment and Climate Change Strategy (ENV) and the former Ministry of Forests, Lands, Natural Resource Operations, and Rural Development (FLNRORD). The goals of the Caribou Recovery Program are to reverse the decline, and to achieve stable, increasing populations, of woodland caribou herds, to provide certainty to affected natural resource users, to advance collaboration and reconciliation with Indigenous nations, to collaborate with partners in caribou recovery, and to increase public confidence via accountable, effective program delivery/management (FLNRORD 2018). In 2020, the federal government of Canada and provincial government of BC signed a Section 11 Agreement regarding woodland caribou. The Section 11 Agreement apply to all Southern Mountain Caribou herds (Government of BC 2025b). This partnership focuses on specific caribou conservation and recovery measures for Southern Mountain Caribou that align with the Provincial Caribou Recovery Program Plan. The Government of BC continues to lead the Provincial Caribou Recovery Program with a purpose to develop, implement, and monitor management actions and provincial strategies that meet or exceed the provincial and federal population and habitat objectives for caribou (Government of BC 2025b).

The Cariboo-Chilcotin Land Use Plan (CCLUP) Mountain Caribou Strategy used habitat suitability index modelling to designate 'no timber harvest' and 'modified timber harvest' Wildlife Habitat Areas (WHAs) for the Hart and Cariboo Mountains (CCLUP 2000). Wildlife Habitat Areas encompassing proposed 'no harvest' and 'modified harvest' areas were legally established under the *Forest and Range Practices Act* (FRPA) in 2004, with General Wildlife Measures (GWM) for these areas established in 2005 (ENV 2022). No established Wildlife Habitat Areas overlap with the Project; therefore, no formal provincial conservation measures apply under FRPA.

Critical habitat for Southern Mountain Caribou is identified in the federal recovery strategy as habitat possessing biophysical attributes required to carry out life processes. There are four categories of critical habitat for the Southern Group of Southern Mountain Caribou (EC 2014):

- High elevation winter and/or summer (spring, calving, summer, fall/rut) range delimited by the local population unit (LPU) boundaries.
- Low elevation early winter and/or spring range delimited by the LPU boundaries.
- Type 1 matrix range consisting of areas within an LPU's designated annual range that have not been delineated as summer or winter range and may include seasonal migration areas and areas of lower use compared to delineated seasonal ranges.
- Type 2 matrix range consisting of areas surrounding annual ranges and influence predator/prey dynamics within southern mountain caribou annual ranges. Type 2 matrix range may also include areas of trace occurrence and provide connectivity between subpopulations within and among LPUs.

These four categories are terms used by the federal government, but no the provincial government. This CMMP uses the terms 'core all-season habitat' to refer to high and low elevation range caribou critical habitat and 'matrix range' to refer to Type 1 and Type 2 matrix range caribou critical habitat, as is used by the province of BC. In addition to the four categories of critical habitat defined above, Environment and Climate Change Canada (ECCC) recognizes 'unmapped range' critical habitat which exists to the west of the core all-season and matrix range habitat for the Quesnel Highland Unit 5B (Data BC 2025). The unmapped habitat is considered critical habitat within the context of this CMMP to define a Caribou Assessment Area (CAA; Figure 2). However, the unmapped habitat is habitat which is not currently being managed as caribou habitat by the BC caribou team and is in review between the Province and the federal government to clean up caribou range boundaries (Watters 2024, pers. comm.). More information is required to classify the area into core all-season or matrix range habitat (Seider 2023, pers. comm.).

Mountain caribou core all-season habitat mapping for Quesnel Highland Unit 5B was obtained from the Ministry of Water, Land and Resource Stewardship (WLRS) on March 25, 2025, and includes updated areas designated as core all-season and matrix habitat for the Wells Gray North herd. This updated mapping is currently not available to the public but was used under confidentiality access agreements for this CMMP (WLRS 2025a). As such, calculations to determine disturbance and resulting residual effects are based on this updated mapping; however, these updated maps are not displayed visually on relevant figures.

2.0 ROLES AND RESPONSIBILTIES

2.1 Mount Polley Mining Corporation

MPMC bears overall responsibility for implementing the CMMP, including implementing mitigation measures following the mitigation hierarchy, conducting on-site restoration, and identifying any residual effects predicted following mitigation. Where residual effects cannot be addressed through onsite mitigations, the CMMP identifies offset needs for the Project.

2.2 General Manager

The General Manager bears overall responsibility for the operation of the Project and responsibility for implementing on-site restoration that follows the CMMP, for on-site environmental monitoring, and for compliance related to Project activities. The General Manager, or delegate, will verify:

- That qualified personnel are in place (e.g., caribou qualified professional [QP]) and following the CMMP.
- The required resources are in place to execute the CMMP.
- Compliance with relevant regulations, acts, guidelines, permits and policies.

2.3 Environmental Manager

The Environmental Manager or delegate is responsible for tracking compliance with the Plan, permits and approvals, and applicable provincial and federal regulations. The Environmental Manager coordinates training sessions for MPMC employees and contractors on-site, including the identification and understanding of the effects of the Project on caribou, and mitigation to reduce those effects.

2.4 Mount Polley Mining Corporation Site Personnel and Contractors

Employees or contractors working on the site will be required to undertake a wildlife orientation prior to working on-site. Employees and contractors involved with on-site construction, operations or restoration will be required to review the CMMP initially and when the Plan undergoes major changes. Records of review will be logged with the General Manager and kept with other training records.

2.5 Caribou Qualified Professional

MPMC will retain a QP with experience in potential Project-caribou interactions and effects, mitigation options, restoration and offset planning. The caribou QP will be responsible for preparing updates to the CMMP, reviewing monitoring reports, and identifying any trigger responses or adaptive management required based on the outcomes of monitoring. The caribou QP will also be responsible for auditing of the work conducted under the CMMP, such as auditing implemented mitigation measures, including installed barriers and planting for progressive restoration.

3.0 BOUNDARIES OF THE ASSESSMENT

This section introduces the temporal and spatial boundaries used to describe the existing condition of caribou habitat and population status in the vicinity of the Project.

3.1 Spatial Boundaries

The spatial boundaries selected for the caribou assessment were chosen because they allow for a description of existing conditions in sufficient detail to enable potential Project-caribou interactions and effects to be identified, understood, and assessed. The Project is located along (and partially within) the western boundary of the Wells Gray North herd boundary. Updates to core all-season and matrix habitat polygons within the herd boundary were obtained from WLRS on March 25, 2025; however, these are not yet publicly available. As such, these spatial data were used to prepare data summaries for the CMMP but have been redacted or obscured to protect the sensitive nature of the information.

This CMMP uses the following spatial boundaries (Figure 1, Figure 2):

- Caribou Assessment Area (CAA): The CAA is considered the spatial scale at which mountain caribou require year-round habitat.
- Existing Mine Footprint: The Existing Mine Footprint includes the current footprint of the Mount Polley Mine.
- Project Footprint: The Project Footprint includes areas of new disturbance from the Project based on the amendment for the Springer Pit Expansion.
- Amended Permit Mine Footprint: The Amended Permit Mine Footprint combines both the Existing Mine Footprint and the Project Footprint.

The CAA is specific to southern mountain caribou and covers an area of 861,515.8 ha, which includes 819,752.9 ha of caribou critical habitat. The remaining 41,762.9 ha is comprised of waterbodies that are not included within the caribou critical habitat dataset. The CAA is defined by the boundaries of the Wells Gray North herd boundary (DataBC 2025), plus an additional area of federally designated ‘unmapped range’ caribou critical habitat west of the Wells Gray North herd boundary. Rather than including the entire polygon of unmapped range critical habitat, which would dilute the potential Project-caribou interactions, the CAA includes a buffered area around Project components in this area, an approach which was agreed upon during a meeting between WLRS and WSP to confirm approach to assess effects within the CMMP (WLRS 2025b).

To capture the unmapped habitat applicable to the CMMP, a buffer was applied to the Existing Mine Footprint based on Zone of Influence (ZOI) information and recommendations provided by WLRS (Palm, n.d., unpublished data) that are specific to disturbance type. A ZOI is an area outside direct disturbance, where adjacency effects or indirect impacts may limit habitat use by a species. Table 1 provides a summary of the range of ZOI calculated for each disturbance type based on the report provided by WLRS (Palm [date unknown] unpublished data) and agreed upon during a meeting between WSP and WLRS to confirm approach to assess effects within the CMMP (WLRS 2025b). Portions of the Project are sited within this unmapped range critical habitat. As a conservative approach, the largest buffer in the ZOI range for the Mines disturbance type (i.e., 3.6 km) was used to develop the CAA western boundary within unmapped range caribou critical habitat.

Table 1: Zone of Influence Ranges for Disturbance Types (modified from Palm n.d., unpublished data)

Disturbance Category	Disturbance Type	Description Based on Data Layers Available	Range of Estimates Across Seasons (m)	Buffer applied to Indirect Disturbance Calculation (m)
Polygonal	Burns	<50 years	300 – 1,500	0
	Cutblocks	<40 years	500 – 1,300	800
	Mines	Active Mines	1,500 – 3,600	3,600
		Inactive Mines, Gravel Pits		1,500
	Wells	<40 years	500 – 1,700	n/a[(a)]
	Other Polygonal	Recreation Area	1,500 – 4,000	500[(b)]
		Agriculture, airfields, rural residential areas		1,500
		Urban Areas		4,000
Linear	Roads	<40 years	300 – 800	800
	Seismic Lines	<40 years	50 – 500	500
	Other Linear	Transmission lines	500 – 2,000	2,000

(a) There were no wells identified within the CAA therefore no buffer was applied.

(b) See Section 4.2.1 for rationale in discrepancy of buffer distance.

Within the CAA, high elevation, low elevation and matrix habitat occurs to the east of the Existing Mine Footprint and includes the Wells Gray Park, a provincial park that is protected from various development and recreational activities. The Existing Mine Footprint is 1,224.6 ha, while the Project Footprint is 18.3 ha, for a total footprint of 1,242.9 ha (i.e., the Amended Permit Project Footprint). The 18.3 ha Project Footprint overlaps with existing roads, cutblocks, and natural areas that overlap with the Existing Mine Footprint's ZOI. The Mine is currently permitted for a total of 1,850.0 ha. Similarly, the remaining 607.2 ha within the permitted area where no new disturbance is currently planned includes existing roads, cutblocks, and natural areas that overlap with the Mine's ZOI.

3.2 Temporal Boundaries

Temporal boundaries for the CMMP are used to establish both the baseline conditions and potential Project-caribou interactions based on the life of the Project. Baseline conditions within the CAA are used to understand the degree of disturbance prior to the Project. Baseline conditions for the Project rely on summaries of existing data (Section 4.2.1).

The temporal boundaries for the CMMP to assess Project-related impacts to caribou are based on the current proposed schedule detailed in Table 2. The temporal boundaries include seven years from construction and operation to the start of closure, which is the start of site-wide reclamation.

Table 2: Description of Project Phases

Phase	Years	Reclamation Milestone
Construction – Phase 5	Year 1 to 5 (2025 – 2029)	Pushback of east wall and deepening of Springer Pit.
Construction – Phase 6	Year 3 to 7 (2027 – 2031)	Further deepening of Springer Pit.
Construction – WX and C2	Year 5 to 7 (2029 – 2031)	Deepening of two starter pits (WX and C2).
TSF Raise to 974 m	Year 1 and 2 (2025 and 2026)	Raise of existing TSF to an elevation of 974 m.
TSF Raise to 987 m	Year 2+ (2026 – TBD)(1)	Raise of existing TSF to an elevation of 987 m.
Operation	Year 1 to 7 (2025 – 2031)	Pit at full depth; PAG Stockpile relocation to pit bottom; Other Conventional Reclamation Activities begin.
Closure	Year 7 to 17 (2031 – 2041)	Short term post-Closure activities including conventional reclamation of the roads and TSF; Pits filling with water.
Post-closure	Year 17+ (2041 – onwards)	Long term activities. Pits filled; Site water distributed to various drainages; WTP on standby. Long term site reconnaissance.

(1) TBD = To be determined. Completion date of raise is currently unknown but will be completed prior to 2031.

4.0 BASELINE CONDITIONS

4.1 Caribou Components

The provincial *Policy for Mitigating Impacts on Environmental Values* (MOE 2014a) and the associated Procedures (MOE 2014b) are intended to support and improve efforts to mitigate impacts on environmental values and associated components. An environmental component is defined as "an attribute of the natural resource system that is measured, managed, and maintained to ensure the integrity and well-being of the environmental value with which the component is associated" (MOE 2014a, p. 2). For the purposes of this CMMP, two mountain caribou components are identified as having environmental value that should be managed and maintained through mitigation measures: habitat condition and population structure and dynamics (Table 3). Each component has two indicators identified as metrics used to measure and report upon the condition and trend of the component. This section describes the baseline condition of the identified caribou components.

Table 3: Mountain Caribou Components and Indicators

Component	Indicator
Habitat Condition	Habitat Availability
	Habitat Distribution (and Barriers to Movement)
Population Structure and Dynamics	Population Size
	Mortality Risk

Both habitat condition and population structure and dynamics were selected as environmental components as they are the most likely interactions with the Project. Habitat condition was selected as an environmental component because anthropogenic activities interact with caribou habitat through direct and indirect habitat loss, alteration, or degradation. Loss of habitat or altered habitat that changes predator/prey dynamics have been identified as a threat to woodland caribou (EC 2014). Population structure and dynamics were also selected as an environmental component because, within small populations, such as the Wells Gray (Noth) herd, mortality and population size can have significant impacts on overall population dynamics. Habitat condition and population structure and dynamics are both components that can be measured and managed to assess the condition of the Wells Gray North herd.

4.2 Habitat Condition

The data used to summarize the existing habitat conditions and determine disturbances are described in detail in Section 4.2.1 and include:

- Terrestrial Ecosystem Mapping (TEM) conducted for various other projects within the CAA, which is used to identify anthropogenic features in the CAA such as mines, roads, and urban areas.
- Predictive Ecosystem Mapping (PEM) available from Moon et al. (2008) and GEOWEST (2001), to supplement areas of the CAA outside of available TEM, which is also used to identify anthropogenic features in the CAA.
- Publicly available layers from Data BC (Data BC 2025), including the BC Road Atlas, RESULT – Openings (to identify cutblocks), BC Wildfire Fire Locations – Current, BC Wildfire Locations – Historic, BC Road Atlas, and Forest Tenure Road Segments.

Habitat condition for caribou uses the current timber harvest areas (i.e., up to 2024) and roads (i.e., up to 2025). Timber harvest is recognized as adversely affecting mountain caribou habitat availability and distribution in BC. Forestry selectively removes mature and old forest, resulting in an increase in early seral habitats relative to what would be expected under natural disturbance regimes. Early seral habitats are used by other ungulates such as moose and deer, and the increase in alternative prey, such as moose, has led to a decline in caribou due to higher levels of predation (See Section 4.0). Similarly, roads and other linear ROWs create early seral habitats and facilitate access for predators, hunters, and poachers. Therefore, the assessment includes these disturbance types when assessing the baseline disturbance to caribou within the CAA.

4.2.1 Habitat Availability

At large spatial scales, such as the CAA, mountain caribou rely on late successional and old growth coniferous forest for several life-history requirements, including the abundance of caribou's primary winter food, arboreal lichen, and a scarcity of other ungulates and their predators (Stevenson et al. 2001; Cichowski et al. 2004; Serrouya et al. 2008; Apps and McLellan 2006; COSEWIC 2014). They tend to avoid cutblocks that lack food resources (lichen), although they may forage on cutblock edges where windthrow and lichen litterfall is common (Smith et al. 2000; Serrouya et al. 2006; 2007). Their habitat use varies seasonally and is based on elevational movements (Stevenson et al. 2001; Cichowski et al. 2004). Historically, mountain caribou were likely distributed within suitable habitat throughout their geographic range; however, they now occur in several relatively distinct subpopulations (MCST 2005). Use of high elevation versus low elevation habitats differs between subpopulations and reflects differences in predation patterns and snow conditions (Stevenson et al. 2001; Cichowski et al. 2004). Their winter diet primarily consists of arboreal lichens, while their use of shrubs and conifer foliage is dependent on snow conditions and accumulation (Stevenson et al. 2001; Cichowski et al. 2004).

The Project occurs within Quesnel Highland Unit 5B. In the Quesnel Highlands and adjacent Cariboo Mountains, mountain caribou select mid-elevation forests dominated by subalpine fir during early winter where they forage primarily on arboreal lichens on fallen trees and lichen litterfall, but also understory vegetation that is not buried by snow (Seip 1992; Terry et al. 1996; 2000; Stevenson et al. 2001). In mid- and late-winter, and after the snowpack deepens and hardens, mountain caribou move to high elevation subalpine fir forests and open, subalpine parkland habitats where they primarily forage on arboreal lichens (Seip 1992; Terry et al. 1996; Terry et al. 2000; Stevenson et al. 2001). In spring, some mountain caribou descend to lower elevation subalpine forest habitats where they have access to new vegetation growth, while others remain at higher elevations and continue to feed on lichens and conifer browse (Seip 1992; Stevenson et al. 2001). Pregnant females in spring move to remote high elevation calving areas where predators are less abundant, although forage is limited (Seip 1992; Stevenson et al. 2001). Mountain caribou in the Hart Mountain range utilize areas with an elevation greater than 1,000 m when calving (Seip et al. 2007). Throughout the summer and fall, mountain caribou may use forested habitats at all elevations where they feed on a variety of shrubs, forbs, and graminoids, in addition to lichens and conifer browse (Seip 1992; Stevenson et al. 2001).

Approximately 401,440 ha of Quesnel Highland Unit 5B has been identified as core all-season habitat for mountain caribou based on empirically derived habitat suitability models developed for the Hart and Cariboo Mountains (MOE 2011). Many of the mountain complexes in the CAA were designated as WHAs in 2004 to meet the habitat requirements of mountain caribou and to protect core all-season habitat (CCLUP 2007). All caribou WHAs in the CAA were approved in 2009 (DataBC 2025). WHAs are not protected areas but are designated under the FRPA where specific management practices can be applied and should be designed to limit the impact on the identified wildlife, in this case, caribou, for which the WHA is designated. The specific management practices are provided by the General Wildlife Measures Order – Wildlife Habitat Areas #5-00 to 5-177 Mountain Caribou – Quesnel Highlands Planning Unit, which designates some WHAs to 'no harvest' and some to 'modified harvest' areas (Government of BC [date unknown]c). No harvest areas do not permit timber harvest or road

construction, while modified harvest areas impose limits on harvest practices in terms of the area of harvest, cut cycle, planting prescriptions, and limiting access (Government of BC [date unknown]c).

Threats to southern mountain caribou habitat availability include natural disturbance agents, primarily forest fire and forest insect outbreaks, and anthropogenic disturbance agents, primarily forest harvest (Cichowski et al. 2022). Forest harvest is the greatest contributor to habitat loss in approximately 25% of the woodland caribou herds across BC and Alberta, most of which fall within the southern mountain caribou herd ecotype (Nagy-Reis et al. 2020). Within southern mountain caribou ranges, forest harvesting has been the primary source of habitat alteration for mountain caribou (MCTAC 2002; COSEWIC 2014). Historically, a combination of wet climatic conditions and infrequent wildfires resulted in forests dominated by old stands (Jull et al. 1998). Although there was active logging occurring in southeastern BC from the early 1900s, large scale logging operations did not occur in the area until the 1970s when large amounts of mountain caribou habitat were lost in the region due to forestry (Spalding 2000).

Habitat availability within the Wells Gray North herd boundary has been dramatically altered by forest harvest. Four timber supply areas (TSAs) occur within the Wells Gray North herd boundary, with the majority overlapping with the Williams Lake TSA. Cumulatively, these TSAs have contributed to 2,467 cutblocks within the subpopulation range (Government of BC [date unknown]a) and approximately 65,260 ha of cutblocks. Wilson (2009) reported that there is approximately 1,348 square kilometres (km^2) of early seral habitat (<40 years old) in Quesnel Highland Unit 5B, which is 2.65 times more than is expected under a natural disturbance regime (508 km^2).

Maternal penning and wolf removal has shown success in recovery of some caribou herd populations (McNay et al. 2022); however, it does not solve the main issue of habitat loss. Despite federal policies and recovery strategies, woodland caribou habitat availability has continued to decline and mean annual loss has not substantially decreased since these policies and strategies were put in place (Nagy-Reis et al. 2020). For example, cutblocks in the CAA included in the disturbance layer included those from the past 40 years. The year of cut data associated with the cutblocks was analyzed to produce a summary of cutblock area for five-year intervals from 1985-2025 (Table 4). The results indicate a similar amount of cutblocks are from the first 20 years (i.e., 1985-2004; 54.3%) compared to the last 20 years (45.7%). Further, the average percentage of cutblocks produced over the eight five-year periods was 12.5%. The latest period from 2020 to 2024 produced a higher- than-average percentage, contributing to 13.3% of current cutblocks from the last 40 years.

Table 4: Area of Cutblocks in the past 40 years in the Caribou Assessment Area

Five Year Interval	Area (ha)	% of Total Cutblock Area
1985 – 1989	15,113.6	18.9
1990 – 1994	12,141.6	15.2
1995 – 1999	10,437.5	13.0
2000 – 2004	5,768.8	7.2
2005 – 2009	11,759.6	14.7
2010 – 2014	7,149.9	8.9
2015 – 2020	7,021.4	8.8
2020 – 2024	10,642.2	13.3
Total	**80,034.7**	**100.0**

Notes: % = percent; ha = hectare.

In addition to forestry, other anthropogenic disturbances, including highways, towns, mining, and transmission lines have reduced habitat availability in the CAA. Surface mining results in large-scale alterations to the landscape, while underground mining has smaller footprint related impacts to habitat availability, although it may still result in sensory disturbance. There are no active underground mining operations in the CAA, while the Mount Polley Mine is the only surface mine.

Linear features associated with existing disturbances, such as access roads and cutlines, contribute to the overall disturbance within the CAA. The density of linear features within the Wells Gray North herd boundary is 1.0 km/km^2, which is less than the average density of linear features for the Southern Group of mountain caribou (1.2 km/km^2; Cichowski et al. 2021). Additionally, density of linear features within core habitat of this herd's range is 0.4 km/km^2, which is less than the average for the Southern Group of mountain caribou (0.6 km/km^2; Cichowski et al. 2021).

In addition to direct loss of habitat over the past 50 years, mountain caribou in the region have been affected by indirect habitat loss, which has influenced habitat availability. That is, caribou may respond negatively to anthropogenic disturbance by avoiding areas of otherwise suitable habitat because of its proximity to disturbance (Weclaw and Hudson 2004). Avoidance reduces the amount of functional habitat available within a caribou range. Avoidance by caribou may vary by type and intensity of disturbance (e.g., Oberg 2001), or by season (e.g., Dyer et al. 2001, 2002; Polfus et al. 2011; Golder et al. 2016), and can occur at multiple spatial scales (e.g., Leblond et al. 2011; Apps et al. 2013).

In a literature review, Vistnes and Nellemann (2008) found that caribou and reindeer (*Rangifer tarandus*; a subspecies of caribou that occurs in northern North America and Europe) reduced their use of areas within approximately 5 kilometres (km) of disturbances by 50% to 95%. Some studies suggest that disturbance from snowmobiles may displace mountain caribou from preferred habitats and is a contributing factor to the decline of mountain caribou in BC (Simpson 1987; Webster 1997; CCLUP 2000; Simpson and Terry 2000; Seip et al. 2007; Kinley 2008). For example, Seip et al. (2007) found that intensive snowmobile use caused mountain caribou displacement from their late winter habitat in the Hart Range in east-central BC. Predator efficiency may also be increased during winter if packed snowmobile trails provide easier travel routes for wolves (CCLUP 2000; Simpson and Terry 2000; Kinley 2008), linking habitat condition to population structure. Since 2009, the Provincial government has closed areas to snowmobile use across the range of mountain caribou to support population recovery under the MCRIP (MOE 2009b); however, snowmobiles are still commonly used in the Quesnel Highlands. There are 2,198.2 km^2 of legal snowmobile closure areas within the Wells Gray North herd boundary (Government of BC [date unknown]a). This does not include areas within the Wells Gray Provincial Park and most of the Cariboo Mountains Provincial Park, both of which partially overlap with the CAA, where snowmobiling is not allowed (Government of BC [date unknown]a).

Roads, in particular highways, can act as barriers to caribou movement and may restrict habitat use (Plante et al. 2018). Caribou may also alter behaviour and move faster at road crossings (Plante et al. 2018). Avoidance of roads and anthropogenic features may also increase during the hunting season as these features provide access for humans (Plante et al. 2018). There are no major highways in the CAA; however, numerous forestry and local roads are present and contribute to habitat loss and may impact habitat use and behaviour of caribou.

Research indicates that caribou are not consistent in their avoidance of anthropogenic disturbance, including mines. For example, Polfus et al. (2011) reported caribou in the Northern Mountain DU avoid mines by 2 km in summer, while in winter, when human activity was low, avoidance of mines was negligible. Similarly, Johnson et al. (2015) reported that just one of five sub-populations investigated in the Central Mountain DU avoid mines by

3 km and in the summer only. The use of habitats by caribou near mine developments (Polfus et al. 2011; Johnson et al. 2015) after construction is consistent with previous studies; caribou appear to be more sensitive to the human activities associated with construction, traffic, and noise than to the infrastructure (Curatolo and Murphy 1986; Murphy and Curatolo 1987; Nellemann and Cameron 1998; Smith et al. 2000; Dyer et al. 2001). Surrounding habitat may impact the indirect disturbance associated with anthropogenic features, with avoidance being higher in areas of open habitat where anthropogenic disturbance can be seen from further distances (Plante et al. 2018).

Despite variable responses of caribou to anthropogenic disturbances, and their variable reduced habitat use as a result (indirect habitat loss), analyses of a range of buffer widths demonstrated that a 500 m buffer provided an appropriate, minimum approximation of the ZOI from these features on caribou demography (EC 2011). Through engagement with WLRS, recommendations for the CMMP to define both baseline and Project effects to caribou were to use a ZOI developed for specific disturbance types (WLRS 2025b). A ZOI is an area outside direct disturbance, where adjacency effects or indirect impacts may limit habitat use by a species. WLRS provided guidance on recommended ZOI values for different anthropogenic disturbance types based on on-going research (Palm n.d., unpublished data). The summary report provided by WLRS examined telemetry data for caribou in the central group of the southern mountain caribou and calculated ZOI for eight disturbance types and analyzed data over three seasons (summer, early winter, and later winter) and two elevations (low and high). The result was a range of ZOI estimates for each disturbance type (Palm n.d., unpublished data, provided in Table 1, Section 3.1). With some exceptions, to calculate indirect disturbance levels for the baseline conditions, and to identify potential Project-caribou impacts, the maximum value for each disturbance type was used as the buffer around existing disturbance for baseline conditions, and in the determination of potential Project-caribou impacts, resulting in the following ZOIs for anthropogenic disturbance:

- Mines (active): 3,600 m
- Mines (inactive mines, gravel pits): 1,500 m
- Cutblocks: 800 m
- Other polygon disturbance (i.e., urban areas): 4,000 m
- Other polygon disturbance (i.e., airfields, rural residential areas): 1,500 m
- Other polygon disturbance (i.e., recreation area): 500 m
- Roads: 800 m
- Seismic Lines: 500 m
- Other linear disturbance (e.g., transmission lines and pipelines): 2,000 m

Based on guidance provided in the federal Recovery Strategy (EC 2014), a ZOI is not associated with fire disturbance. As such, no buffer was applied to natural fire disturbances mapped within the CAA at baseline. Separate buffer distances were applied to different types of Mines (i.e., Active Mines and Inactive Mines and Gravel Pits that have been active in the last 40 years) as well as Other Polygonal (i.e., Agriculture, airfields, and rural residential areas, recreation areas, and urban areas) based on the anticipated levels of indirect disturbance due to extent and activity occurring within these features. Finally, the Roads disturbance type includes major and local roads, resource roads, recreation trails (including snowmobile trails), and forest service roads, while the Seismic Lines disturbance type includes overgrown, loose, or rough trails and cutline trails.

To determine the baseline condition for disturbance in the CAA, data layers of existing disturbance were compiled and edited as described in Table 5. The data layers were then combined to create one map layer. In places where overlap occurred that included multiple disturbances, the following hierarchy (in order of priority for overlap) was applied to determine which layer would be preserved, and was based on preserving the disturbance with the greatest impact to caribou based on the ZOI in Table 1:

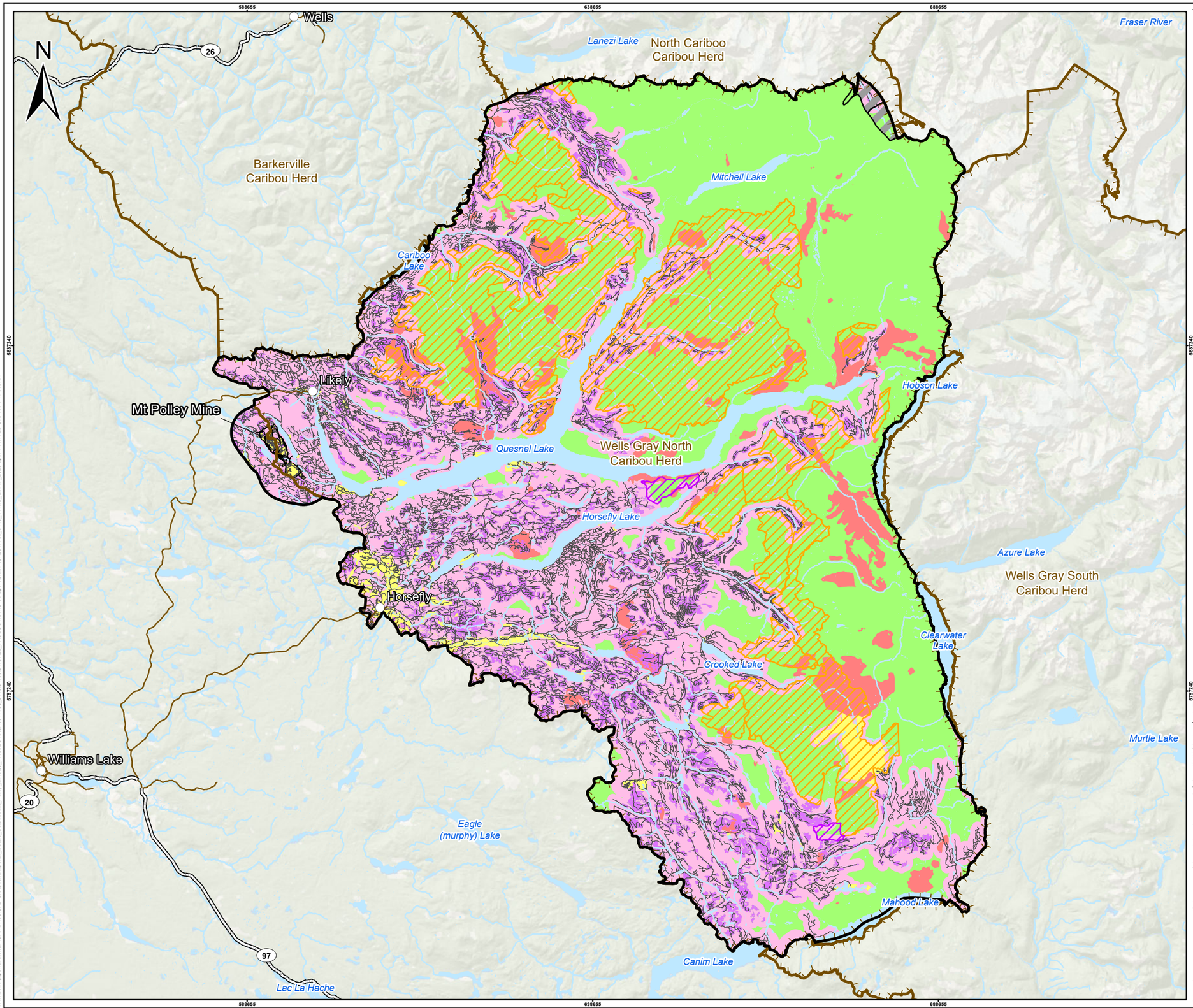
1) Other Polygonal Disturbance (i.e., urban areas)
2) Mines (active)
3) Mines (inactive, gravel pits) / Other Polygon Disturbance (i.e., airfields, rural residential areas)
4) Other Linear Disturbance (e.g., transmission lines, pipelines)
5) Cutblocks
6) Roads
7) Seismic Lines / Other Polygon Disturbance (i.e., recreation areas)

Table 5: Data Layers Used to Identify Disturbance in the Caribou Assessment Area

Data Layer	Source, Year	Data Description	Data Manipulation
RESULTS – Openings	Data Catalogue 2025	Shows the boundaries of forest areas that have been harvested.	Include only those areas that were harvested in the last 40 years (1985 – 2025). Beyond 40 years, areas are assumed to be regenerating and not part of the disturbance layer at baseline.
BC Wildfire Fire Locations – Current	Data Catalogue 2025	Provides boundaries of active and inactive fires from the current wildfire season.	Include only those areas that have been impacted by wildfire in the last 40 years (1985 – 2025). The 'current' data layer was current to 2025.
BC Wildfire Fire Locations – Historic	Data Catalogue 2025	Provides boundaries of fires from past wildfire seasons.	Include only those wildfires in the last 40 years. Beyond 40 years, areas are assumed to be regenerating.
Digital Road Atlas	Data Catalogue 2025	Provides spatial data on the location of urban, rural, and resources roads in BC.	N/A
Forest Tenure Road Segment Lines	Data Catalogue 2025	Provides additional information on roads, particularly forest service roads.	All segments attributed as 'road'.
Terrestrial Ecosystem Mapping (TEM)	GEOWEST 2001	TEM developed for the Eastern Cariboo Area.	Extract anthropogenic areas from natural areas.
Predictive Ecosystem Mapping (PEM)	Moon et al. 2008	PEM available within the CAA used in areas that did not have coverage by the TEM.	Extract anthropogenic areas from natural areas in areas not covered by the TEM.

Notes: CAA = Caribou Assessment Area; N/A = not applicable; PEM = Predictive Ecosystem Mapping; TEM = Terrestrial Ecosystem Mapping.

Using the disturbance layer, it was determined that the CAA is currently 56.5% disturbed (total disturbed area of 486,727.9 ha; (Figure 3). Indirect disturbance (i.e., habitat within the defined ZOI for anthropogenic disturbance) constitutes 337,423.1 ha (39.2%) of the disturbed habitat total area. Direct disturbance is comprised primarily of forestry cutblocks (53.6% of direct disturbance within the CAA) and areas disturbed by wildfire (32.9% of direct disturbance within the CAA). The disturbance from forestry in the CAA is consistent with Nagy-Reis (2020), who suggests that forestry is a leading cause of landscape change and, therefore, caribou habitat loss in the southern mountain caribou herds. The remaining direct disturbance is comprised of Other Polygon Disturbance types (e.g., airfields, agricultural areas, recreation areas; 9.5%), roads (2.6%), active mines (0.8%), inactive mines and urban areas (0.2%, respectively), transmission lines (0.1%), and trails/cutlines (<0.1%).



LEGEND

- EXISTING MINE FOOTPRINT
- CARIBOU ASSESSMENT AREA
- CARIBOU HERD BOUNDARY
- MOUNTAIN CARIBOU WILDLIFE HABITAT AREA - MODIFIED HARVEST ZONE
- MOUNTAIN CARIBOU WILDLIFE HABITAT AREA - NO HARVEST ZONE
- UNGULATE WINTER RANGE

DISTURBANCE TYPE

- ROAD AND TRAIL
- CUTBLOCK
- WILDFIRE
- OTHER ANTHROPOGENIC DISTURBANCE
- HABITAT WITHIN A ZONE OF INFLUENCE OF ANTHROPOGENIC DISTURBANCE
- UNDISTURBED HABITAT

BASE DATA

- TOWN
- HIGHWAY
- MAJOR ROAD
- WATERCOURSE
- WATERBODY

0 12.5 25

1:550,000 KILOMETRES

NOTES

1. DATA OUTSIDE OF THE CAA HAS BEEN REMOVED FOR VIEWABILITY PURPOSES.

REFERENCES

1. MINE FOOTPRINT AND PROJECT DATA PROVIDED BY CLIENT, 2025.
2. DISTURBANCE DATA CREATED BY WSP, 2025.
3. BASE DATA AND CARIBOU DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – BRITISH COLUMBIA.

COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N

CLIENT
MOUNT POLLEY MINING CORPORATION

PROJECT
CARIBOU MITIGATION AND MONITORING PLAN

TITLE
EXISTING DISTURBANCE IN THE CARIBOU ASSESSMENT AREA

CONSULTANT

wsp

YYYY-MM-DD	2025-07-23
DESIGNED	NM
PREPARED	CD | JG
REVIEWED	NM
APPROVED	PB

PROJECT NO.	PHASE	REV.	FIGURE
CA0047730.8440	81100.81151	0	3

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25mm

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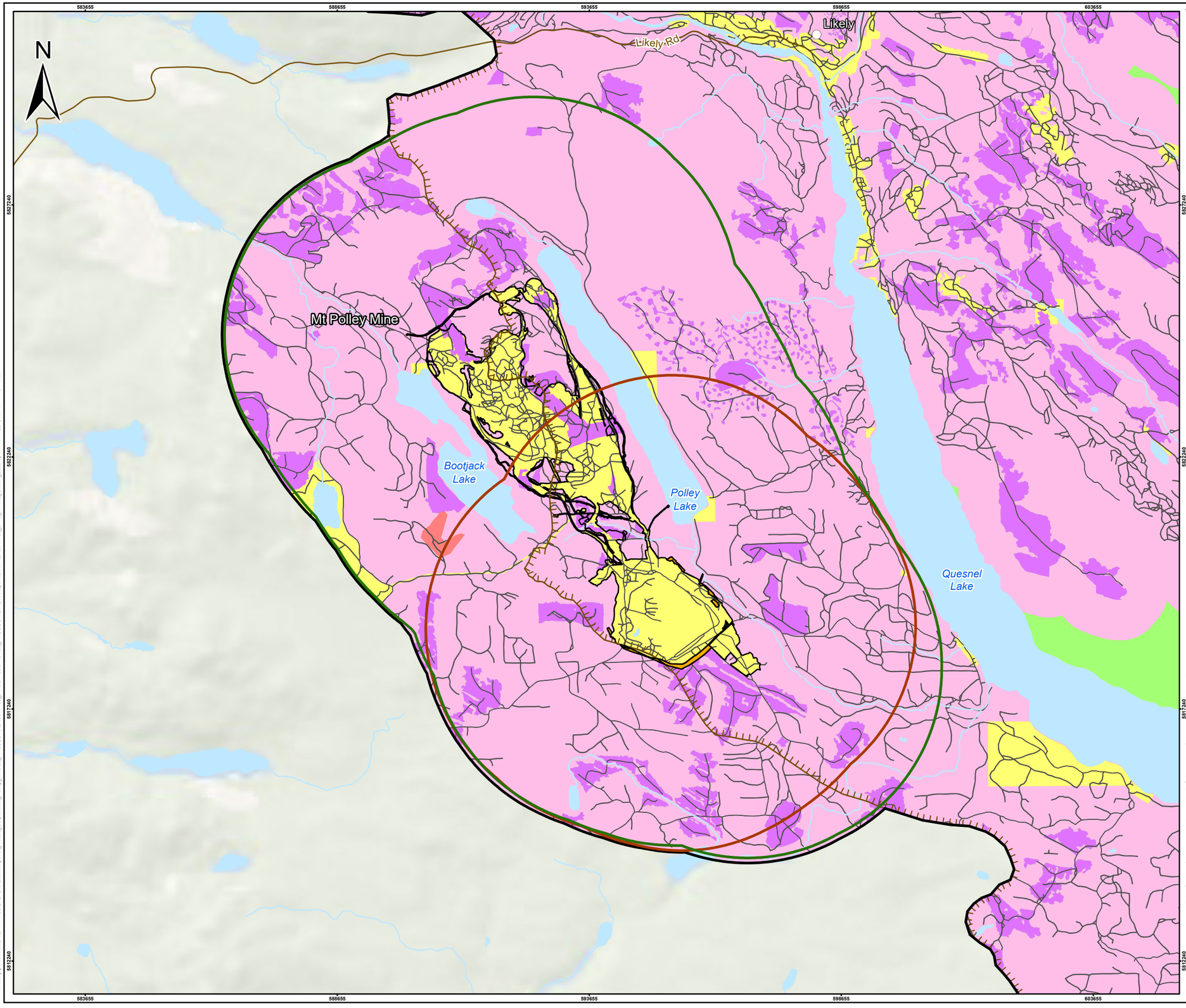
The CAA contains 819,752.9 ha of caribou critical habitat, comprised of 337,005.7 ha of matrix range habitat, 475,942.0 ha of core all-season habitat, and 6,646.1 ha of unmapped range critical caribou habitat (Table 7; Figure 3). Approximately 198,651.6 ha (24.2%) of caribou critical habitat within the CAA has been legally designated as mountain caribou WHAs with restrictions on timber harvest to support recovery to a self-sustaining population. There is a 41,762.9-ha difference between the total CAA area and caribou critical habitat, despite critical habitat polygons overlapping the entire CAA. This discrepancy exists because the critical habitat dataset does not include waterbodies.

The Project Footprint overlaps with designated critical habitat, comprising of 15.7 ha of matrix range and 2.5 ha of unmapped critical habitat. Using the disturbance layer, it was determined that the Project Footprint is 28.2% (5.1 ha) directly disturbed at baseline conditions (Table 6; Figure 3). The remaining 71.8% (13.1 ha) overlaps a mixture of early to mature seral stage forests. According to PEM, age of overlapping forests ranges from 16 years in the southern portion of the Project Footprint, 44 years in the eastern portion, 165 years in the northeastern portion, and 316 years in the western portion (Government of BC 2025c). Much of the mature forest present in the larger region is fragmented from previous logging activity and existing intersecting roads. Forests that overlap with the Project Footprint all fall within the ZOI of existing anthropogenic direct disturbance and, as such, are considered disturbed.

The maximum ZOI for mines (i.e., 3.6 km) was applied to the Project Footprint to assess the associated ZOI. The Project Footprint's ZOI is 6,847.8 ha, overlapping 3,838.3 ha of matrix range habitat and 1,403.9 ha of unmapped critical habitat (Table 7), along with an additional 201.7 ha lake that is not attributed to critical habitat. At baseline, there is 1,588.4 ha of direct disturbance within this ZOI, while the remaining 5,259.4 ha is indirectly disturbed, largely from the Existing Mine Footprint's ZOI (Table 6). The Project Footprint will result in an incremental increase of 1.2 ha[1] to the Existing Mine Footprint's ZOI, for a total ZOI of 12,839.6 ha (Figure 4).

[1] Incremental increase is 1.2 ha rather than 1.1 ha due to rounding of decimals.



LEGEND

- PROJECT FOOTPRINT
- PROJECT FOOTPRINT ZONE OF INFLUENCE
- EXISTING MINE FOOTPRINT
- EXISTING MINE FOOTPRINT ZONE OF INFLUENCE
- CARIBOU HERD BOUNDARY

DISTURBANCE TYPE

- ROAD AND TRAIL
- CUTBLOCK
- WILDFIRE
- OTHER ANTHROPOGENIC DISTURBANCE
- HABITAT WITHIN A ZONE OF INFLUENCE OF ANTHROPOGENIC DISTURBANCE
- UNDISTURBED HABITAT

BASE DATA

- TOWN
- HIGHWAY
- MAJOR ROAD
- WATERCOURSE
- WATERBODY

0 1.5 3

1:75,000 KILOMETRES

NOTES

1. UPDATED MATRIX AND CORE HABITAT BOUNDARIES HAVE BEEN CREATED BUT ARE NOT YET PUBLICLY AVAILABLE SO CANNOT BE DISPLAYED ON THIS FIGURE. CRITICAL HABITAT OVERLAPS THE ENTIRE FIGURE; HOWEVER, FOR CLARITY IS NOT DISPLAYED.

REFERENCES

1. MINE FOOTPRINT AND PROJECT DATA PROVIDED BY CLIENT, 2025.
2. DISTURBANCE DATA CREATED BY WSP, 2025.
3. BASE DATA AND CARIBOU DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – BRITISH COLUMBIA.

COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N

CLIENT
MOUNT POLLEY MINING CORPORATION

PROJECT
CARIBOU MITIGATION AND MONITORING PLAN

TITLE
EXISTING AND PREDICTED PROJECT-RELATED DISTURBANCE TO CARIBOU HABITAT

CONSULTANT

wsp

YYYY-MM-DD	2025-07-23
DESIGNED	NM
PREPARED	CD | JG
REVIEWED	NM
APPROVED	PB

PROJECT NO.	PHASE	REV.	FIGURE
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Table 6: Disturbance within the Project Footprint, Project Footprint Zone of Influence, and Caribou Assessment Area at Existing Conditions

Disturbance Category	Disturbance Type	Disturbance within Project Footprint at Existing Conditions (ha)	Disturbance within Project Footprint ZOI at Existing Conditions (ha)	Disturbance within Caribou Assessment Area at Existing Conditions (ha)
Undisturbed	N/A	**0.0**	**0.0**	379,787.9
Existing Direct Disturbance	Cutblocks	3.8	654.5	80,034.7
	Fire	0.0	34.0	49,144.5
	Mines[a]	0.0	771.5	1,583.5
	Other Polygon Disturbance[b]	0.0	22.3	14,416.8
	Transmission Lines	0.0	10.2	180.0
	Roads	1.4	121.4	3,937.5
	Seismic Lines	0.0	0.0	7.7
Existing Directly Disturbed Habitat Subtotal		*5.1*	*1,588.4*	*149,304.8*
Existing Indirectly Disturbed Habitat		13.1	5,057.7	337,423.1
Total Existing Disturbed Habitat		*18.3*	*6,847.8*	*486,727.9*
Total		**18.3**	**6,847.8**	**861,515.8**

Notes: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
ha = hectare; ZOI = Zone of Influence.
(a) Includes both active and inactive mines.
(b) Includes urban areas, rural residential areas, airfields and airstrips, agricultural areas, and recreation areas.

Table 7: Area of Caribou Critical Habitat Types within the Spatial Boundaries of the Caribou Assessment Area

Critical Habitat Type	Project Footprint (ha)	Project Footprint ZOI	CAA (ha)
Core All-Season	0.0	0.0	475,942.0
Matrix	15.7	3,838.3	337,005.7
Unmapped	2.5	2,807.9	6,805.2
Total	**18.3**	**6,646.1**	**819,752.9**

Notes: Numbers are rounded for presentation purposes. Therefore, it may appear that the total does not equal the sum of individual values.
CAA = Caribou Assessment Area; ha = hectare.

4.2.2 Habitat Distribution

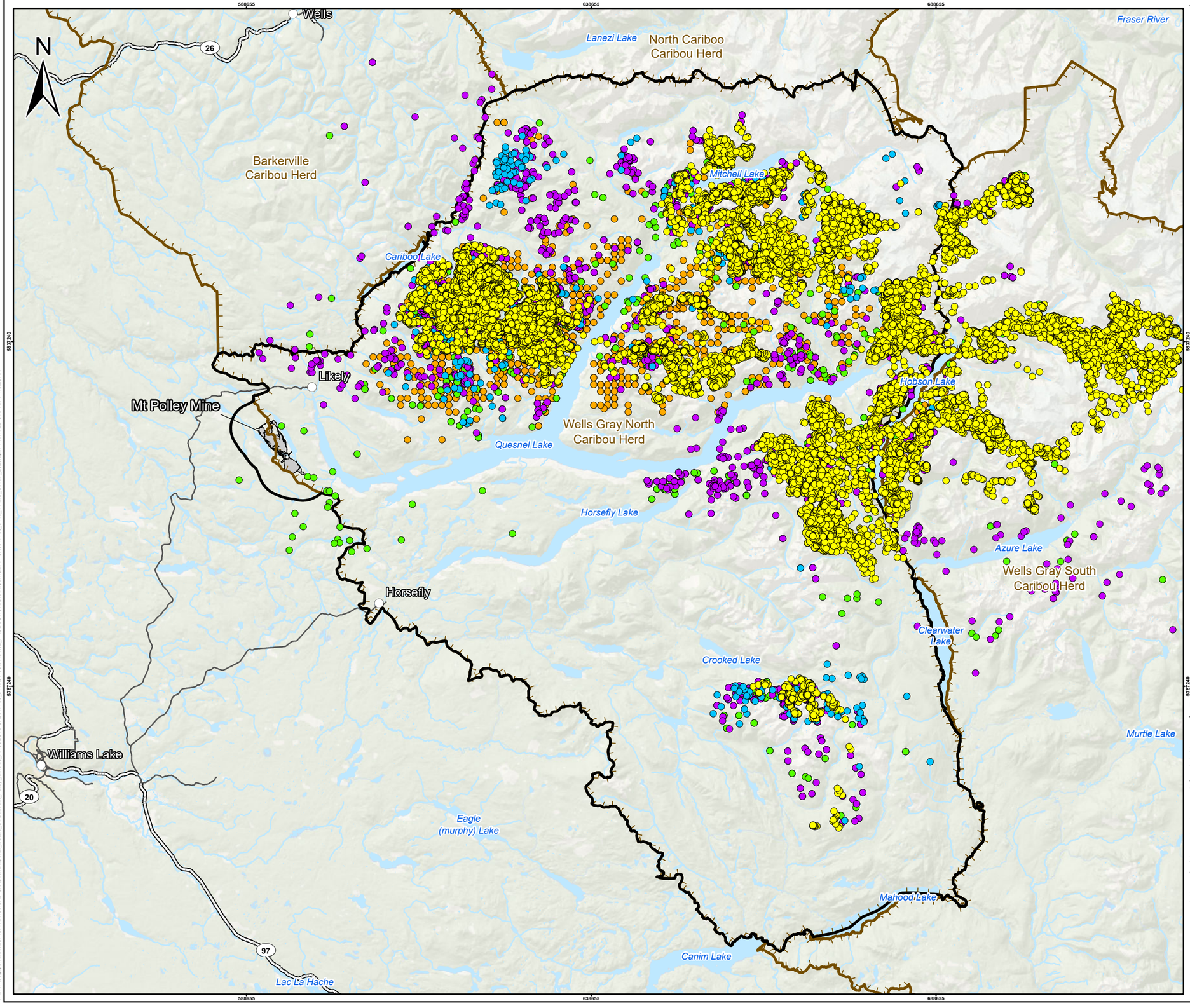
For wide ranging species such as caribou, movement is crucial to facilitate access to resources across space and time (Johnson et al. 1992; Nathan et al. 2008; Taylor et al. 1993). Restricted movement can reduce home range size (Beauchesne et al. 2014; Muhly et al. 2015) and reduce access to resources required for survival, such as predator-free space (Muhly et al. 2015; Nellemann and Cameron 1998; Polfus et al. 2011; Pinard et al. 2012; Johnson et al. 2015). In the Southern Mountain DU, migration is generally altitudinal, and mountain caribou tend to exhibit greater fidelity to calving/summer areas than they do to wintering areas (Wittmer et al. 2006). Increasing levels of habitat fragmentation in the Southern Mountain DU have resulted in several isolated sub-populations with severely restricted dispersal (COSEWIC 2014). Van Oort et al. (2011) documented no dispersal between mountain caribou sub-populations for juveniles and an adult dispersal rate between sub-populations of less than 0.5%. Those dispersal rates are considered insufficient to rescue the smaller and declining sub-populations (Van Oort et al. 2011).

Several studies suggest that caribou avoid roads and areas of high road density (Apps et al. 2006). Polfus et al. (2011) and Johnson et al. (2015) found that caribou avoided roads during both summer and winter. Dyer et al. (2002) found that roads act as semi-permeable barriers to caribou movement; the frequency of crossing events by collared animals on actual roads was reduced relative to crossing rates on simulated road networks (i.e., road networks created randomly on the landscape for use in modelling scenarios) at the same road densities. The magnitude of this effect may vary across seasons. During late winter when road activity for industry was assumed to be high, caribou road crossing rates were six times lower than the rates calculated using simulated road networks (Dyer et al. 2002). Similarly, Wilson et al. (2016) found that some individuals crossroads more slowly, which can delay arrival of caribou at seasonal ranges (Mahoney and Schaefer 2002; Wilson et al. 2016).

Features that act as semi-permeable barriers may exacerbate indirect habitat loss caused by avoidance of disturbance features (Dyer et al. 2002). Beauchesne et al. (2014) suggested that over a certain disturbance threshold, it is likely that individuals cannot avoid using unsuitable habitats, leading to decreased movement rates and increased use of suboptimal habitats as movement becomes increasingly risky (Smith et al. 2000; Hebblewhite 2008). Reduced movement rates and restricted home ranges increase the amount of time spent in lower suitability habitats and, therefore, increase vulnerability to predation (Rettie and Messier 2000; Morales et al. 2010; Beauchesne et al. 2014; Muhly et al. 2015). Caribou confined to smaller home ranges could be forced into less suitable habitat and be more easily detected by predators (Beauchesne et al. 2014).

The Government of BC has collected telemetry data and survey observation data on the Wells Gray North mountain caribou sub-population since 1974 (Dodd and Shore 2023). Telemetry data indicate recent locations of those collared caribou within the Wells Gray North herd are focused in the central and eastern portions of the herd range boundary, overlapping with the WHAs and the Wells Gray Provincial Park. Telemetry locations have not occurred close to the Project or Existing Mine Footprint since 1993 – 1994 and from 1995 – 1999; with the closest distance of a collared caribou recorded to the Mine of 504 m occurring in 1994, indicating historical use of the area, including where the current mine is situated (Figure 5). It should be noted that collared caribou for the Wells Gray North herd has never exceeded 10% of the population, and that only females have been collared, meaning telemetry data does not necessarily reflect spatial and temporal movements of the entire herd. Further, a large gap where data was not collected exists between 2004 and 2021. Additionally, prior to 2021, telemetry data were collected at most once a month, resulting in rough estimations of location and movement information. In 2021, the number of collared caribou was at its highest proportion relative to the herd at 9%; however, numbers have decreased to 1% in more recent years (Simpson 2025; pers.comm.).

In addition to telemetry, late-winter aerial surveys have been completed from 1985 to 2023 to monitor population trends and calf recruitment within the Quesnel Highland and Cariboo Mountains. Observation locations from these surveys are similar to telemetry data described above, with observations largely absent from the western portion of the herd boundary (Dodd and Shores 2023) where the Project is located. Results of these surveys reflect a single location of individual caribou in March of a given year and therefore do not provide an encompassing representation of spatial and temporal movements throughout the year.



LEGEND

- EXISTING MINE DISTURBANCE
- CARIBOU ASSESSMENT AREA
- CARIBOU HERD BOUNDARY

CARIBOU TELEMETRY LOCATION / YEAR

- 2021-2024
- 2000-2004
- 1995-1999
- 1993-1994
- 1984-1988
- 1974

BASE DATA

- TOWN
- HIGHWAY
- MAJOR ROAD
- WATERCOURSE
- WATERBODY

0 12.5 25

1:550,000 KILOMETRES

NOTES

1. SOME TELEMETRY POINTS ARE NOT VISIBLE DUE TO OVERLAPPING DATA. MORE RECENT DATA ARE DISPLAYED IN PRIORITY OVER OLDER DATA.

REFERENCES

1. BASE DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – BRITISH COLUMBIA.
2. WLRS. 2025. TELEMETRY – WELLS GRAY NORTH. SPATIAL DATA FILES PROVIDED BY ANNA SIMPSON. PROVINCIAL WILDLIFE DATA COORDINATOR TO WSP. 24 MARCH 2025.
COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N

CLIENT
MOUNT POLLEY MINING CORPORATION

PROJECT
CARIBOU MITIGATION AND MONITORING PLAN

TITLE
TELEMETRY DATA FROM 1974, 1984-1988, 1993-2004, AND 2021-2024 FOR THE WELLS GRAY NORTH HERD

CONSULTANT

wsp

YYYY-MM-DD	2025-07-23
DESIGNED	NM
PREPARED	CD | JG
REVIEWED	NM
APPROVED	PB

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4.2.2.1 Seasonal Movements and Habitat Use

Mountain caribou exhibit seasonal movements across habitat type and elevations. Seip (1990) considered the spatial and temporal distribution of caribou within the Wells Gray Provincial Park using radio-collared caribou data. A portion of the collared caribou within the dataset used areas within the CAA, including the southeastern and northeastern areas.

Seip (1990) reported three areas within the Wells Gray Provincial Park that were used during winter: the Shuswap Highland (located outside the CAA) at the southern portion of the park, the Quesnel Highlands (located in the CAA) in the western portion of the park, and the Cariboo Mountains (partially located in the CAA) in the interior, northern, and eastern portions of the park. Three general movement patterns were observed between winter and summer ranges, with exceptions and annual variations noted (Seip 1990). Caribou either migrated and used similar winter and summer ranges year-over-year, migrated but did not use the same seasonal ranges annually, or did not migrate. Collared caribou that occurred in the Highlands area over winter generally migrated to the Cariboo Mountains in May and returned in November, while those that wintered in the Cariboo Mountains exhibited minimal horizontal migration and instead stayed in the area throughout the year (Seip 1990).

The average winter home range size was 101 km^2, with a range of 34.5 to 247 km^2, while the average summer home range size was 101 km^2, with a range of 7 to 345 km^2 (Seip 1990). Linear distances between winter and summer home ranges varied from 10 to 60 km, using areas from 20 to 60 km^2 (Seip 1990; Young and Freeman 2002). It should be noted that the entire area was not used during migration; instead, calculated areas were based on polygons created by joining the outermost collared caribou.

Habitat use differed between those that wintered in the Highland areas to those that wintered in the Cariboo Mountains. During early winter in the Highland areas, caribou predominantly occurred in mid-elevation spruce/subalpine fir-dominated forests and upper elevation subalpine fir/spruce-dominated forests in the Engelmann Spruce-Subalpine Fir biogeoclimatic zone (ESSF) (Seip 1990). Similar habitats were used in the late winter; however, vertical migration was exhibited with higher elevations used. Those caribou that wintered in the Cariboo Mountains predominantly occurred in low elevation cedar/hemlock-dominated forests in the Interior Cedar-Hemlock biogeoclimatic zone and mid-elevation spruce/subalpine fir-dominated forests in the ESSF zone. Similar to those that occurred in the Highland areas, vertical migration occurred in the late winter, with rare use of low-elevation habitats (Seip 1990).

Habitat types used in January and February consisted of forested and non-forested habitats, including subalpine parkland and meadows, clearcuts, and burns. Approximately 60% of collared caribou were located in mid-to-upper elevation forested habitats, approximately 30% were in non-forested habitats, with the remaining 10% occurring in low-elevation forested habitats (Seip 1990). In March and April, habitat type use shifted more to open habitats, with approximately 60% using these habitats, with the remaining 40% occurring in forested habitat (Seip 1990). Similar to late winter, some low elevation habitat was used in spring, including cedar/hemlock-dominated forests, slides, and burns, but the majority of collared caribou remained in mid-to-high elevation habitats. In summer, most caribou occurred in open, high-elevation habitats in the ESSF and the Alpine Tundra biogeoclimatic zones, including alpine, subalpine parkland, subalpine meadows, and burns (Seip 1990).

No known caribou movement corridors or paths have been documented by WLRS within the Project or Existing Mine Footprint areas (WLRS 2025c). No caribou or caribou calving or movement have been confirmed to have been observed within the Project Footprint ZOI since 1994 (30 years). Seasonal movement data includes movements made in early winter (November 1 to January 14), late winter (January 15 to March 31), spring (April 1 to May 14), calving (May 15 to July 15), and summer/fall (July 16 to October 31), are generally consistent in terms of spatial extent and movement patterns across these defined seasons and do not occur in the vicinity of the ZOIs of either the Mine or the Project Footprint (WLRS 2025c). However, seasonal movement patterns are based on telemetry data, with active collars on 8% of the herd in 2021 down to 1% in 2024 (WLRS 2025c). As such, current seasonal movement data may not display the Wells Gray North herd's annual movements in a fulsome manner.

Based on caribou data and movement paths provided by WLRS, its unlikely that the Project Footprint ZOI is being used as low elevation habitat for mountain caribou.

4.3 Population Structure and Dynamics

4.3.1 Population Size

Evidence suggests that historically, mountain caribou were plentiful in the Cariboo Plateau and Quesnel Highlands; however, population estimates from this time period are largely unavailable. Estimates from 1935 from what is now Wells Gray Park noted that the caribou population were declining, however, in 1952, the population was noted to have increased since 1945, with an estimate of 220 individuals (Spalding 2000). Population estimates peaked in 1970, with an estimated herd size of 350 to 400 animals. The herd likely then started to decline following 1970 (Spalding 2000). Additionally, multiple recorded observations of caribou around Quesnel Lake occur between 1909 and 1930, noting "plentiful" numbers; however, by 1936, observations appeared to decrease (Spalding 2000).

Population census surveys for areas overlapping the Wells Gray North sub-population have been conducted since the mid-1980s (Dodd and Shores 2023). Caribou numbers observed during surveys fluctuated through the 1990's, with uncorrected numbers from 172 animals in 1992 down to 151 animals in 1999, with a high of 249 animals in 1994. Similar fluctuations in calf recruitment were also recorded, with calves comprising on average 16.5 percent of the population from 1993 to 1995, dropping to an average of 9.8% from 1996 to 1998, and then rising again in 1999 to 15.2% (Young and Roorda 1999). Considering additional data up to 2006, the Wells Gray North herd was considered to be stable-to-declining (Freeman 2011). In 2011, the population was estimated at 225 individuals, down from 300 in 1997, representing a 25% decrease (Freeman 2011). The latest survey completed in 2023 resulted in a population estimate of 199 animals, down 16% since 2020 which had an estimate of 236 animals, but considered stable over the last 20 years with population estimates ranging from 190 to 260 individuals (Cichowski et al. 2021; Ganon 2023). Calf percentage of the population was 12.2%, which is below the 15% threshold considered stable for populations (Bergerud 1980); however, this percentage was consistent with data from the last 20 years where calves have been estimated to comprise between 8 to 19% of the Wells Gray North herd (Ganon 2023).

4.3.2 Mortality Risk

Access (e.g., roads, trails, seismic lines, pipelines, transmission lines, and mines) provides increased opportunities for humans and predators to use an area, which can result in increased caribou mortality from human hunters and poachers (Seip and Cichowski 1996; Jalkotzy et al. 1997; James and Stuart-Smith 2000; Hatter 2000), and mortality from wolf predation, as access provides ease of movement into previously less accessible areas (Horejsi 1979; Bergerud et al. 1984; James and Stuart-Smith 2000). Linear features that allow vehicular use (e.g., snowmobiles) also provide more opportunities for wildlife travel because vehicles compact snow. Accessibility for predators, specifically wolves, increases because snow compaction facilitates movement through areas with deep snow (Shideler et al. 1986; James and Stuart Smith 2000), and increased predation rates may result.

Wolf predation is the suspected cause of low caribou calf recruitment and declining caribou populations in BC, including in Quesnel Highland Unit 5B (Seip 1992, CCLUP 2000; Roorda and Wright 2010). The Quesnel Highland wolf project was initiated in 2001 to reduce the number of wolves preying on caribou to a recommended density of 6.5 wolves/1,000 km^2 (Bergerud 2007) and used a combination of lethal control of sub-dominants and sterilization of dominant wolves (Roorda and Wright 2010). Between 2001 and 2004, 16 wolves were sterilized, and 30 wolves were removed, and there was an observed increase in caribou calf recruitment in 2004 in the Quesnel Highlands planning unit. Between 2007 and 2010, an additional 35 wolves were sterilized and 48 removed; with the resultant wolf density in 2010 estimated at 6.4 wolves/1,000 km^2 in the Quesnel Highland caribou core and matrix habitat study area (Roorda and Wright 2010). More recently, wolf control measures were implemented in the winter of 2023 to 2024 and 14 wolves were removed by helicopter-based aerial shooting measures (BC WLRS 2024b).

Telemetry data collected between 1993 and 2010 in the Barkerville sub-population range, which borders the northern boundary of the Wells Gray North herd, showed an overlap of wolf and caribou habitat use when caribou moved to lower elevations (below 1,500 m) during April and May (the calving period) and in October and November (Roorda and Wright 2010). Linear features may increase access and travel efficacy of predators, which increases predation risk for ungulate species. Previous studies have found that wolves select seismic lines over other available habitat and, in particular, select seismic lines with low vegetation height (Pigeon et al. 2020). Seismic lines with low vegetation height likely provide easier travel for wolves and facilitate searching for prey (Pigeon et al. 2020). Studies in Wells Gray Provincial Park indicated that wolf spatial distribution were associated with moose movement, and that mountain caribou were separated from wolves and moose in the winter by differential habitat use (Seip 1990). Wolf telemetry data from 2021 to 2023 that overlapped with the CAA was obtained from WLRS under a Confidentiality and Non-reproduction Agreement (WLRS 2025d). Wolf location data can be described as ubiquitous, both spatially and temporally, within the herd boundary throughout the year, with overlapping areas used by the Wells Gray North herd.

Declines in caribou populations are linked to increases in moose and deer populations, which sustain a higher density of predators (Seip 2008). In the Cariboo Region, moose did not become numerous until after the early 1900s (CCLUP 2000). In addition to wolf control, moose harvest quotas in the Quesnel Highland region were increased beginning in 2001 as a mechanism to decrease alternate prey density. Moose densities in 2008 were below average densities in adjacent parts of the province, and recruitment was estimated to be lower than that required to stabilize a population, indicating that moose populations were not a main contributor to high wolf populations (Hayes 2013).

There is a very limited risk of human-caused mortality to caribou from hunting. Recreational hunting of caribou is not permitted in Provincial Wildlife Management Unit 5-2, where the Project is located (MOF 2025). The herd also overlaps with Provincial Wildlife Management Units 5-15 and 3-46, both of which have not had an open season on caribou hunting since 1997 (Government of BC [date unknown]a). In addition, many Indigenous nations have voluntarily stopped subsistence hunting of southern mountain caribou (EC 2014). However, increased access to the region from roads may result in some limited poaching.

Vehicle mortality affects virtually all wildlife species and has been the topic of several literature reviews (Kelsall and Simpson 1987; Jalkotzy et al. 1997). Road mortalities may cause a decline in local populations but are generally site- and species-specific. Frequencies of road mortalities are often related to type of road, location, traffic volume, and speed (Jalkotzy et al. 1997). There have been no reported caribou mortalities resulting from vehicle strikes within the Mine.

5.0 ASSESMENT METHODS

The mountain caribou components and their associated indicators (Table 3) are used as the basis for an assessment of potential effects to caribou from the Project and to support the identification of associated mitigations to reduce effects (Section 7.0).

To assess effects of the Project, project effects pathways (Section 5.1) based on Project interactions with mountain caribou were determined. For the Habitat Condition Component, effects were predicted by quantitively assessing the change from the baseline habitat condition to a predicted Project habitat condition. To complete the quantitative change in habitat condition, a habitat disturbance layer was created for the CAA (as described in Section 3.1) and overlaid onto the federally mapped critical habitat for the Wells Gray North herd within the CAA. Both a review of change in direct habitat loss, as well as indirect habitat loss was completed.

For Project-related effects on the Population Structure and Dynamics Component, a qualitative assessment was completed, informed by WLRS provided historical telemetry data, mark/re-sight survey data, available reports on the Wells Gray North herd, and existing peer-reviewed literature.

5.1 Project Effects Pathways

Identified interactions between Project activities and mountain caribou are presented in Table 8. Potential interactions are characterized as:

- Positive, none or negligible, requiring no further consideration.
- Potential effect requiring further consideration and possibly additional mitigation.

Based on the spatial boundaries described in Section 3.1, construction, operations, and restoration/closure of the Mine may interact with the mountain caribou components (i.e., Habitat Condition and Population Structure and Dynamics).

Table 8: Caribou Interactions with Amended Permit Project Footprint Activities and Potential Effects Pathways

Project Activity	Description	Mountain Caribou Component		
		Potential Interaction(1)	Potential Indicator Affected	Potential Effect
Phase 5, 6, and WX and C2 Construction and SERDS Expansion	These phases involve the deepening of the Springer Pit and WX and C2 starter pits.	No	None. These project activities are within the Existing Mine Footprint. No direct habitat loss will result as part of this activity, nor is an increase in the Project's ZOI anticipated.	n/a
Construction (TSF Raises)	The Project Footprint overlaps with forests ranging from early to mature seral stages, which will require clearing and grubbing prior to Project construction. Under baseline conditions, the area of new direct habitat loss is indirectly disturbed at baseline.	Yes	Habitat Availability Population Size	Long term loss of matrix and unmapped critical habitats (13.1 ha direct habitat loss which is indirectly disturbed under baseline conditions) Habitat distribution through displacement from potential foraging and security habitat and/or disturbance during movement is not predicted based on lack of caribou location data within the past 30 years within the Project's ZOI. Project footprint and ZOI within unmapped habitat and fringe of matrix habitat (no core habitats or movement areas identified) Increased risk of predation, as an increase in early seral habitat may result in increased alternate prey and subsequent predator functional response.
Operation	Routine mine operations are not anticipated to change from existing conditions post-construction of the Project.	Yes	Habitat Availability (sensory disturbance)	Decreased availability of habitat through increased indirect disturbance (1.2 ha's).
Closure	Conventional reclamation of roads and TSF, and infilling of pits with water.	Yes	Habitat Availability (direct and sensory disturbance)	Decreased availability of habitat through direct habitat loss and indirect disturbance during closure activities.
Post-closure	Ongoing, progressive site reclamation and restoration	Yes	Habitat Availability	Succession of forested habitat towards preferred mature seral stages.

(1) "No" = interactions with mountain caribou are not predicted after mitigation measures are implemented. Therefore, this interaction is not carried forward to the effects assessment.

"Yes" = interactions with mountain caribou are predicted after mitigation measures are implemented, and this interaction is carried forward to the effects assessment.

5.2 Evaluating Residual Effects

Potential Project-related residual effects were characterized as the basis for determining the significance of potential residual adverse effects for mountain caribou. The characterization of direct and indirect effects to mountain caribou and their habitat was undertaken after mitigation measures to avoid, minimize, and restore on-site are implemented. Mitigation measures are summarized in Section 7.0.

An effect is considered to occur where anticipated future conditions resulting from the Project differ from the conditions otherwise expected from natural change or from baseline conditions. In some situations, the recommended mitigation will eliminate a potential adverse effect, while in another situation the mitigation will lessen, but not eliminate, the effect. Any adverse effect that will be eliminated, or is considered unlikely after mitigation, is not identified as a residual effect and is not considered further. Any adverse effect that may remain after the application of a feasible mitigation is identified as a residual effect.

Residual effects are categorized using the following standard residual effects criteria and described in detail in Table 9.

- Context: describes the current and future sensitivity and resilience of mountain caribou to change caused by the proposed Project.
- Magnitude: the expected size or severity of the residual effect. This is described quantitatively for the Habitat Condition component and qualitatively for the Population Structure and Dynamics component.
- Geographic extent: the spatial scale over which the residual effect is expected to occur.
- Duration: the length of time the residual effect persists.
- Reversibility: indicating whether the effect is fully reversible, partially reversible, or irreversible.
- Frequency: how often the residual effect occurs.
- Likelihood: the likelihood of a causal disturbance occurring or the likelihood of mitigation being successful.

Table 9: Criteria for Characterizing Potential Residual Effects

Criteria	Description
Context	Resilient: a high natural resilience to imposed stresses
	Moderately resilient: a moderate natural resilience to imposed stresses
	Sensitive: a low natural resilience to imposed stresses
Magnitude	Negligible: Project effect will have no measurable change from baseline conditions
	Low: Project effect will result in small (1% to <10%) change from baseline conditions
	Medium: Project effect will result in moderate (10% to 20%) change from baseline conditions
	High: Project effect will result in high (>20%) change from baseline conditions
Geographic Extent	Local: effects restricted to the Amended Permit Project Footprint and associated mine disturbance type ZOI (i.e., 3.4 km)
	Regional: effect restricted to CAA
	Beyond Regional: effect extends beyond the CAA

Table 9: Criteria for Characterizing Potential Residual Effects

Criteria	Description
Duration	Short-term: less than 1 year
	Medium-term: 1 year to life of the proposed Project
	Long-term: greater than the life of the proposed Project
Reversibility	Fully reversible: effect reversible with restoration and/or over time
	Partially reversible: effect can be reversed partially
	Irreversible: effect cannot be reversed with restoration and/or over time
Frequency	Low: occurs rarely or during a specific period
	Medium: occurs intermittently
	High: occurs continuously
Likelihood	Low: likelihood of occurrence of residual effect is possible but unlikely
	Medium: likelihood of occurrence of residual effect may occur, but is not certain to occur
	High: likelihood of occurrence of residual effect is likely or certain to occur

The level of confidence for each predicted effect is discussed to characterize the level of uncertainty associated with both the significant and likelihood determinations. Confidence is related to the adequacy of baseline data for understanding current conditions and future changes unrelated to the proposed Project (e.g., extent of future developments, climate change), understanding of the proposed Project-related effects on complex ecosystems, and knowledge of the effectiveness of the mitigation actions. Level of confidence is characterized as:

- Low – limited evidence is available and/or evidence about potential effects is contradictory.
- Medium – sufficient evidence is available and generally supports the prediction.
- High – sufficient evidence is available and most or all available evidence supports the prediction.

6.0 PROJECT EFFECTS ASSESSMENT

The assessment of the effects of the Project on mountain caribou is based on Project footprint shapefiles provided by MPMC, publicly available data on existing disturbances within the CAA, habitat and species information, and information provided by WLRS specific to the Wells Gray North herd. The current assessment focuses on predicting Project effects during the life of the Mine from the Amended Permit Project Footprint itself, as well as indirect effects associated with caribou habitat availability as well as potential contributions to mortality risk. To account for indirect effects, recommended ZOI's were implemented, as described in Section 3.1.

6.1 Habitat Condition

6.1.1 Habitat Availability

The Amended Permit Project Footprint overlaps with identified matrix and unmapped critical habitat for mountain caribou. The Project is anticipated to directly disturb 18.3 ha, including 15.7 ha of matrix range habitat and 2.5 ha of unmapped range habitat. Of the 18.3 ha, 13.1 ha is currently physically undisturbed, but overlaps with the Existing Mine Footprint's ZOI. The remaining 5.1 ha is comprised of existing cutblocks and roads.

In addition to direct habitat loss, mountain caribou habitat quality around the Amended Permit Project Footprint may be indirectly disturbed by 1.2 ha if mountain caribou exhibit reduced use around areas near the Project due to sensory disturbance. The Existing Mine Footprint's ZOI is 12,838.4 ha. The Project Footprint's ZOI largely overlaps the Existing Mine Footprint's ZOI, with an additional 1.2 ha added, representing a <0.1% increase (Figure 4). Further, the entire area within the Project Footprint's ZOI is considered disturbed at baseline, with 1,588.4 ha directly disturbed (23.2% of total ZOI area) and 5,259.4 ha indirectly disturbed (76.8% of total ZOI area) either through the Existing Mine Footprint's ZOI or ZOI's of other direct disturbances present (e.g., cutblocks, roads). Therefore, little to no indirect habitat impacts due to the Project are expected to occur. Based on the available mountain caribou data, mountain caribou have not been recorded since 1994 within the ZOI of the Existing Mine's Footprint's ZOI. Therefore, based on mountain caribou current core area distribution within the eastern portion of the CAA (opposite end of the CAA from the Project), known caribou location data, and the limited change in indirect habitat loss; a contraction in the range of the Wells Gray North herd is not expected due to localized changes in habitat quality associated with the Project.

6.1.2 Habitat Distribution

Habitat alteration can result in changes to the distribution of available habitat and localized changes in the distribution and movement patterns of animals. As the Project involves the expansion of an existing footprint with no additional disturbance bisecting undisturbed habitat, increases in fragmentation of the CAA is not anticipated. Further, as noted above in Section 6.1.1, the entire ZOI of the Project Footprint is considered disturbed at baseline.

6.2 Population Structure and Dynamics

6.2.1 Population Size

Although the Wells Gray North herd is estimated to be stable (Zimmerman et al. 2025), any amount of increased habitat loss, which is modelled to affect population size and recovery for mountain caribou populations (EC 2014) needs to be considered (EC 2014). For the Project, the effect is considered to be of low magnitude and is discussed further in Section 6.2.2 in relation to predator functional response to early seral habitats.

6.2.2 Mortality Risk

Although the Wells Gray North herd is estimated to be stable (Zimmerman et al. 2025), any amount of increased adult or calf mortality could potentially have negative effects on population stability size due to the small size and isolation of mountain caribou populations. However, the Project does not involve the construction of new roads or trails, while existing Mine-related roads are not publicly accessible. As such, an increase in predation risk due to increases in predatory movement efficiency is not anticipated. Similarly, increases in potential instances of poaching is not anticipated for this same reason, while recreational hunting of caribou is not permitted in Wildlife Management Unit 5-2, where the Project is located (MOF 2025).

Direct mortality due to clearing is unlikely to occur because mountain caribou are likely to flee ahead of clearing activities. An increase in traffic during construction may increase occurrences of vehicle-caribou collisions. The risk of mortality due to vehicular collisions along access roads is considered unlikely because speed restrictions are implemented on all Mine roads to reduce the risk of vehicle-related mortality, with no records of injury or mortality of mountain caribou. The Project is not anticipated to result in an increase in operational traffic. Therefore, there is not an anticipated increase in vehicle-caribou collision risk.

Overall, an increase of risk of mountain caribou adult or calf mortality from increased predation, poaching, or vehicle collisions are not anticipated. Additionally, Mine-related roads will be reclaimed during the Closure period.

Vegetation clearing for the Project will create approximately 13.1 ha of early seral habitat during the closure and reclamation phases, which may be more favourable for moose. Increased moose habitat may influence moose densities which can trigger a response in the number of mountain caribou predators; and in particular the increase in early seral habitat is associated with increases in wolf abundance, which increases predation risk for caribou (Seip 1992). The risk of increased mortality from the functional response in predators is predicted to be not applicable during construction or operations of the Project. During closure and reclamation, habitats will be recovering to early seral habitats suitable for moose. On-site restored habitats will shift from early seral structural stages following on-site restoration, and over time will move to late successional habitats for mountain caribou (Section 7.3). Restoration planning for mountain caribou will include reducing the attraction of the area for moose and associated predators through careful planting prescriptions which focus on bringing the area back to conifer cover.

Despite the potential addition to an increase in mortality risk in the area via predator functional response, the overall magnitude of the effect is predicted to be negligible given the presence and extent of surrounding cutblocks in the larger region. As the Project Footprint is small relative to the surrounding area of with cutblocks and other anthropogenic disturbances at baseline, it is anticipated that the Project will not be the key driver of early seral habitats in the CAA or the associated alternate prey and ultimate functional response of predators.

7.0 MITIGATION HIERARCHY

Mitigation measures for the Project follow the mitigation hierarchy outlined in the provincial *Procedures for Mitigating Impacts on Environmental Values* (MOE 2014b):

- Level 1: Avoid
- Level 2: Minimize
- Level 3: Restore on-site
- Level 4: Offset (off-site or on-site) or Compensate

The mitigation measures included in this CMMP are intended to reduce potential adverse effects to caribou. The mitigation measures follow provincial and federal standards, best management practices, and guidelines. MPMC will consider all practical solutions before moving down the hierarchy of mitigation options. For each mitigation level, the type of mitigation approach, the results and discussion of the effectiveness of the mitigation measures, and the rationale for moving to the next mitigation level are described.

7.1 Avoid

7.1.1 Approach

Location

The Project avoids mountain caribou core all-season habitat, WHAs, provincial parks and known caribou locations and habitat use areas. The Project does straddle the edge of the provincially managed herd boundary and associated matrix habitat and extends into unmapped critical habitat. Spatial avoidance of matrix habitats is not possible as the Project seeks to expand the existing Mine and utilize existing Mine access and infrastructure. The Project Footprint is 18.3 ha, of which 13.1 ha is indirectly disturbed at baseline conditions. This 13.1 ha includes 11.2 ha of matrix habitat and 1.9 ha of unmapped range. This represents less than 0.1% of both critical habitat types within the CAA.

Timing

The Project is partially located in matrix caribou habitat of low elevation, which may be used by caribou in late winter and early spring; however, mountain caribou in the Quesnel Highlands do not have a well-defined seasonal migration and typically range from high to low elevation habitat within their home range (Government of BC [date unknown]a; Seip 1992). Construction and operations of the Mine overlap with sensitive caribou periods. However, given the current understanding of caribou presence and seasonal movements of the Wells Gray North herd within the CAA, caribou are not anticipated to occur within the ZOI of the Mine or of the Project during these times.

If caribou are observed during construction or operations, a Trigger Action Response Plan will be implemented. This plan is discussed in further detail in Section 7.2.1.

7.1.2 Results and Discussion

There is no option for physical avoidance of mountain caribou habitat for the Project because of the location of the existing Mine which is to be expanded upon. The Project will result in an increase in the amount of directly disturbed habitat relative to existing conditions that may otherwise be available for reclamation or restoration. Indirect disturbance, such as noise and light, that is directly attributed to the Project will expand, with an anticipated increase in ZOI area of 1.2 ha. Despite this increase, there are currently no undisturbed habitats within the Amended Permit Project Footprint's ZOI, all of which are either directly or indirectly disturbed at baseline.

7.1.3 Rationale for Moving to Minimize

The Project is unable to fully avoid direct or indirect increase in disturbance to matrix or unmapped mountain caribou habitat; with the Project Footprint overlapping 15.7 ha and 2.5 ha of these critical habitat types, respectively. Therefore, efforts to minimize effects to mountain caribou from the Project will be implemented as described in Section 7.2.

7.2 Minimize

7.2.1 Approach

The following mitigation measures will be implemented to minimize Project effects to mountain caribou components within the areas of the Project that overlap the CAA. Where mitigation measures cannot be implemented as indicated below, consultation with the Ministry of Forests (MOF) and WLRS would occur to determine alternative mitigation.

Location

- The Project Footprint occurs in an area with no undisturbed habitat as a result of overlapping direct and indirect disturbance. Specifically, the Project Footprint overlaps with 5.1 ha and 13.1 ha of directly and indirectly disturbed habitat at baseline, respectively.

Vegetation Clearing

- Vegetation clearing, soil stripping, grubbing, and grading for construction, temporary workspaces, or storage areas, will occur only within the Project Footprint and be minimized to the extent possible.
- Danger trees adjacent to the clearing boundaries that are currently wildlife trees or have the potential to become wildlife trees will be topped to remove the hazard while still allowing caribou to access lichen or provide a site for lichen to establish. Trees will be assessed by a Professional Forester.
- Retention of vegetation, as well as use of coarse woody debris or felled trees, will be undertaken where possible.
- Mature coniferous trees may be de-limbed, as required (e.g., for work safety), with the stumps and limbs retained on-site to provide a seed source. Retaining limbs and trees on site maintains cones or seeds attached to the limbs on site.
- Invasive plant management techniques will be implemented according to MPMC's Invasive Plant Management Plan (Appendix O in MPMC 2023).
- During continuous progressive reclamation, grass seeding will only be used where there is an immediate need for sediment and erosion control. This will minimize foraging-attractant and will discourage wildlife from entering the reclamation area.
- Trees and branches with arboreal lichen coverage could be placed in areas to be progressively reclaimed to provide nutrients to support natural recovery of vegetation following construction.

Access Management

- No new access is required for the Project.
- Access control barriers will be placed in areas where progressive reclamation is underway.

- Retention of vegetation, as well as the use of coarse woody debris or felled trees, will be strategically implemented within areas undergoing progressive reclamation to provide nutrients to support seeding establishment or access control

Barriers to Movement

- If Project activities appear to be interfering with wildlife movement around the Mine or within forested areas of the Mine, the General Manager may temporarily suspend activities until the animals have safely departed the area.

Spill Prevention

- Employees and contractors working with machinery will be trained in proper fuel transfer procedures and standard operating procedures for spill prevention.
- Equipment will be inspected and maintained as required to minimize losses of hydraulic fluids, lubricants, or fuels.
- Waste streams will be managed so as not to create a wildlife attractant.
- Hazardous materials, including batteries, petroleum products, sewage, or contaminated soil will be transported off-site and disposed of in accordance with the Transportation of *Dangerous Goods Act*.

Trigger Action Response Plan

A Trigger Action Response Plan will be implemented if caribou are observed immediately prior to, or during construction, or during ground or aerial operations. If a caribou is observed in the vicinity of construction or operations activities, the following measures will be implemented:

- Cease construction activities, mining or other work-related activities in the immediate vicinity of the observation. Temporary suspension of work in one area for caribou sitings will not affect work in areas sited away from the observation.
- Allow caribou to move freely out of the area. Caribou will not be harassed, and no actions will be taken by Mine staff to directly or indirectly move individuals (e.g., no use of truck horns, positioning trucks to herd caribou).
- Work activities will recommence following a 30-minute period after caribou are no longer within sight to reduce chances of disturbance.

If caribou are observed on mine roads while driving, the following measures will be implemented:

- Pull over and turn off the vehicle and high-beams, as long as conditions are safe to do so.
- Wait until caribou are no longer within sight before proceeding.
- Caribou will not be harassed in any manner to encourage movements off of roads.

Any observations of caribou or caribou sign (e.g., tracks, scat) will be reported to the provincial Caribou Recovery Program via email (caribou.recovery@gov.bc.ca).

Other measures that will be implemented to reduce potential sensory disturbance include the following:

- MPMC will comply with appropriate regulatory requirements related to noise during Project construction and operations to minimize disturbance related to noise.
- No vehicle alarms will be armed if caribou are in the vicinity of the vehicle.
- The use of off-road or recreational vehicles (e.g., All Terrain Vehicles, snowmobiles) will be prohibited at the Project unless appropriate approvals have been obtained.

Aerial Operations

Aerial operations for the Mine are restricted to monthly drone flights and an annual fixed-wing flight for obtaining site-wide imagery. To minimize the effects from aerial operations, the following mitigation measures will be implemented:

- The annual fixed-wing flight will be scheduled to avoid sensitive caribou periods (i.e., May 15 to July 15) of calving and post-calving.
- No direct flight approaches will be made towards caribou during either drone or fixed-wing flights (FLNRO 2014). If caribou are observed prior to, or during flights, the Trigger Action Response Plan, as described above, will be implemented.

Mineral Licks

- A pre-clearing survey will be completed for wildlife features such as mineral licks prior to clearing. If a mineral lick is recorded, a 500 m buffer will be implemented, where feasible. If a 500 m buffer is not feasible, MPMC will consult with a QP for additional guidance on a reasonable buffer and additional mitigation measures, as required.
- If a mineral lick is discovered, the discovery will be reported to the General Manager and additional measures may be implemented. If a mineral lick is compromised by Project-related activities, MPMC will consult with the appropriate regulating bodies (i.e., WLRS) on the method of management.
- Locations of mineral licks will not be made available to the public.

Traffic Management

- Speed limits will be implemented and posted on all non-highway access roads to reduce the risk of wildlife-vehicle collisions and to suppress dust, minimizing potential impact on adjacent vegetation. On public gravel or forest service roads, the maximum speed limit is 60 km/h, while the maximum speed limit on all roads within the Mine is 40 km/h.
- Use of salt for road traction will be prohibited.
- Road signage that informs mine personnel to be attentive for wildlife will be established, as necessary. Signage will be placed where potential collisions are predicted (e.g., at known wildlife crossings, blind hills, blind corners, etc.) or have already occurred.

Worker Education

- Project personnel will receive a mandatory site orientation and training, which will address specific education on mountain caribou. This will include specific procedures for minimizing harassment of caribou, immediate reporting of encounters, and methods to minimize caribou-vehicle collisions.
- A no wildlife harassment policy will be implemented at the Project.
- Hunting and the possession or use of firearms, including carrying personal firearms in vehicles, will be prohibited on-site.
- Pets will be prohibited on or in the vicinity of the Project.
- Project personnel will report caribou observations, including any observations to and from the Mine.

Project Construction and Mine Operations

- Implement measures to manage fugitive dust, as outlined in Appendix P of MPMC's MPRP. These measures include, but not limited to:
  - Regularly maintaining roads in good repair;
  - Installing wind breaks or fences around problem areas known to generate fugitive dust;
  - Reducing drop heights during material transfer;
  - Optimizing the operation of equipment to reduce dust generation (e.g., reducing vehicle speeds);
  - Optimizing site layout to reduce travel distances; and
  - Using dust suppressants, as needed and if temperatures permit, to mitigate dust generation at work areas, along unpaved roads, for tailings, and at storage piles.
- Snowbanks resulting from ploughing access roads will have escape breaks every 200 m.
- If mining activities appear to be interfering with wildlife movement through the Project area, the General Manager may temporarily suspend activities until the animals have safely departed the area. Temporary suspension of activities in one work area will not impact work in areas sited away from the observation.
- Explosives will be stored on-site in approved explosive magazines, and any handling of explosives or blasting activities will follow relevant standard operating procedures to prevent the potential for ammonium contamination.

7.2.2 Results and Discussion

Mitigation measures that minimize Project effects are based on provincial guidelines, best management practices, or regulatory requirements, and are generally considered effective. However, residual effects to caribou components are still anticipated following implementation of mitigation due to residual direct and indirect impacts to habitat, such as sensory disturbance, that will persist for the life of the Project.

7.2.3 Rationale for Moving to Restore On-site

Despite mitigation measures to minimize Project effects to mountain caribou, the Project is still predicted to affect caribou habitat. Therefore, mitigation measures will be implemented to restore the affected mountain caribou habitat in the Project footprint.

7.3 Restore On-site

MPMC has prepared a Mine Plan and Reclamation Program (MPMC 2023) that outlines, among other components, previous and ongoing reclamation activities and associated research, end land use plans, and associated planting prescriptions. The Mine will be restored to equal or better conditions following mine closure, with the exception of permanent structures, such as pit walls. Progressive reclamation activities for the Mine will be monitored in the Closure and Post-Closure phases.

Temporary areas of vegetation clearing will be progressively revegetated, by planting conifer seedlings within the disturbance area, once construction within the area is complete. Revegetation efforts should employ findings outlined in MPMC's 2022 MPRP (2023), which summarizes strategies for revegetation based on several reclamation research programs conducted at the Mine.

Seedling prescriptions, including species and densities, will be appropriate to the adjacent natural ecosystem. MPMC has developed a reclamation prescription matrix that outlines site series, site-specific characteristics (e.g., gradient %, aspect, slope position) and associated vegetation and stem density (MPMC 2023). This matrix, along with the *Operational Restoration Framework – Woodland Caribou Habitat Restoration in British Columbia* (FLNRORD 2021) will be followed to guide seedling prescriptions.

7.3.1 Ongoing and Planned Reclamation Activities and Research

MPMC currently has several progressive reclamation sites, which are treated as large-scale research projects, with outcomes influencing future reclamation plans and prescriptions. Much of the progressive reclamation achieved at the Mine Site occurred in the 2010's. Many of the monitoring programs associated with progressive reclamation have been executed as planned or have been put on hold due to the Mine Site's recent care and maintenance status.

More recent progressive reclamation included salvage of approximately 7,838 m^3 of soil from Cariboo Pit Access and subsequent placement of the salvaged soil at Southeast Zone-1 (SEZ-1) and Mill Site 1 in 2017. In 2018, approximately 3,691 m^3 of till was placed in the Breach Zone, the Northeast Zone (NEZ) Dump, and the 9 km Wetland. Tree planting also occurred in 2018 on the North Bell Dump.

In addition to decommissioning portions of the Mine, progressive reclamation also acts as a research tool. The reclamation research program at the Mine commenced in 1998. Since this time, many research trials have been established at various locations around the Mine. Progressive reclamation sites provide monitoring results and information on which treatments and vegetation strategies are most successful and provide insight into considerations for scaling up reclamation prescriptions for large-scale implementation. Historically, reclamation research focused on improving coversoil quality (e.g., using biosolids). However, since the TSF embankment breach in 2014, most research has focused on post-closure water quality.

The Mine has an extensive record of reclamation research experience that was presented in the 2017 MPRP Update (MPMC 2017). An example of this includes the East Rock Disposal Site Reclamation Research Trial, which was established between 1998 and 2000 and has since concluded. The trial was designed to test the effect of coversoil placement thickness on grass and conifer seedling performance, while amending coversoil with biosolids. The NEZ Dump Trial also investigated the amendment of coversoil (biosolids and fertilizer “tea bags”) and revegetation prescriptions. The North Bell Dump trial also investigated coversoil amendment with biosolids sourced from Metro Vancouver. Key findings from these trials have been used to inform current reclamation prescriptions.

Coversoil Placement Findings:

- Direct placement of stripped soil is an effective way to maintain soil nutrients.
- Placement of 15 cm of coversoil is adequate for tree survival and growth.
- Trees at the Mine Site require a minimum rooting depth of 25 to 30 cm for normal root development and this can be provided by overburden (till) or a combination of overburden (15 cm or greater) and waste rock.
- Tailings combined with overburden and biosolids provide a suitable root growing medium, equivalent to overburden.
- A rate of 50 dt/ha of biosolids provided a similar degree of rooting enhancement as 15 to 30 cm of overburden.
- 20 cm of overburden with ~100 dt/ha of biosolids is sufficient for establishment of vigorous conifer seedlings.
- Biosolids in combination with 15 cm of overburden substantially increased the rooting depth on plots located on upper slopes and crests (McDougall 2015).
- Biosolids accelerated LFH development on reclaimed sites (McDougall 2015).
- Amendment of soil with biosolids improved tree growth but has a limited period of effect (less than 15 years).
- Sites that received biosolids demonstrated soil chemistry to be within acceptable ranges for plant growth.

Revegetation Findings:

- Native species will grow from the seed bank within directly placed soil; fully or partially negating the need for seeding of ground cover.
- Plant growth is improved on reclamation areas with surface roughening and coarse woody debris.
- Seedling mortality on reclaimed areas is high, likely due to the exposed locale and harsh climate and should be mitigated through overplanting.
- Selection of trees and shrubs should consider site-specific conditions, specifically hot, dry conditions on south and west facing slopes.
- Timely establishment of overstory vegetation (primary successional trees and shrubs) is important for preventing establishment of invasive and non-native species.

- Natural ingress of diverse native species is occurring in reclaimed areas, including shrubs/trees such as raspberry (*Rubus idaeus*), elderberry (S*ambucus spp.*), cottonwood (*Populus trichocarpa*), and willow (*Salix* spp.).
- Lodgepole pine (*Pinus contorta*) had greater survival than Douglas fir (*Pseudotsuga menziesii*) in most treatments.
- Other species, such as woods rose (*Rosa woodsia*), black cottonwood (*Populus trichocarpa*), willow (*Salix spp.*) and alder (*Alnus glutinosa*), performed more successfully than paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*) and saskatoon (*Amelanchier alnifolia*).
- The application of biosolids can increase grass growth leading to competition with woody species and forbs (McDougall 2015).
- Increased grass layers can provide habitat for rodents who can impact tree survival through girdling of seedlings.
- The growth of conifers was higher on the parcels amended with biosolids compared to control parcels.
- The understory on biosolids-amended soils should be seeded at low seeding rates with native forbs to promote the highest conifer survival rate while still providing erosion and invasive plant control.

As per the Mine's Amended M-200 Permit, MPMC is to prepare and submit a Reclamation Research Plan by December 31, 2027, that outlines site-specific proof of success of the mine closure concept and reclamation prescriptions outlined in the Reclamation and Closure Plan. Additional research activities will be outlined in this plan.

7.3.2 Reclamation Objectives

The main objective of the reclamation program is to return all areas that have been disturbed by mining operations (except pit walls) to equivalent or greater land capability than existed prior to mining, on an average property basis. To help achieve this overarching goal, an End Land Use Plan has been developed, which focusses on ecosystem rehabilitation as the main goal with a target towards ecosystems that occurred prior to disturbance.

The End Land Use Plan also estimates shifts in the end land use objectives over time as the ecological trajectories of the ecosystem evolve. This allows for end land use planning to be considered over the long-term and considers that a variety of end land uses can occur on the landscape over different temporal scales. To achieve successful closure of the Mine, the following objectives must be achieved:

- Long-term stability of engineered structures, including the Rock Disposal Sites, TSF and open pits, as well as all exposed erodible materials.
- Removal and proper disposal of access roads, structures, and equipment not required after the Mine Site closes.
- Sufficient coversoil (e.g., reclamation material) to achieve the desired target ecosystems on the post-closure landscape.
- Geochemical stability of Waste Rock Dumps, open pits, the TSF, and all other major components of the Mine Site in the post-closure landscape.

- Long-term preservation of water quality within and downstream of decommissioned operations.
- A water balance that meets the requirements for a functional landscape that aligns with the targeted end land use.
- Natural integration of disturbed lands into surrounding landscape, and restoration of the natural appearance of the area after mining ends, to the extent practicable.
- Self-sustaining vegetation covers established, consistent with the end land uses and desired ecosystems.
- Use of reclaimed ecosystems by their desired stakeholders (e.g., recreational users, wildlife, and traditional use practitioners).

Once these aspects are in place, flexibility exists to modify ecosystem composition, patch size, and vegetation mosaic and to provide additional structural components, as desired. By reclaiming disturbed land to stable, functioning, and locally appropriate ecosystems that can reasonably be expected to thrive on a specific landform or location, a variety of end land use objectives can also be met.

7.3.3 Reclamation Strategies

To promote successful reclamation and closure of the Mine, MPMC has developed protocols and plans related to the following topics:

- physical stability
- water quality and watercourse protection
- soil management
- revegetation prescriptions
- invasive plant management
- fugitive particulate management
- waste management
- contingency plans

These plans are discussed in detail in the Mine's MPRP (MPMC 2023). The End Land Use Plan, contained within the MPRP, informs several of these plans, such as revegetation prescriptions. The plan outlines targeted ecosystems, with both spatial and temporal objectives, with five overarching ecosystem types identified:

1) dry forest
2) mesic forest
3) wet forest
4) grassland/brushland
5) rocky talus cliffs

Once forested ecosystems have reached a mature seral stage, these areas may become suitable for mountain caribou use. The Mine is located within the Interior Cedar-Hemlock biogeoclimatic zone, where mature forests are considered to be greater than 100 years old, while old-growth forests are greater than 140 years old (WLRS 2024a). Adaptive management may be required to promote suitability for mountain caribou where conflicting land use occurs (e.g., use of habitats by ungulate species other than mountain caribou that may increase predation risks).

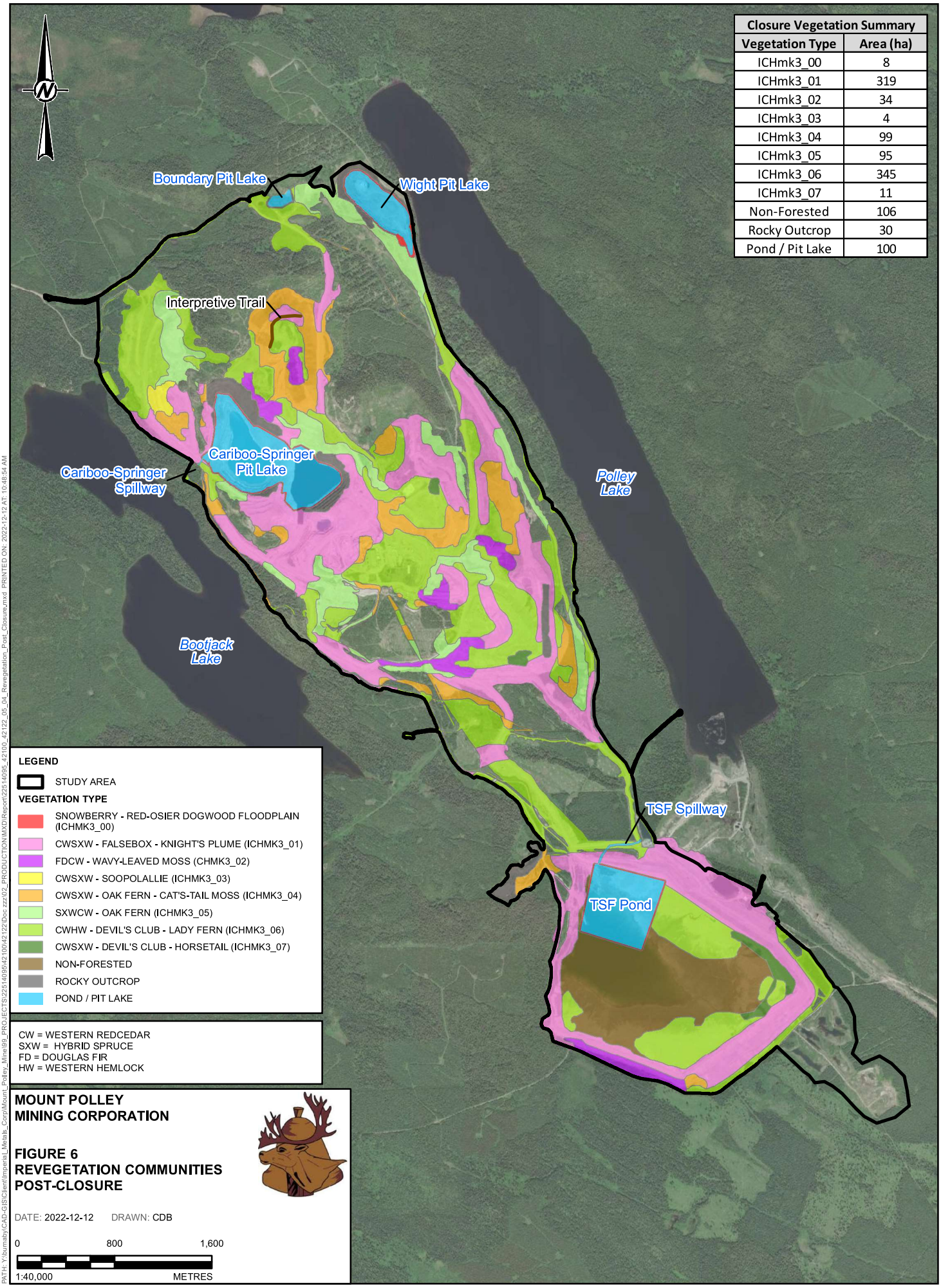
7.3.3.1 End Use Targeted Ecosystems

The approach for re-vegetative species selection and targeted ecosystems is based on the biogeoclimatic zone system. Identification of the site series of a specific area considers slope, elevation, and aspect assessed using a GIS model. This is further informed by site-specific substrate characteristics that suggest soil moisture and nutrient conditions. Targeted ecosystems are summarized in Table 10 and spatially displayed in Figure 6.

Table 10: Targeted Ecosystems for Restoration

Ecosystem	Site Series Code	Site Series Name
Dry Forest	ICHmk3_02	Douglas-fir – western redcedar / wavy-leaved moss
	ICHmk3_03	Western redcedar – hybrid white spruce / Soopolallie
Mesic Forest	ICHmk3_01	Western redcedar – hybrid white spruce / falsebox / knight's plume
	ICHmk3_04	Western redcedar – hybrid white spruce / Oak fern / Cat's-tail moss
	ICHmk3_05	Hybrid white spruce – western redcedar / Oak fern
Wet Forest	ICHmk3_06	Western redcedar – western hemlock / Devil's club / Lady fern
	ICHmk3_07	Western redcedar – hybrid white spruce / Devil's club / Horsetail
Grassland/Brushland	Non-forested	Grassland/Brushland
Rocky Talus Cliff	Rocky Outcrop	Exposed Rocky Slopes

To achieve the targeted ecosystems described in Table 10 and shown in Figure 6, reclamation prescriptions, as described in Table 11, are proposed.



Closure Vegetation Summary	
Vegetation Type	Area (ha)
ICHmk3_00	8
ICHmk3_01	319
ICHmk3_02	34
ICHmk3_03	4
ICHmk3_04	99
ICHmk3_05	95
ICHmk3_06	345
ICHmk3_07	11
Non-Forested	106
Rocky Outcrop	30
Pond / Pit Lake	100

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Table 11: Proposed Reclamation Prescriptions (from MPMC Mine and Reclamation Plan)

Site Series		Moisture	Gradient (%)	Slope Position	Aspect	Soil Profile Type	Grasses/Forbs[1]	Deciduous Trees[2]	Coniferous Trees[3]	Shrubs[4,5] 200 – 500 sph
Zonal	ICHmk3/01	Mesic/submesic	0 to 20	Middle	Variable	B	native grasses/forbs (30 kg/ha)	black cottonwood – 200sph trembling aspen – 50 sph paper birch – 50 sph	Douglas fir – 1,400 sph lodgepole pine – 600 sph hybrid spruce[e] Western redcedar[e] alpine fir[e]	Sitka alder, saskatoon, prickly rose, willow, huckleberry, blueberry, common juniper [6], soopolallie
Xeric to Subxeric	ICHmk3/02	Xeric, subxeric	0 to 10	Crest	South or west facing	A		trembling aspen – 200 sph	Douglas fir – 1,400 sph lodgepole pine – 600 sph hybrid spruce	
	ICHmk3/03		50 to 70	Upper	Variable	A		trembling aspen – 200 sph	Douglas fir – 1,400 sph lodgepole pine – 600 sph Western redcedar[e] hybrid spruce[e]	
Mesic to Moist Nutrient Rich	ICHmk3/04	Subhygric, mesic	10 to 35	Lower, middle	Variable	C		black cottonwood – 200 sph trembling aspen – 50 sph paper birch – 50 sph	Douglas fir – 1,400 sph hybrid spruce – 600 sph alpine fir[e] Western redcedar[e] lodgepole pine[e]	
	ICHmk3/05	Subhygric		Middle, lower	Variable			black cottonwood – 200 sph trembling aspen – 50 sph	hybrid spruce – 1,400 sph lodgepole pine – 600 sph Western redcedar[e] alpine fir[e]	
Moist, Very Rich	ICHmk3/06	Subhygric, mesic	0 to 25	Lower, middle	Variable	C		black cottonwood – 200 sph trembling aspen – 50 sph paper birch – 50 sph	Douglas fir – 1,400 sph hybrid spruce – 600 sph Western redcedar[e] alpine fir[e] lodgepole pine[e]	
	ICHmk3/07	Hygric	0	Toe of long slopes or depression	Level			black cottonwood – 200 sph	hybrid spruce – 1,400 sph western redcedar – 600 sph alpine fir[e] lodgepole pine[e]	
Organic non-Forested	Non-forested	Subhygric	0	Depression	Level	D		n/a	n/a	
TSF		Hygric	0	Lower	Level	0		black cottonwood – 500 sph	n/s	

Notes:

(1) Grass and forb seeding rate should be reduced (5 to 10 kg/ha) if amendments such as biosolids or fertilizer are used.

(2) Species chosen based on BC Forest Development Stocking Standards (ICHmk3 biogeoclimatic subzone).

(3) Species chosen based on BC Forest Development Stocking Standards (ICHmk3 biogeoclimatic subzone).

(4) Later successional species to be considered for underplanting after primary canopy is established.

(5) Shrub species to be selected appropriate for each site based on research and availability.

(6) Juniper will be targeted for drier sites.

sph = stems per hectare.

7.3.3.2 Road Reclamation

Two types of roads exist at the Mine: light vehicle roads (often old forestry roads that pre-date mine operations) and large haul roads made from non-acid generating (NAG) waste rock (often built up and are essentially linear rock disposal sites). No new roads are required for the Project; with roads associated with the Mine scheduled for reclamation to target the adjacent end land uses (generally wildlife habitat and forestry).

Roads not necessary for access will be identified and reclaimed. Culverts will be removed and replaced with cross-drainages where required to minimize long-term maintenance and re-establish natural surface drainage patterns. Surface runoff channels will be improved to accommodate closure design capacity flows, and cleared of debris, to prevent new channels from interfering with newly reclaimed areas.

Roads that will not be required post-closure will be “ripped” (scarified) to a minimum depth of 30 cm, and side-cast material and cutbanks will be recovered and spread over the road surface. This material can be supplemented with stockpiled soil to reach an appropriate depth for vegetation. Cutbanks will be re-contoured to below the angle of repose to reduce future slumping. The surface will be planted according to the prescriptions outlined in the Mine’s MPRP (2023) with any adjustments made to match the end land uses designations.

Mine haul roads are essentially linear NAG waste rock dumps. These roads will have sides sloped to 2H:1V or flatter, to the extent possible. There are some limitations to achieving this slope related to water body crossings and proximity to sensitive undisturbed land. Re-sloping will incorporate landform design and geomorphic considerations, with wildlife passage pathways being a key feature. Culverts will be removed and replaced with cross-drainages as appropriate. Surface runoff channels will be improved to accommodate design capacity flows, and cleared of debris, to prevent new channels from interfering with newly reclaimed areas.

Roads not required for access during closure will be fully reclaimed to match their end land use designations following the coversoil application and revegetation approaches for waste dumps. Roads required for access will be partially reclaimed (edges re-sloped and revegetated as discussed above), with light vehicle and/or equipment access maintained.

7.3.3.3 Standing Dead Tree or Snag Installation

Standing dead trees and artificial snags will be staked a minimum of 25 snags/ha, with 5 snags/ha using trees that are greater than 50 cm diameter at breast height (DBH), to provide some structural complexity, bird habitat, and, potentially, future attachment sites for arboreal hair lichen and *Alectoria* species (Hamilton 2011).

7.3.3.4 Log, Rock Pile, Stump, and Coarse Wood Debris Placement

Rock piles, stumps, large logs, and coarse woody debris will be placed to provide micro-habitats for vegetative re-establishment, conserve soil moisture, moderate soil temperatures, prevent soil erosion, provide nutrients to the soil, provide a source of seed for natural regeneration, protect seedlings from wildlife trampling, and provide habitat for wildlife. Large logs, rock piles, stumps, and other coarse woody debris also provide micro-habitats for small mammals. Woody debris used will be native species from the local area. Vinge and Pyper (2012) recommend applying between 60 to 100 m^3/ha of native woody material to restored sites to mimic the natural range of variability for woody material in a mature forest.

7.3.3.5 Key Intervention Points

Once a coniferous forest of the target density has established, the following interventions will be considered to assist in achieving the conservation objective (Hamilton 2011):

- Thinning or spacing homogenous stands to encourage the development of a multi-layered stand structure and heterogeneous spacing.
- Promoting open-growing conditions for individual trees and tree clumps/clusters (e.g., removing competing non-native invasive species).
- Under planting with later successional floral species.
- Removing selected shrubs that are preferred by moose and deer if they begin to dominant the understorey.
- Controlling the spread and extent of non-native invasive species infestations.
- Transplanting *Bryoria* and *Alectoria* species to provide a spore source.
- Planting additional conifer seedlings if the initial seedlings do not meet an 80% survival target during Years 1, 2, 3, and 6 of monitoring.

7.3.4 Reclamation Schedule

Reclamation and restoration activities will begin during the Operations phase and into the Closure phase. These include progressive reclamation, decommissioning, and implementation of monitoring measures. Scheduling of activities can be expected to evolve based on findings of reclamation research and progressive reclamation projects.

Table 12: Reclamation Research, Closure, and Post-closure Schedule

Activity	Description
Hoarding	Installation of hoarding (fast fence) around the work site to provide a working environment delineated from other operations at the site.
Backfilling/site grading	Bulldoze and grade all site areas to a self-draining condition, with re-contouring of site to mimic surrounding natural landscape and restore drainage patterns towards Mine Drainage Creek (the Mill Site Sump and Ditch will be removed when no longer required and when water quality meets discharge guidelines).
Final cleanup	Removal of any final small debris (75 mm or larger) such that reclamation activities can be undertaken so the area can naturalize.
Reclamation	Site preparation and re-distribution of stockpiled overburden. Revegetation using early successional species and diverse habitat enhancements.
Post-reclamation monitoring	Monitoring of reclamation success.

8.0 RESIDUAL EFFECTS BEFORE OFFSETTING

A summary of the predicted residual effects and the characterization of residual effects of the Project on mountain caribou habitat are provided in Table 13 and Table 14, respectively. Net effects were described after the implementation of effective mitigation, and summarized according to direction, magnitude, geographic extent, duration/reversibility, frequency/timing, and probability of the effect occurring following the methods described in Section 5.0. The implementation of mitigation summarized in Section 7.0 is expected to reduce the magnitude and duration of net effects on mountain caribou.

8.1 Habitat Condition

The Project will result in the direct disturbance of 13.1 ha of previously physically undisturbed habitat, comprising 11.2 ha of matrix range and 1.9 ha of unmapped critical habitat. Mountain caribou are at risk largely due to habitat alteration, which includes habitat loss, degradation, and fragmentation, which has direct (e.g., loss of useable habitat) and indirect (e.g., increased predation through functional responses of predators) effects (EC 2014). As such, the Wells Gray North herd is anticipated to be sensitive (i.e., low resilience) to habitat loss.

Given the scale of the loss in relation to the CAA (861,515.8 ha) and that the 13.1 ha of the Project Footprint is classified as disturbed habitat under baseline conditions (i.e., indirectly disturbed; Table 13), the magnitude of habitat loss is considered low. Effects from direct habitat loss will be limited to the Project Footprint (local scale) and change to habitat availability would affect mountain caribou continuously over the life of the Project (high frequency) and into the closure and post-closure stages (long-term) with a high likelihood of occurrence (Table 14). Following closure, the effects of direct habitat loss are expected to be fully reversible through restoration, with the exception of the pit wall and open pits that will be replaced by anthropogenic lakes. There will be a time-lag between habitat loss due to construction of the Project, operation of the Mine, and availability of restored habitat for mountain caribou. Restored areas may begin to provide suitable habitat for mountain caribou 100 years after restoration (i.e., mature coniferous forest), resulting in a long-term duration (Table 14).

Habitat loss due to sensory disturbance is anticipated to be negligible in magnitude, with an increase of 1.2 ha in the Mine's ZOI, for a total ZOI extending from the Amended Permit Project Footprint of 12,839.5 ha (Table 13). The Project Footprint's ZOI is considered to be disturbed at baseline conditions, with 1,588.4 ha of direct disturbance present within this area and the remaining 5,259.4 ha indirectly disturbed through either the Existing Mine Footprint's ZOI, or the ZOI's of other direct disturbance present on the landscape. It is assumed that the effects of habitat loss due to sensory disturbance are limited to the temporal bounds of the Project. Therefore, effects from avoidance are predicted to be local and changes to habitat availability would affect mountain caribou continuously over the life of the Project (high frequency) with a high likelihood of occurrence (Table 14). The effects of sensory disturbance will be reduced by maintaining vegetation cover in areas adjacent to roads and other Project components, where feasible. The effects of habitat loss due to sensory disturbance are fully reversible as they are anticipated to cease once operations are complete (Table 14).

After mitigation, a measurable residual adverse Project-related effect on mountain caribou habitat availability is anticipated (i.e., 13.1 ha of direct disturbance overlapping critical habitat previously physically undisturbed and 1.2 ha of incremental indirect disturbance). Although on-site restoration will occur at closure, the time-lag associated to reach late seral habitats leads to a long-term effect. Confidence that the effect will not be greater than predicted is high, given the large ZOI that has been used to quantify residual effect, the existing baseline conditions of habitat in the CAA and caribou use of core habitats within the CAA.

Changes to the movement of mountain caribou among habitat patches is predicted to be negligible in magnitude. Areas within the Project Footprint are considered to be disturbed at baseline, either through existing direct or indirect disturbance. Additionally, the Project involves the outward expansion of an existing disturbance with no additional linear disturbances bisecting habitat that would otherwise lead to additional fragmentation. Any potential changes to movement among habitat patches as a result of the Project, either through direct or indirect disturbance, will be local in scale, and low in frequency and likelihood based on known movement patterns of the Wells Gray North herd (Table 14). Following closure, the effects of direct habitat loss are expected to be fully reversible through restoration, with the exception of open pits that will be replaced by anthropogenic lakes. There will be a time-lag between habitat loss due to construction of the Project, operation of the Mine, and availability of restored habitat for mountain caribou. Restored areas may begin to provide late seral mature forested habitat for mountain caribou 100 years after restoration. After mitigation, the effects of the Project on mountain caribou habitat distribution are predicted to not result in an adverse effect. Therefore, habitat distribution is not carried forward to offsetting (Table 14). Confidence that the effect will not be greater than predicted is high given the known location and movement patterns of the Wells Gray North herd.

Table 13: Predicted Residual Effects of Habitat Loss

Type of Disturbance	Direct Disturbance of Project Footprint from Baseline (ha)	Indirect Disturbance of Project ZOI from Baseline
Direct Disturbance	5.1	1,588.4
Indirect Disturbance	13.1	5,259.4
Total Disturbance	18.3	6,847.8
Existing Mine Footprint ZOI		12,838.4
Amended Permit Project Footprint ZOI		12,839.5
Residual Effect	*13.1*	*1.2*
Combined Residual Effect	**14.3 ha**	

Notes: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
ha = hectares.

8.2 Population Structure and Dynamics

The Wells Gray North herd is considered stable (Zimmerman et al. 2025), although historic declines in mountain caribou numbers in Quesnel Highland Unit 5B are largely due to the influence of habitat changes that influence predator-prey relationships and predation risk (Seip 1992; CCLUP 2000; Roorda and Wright 2010). As such, caribou are anticipated to be sensitive (i.e., low resilience) to adverse changes in population size and mortality.

A loss of 13.2 ha of critical habitat comprised of matrix range and unmapped range habitats, combined with other Project-related mortality sources after mitigation, is not anticipated to result in a measurable effect on the population size of the Wells Gray North herd. Following mitigation, any potential effects are anticipated to be negligible in magnitude, regional in scale as any changes would impact the Wells Gray North herd, medium-term in duration, partially to fully reversible, depending on the extent of change in population, and low in both frequency and likelihood. As such, population size is not carried forward to offsetting (Table 14).

Mitigation measures, both existing and proposed, to reduce Project-related Mountain caribou mortality, including access road speed limits, prohibitions against public access, and on-site restoration, are expected to be effective. Direct mortality is not predicted to occur during construction as mountain caribou are expected to vacate active work areas, limiting their exposure to mortality factors. Further, new roads or any other linear disturbance features that would facilitate predator movement are not part of the Project. Following mitigation, any potential effects are anticipated to be negligible in magnitude, regional in scale as any mortality would impact the Wells Gray North herd, medium-term in duration, partially to fully reversible, depending on the extent of change in population, and low in both frequency and likelihood. As such, mortality risk is not carried forward to offsetting.

Confidence that effects to the Population Structure and Dynamics indicators will not be greater than predicted is high given the Project's distance to all-season core habitat, known caribou movement corridors, the relatively small spatial extent of the Project, which does not include building additional roads, and low likelihood of the effects occurring.

8.3 Summary of Residual Effects

A summary of Project-related residual effects is provided in Table 14. Where two types of effects are considered together but have different characterizations (e.g., direct and indirect habitat loss), the more conservative characterization is presented.

Table 14: Characterization of Potential Project-related Residual Effects to Mountain Caribou

Indicator	Move to Offset	Context	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Habitat Availability	Yes	Sensitive	Low	Local	Long-term (direct loss)	High	Fully Reversible	High
Habitat Distribution	No	Sensitive	Negligible	Local	Long-term (direct loss)	Low	Fully Reversible	Low
Population Size	No	Sensitive	Negligible	Regional	Medium-term	Low	Partially to Fully Reversible	Low
Mortality Risk	No	Sensitive	Negligible	Regional	Medium-term	Low	Partially to Fully Reversible	Low

8.4 Rationale for Moving to Offsets

Mountain caribou populations in BC are currently in decline. Primary threats include habitat alteration that impacts predator-prey relationships and increases predation risk (Government of BC [date unknown]a, [date unknown]b; MCTAC 2002; EC 2014). Therefore, any additional anthropogenic changes are considered to negatively compromise the resilience and ecological thresholds of the caribou population. The Project is predicted to result in a loss of caribou critical habitat, which is quantified in Table 7.

At post-closure adequate ecosystem restoration and ecological succession to late seral habitats is predicted to increase habitat relative to baseline conditions with the establishment of mature coniferous forest. MPMC recognizes that there is a time-lag and uncertainty associated with on-site habitat restoration measures. A time lag of 100 years has been included as a residual impact for the Project Footprint for areas of restore on-site to take effect. The residual impact to caribou critical habitat will require an offset because the impact cannot be further mitigated through measures to avoid, minimize, or restore on-site within an acceptable timeframe.

9.0 OFFSET STRATEGY

The final level of the mitigation hierarchy is offsetting (MOE 2014b). The offset strategy outlined within this CMMP focuses on the residual effect that will remain after mitigation to mountain caribou habitat. MPMC is committed to working with MOF, WLRS, and Indigenous nations to provide offsetting measures that address the residual effects outlined within the CMMP, and which have the most conservation value to mountain caribou and their habitat. Habitat restoration and financial offsets as conservation mechanisms to offset the remaining residual effects from the proposed Project are being considered and are discussed briefly below.

9.1 Off-Site Habitat Restoration

Residual effects from the Project to mountain caribou matrix habitat, although small based on habitat condition under baseline conditions, are anticipated. Off-site habitat restoration is one option to offset the residual effect. Off-site habitat restoration would involve identifying habitat parcels to be acquired and/or conducting restoration on currently impacted habitat parcels to improve or increase suitable caribou habitat within the Wells Gray North herd boundary. MPMC is committed to work with participating Indigenous nations (i.e., Xatsull First Nation and Williams Lake First Nation) to identify and support restoration opportunities, using priority zones (Cichowski et al. 2021) to guide conversations, as necessary.

The CMMP considers the technical report *A Tactical Plan for Restoration of Habitat for the Southern Group of Southern Mountain Caribou* (hereafter the Tactical Plan; Cichowski et al. 2021). The scope of the Tactical Plan is to guide restoration priorities and provides prioritization of restoration areas at the range level and group level over the next 20 years. The range level sets priority zones within individual herd boundaries and priorities for linear features, while the group level sets the priority among herds (Cichowski et al. 2021). The Wells Gray North herd was ranked as Priority 1 out of four in the Tactical Plan at the group level due to the existing density of roads in core habitat being less than 1.2 km per square kilometre, having more than 90% of linear features in core habitat available for restoration, and more than 50% of core habitat is in the high protection category (Cichowski et al. 2021). The Tactical Plan sets out next steps for prioritizing restoration within the High Priority Zones, as the cost to restoration is high; at this time, no timeline is available for when priority areas will be restored (Cichowski et al. 2021).

The Project Footprint and Amended Permit Project Footprint were spatially intersected with the Priority Restoration Features and Priority Restoration Zones as identified by the Tactical Plan, to identify areas of overlap (Figure 7). Both footprints were included to provide further context for potential restoration features surrounding the Mine. Similarly, the ZOI's of both footprints were spatially intersected with the Priority Restoration Features and Zones.

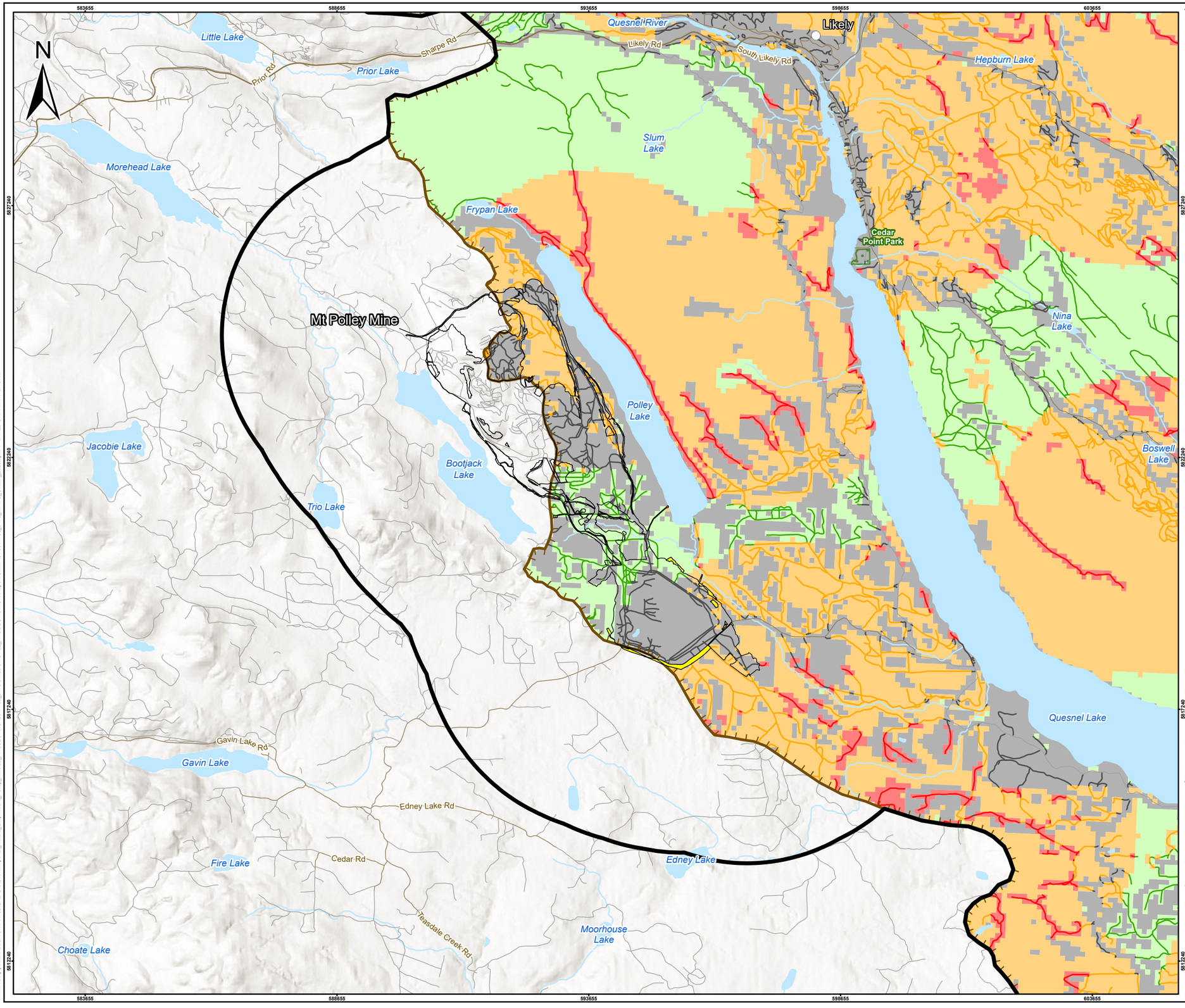
Priority Restoration Features and Priority Restoration Zones are ranked in the following hierarchy: high, moderate, low, and nil (Cichowski et al. 2021).

Restoration priorities are to restore linear features as quickly as possible to reduce predator travel and hunting efficiency (Cichowski et al. 2021). A summary of overlap of the Project with Priority Restoration Features and Priority Restoration Zones is provided in Table 15 and spatially displayed on Figure 7. Within the Amended Permit Project Footprint ZOI, High Priority Restoration Zones are located east of Polley Lake and southeast of the Mine. These areas are largely smaller, disconnected polygons within large Moderate Priority Restoration Zone polygons.

Table 15: Overlap of the Project Footprint, Amended Permit Project Footprint and Associated Zones of Influence with Priority Restoration Zones and Features from the Tactical Plan

Priority Level of Restoration Zones and Features	Overlap with Project Footprint (ha)	Overlap with Project Footprint's ZOI (ha)	Overlap with Amended Permit Project Footprint (ha)	Overlap with Amended Permit Project Footprint's ZOI (ha)
Priority Restoration Zones				
High	0.0	188.5	<0.1	361.9
Moderate	3.2	1,452.7	60.0	3,125.4
Low	2.5	540.0	124.9	1,248.9
Nil	9.8	1,844.8	703.5	1,795.3
Priority Restoration Features				
High	0.0	6.0	<0.1	12.5
Moderate	<0.1	32.1	3.1	41.3
Low	0.0	17.6	7.4	12.4
Nil	0.1	21.5	27.6	3.6

Notes: ha = hectare.



LEGEND

- PROJECT FOOTPRINT
- EXISTING MINE FOOTPRINT
- CARIBOU ASSESSMENT AREA
- CARIBOU HERD BOUNDARY

RESTORATION ROAD PRIORITY

- HIGH
- MODERATE
- LOW
- NIL

RESTORATION ZONE PRIORITY

- HIGH
- MODERATE
- LOW
- NIL

BASE DATA

- TOWN
- MAJOR ROAD
- ROAD - LOCAL
- ROAD - RESOURCE / RECREATION / UNCLASSIFIED
- WATERCOURSE
- PARK / PROTECTED AREA
- WATERBODY

0 1.5 3

1:75,000 KILOMETRES

NOTES

1. UPDATED MATRIX AND CORE HABITAT BOUNDARIES HAVE BEEN CREATED BUT ARE NOT YET PUBLICLY AVAILABLE SO CANNOT BE DISPLAYED ON THIS FIGURE. CRITICAL HABITAT OVERLAPS THE ENTIRE FIGURE; HOWEVER, FOR CLARITY IS NOT DISPLAYED.

REFERENCES

1. MINE FOOTPRINT AND PROJECT DATA PROVIDED BY CLIENT, 2025.
2. RESTORATION DATA PROVIDED BY MINISTRY OF WATER, LAND AND RESOURCE STEWARDSHIP, 2024.
3. BASE DATA AND CARIBOU DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – BRITISH COLUMBIA.
COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N

CLIENT

MOUNT POLLEY MINING CORPORATION

PROJECT

CARIBOU MITIGATION AND MONITORING PLAN

TITLE

PRIORITY RESTORATION AREAS IN PROXIMITY TO THE MOUNT POLLEY MINE

CONSULTANT

wsp

YYYY-MM-DD	2025-07-23
DESIGNED	NM
PREPARED	CD | JG
REVIEWED	NM
APPROVED	PB

PROJECT NO.	PHASE	REV.	FIGURE
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Off-site habitat restoration would have the following objectives (FLNRORD 2021):

1) Control access to caribou habitat by predators and humans.

6) Accelerate the rate of recovery of native vegetation.

7) Provide habitat that supports the life processes required by caribou as much as undisturbed areas, over the long-term.

Opportunities for habitat restoration would be determined in consultation with Indigenous nations and brought forward to MOF, and WLRS to compliment other restoration projects within the Wells Gray North herd boundary.

The land within the Wells Gray North herd boundary is predominantly Crown land and land within existing provincial parks. As such, opportunity for MPMC to acquire this land to restore and protect may be limited. An alternative to off-site habitat securement and restoration is providing an in lieu payment.

9.2 Financial Offset

Financial offset involves providing compensation to support the implementation of caribou conservation measures such as habitat restoration of degraded habitats, or support for population enhancement measures. Compensation may be provided directly to WLRS, or compensation may be provided to Indigenous nations or other non-government organization to fund restoration projects or for population enhancement measures, such as maternal pens. Financial offset would preferentially target restoration projects within the Wells Grey herd boundary where habitat degradation is occurring.

Restoration of linear features would improve degraded habitat, address predator efficiency and would also remove indirect impacts to adjacent areas impacted by roads and other linear features. Therefore, calculations on area gained by linear restoration typically assume a net benefit of the surrounding areas proportional to the indirect impacts from that feature.

9.3 Timeline

Preferred offsetting strategies will be determined following conversations with WLRS and interested Indigenous nations. An offsetting plan will be completed that describes the preferred option, an associated multiplier based on BC’s draft Decision Support Tool, along with a timeline for implementation, which will be made in discussion with WLRS, Indigenous nations, and other stakeholders.

10.0 MONITORING AND REPORTING

The conservation target is to restore 100% of mountain caribou habitat disturbed by the Project through on-site restoration or offsets.

The minimum habitat requirements to meet the conservation target are based on multiple guidance documents and are outlined below (MCST 2006; Hamilton 2011; EC 2014):

- Mature coniferous forest (MPMC recognize there will be a time-lag between the completion of monitoring activities and the establishment of suitable mature coniferous forest for mountain caribou).
- Sufficient abundance (≥ Lichen Class 3, with some Class 4 and 5; Armleder et al. 1992) of arboreal lichen forage, the primary food source of mountain caribou. Arboreal lichens occur in mature systems and are slow to develop.
- Moderate density tree canopy (>35%, achieved by planting 1,400 stems/ha) to provide the level of openness required for arboreal lichen growth. Forests should support both live and dead standing trees.
- Habitat characteristics that minimize habitat preferred by other ungulate species, such as moose and deer, which are prey species for wolves. This includes limiting the abundance of grass, forb, shrub, or young forest habitat within the Project footprint that overlaps the CAA and limiting certain understorey species.

MPMC recognizes the value of implementing a monitoring program to measure the success of mitigation and restoration measures. The provincial *Procedures for Mitigating Impacts on Environmental Values* (MOE 2014b) outlines two types of monitoring that should be conducted following mitigation measures: implementation monitoring and effectiveness monitoring. Implementation monitoring is assessing whether the activities identified in the CMMP were implemented as planned or directed. Effectiveness monitoring is evaluating environmental components based on the performance of the restoration plan and the progress towards the conservation target (i.e., did the restoration treatments achieve the conservation target).

Reclamation monitoring and inspections of progressive reclamation sites will continue into closure. Monitoring is typically completed in the summer or early fall when plants are most easily identifiable. A general schedule for reclamation assessments is as follows:

- Post-application visual inspections (e.g., soil test pits) after placement of coversoil to assess placement depth and to verify if recommended reclamation methods outlined in the Mine's MPRP (MPMC 2023) were appropriately implemented.
- Assessment of revegetated areas following the first growing season to determine species composition (including presence of invasive species) and cover, as well as documentation of any areas of erosion.
- Observations of wildlife or grazing occurrences and usage.
- Survival surveys of planted trees and shrubs immediately after planting (for quality control purposes).
- Survival surveys of planted trees and shrubs following their first growing season.
- Periodic assessments of tree survival/growth and ground cover vegetation, decreasing in frequency over time.

Monitoring will continue with additional reclamation activities occurring in an adaptive management process until performance criterion for these assessments have been met. Relevant criteria from the Mine's MPRP (MPM 2023) are summarized in Table 16.

Table 16: Reclamation Monitoring Criteria

Criteria	Indicator	Measure
Landform Function		
Landscape enhancements are appropriate to the ecosystem and increase the diversity of the landscape	Landscape enhancements	Presence of rocks, coarse woody debris, brush piles, snags, bird/bat boxes, etc.
Vegetation		
Terrestrial and aquatic vegetation common to the surrounding area is established	Plant community composition (terrestrial, riparian and, marsh/aquatic)	Presence, percent cover, distribution of noxious and prohibited noxious weeds
Emergent Properties		
The reclaimed landscape provides for biodiversity	Patch size and shape	Patch sizes (ha)
	Food vegetation species	Food species for target wildlife species are present
	Plant community composition – diversity, richness, evenness and abundance	Species inventory, percent cover and density (stems/ha)

Establishment surveys are recommended after restoration to confirm whether the site is on a trajectory to the desired ecosystems and end land use target (FLNRORD 2021). Establishment surveys and monitoring will be conducted for progressive reclamation during the Closure and Post-closure Phases of the Project to measure performance as per the Mine's MPRP (MPMC 2023).

10.1 Permanent Restoration Research Plots

As per the Mine's Amended M-200 Permit, MPMC is to prepare and submit a Reclamation Research Plan by December 31, 2027, that outlines site-specific proof of success of the mine closure concept and reclamation prescriptions outlined in the Reclamation and Closure Plan. The following provides a basis for conducting caribou-specific restoration research plots and can serve as a basis for inclusion in the Reclamation Research Plan.

Permanent research plots will be established in the Mine disturbance area where revegetation trials will be conducted to assess the success of initial revegetation prescriptions. Findings from the permanent research plots will be used to inform final caribou habitat restoration, which will be applied to the areas of Mine disturbance area that overlap the CAA during final reclamation and closure. A stratified random approach will be used to sample the plant communities in reclamation areas that encompass the range of moisture regimes while minimizing the variability due to disturbance. From the outlined stratified polygons, a random selection of circular sample plots (one to three per stratified polygon), with an area of 400 m^2 (11.28 m radius) and located at least 30 m from the polygon edge and 50 m from another plot center, will be created, where possible. Specific aspects of the revegetation strategy to be tested to improve success rates at closure, include:

- Seed mixture
- Species composition

- Structural diversity (i.e., tree, shrub, forb, fern, and grasses)
- Density and arrangement of plantings
- Varying combinations of surface treatments
- Soil amendments (e.g., mulch types)
- Vigour and height of plantings over time

Permanent research plots established for reclamation research will be monitored during reclamation monitoring. Vegetation monitoring within permanent research plots will provide information on the success of the implemented treatments, based on the defined success criteria and measurable indicators as outlined in the Mine's MPRP (MPMC 2023). Conifer tree seedling survival will be assessed using a 50 m^2 (3.99 m radius) stocking survey and free growing survey plots as per provincial standar ds (MOF 2002; FLNRORD 2020). Changes may be necessary if trials indicate more suitable species or methods for certain areas. Conversely, change may be required if methods or species prove to be unsuitable for particular areas. Experimentation with different methods of planting alder species for the achievement of short-term physical and visual obstructions beneficial for caribou, soil improvement, and potential winter forage will be undertaken. Planting of alder will be limited to areas where soil conditions are poor to promote conifer establishment.

Maintenance will be planned for in MPMC's reclamation planning. Long-term monitoring and maintenance will be conducted until the Project footprint area is ready for certification. If, during monitoring, sites are found that are not performing as expected, mitigation may be applied, including infill planting, fertilization, mulching, weed control, pest control, watering, and, where required, further investigation into soil and foliar chemistry.

Results from research programs will be incorporated where opportunities exist. MPMC relies upon past experience, topic specific experts, and research findings to identify methods for achieving reclamation and closure objectives.

10.2 Adaptive Management

There is a lack of long-term caribou habitat restoration monitoring in Canada, resulting in uncertainty surrounding the long-term success of restoration treatments (Golder 2016). Thus, adaptive management "will increase the probability of achieving mitigation commitments" (MOE 2014b, p. 48). The CMMP is intended to be a living document and will be updated as site conditions change and following evaluation of monitoring activities. Restoration strategies and monitoring methods will be adapted or revised over time, based on the monitoring results or advancements in the field of caribou habitat restoration.

The objectives of adaptive management are to address the circumstances that would require MPMC to implement alternative or additional mitigation measures to address the effects of the Project. Reasons for implementing adaptive management for the CMMP include:

- The effects to caribou are not being mitigated to the extent indicated in this Plan.
- The effects to caribou are different than what was predicted in this Plan.
- The effects to caribou have exceeded triggers identified below.

Triggers are monitoring end points that, once reached, would require adaptive management protocols to be followed. Triggers and the associated adaptive management actions are identified in Table 17.

Table 17: Mitigation Program Objectives, Metrics, Targets, and Adaptive Management

Objective	Metric	Target / Trigger	Adaptive Management
Minimize vegetation disturbance resulting from the Project	Determine total area of new disturbance	Based on the current plan, the Project will result in 13.1 ha of direct disturbance.	Evaluate the construction plans to determine areas of further minimization to vegetation disturbance ad calculate as built disturbance to compare to the plans. Use visual aids, such as flagging tape, to identify the limits of construction.
Minimize vehicle-caribou collision	Number of caribou-vehicle collisions reported to staff on an annual basis.	Zero vehicle-caribou collisions.	If vehicle-caribou collisions occur, assess the speed limit, road conditions, road mitigations, and operator compliance, and make amendments.
Educate Workers	Percentage of workers to receive caribou specific education for the Project.	All workers (100%) on site during construction and operations to have completed worker education on caribou.	Workers will be required to show proof of successful completion or will be required to complete the worker education course. Where workers are observed to be non-compliant with the mitigation measures for caribou or the worker education course, workers will be required to repeat the training before returning to site.
Caribou habitat restoration areas in the Project footprint area	Survival surveys	80% survival in Year 5 of monitoring.	If 80% survival is not achieved by Year 5, conduct supplemental planting or conduct soil sampling to determine whether soil amendments may be required.
Caribou Conservation Target - Tree Density in Habitat Restoration Areas	Count the number of trees within the survey plot to determine the stems per hectare. Average over reclamation areas that are planted to the same target ecosystem.	Minimum stem density targets will vary depending on elevation. Conservative target stem density in caribou restoration areas is minimum density (1,000 to 2,000 stems/ha) based on FLNRORD (2021) at lower elevation sites and low density at higher elevation (400-500 stems per ha).	Minimum stem density target achieved. If stem density is less than the minimum target per ha, supplemental planting will be undertaken. If conditions persist, soil sampling to determine whether conditions are suitable for tree species will be undertaken.

Notes: % = percent; FLNRORD = BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development; ha = hectare.

10.3 Reporting

MPMC will share information on mitigation measures and restoration activities with ENV, MOF, WLRS, Indigenous nations, and other interested parties per timelines identified in the Plan. Reporting as outlined in the Plan may be included as an independent report or as a component of a reclamation report.

Information to be reported on includes:

- The implementation, successes, and failures of mitigation measures.
- The implementation, successes, and failures of restoration activities.
- Key learnings from monitoring activities.
- Proposed changes to mitigation measures or restoration prescriptions (i.e., adaptive management).

11.0 CONSULTATION

MPMC has consulted with WLRS and participating Indigenous nations during the development of this CMMP. As part of MPMC's commitments to consultation, MPMC will complete the following steps:

- Provided a written notice to each party that includes:
  - A copy of this CMMP;
  - An invitation for parties to provide views on the contents of the CMMP; and
  - A written timeframe for views to be provided to MPMC on the CMMP.
- Undertake a full and impartial consideration of the views and of the information provided by each party.
- Provide a written response to each party that provided views as to how the views and information have been considered and addressed in the revised CMMP or why the views and information have not been addressed in the revised CMMP.
- Maintain a record of consultation with each party regarding the CMMP.

Going forward, MPMC will continue to work with WLRS and participating Indigenous Nations on determining the final offset requirement for the Project. Offset options for the Project will be considered based on those that are within the control of MPMC and which are economically feasible. The outcome of final negotiations on the offset requirement for the Project and the steps that will be taken by MPMC to implement the offset option will be outlined in the Offset Plan.

12.0 NEXT STEPS

The CMMP is designed to be a living document that will be updated. The CMMP outlines the proposed mitigation measures for minimizing impacts to woodland caribou and a summary of planned on-site restoration. In addition, an initial estimate of residual effects to mountain caribou habitat and habitat offset options have been explored for the Project. Next steps are as follows:

- Continue consultation with provincial caribou experts and participating Indigenous nations regarding the CMMP and offset opportunities that align with participating Indigenous nation input, regional management and monitoring programs for the Wells Gray North herd. MPMC will continue to document consultation.
- Determine whether offsets will be provided by off-site habitat restoration, financial offsets, or a combination of both. A detailed offsetting plan will be prepared outlining an in lieu payment and/or off-site restoration plan to offset residual effects to mountain caribou matrix habitat.
- For off-site habitat restoration, identify areas where habitat restoration would improve caribou habitat. Identify an Indigenous nation interested in implementing and leading (or capacity building) habitat restoration. Where possible, incorporate the findings of reclamation research conducted on-site to inform the restoration prescriptions.
- For financial offsets, determine in consultation with the applicable regulatory authorities, regional stakeholders, and participating Indigenous nations what financial offsets will be used to support and the monetary requirement to achieve offset.
- Confirm whether the monitoring and reporting plan in the CMMP is sufficient to monitor the final offset plan and update as needed.

The CMMP will be reviewed and updated at the following milestones:

- Transition of the final Project Footprint disturbance areas for the Project from construction to operations to confirm final disturbance numbers.
- If adaptive management requires updates to mitigation or monitoring programs.

Signature Page

WSP Canada Inc.

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APPENDIX A

Declaration of Competency

BRITISH COLUMBIA | Ministry of Environment and Climate Change Strategy

Declaration of Competency

The Ministry of Environment and Climate Change Strategy relies on the work, advice, recommendations and in some cases decision making of qualified professionals[1], under government's professional reliance regime. With this comes an assumption that professionals who undertake work in relation to ministry legislation, regulations and codes of practice have the knowledge, experience and objectivity necessary to fulfill this role.

1. Name of Qualified Professional: Paula Bentham

   Title: Senior Principal Ecologist

2. Are you a registered member of a professional association in B.C.? ☒ Yes ☐ No

   Name of Association: College of Applied Biology Registration # 3218

3. Brief description of professional services:

   Senior Principal Ecologist at WSP Canada with over 24 years of experience in the area of impact assessment, project planning to reduce residual effects to wildlife and species at risk, mitigation expertise, restoration, offset planning/compensation, regulatory compliance. Woodland caribou expert in Canada.

This declaration of competency is collected under section 26(c) of the *Freedom of Information and Protection of Privacy Act* for the purposes of increasing government transparency and ensuring professional ethics and accountability. By signing and submitting this statement you consent to its publication and its disclosure outside of Canada. This consent is valid from the date submitted and cannot be revoked. If you have any questions about the collection, use or disclosure of your personal information please contact the Ministry of Environment and Climate Change Strategy Headquarters Office at 1-800-663-7867.

Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X Paula Bentham

Print Name: Paula Bentham

Witnessed by:

X Thompson Hyggen

Print Name: Thompson Hyggen

Date signed: April 28, 2025

[1] *Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

a) is registered in British Columbia with a professional association, is acting under that organization's code of ethics, and is subject to disciplinary action by that association, and

b) *through suitable education, experience, accreditation and knowledge, may reasonably be relied on to provide advice within his or her area of expertise, which area of expertise is applicable to the duty or function.*

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APPENDIX 9-1: 2023 COMPREHENSIVE ENVIRONMENTAL MONITORING PLAN

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Comprehensive Environmental Monitoring Plan 2023

Submitted to:

Ministry of Environment and Climate Change Strategy
Environmental Protection Division
South Interior Region – Cariboo

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Document Review and Revision Control

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	1.1	Updated to include CEMP revisions	April 2021	
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	6.6.3, Table 6.4	Updated to include monthly sampling at EDC-01a in place of EDC-01; stipulates that QUL-57 and QUL-59 will be sampled at the same depths as QUL-58 where possible; updated footnote 13; updated to include QUL-120a and QUL-2a; updated to include W1b	April 2021	
	6.6.4.1, Table 6.6	Updated references to QUL-120a and QUL-2a	April 2021	

	6.6.4.2, Table 6.7	Updated HAC-01c, EDC-01 sites as they were removed following the 2020 construction season, included EDC-01a as this site was added following the 2020 construction season	April 2021	
	6.6.6, 6.8.6, 6.9.6, 6.10.6, 6.11.6	Updated reference to most recent British Columbia Environmental Laboratory Manual	April 2021	
	6.7.3, 6.7.4, Table 6.9, Table 6.10, Table 6.12	Updated to include new hydrology station H3a in place of H3 which was lost as a result of 2020 remedial construction; stipulates that manual flow gauge readings will be conducted when the sites are accessible; removed reference to water sampling at W1b, W5 and W12	April 2021	
	6.8.3, Table 6.14	Updated to state that GW15-2a and GW15-2b weekly sampling is required when the water level in the Springer Pit is over 1025 masl	April 2021	
	6.9.4, Table 6.19	Updated reference to E11	April 2021	
	6.11.3, Table 6.28	Updated Biological Test Method for Algal species	April 2021	
	6.12.1, 6.12.3, 6.13.1, 6.13.3, 6.15.1, 6.15.3, 6.16.1, 6.16.3,	Updated to include proposed revisions to the CEMP provided by Minnow Environmental	April 2021	
	6.14.4	Updated sample design/methodology as per Minnow Environmental's guidance	April 2021	
	6.17	Updated with details from mammal monitoring studies	Feb 2023	
	6.21	Updated to include Golder's Detailed Study Design for Terrestrial Wildlife Monitoring	April 2021	

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Appendix B – Detailed Study Designs for CEMP Components
Appendix C – Sample of Monthly Monitoring Schedule
Appendix D – Site Matrix
Appendix E – Declarations of Competency

ACRONYMS

°C	degrees Celsius
µm	micrometer
µS/cm	micro Siemens per centimetre
ADP	Annual Discharge Plan
AERR	Annual Environmental and Reclamation Report
ARD	acid rock drainage
BC	British Columbia
CALA	Canadian Association of Laboratory Accreditation
CCS	Central Collection Sump
CEMP	Comprehensive Environmental Monitoring Plan
cm	centimetre(s)
COPC	constituents of potential concern
CRM	certified reference material
CRP	Conceptual Remediation Plan
CSM	Conceptual Site Model
CSR	Contaminated Sites Regulation
DFO	Fisheries and Oceans Canada
DGT	diffusive gradients in thin-film
DQO	data quality objectives
EEM	Environmental Effects Monitoring
EMA	*Environmental Management Act*
EMP	Environmental Monitoring Plan
EMPR	Energy, Mines, and Petroleum Resources
ENV	Ministry of Environment and Climate Change Strategy
ERA	Ecological Risk Assessment
ESCP	Erosion and Sediment Control Plan
Golder	Golder Associates Ltd.
ha	hectares
HHRA	Human Health Risk Assessment
IDZ	initial dilution zone
km	kilometre(s)
km^2	square kilometre(s)
LOR	limit of reporting
LTWM	long term water management
NPM	Numeric Performance Metric
m^3/s	cubic metres per second
masl	metres above sea level
MDL	method detection limit
Minnow	Minnow Environmental Inc.
mL	millilitre(s)
ML	metal leaching
mm	millimetre(s)
MPMC	Mount Polley Mining Corporation

MDMER	Metal and Diamond Mining Effluent Regulations
PAG	potentially acid-generating
PAO	Pollution Abatement Order
PEEIAR	Post-event environmental impact assessment report
PETBP	Perimeter Embankment Till Borrow Pond
PLC	Public Liaison Committee
QA	quality assurance
QC	quality control
RCP	Reclamation and Closure Plan
RPD	relative percent difference
SFS	Society for Freshwater Science
SOP	standard operating procedure
SWL	static water level
TAR	Technical Assessment Report
TOR	terms of reference
TSF	Tailings Storage Facility
TSS	total suspended solids
WaterSmith	WaterSmith Research Inc.
WLFN	Williams Lake First Nation
WM	work method
WTP	water treatment plant
XFN	Xatśūll First Nation

1 INTRODUCTION

The Mount Polley Mine is located eight kilometres (km) southwest of Likely and 56 km (100 km by road) northeast of Williams Lake, British Columbia (BC; Figure 1.1). On November 29, 2015, Mount Polley Mining Corporation (MPMC), which operates the mine, received an amendment to Permit 11678 (herein referred to as the Permit) issued by the BC Ministry of Environment and Climate Change Strategy (ENV; previously known as the Ministry of Environment) pursuant to the *Environmental Management Act* (*EMA*; SBC 2003, Chapter 53) for a short-term water management strategy to discharge treated mine effluent into Quesnel Lake via Hazeltine Creek. An amendment of the Permit was granted on April 7, 2017 for a long-term water management strategy to discharge treated mine effluent directly to Quesnel Lake. Section 3.2 of the most recently amended Permit issued on December 1, 2022 requires MPMC to develop and implement a Comprehensive Environmental Monitoring Plan (CEMP) for the Mount Polley Mine site and surrounding receiving environment that combines pre-existing monitoring programs into an integrated plan as follows:

> *"The Permittee must continue to develop, submit, and implement an ongoing Comprehensive Environmental Monitoring Plan (CEMP) to evaluate the effects of mining-related activities on the physical, chemical, and biological characteristics of Hazeltine Creek, Edney Creek, Bootjack Lake, Morehead Creek, Polley Lake, Quesnel Lake, Quesnel River, and associated riparian and upland areas.*
>
> *The CEMP must meet all of the following requirements:*
>
> *a) Consolidate and integrate all the monitoring programs that are being conducted in the vicinity of the mine site and include, at minimum, surface water (quality and quantity), groundwater (characterization and interactions with surface water), sediments, soils, periphyton, phytoplankton, benthic invertebrates, zooplankton, fish, floodplain and upland vegetation, and wildlife.*
>
> *b) At minimum address a three year time span.*
>
> *c) At a minimum include all sampling sites, frequency of sampling, variables to be analysed, method detection limits, sampling methods, sample analysis methods, and data analysis methods."*

The June 23, 2016 version of the CEMP was approved in the April 7, 2017 Permit amendment. Subsequently, in 2017, MPMC submitted several versions of a CEMP to ENV for review, however, a plan for 2017 was not approved. On October 31, 2019, MPMC submitted an updated version of the CEMP to ENV for review, which was approved on February 10, 2021 with conditions provided in an approval letter. This updated CEMP covers the 2023 to 2025 time period and was developed based on the approved updated Terms of Reference (TOR) included as Appendix A. Based on the requirements of the permit, the next CEMP will be submitted in March 2025.

This CEMP is a unique and integrated monitoring plan that has been developed to capture a number of independent and interdependent monitoring programs, including; site monitoring, water discharge, *Metal and Diamond Mining Effluent Regulations* (MDMER) requirements, and Tailings Storage Facility (TSF) embankment breach response and remediation. Monitoring programs are normally developed by requirements of sector-specific regulations (e.g., MDMER of the federal *Fisheries Act* [Government of Canada 2018]) or by conditions in a permit with a specific monitoring plan that ties together permit-required and MDMER-required monitoring. As there is no ENV Technical Guidance document for this type of plan, this CEMP has been developed through an extensive consultative process that encompasses a number of permitting and other regulatory processes. Through these efforts, it has been suggested by various parties that all of the monitoring programs (e.g., water discharge monitoring, MDMER, TSF embankment breach response, etc.) be combined into one overarching program that takes advantage of the broader data set. This integrated monitoring plan offers the additional benefit of facilitating more efficient monitoring plan review by regulatory agencies, First Nations, and stakeholders. A constraint on this CEMP is where there are specific programs compelled by regulation such as the Environmental Effects Monitoring (EEM) Program that is required under the MDMER. In such instances, transparency of objectives and best efforts will be required to consolidate these different programs to the extent possible.

The CEMP is structured as follows:

- **Section 1:** Describes the CEMP objectives, a brief summary of the monitoring programs that have been integrated into the CEMP, and regulatory requirements.
- **Section 2:** Provides an overview of the integration of the various environmental monitoring programs being undertaken at the mine. Conceptual Site Models (CSMs) for the mine site and the TSF breach affected areas have also been provided, along with further details of the monitoring plans that have been integrated into the CEMP.
- **Section 3:** Provides an overview of First Nations and Stakeholders.
- **Section 4:** Provides a summary of the mine operations and the receiving environment.
- **Section 5:** Describes the environmental management practices in place, including water management.
- **Section 6:** Describes all monitoring components, including climate, surface water, hydrology, groundwater, contact water, seepage water, effluent, sediment quality, benthic invertebrate, plankton and chlorophyll *a*, periphyton, fish, wildlife, amphibian and reptile, soil, soil invertebrate, vegetation, and biosolids.
- **Section 7:** Describes the process for CEMP revisions and updates, along with a summary of changes made since the approved plan was submitted on June 23, 2016.
- **Section 8:** Summarizes relevant components of the post-TSF breach reclamation and remediation plans and interactions with CEMP components.
- **Section 9:** Provides an overview of the reporting of CEMP results.
- **Section 10:** Provides an overview of the future outlook.

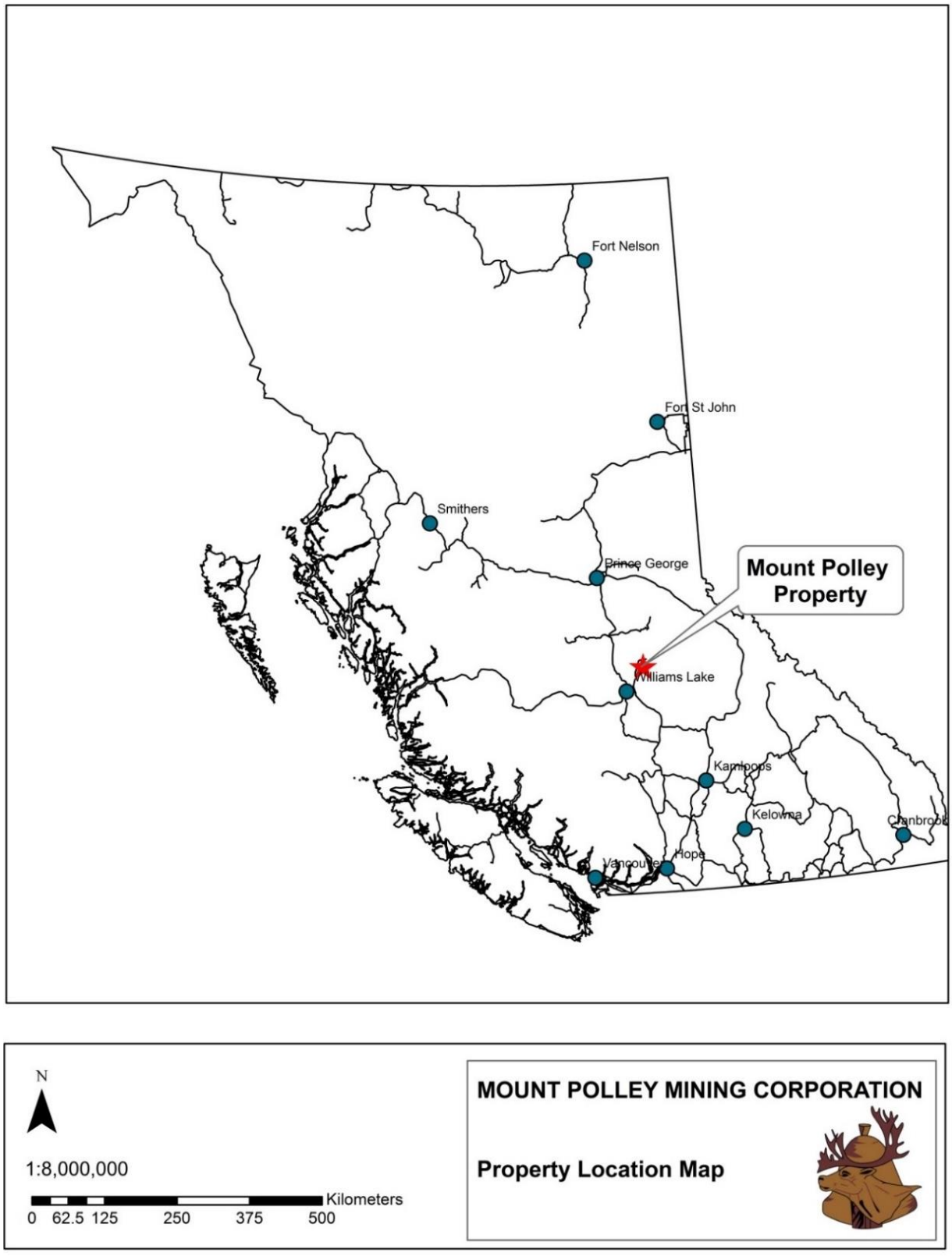


Figure 1.1 Mount Polley Mine property location

The appendices attached to the CEMP are summarized below:

- **Appendix A:** Approved CEMP TOR (April 28, 2017).
- **Appendix B:** Contains the Detailed Study Designs for CEMP components, as referenced in document.
- **Appendix C:** Sample of Monthly Monitoring Schedule, which is a sample of the monthly environmental monitoring schedule provided to environmental department staff.
- **Appendix D:** Site Matrix, which describes all water sample locations in the CEMP, including site descriptions, site locations, access or safety concerns, and rationale for monitoring.
- **Appendix E** Declarations of Competency forms for Qualified Professionals contributing to the CEMP

1.1 OBJECTIVES

As specified in the Permit, the CEMP describes monitoring activities intended to support the evaluation of the potential for effects of mine-related activities on the physical, chemical, and biological characteristics of Bootjack Lake and Morehead Creek in the Springer Pit area, the Hazeltine and Edney Creek drainages, Polley Lake, Quesnel Lake, and Quesnel River, and associated riparian and upland areas. Specifically, the CEMP objectives are:

1. To evaluate if pollution[1] is occurring in the receiving environment as a result of the existing water discharge or mine-related activities;
2. To evaluate the environmental impacts of the August 2014 TSF embankment breach, to inform the rehabilitation plan, as well as to evaluate the effects of mitigation measures that are implemented as part of the rehabilitation strategy;
3. To integrate, to the extent feasible, the requirements of the MDMER; and
4. To inform reclamation and closure (*Mines Act* Permit M-200).

This CEMP includes monitoring of: effluent, surface water, groundwater, sediment, periphyton, plankton, benthic invertebrates, and fish in the aquatic environments; and soil, floodplain and upland vegetation, and wildlife in the terrestrial environments. Specific objectives for individual monitoring program components are stated in the subsequent sections. Supporting summary tables and maps are also provided.

Since the original integration of these plans and submission of the CEMP on March 31, 2016, many iterations of the CEMP have been reviewed, revised, and submitted in 2016, 2017 and 2019. Pre-existing monitoring plans that were integrated into the initial CEMP and have subsequently been revised within CEMP revisions (instead of individually) are:

- The *Monitoring Plan for Discharge of Treated Effluent to Quesnel Lake via Hazeltine Creek* (MPMC 2016a);

[1] Pollution as defined in the BC EMA (S.1(1)) means "*…the presence in the environment of substances or contaminants that substantially alter or impair the usefulness of the environment*".

- The *Annual Monitoring Plan* for surface water and groundwater (MPMC 2015a);
- The *Biological Monitoring and Lake Sampling Plan* (MPMC 2015b); and
- The *Post-TSF Breach Monitoring Plan – 2015 Revision 1* (MPMC 2015c), which references the *Post Breach Fish Tissue Collection Plan – 2015* (MPMC 2015d) and the *Sampling and Analysis Plan: Detailed Site Investigation and Human Health and Ecological Risk Assessment* (Golder 2015a).

Previous results were used to inform and structure this version of the CEMP and are summarized below in their respective sections or provided in Appendix B, as appropriate. A summary of results along with a discussion is provided in each relevant section. Throughout the CEMP, references are made to semi-x monitoring. This refers to monitoring that occurs twice per unit time, for example semi-annual monitoring indicates twice per year, and semi-monthly monitoring indicates twice per month.

It is expected that monitoring will be updated from time to time, consistent with an adaptive monitoring program (see Section 2.3). When changes are made to the monitoring, this amended plan (or relevant replacement pages) will be resubmitted to the Director and MPMC's Implementation Committee.

Work plans will be developed for all future monitoring programs and submitted to the ENV at least 30 days prior to commencing the program. These programs will be developed by a Qualified Professional (QP) and will consider linkages and dependencies with existing programs using previous data and review of the CSMs, which are presented in Section 2.2.

2 INTEGRATION OF MONITORING ACTIVITIES

The CEMP integrates environmental monitoring programs being carried out at the mine to meet multiple requirements which have different drivers and, therefore, objectives. Figure 2.1 shows the linkage between these drivers and associated monitoring objectives, as well as the resulting monitoring components that addresses those objectives. Further discussion is provided on these linkages in the sections following.

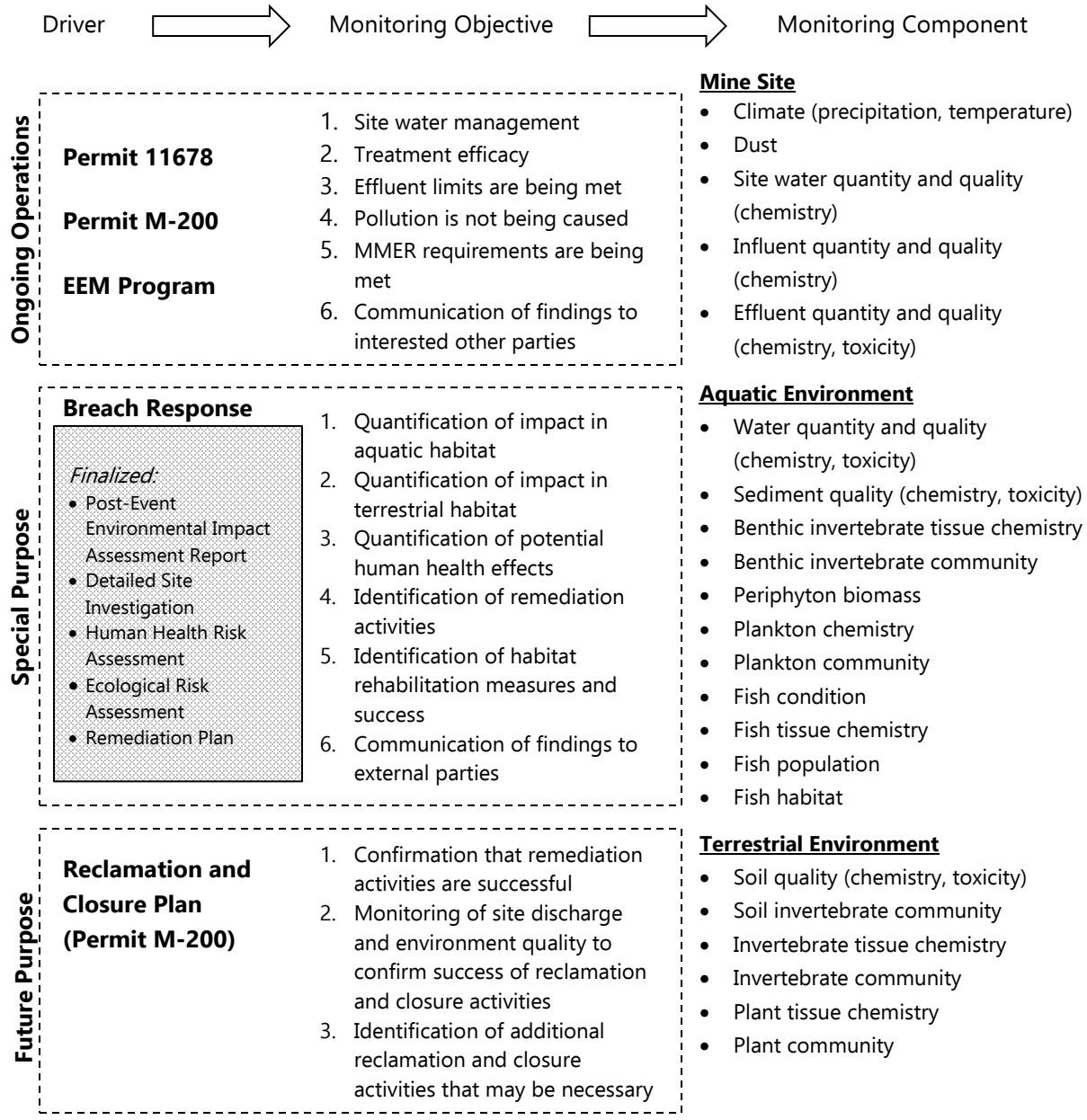


Figure 2.1 CEMP integration framework

2.1 MONITORING DRIVERS AND OBJECTIVES

There are three different drivers for current monitoring activities: ongoing operations, the TSF embankment breach response (special purpose program distinct from normal mine operations monitoring), and reclamation and closure planning (future purpose; note that some progressive reclamation has been done to date). These drivers and their associated monitoring objectives are described below. Previous monitoring results are continually reviewed to inform and structure the monitoring as well.

2.1.1 ONGOING OPERATIONS

Mount Polley Mine is an operational facility that is governed by provisions of the provincial *EMA* and *Mines Act* and the federal MDMER (a sector-specific regulation of the *Fisheries Act*). These permits and regulations contain specific requirements for on-going monitoring of site activities and downstream aquatic receiving environments. The objectives of ongoing operations monitoring are to:

1. Evaluate and plan for site water management.
2. Evaluate treatment efficacy to provide information for the ongoing management of the water treatment system installed at the time.
3. Verify that effluent limits are being met.
4. Verify that pollution is not being caused.
5. Verify that MDMER requirements are being met.
6. Communicate the findings to all interested parties.

Monitoring in accordance with conditions contained within BC *Mines Act* Permit M-200 is also summarized in the CEMP. This monitoring is only described in the CEMP for completeness purposes. Monitoring is summarized and future changes will be presented in CEMP revisions, but changes to this monitoring are subject to BC *Mines Act* Permit M-200 and not Section 7 in the CEMP or Section 5 in the CEMP TOR (Appendix A). This permit requires monitoring for metal leaching and acid rock drainage (ML/ARD) characteristics, water quality of on-site contact water (Section 6.11), and water quality of seeps from open pits and waste rock piles (Section 6.10). Permit M-200 also contains conditions related to reclamation and closure planning and monitoring. Results of monitoring conducted under the M-200 permit will continue to be reported annually, along with the monitoring results directed under the CEMP, in an AER (Annual Environmental Report) and ARR (Annual Reclamation Report) that are submitted to ENV and the BC Energy, Mines, and Low Carbon Innovation (EMLI; formerly the Ministry of Energy, Mines and Petroleum Resources [EMPR]). Refer to Section 9 for information on reporting associated with the CEMP.

MPMC is also subject to the conditions of the BC *Water Sustainability Act* (which replaced the *Water Act* in 2016) that includes provisions related to sediment and erosion control and working around water. MPMC holds conditional water licences, which were issued under the former *Water Act*.

2.1.2 SPECIAL PURPOSE

On August 4, 2014, a foundation failure of the Mount Polley TSF perimeter embankment occurred. ENV issued a Pollution Abatement Order (PAO) that specified the need for specific impact studies and monitoring

to address impacts of the breach event, inform remedial measures, and evaluate changes over time. These studies are referred to as "special purpose" studies (now primarily monitoring) because they relate to a unique event with program objectives that differ considerably from an operating mine. The objectives of the special purpose monitoring are to:

1. Monitor and assess impact to aquatic habitat.
2. Monitor and assess impact to terrestrial habitat.
3. Monitor and assess potential human health risks.
4. Identify remediation activities needed to address identified impacts.
5. Identify habitat rehabilitation measures and related works as well as the success of those works.
6. Communicate findings of the impact assessment and ongoing monitoring to external parties.

2.1.3 Future Purpose

As an operating mine, MPMC is required to plan for eventual closure. Reclamation and closure monitoring takes place after the closure plan is implemented. Although progressive reclamation and reclamation research have already been initiated at the site, the Reclamation and Closure Plan (RCP) continues to be refined during operations in preparation for closure and is not yet finalized. However, in the context of a CEMP, future monitoring needs are appropriate to start considering. Because this CEMP is intended to be an adaptive plan, these will be updated as reclamation and closure planning progresses and greater certainty of locations, measurement endpoints, etc. are available.

The objectives of the future monitoring program are to:

1. Confirm that mine site reclamation activities are successful in achieving their stated objectives.
2. Monitor site discharge quality and receiving environment quality as appropriate to confirm that reclamation and closure works have been successful in preventing pollution and that discharges are compliant with applicable requirements.
3. Identify additional reclamation and closure activities that may be necessary.

Additional and more specific objectives will be developed as the reclamation and closure planning process progresses.

2.2 Monitoring Components and Conceptual Site Model

Figure 2.2 provides an overview of the Mount Polley Mine, in particular the CEMP study areas along with their respective monitoring components. Figure 2.3 and Figure 2.4 show greater detail of the TSF area and the mine site, respectively, of the sources of mine-contact water to the surrounding aquatic receiving environment and areas of ground disturbance. The measurement endpoints are detailed in the applicable sections later in this plan.

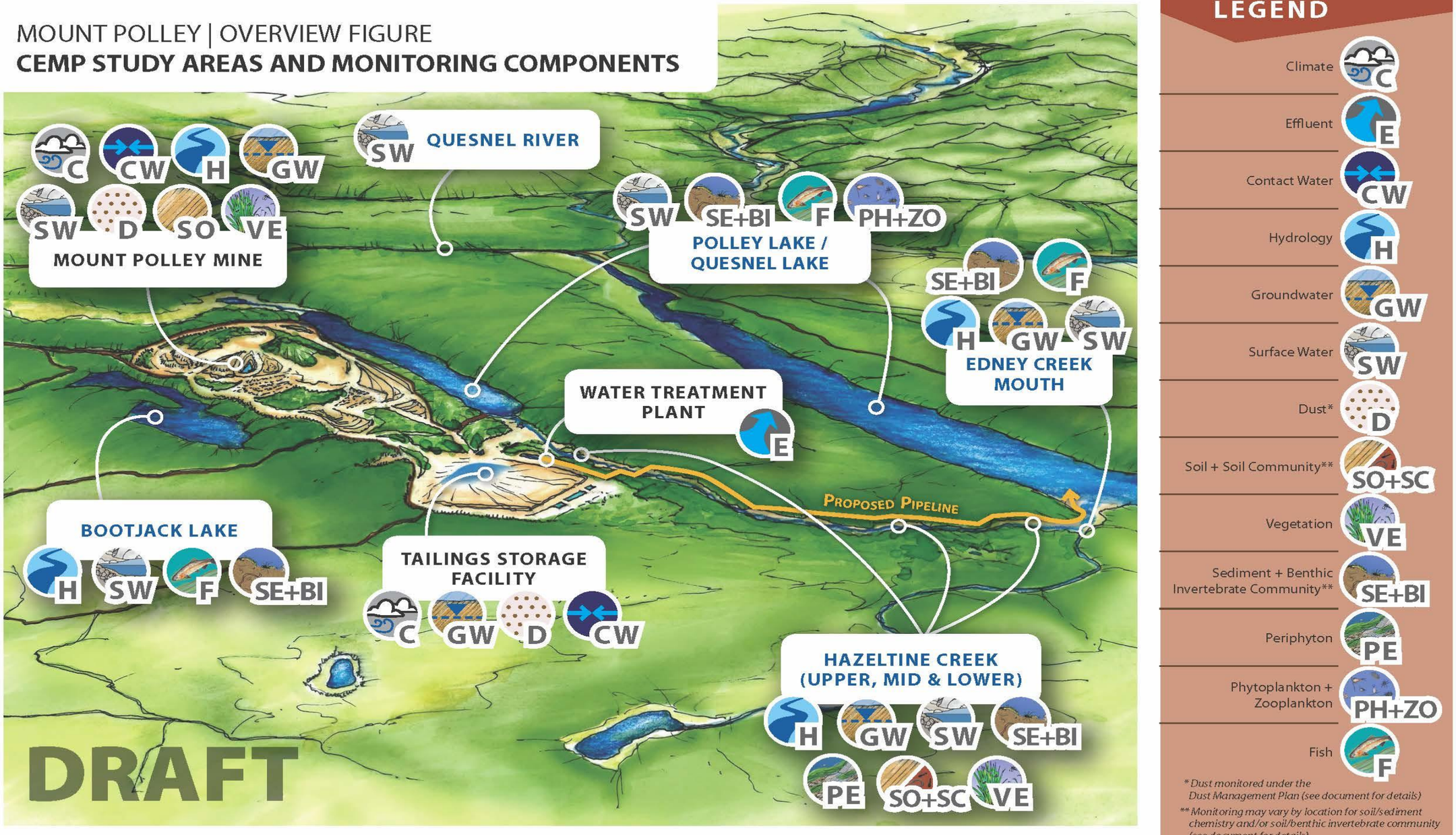


Figure 2.2 CEMP Study Areas and Monitoring Components

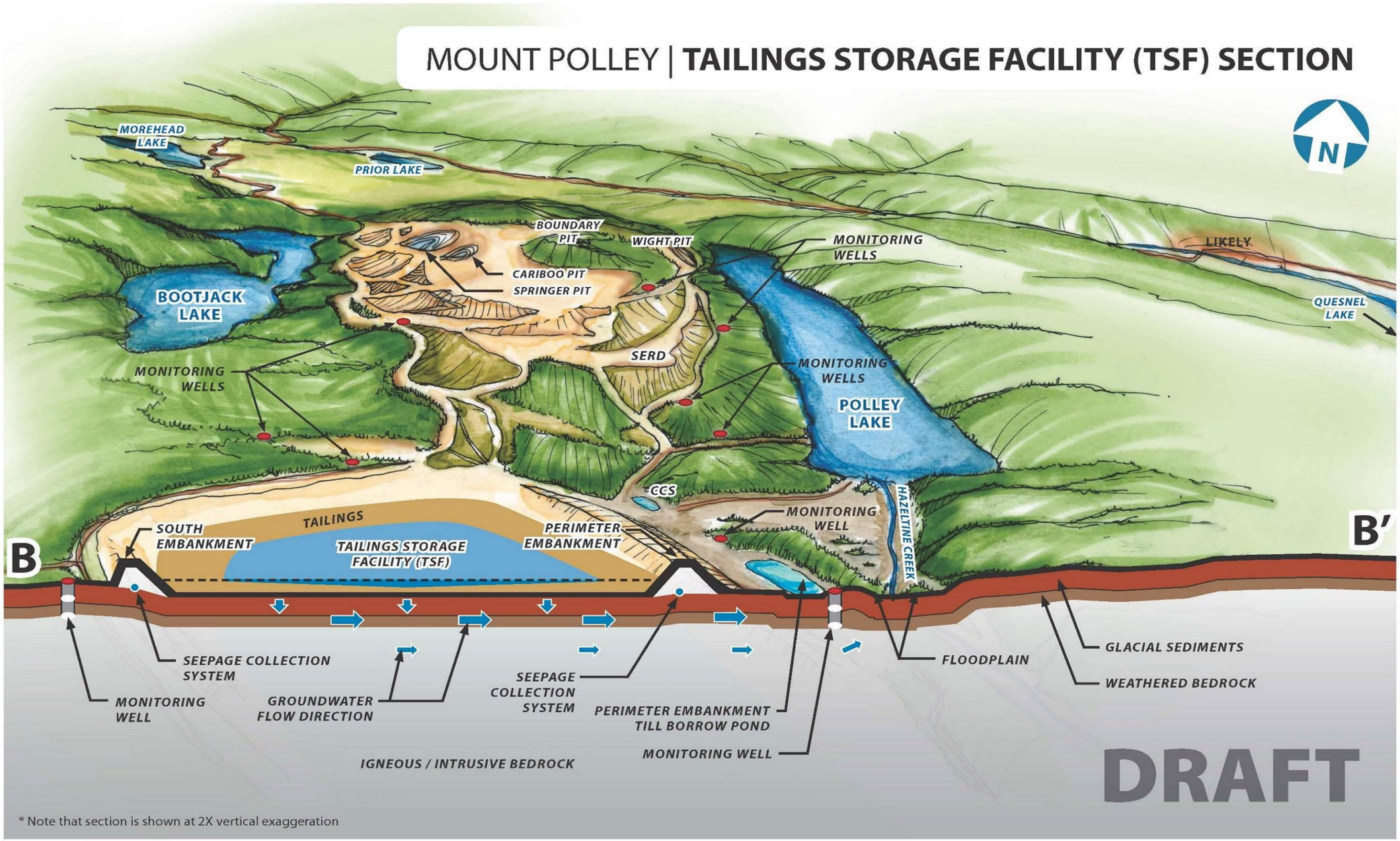


Figure 2.3 Tailings Storage Facility Section

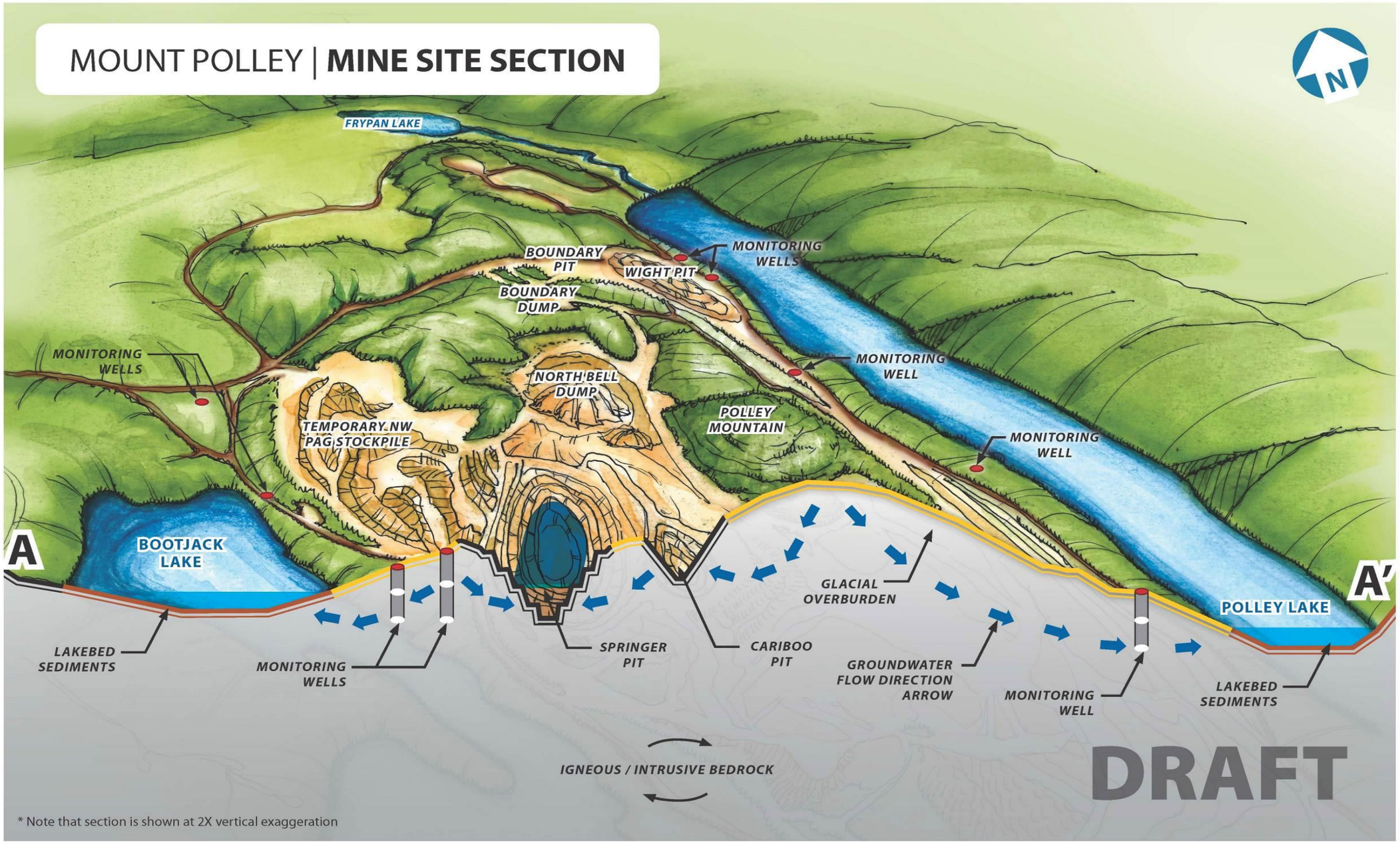


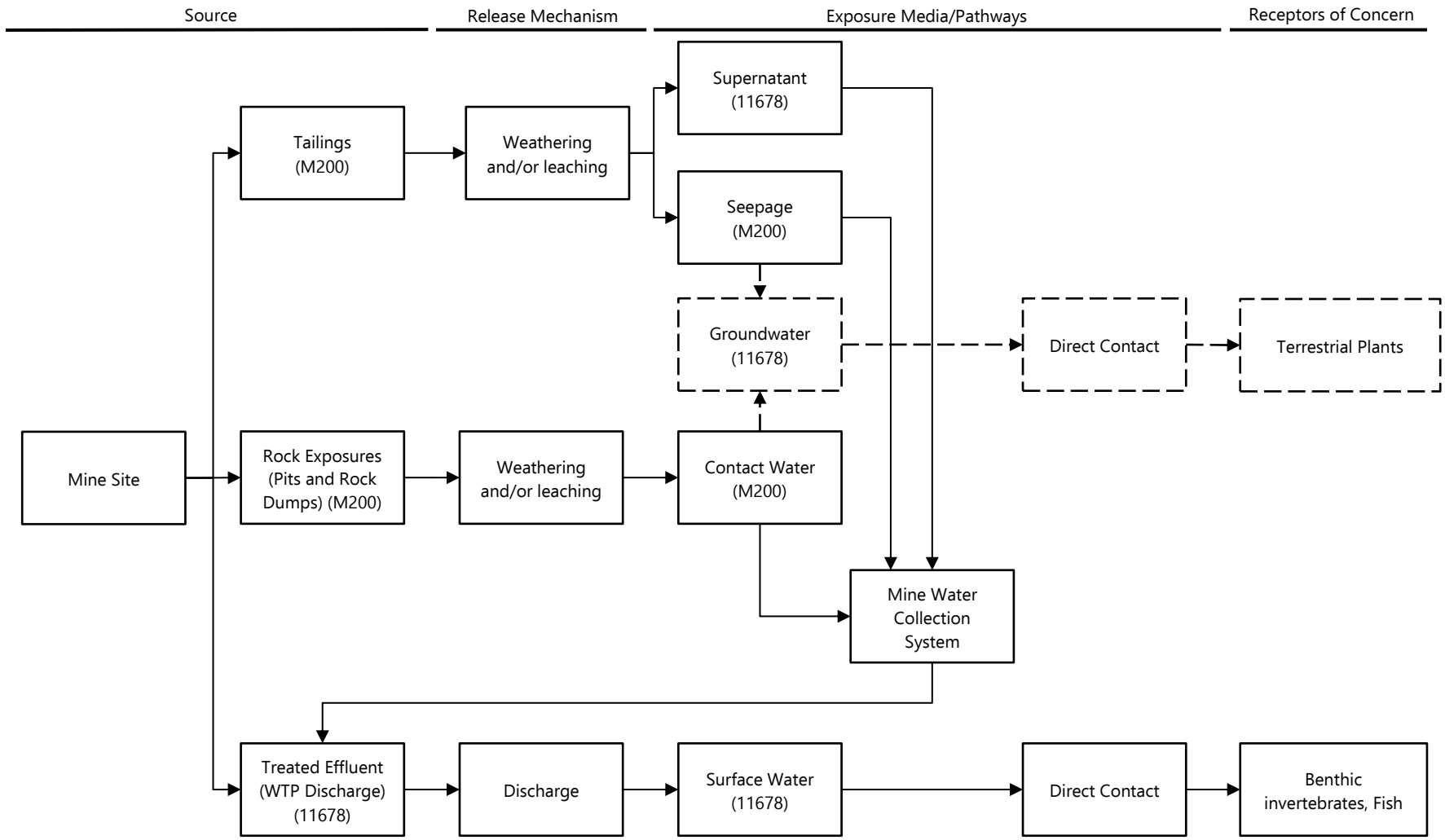
Figure 2.4 Mine Site Section

A CSM helps provide the basis for selecting appropriate monitoring components and suitable locations for those measurements. A CSM provides a graphical articulation of the understanding upon which the CEMP is based including movement of substances, pathways by which organisms (receptors) might become exposed to and interact with those substances in the environment. CSMs are often used in risk assessments to communicate similar concepts; however, in this CEMP, the focus of the study on specific constituents of potential concern (COPCs) has not been an objective because the monitoring program includes broader purposes and will include, for example, the full commercial analytical package for elemental analysis (frequently called "metals analysis"). Groups of substances that will be analyzed for, however, are those related to the potential sources. A CSM specific to the mine site was developed and is shown in Figure 2.5. A CSM for the TSF breach affected areas was developed for the Ecological Risk Assessment (ERA; Golder 2017) and is shown in Figure 2.6.

As discussed in Section 2.1.1, the mine has ongoing operational monitoring needs that centre on permit compliance that include management of site water and ultimately treated water discharges. The mine also needs to address disturbed ground through dust management in the short term. The measurable characteristics or components that contribute information to the stated monitoring objectives can then be identified as variables such as: precipitation and temperature (i.e., climate); dust; mine contact water, groundwater, and surface water quantity and quality; and influent and effluent quantity and quality. These are considered "Site" monitoring components (Figure 2.1). This information contributes to understanding the site water balance, function of site water collection systems, and management of the water treatment plant (WTP; e.g., capacity and treatment efficacy). This information is also useful in understanding the groundwater and seepage flow pathways to Bootjack and Polley lakes.

Ongoing operational activities at the site also have the potential to influence aquatic receiving environments related to effluent discharges. Under the long-term water management plan effluent is discharge from the WTP to Quesnel Lake. Relevant monitoring components for "Aquatic Habitat" include receiving water and sediment chemistry and toxicity, as well as biotic (e.g., plankton, benthos, fish) communities and tissue chemistry as summarized in Figure 2.1.

Following the TSF embankment failure in 2014, the environmental monitoring program was expanded to either incorporate additional monitoring components or increase the frequency of sampling. Many of the same existing operational monitoring components applied to this program and others were added. Additional measurements, related to physical impacts from the event, were collected to contribute to the Post-event Environmental Impact Assessment Report (PEEIAR) and to contribute to the Human Health Risk Assessment (HHRA) and the ERA. This "special purpose" monitoring information is relevant to the Remediation Plan for which an annotated table of contents has been submitted to ENV. As noted in the Risk Monitoring Considerations section of the ERA, further sample collection and evaluation of monitoring data will be done to further refine toxicity reference values for wildlife and confirm bioavailability of copper continues to be low and does not present a risk to wildlife.



Notes:
Solid lines indicate pathways that are likely to be complete or operative.
Dotted lines indicate pathways that are likely to be incomplete or inoperative.

Figure 2.5 Conceptual Site Model for the mine site

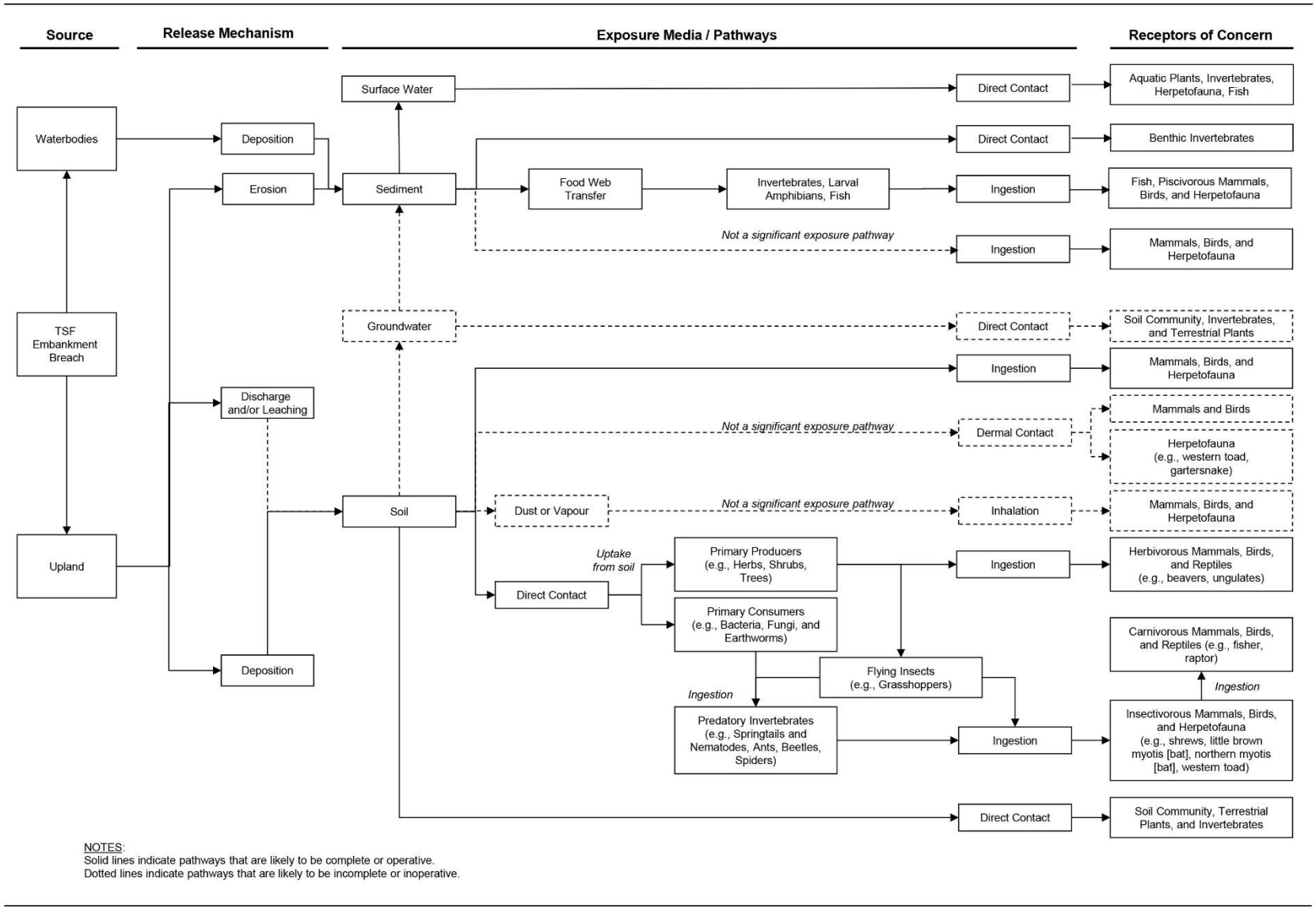


Figure 2.6 Conceptual Site Model for TSF breach affected areas, as developed for the ERA (from Golder 2017)

2.3 Adaptive Management Framework

The CEMP will be adaptive based on the results of ongoing operational and special purpose monitoring (illustrated in Figure 2.7) and based on the developing RCP. The adaptive framework recognizes that studies and monitoring can lead to new information that should be used to inform future monitoring. The framework provides feedback of this new information into the decision-making process that links monitoring and management actions that may need to be implemented to keep MPMC in compliance. For example, more immediate management actions may need to be undertaken in response to pre-defined triggers for unexpected changes in condition. The progressive implementation of the adaptive management framework will also include an annual review of the monitoring program to determine the potential need for revisions to planned sampling and analysis tasks. This review could include cessation of monitoring components that data show may no longer be necessary, or increase of monitoring based on changing conditions or monitoring results. Recommendations for monitoring related to the findings of post-breach-related studies have been included in this CEMP with the intention of forecasting monitoring that may be undertaken in the next three years. Monitoring for a specific year will be verified in monitoring program work plans following the adaptive management framework.

Figure 2.7 Adaptive Management Framework

3 First Nations and Stakeholders

3.1 First Nations Engagement

First Nations with recognized claimed traditional territory for the Mount Polley Mine are the T'exelc (Williams Lake First Nation; WLFN) and the Xatśūll First Nation (Soda Creek First Nation; XFN). In 2011 and 2012, MPMC executed Participation Agreements with the WLFN and the XFN, respectively. Through these respective Participation Agreements, Implementation Committees were formed to facilitate open dialogue between each of the First Nations and MPMC, providing a formalized and regular venue to discuss environmental, social, and economic matters related to mine development, operation, reclamation, and closure (e.g., mine updates, permitting, environmental protection, reclamation, employment opportunities, and potential joint ventures). Meetings with the WLFN have taken place since March 16, 2012 and since July 19, 2012 with the XFN. Effective October 18, 2012, Joint Implementation Committee meetings have been held with representatives from MPMC, the WLFN, and the XFN, replacing the previous MPMC/XFN and MPMC/WLFN Implementation Committee meetings. Joint Implementation Committee meetings are held at minimum quarterly, but typically more frequently. These meetings and associated documentation (TOR, minutes, and action items) provide a well-defined, constructive forum in which issues, reviews, and comments relating to the current and anticipated future operations of the Mount Polley Mine may be discussed. This CEMP and the AER/ARR will be provided in their current forms to the XFN and the WLFN for review, and discussion regarding any comments or concerns will be facilitated through the Joint Implementation Committee.

3.2 Public Liaison Committee

The Public Liaison Committee (PLC) for the Mount Polley Mine was formed in 1999, and meetings have been maintained through the operating years of the Mine. Meetings were historically scheduled in conjunction with updates on proposed developments and projects, with a minimum frequency of one meeting per year. An annual PLC meeting became a requirement of the Permit in 2013 and quarterly meetings became a requirement in 2015. The PLC is intended to provide an opportunity for MPMC to share information about mine activities and the results of monitoring programs with its members, and for members to share such information with their respective membership. The PLC does not replace or diminish the use of other communication procedures that MPMC will use regularly to inform the public, including but not limited to: public meetings, newsletters, emails, and internet websites. The PLC is seen as a medium to add value to parties with interest in the Mount Polley Mine, including, but not limited to: MPMC and its personnel, the public and public interest groups, local communities, First Nations, and regulators.

3.3 Communication Plan

The Permit requires a Communication Plan between MPMC and the WLFN, XFN, Cariboo Regional District, and the Community of Likely to be in place. The original Communication Plan was submitted to the Director (ENV Statutory Decision Maker) on March 20, 2016 and was approved by the Director on May 11, 2016. The amended Permit required that an updated Communication Plan be submitted by June 30, 2017. The final Communication Plan was submitted to ENV on March 20, 2016.

4 MOUNT POLLEY MINE PROJECT OVERVIEW

4.1 PROJECT HISTORY

Mount Polley Mine, operated by MPMC (a wholly-owned subsidiary of Imperial Metals Corporation), is an open pit copper/gold mine with an underground component, and has the capacity to process 20,000 to 22,000 tonnes per day (tpd) of ore. The Mount Polley property covers 18,892 hectares (ha), which consist of seven mining leases totaling 2,007 ha, and 43 mineral claims encompassing 16,855 ha, as of March 2018.

Clearing of the site and construction of the entire facility began in 1995, with the mill being commissioned in June 1997. In May 1997, the Mine received an ENV (known as the Ministry of Water, Land and Air Protection at that time) Effluent Permit, issued under the provisions of the provincial *EMA*. This permit authorized the discharge of concentrator tailings, mill site runoff, mine rock runoff, open pit water, and septic tank effluent to a tailings impoundment. Approval of the "Mount Polley Mine Reclamation and Closure Plan" by the EMPR, now known as EMLI, resulted in the issuance of Permit M-200 in July 1997. The first full year of mining and milling at Mount Polley Mine took place in 1998. The mine suspended operations in October 2001 due to low metal prices, then reopened in December 2004 with mill production commencing again in March 2005. A summary of Permit 11678 amendments is provided in Table 4.1.

Table 4.1 Summary of Permit 11678 amendments

Date	Scope of Amendment
30-May-1997	Original permit
20-Oct-1997	Amended authorized tailings discharge rate (10,000 tpd increase)
12-Jun-1998	Amended reporting requirements
08-Sep-1999	Amended monitoring requirements
01-Feb-2000	Amended authorized tailings discharge rate (4,500 tpd increase)
07-Feb-2002	Approval to discharge effluent from the PESCP and MESCP; approval to store TSF supernatant and Mine Site contact water in the Cariboo and Bell Pits
04-May-2005	Amended authorized tailings discharge rate (5,000 tpd increase); discharge of groundwater to Polley Lake; updates to reference analytical procedures and monitoring program
17-Apr-2009	Amended monitoring, water level and supernatant characteristic requirements for the Cariboo and Bell Pits
07-Nov-2012	Approval to discharge to Hazeltine Creek
07-Jun-2013	Sulphate guidelines
09-Jul-2015	Tailings discharge to the Springer Pit
29-Nov-2015	Approval to discharge to Hazeltine Creek
04-Apr-2016	Discharge of additional tailings to the Springer Pit
09-Sep-2016	Hazeltine Creek discharge total suspended solids limit change
07-Apr-2017	Approval to discharge directly to Quesnel Lake
02-Oct-2018	Amended discharge characteristics
01-Feb-2020	Amended water treatment and discharge program, water management progress reporting and 2022 Water Management Plan requirements
31-Dec-2020	Amended water treatment and discharge program, water management progress reporting, water management planning and annual reporting requirements
01-Dec-2022	Amended water discharge period, ESCP, NPM and veracity of data requirements, and added Storm Event Reporting and Flocculant Management Plan requirements

Notes: tdp: tonnes per day; PESCP: Perimeter Embankment Seepage Collection Pond; MESCP: Main Embankment Seepage Collection Pond; TSF: Tailings Storage Facility; ESCP: Erosion and Sediment Control Plan; NPM: Numeric Performance Metric

As a result of a foundation failure of the perimeter embankment of the TSF on August 4, 2014 (see Section 2.1.2), the mine was placed in care and maintenance until August 5, 2015, when restricted operations under a short-term permit commenced. This restricted operations permit allowed processing of up to 4 million tonnes of ore over a one-year period, with tailings deposition into the Springer Pit.

The Mount Polley Mine became subject to the MDMER on April 10, 2014, following a planned discharge of mine effluent into Hazeltine Creek. The MDMER are also applicable to the long-term discharge approved for the Mount Polley Mine.

4.2 CURRENT OPERATIONS

MPMC was granted full restart permits on June 23, 2016 and operated at full capacity from June 2016 to May 2019. The mine went into a care and maintenance phase from May 2019 to November 2021 when pit operations resumed. Mill operations began in the summer of 2022 and full-scale operations resumed in the fall of 2022. The Mount Polley Mine site includes a crusher and mill (includes office spaces), a TSF, waste rock disposal sites, seepage collection ponds, haul roads, access roads, and various small buildings and storage areas (Figure 4.1). Concentrate is transported by truck from the site to the Port of Vancouver, where it is distributed to domestic or overseas markets.

4.3 ENVIRONMENT

4.3.1 TOPOGRAPHY AND CLIMATE

The Mount Polley property is located on the eastern edge of the Fraser Plateau physiographic sub-division, characterized by rolling topography and moderate relief. Elevations range from 920 metres above sea level (masl) at Polley Lake to 1266 masl at the summit of Mount Polley. Volcanic rocks generally underlay this part of the plateau with inclusions of intrusive rocks. Most of the area is covered by a deposit of unconsolidated till which contains fluvial, lacustrine, and colluvial deposits. Some patches of organic soils are present in poorly drained areas (i.e., wetlands). The property is located in an alkali porphyry copper-gold deposit hosted in the Central Quesnel Belt along the Intermontaine Belt of BC.

The site is located within the Interior Cedar Hemlock biogeoclimatic zone. Local forests consist of Western red cedar, Douglas-fir, hybrid spruce, and subalpine fir, with a lesser presence of trembling aspen, black cottonwood, and paper birch. Much of the area has been harvested in commercial logging operations and is also used for cattle grazing.

Average annual precipitation in the study area is 670 millimetres (mm). Precipitation typically occurs as snowfall from November through March, with an average maximum of snowpack of 178 mm snow water equivalent occurring at the end of March (Golder 2015b). Average monthly temperatures at the Mount Polley Mine range from -6.0 degrees Celsius (°C) in January to 15.3°C in July and August (MPMC 2016b). Prevailing winds are from the north-north-east and from the south-south-west near the TSF, and from the northwest (and to a lesser extent the southeast) near the mill, with a predominance of winds designated as calm (below 3 metres per second; Golder 2015b).

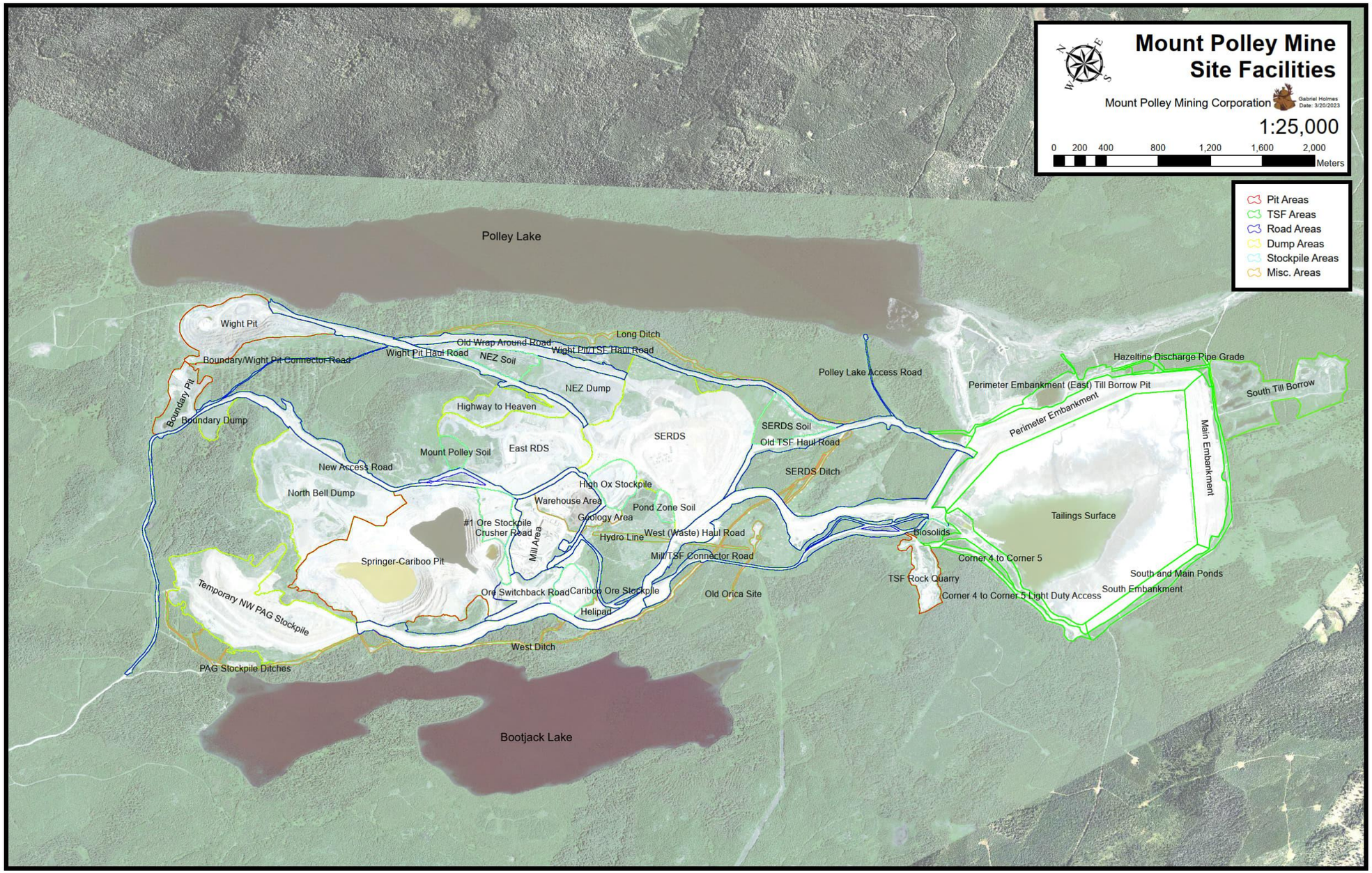


Figure 4.1 Mount Polley Mine site facilities

4.3.2 HYDROGEOLOGY

The groundwater flow at the site occurs primarily in the bedrock units in response to recharge from precipitation in the area between Polley Lake and Bootjack Lake. Flow in the overburden is less significant due to its limited thickness and discontinuous nature. Prior to mining, the water table at the site generally followed the surface topography, but the water table was deeper below the topographic heights and shallower in the low areas. At that time, the direction of groundwater flow was inferred to be from the top of the ridge between the Polley Lake and the Bootjack Lake towards the low-lying areas associated with these lakes northeast and southwest from the ridge.

Mine dewatering has altered the groundwater flow pattern at the site, with the open pit and underground workings acting as sinks for groundwater flow. Mine dewatering lowered the water table elevation and created radial patterns of groundwater flow towards these facilities. Following the formation of the pit lake in the Cariboo Pit, seepage from this pit started to provide a contribution to groundwater inflow to the Springer Pit. At present, Springer Pit and Cariboo Pit continue to act as groundwater sinks. The currently available information suggests that some seepage from the Springer Pit lake towards Bootjack Lake occurred when the pit lake level exceeded 1030 m elevation in 2016 (Golder 2016b).

4.3.3 DRAINAGE AND HYDROLOGY

The mine is located on the divide of two sub-watersheds within the Quesnel Lake watershed. Quesnel is a large, deep fjord lake with a surface area of 255 square kilometres (km^2), and is composed of East, West, and North Arms. It is the deepest fjord-type lake in the world, with a maximum depth of more than 511 m in the East Arm (Laval et al. 2008). The West Basin is a shallower (113 m maximum depth) portion of the west arm that is demarcated in the east by a shallow sill near Cariboo Island that is approximately 35 m deep (Laval et al. 2008). The lake drains to the west via the Quesnel River to the Fraser River. The Horsefly River, Mitchell River, and Niagara Creek are the main tributaries to Quesnel Lake, entering from east of the sill.

The western watershed, which includes drainage from Bootjack Lake, Trio Lake, and Morehead Lake, discharges to Quesnel River via Morehead Creek and drained approximately 60% of the Mount Polley area prior to mine construction.

The eastern watershed includes Polley Lake (surface area of 3.8 km^2), which discharges to the east via Hazeltine Creek and then to the western arm of Quesnel Lake. The Hazeltine Creek and Edney Creek watershed areas at Quesnel Lake are currently approximately 30.2 km^2 and 87.4 km^2, respectively. Approximately 10.5 km^2 that historically reported to this watershed is now within the mine contact water runoff collection system catchment.

Bootjack Creek is a small tributary that previously flowed into Hazeltine Creek downstream of Polley Lake. Following the TSF embankment breach, Bootjack Creek was re-routed to Polley Lake; fish access is currently restricted. Historically, Bootjack Lake (surface area of 1.2 km^2) discharged into Hazeltine Creek via Bootjack Creek, but in 1913 a dam was constructed at the south end of Bootjack Lake and the flow direction was reversed in order to direct water into Morehead Lake for hydropower production. This resulted in 14 km^2

being diverted from the Hazeltine Creek catchment. The Morehead Creek watershed, including the Bootjack Lake catchment area, is approximately 11.2 km^2. Approximately 2.3 km^2 that historically reported to this watershed is now within the mine contact water runoff collection system catchment.

Pre-mining watersheds are shown in Figure 4.2. In general, the hydrology of the Mount Polley area is snowmelt driven, with the majority of annual runoff occurring in April and May during snowmelt (i.e., freshet; Knight-Piésold 2014).

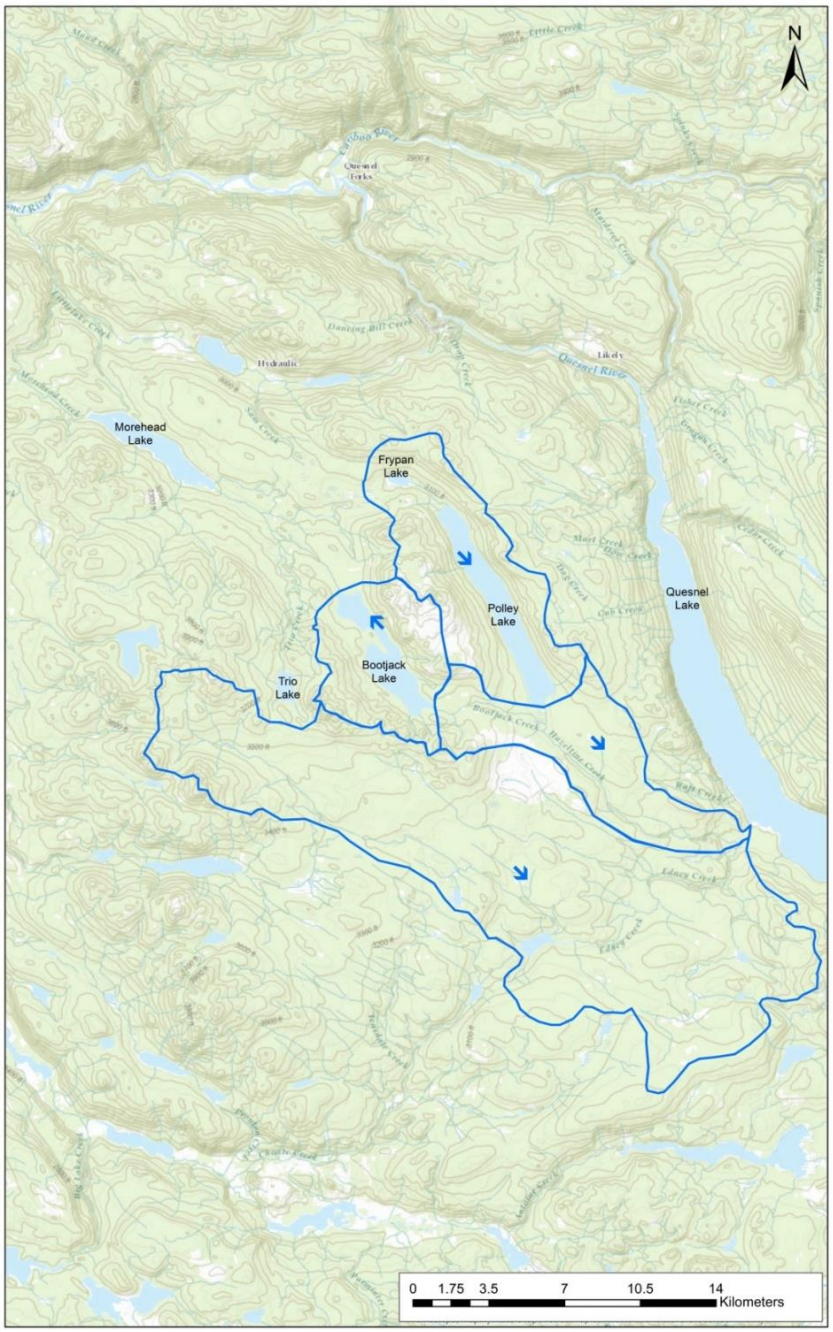


Figure 4.2 Mount Polley area pre-mining watersheds

5 ENVIRONMENTAL MANAGEMENT

5.1 WATER MANAGEMENT

To protect natural watercourses from mine-influenced contact water from roads, haul roads, waste rock piles, and other Mine areas, water is collected in a system of ditches and sumps located around the Mine site. Based on site water management objectives, site contact water is either pumped directly to the TSF or reports to the gravity-driven sections of the West Ditch or Long Ditch, the latter two of which both flow to the Central Collection Sump (CCS). Water in the CCS is currently allowed to overflow to the Perimeter Embankment Till Borrow Pond (PETBP) where it is pumped to the WTP or can be returned to the TSF. Pumping infrastructure also exists at the CCS such that it can be directed to the TSF. Water from the TSF is primarily pumped to the Mill via the Booster Station to meet process requirements, but can also be diverted to the CCS. A map of water collection infrastructure, including site collection ditches (including flow direction) and sumps, is shown in Figure 5.1. All water, primarily rain and snow melt, ultimately reports to the PETBP from which it is pumped to the WTP. At the time of writing, any contact water that requires temporary storage on site (i.e., when flows exceed those able to be treated and discharged) is pumped to the TSF. Tailings and process water from the Mill reports by gravity from the Mill to the TSF.

The Mount Polley site has a positive water balance, and a permit for a long-term water discharge system was received on April 7, 2017 (with amendments issued in 2019, 2020 and 2022). Treatment is conducted for removal of suspended solids and associated metals using a Veolia ACTIFLO® system, which is described in detail in Section 5.1.2. Under the long-term water management strategy, treated mine effluent is discharged to Quesnel Lake via a direct pipeline to the submerged diffusers installed in the lake. A continuous discharge of up to 0.6 m^3/s, with an annual average of 0.33 m^3/s is currently permitted until June 20, 2025.

5.1.1 ANNUAL DISCHARGE PLAN

Permit 11678 requires the yearly submission of an Annual Discharge Plan (ADP). The intent of the plan is to identify the specific sources and quantities of water that will be discharged; however, the discharge system (which is described in Section 5.1.2) at Mount Polley is not designed to be able to solely discharge from specific sources and it is not realistic for MPMC to estimate the volumes of precipitation that will occur from year to year. The overall water management at the mine is described in detail in the Long-Term Water Discharge Technical Assessment Report (TAR) that was submitted to ENV October 17, 2016 (Golder 2016e).

5.1.2 DISCHARGE SYSTEM

The WTP sources water from the PETBP. During treatment, the feed water of the WTP undergoes suspended solids removal using Veolia ACTIFLO® water treatment technology. The WTP doses the raw water with coagulant to a tank where a polymer is injected to create floc particles. Microsand is added to ballast the flocculants, which move on to another tank that allows them to swell and mature. The water flows to the next stage, which uses lamella to clarify the water and promote fast settling of the microsand ballasted sludge. The clarified water is discharged and the sludge is separated from the microsand, which is reused.

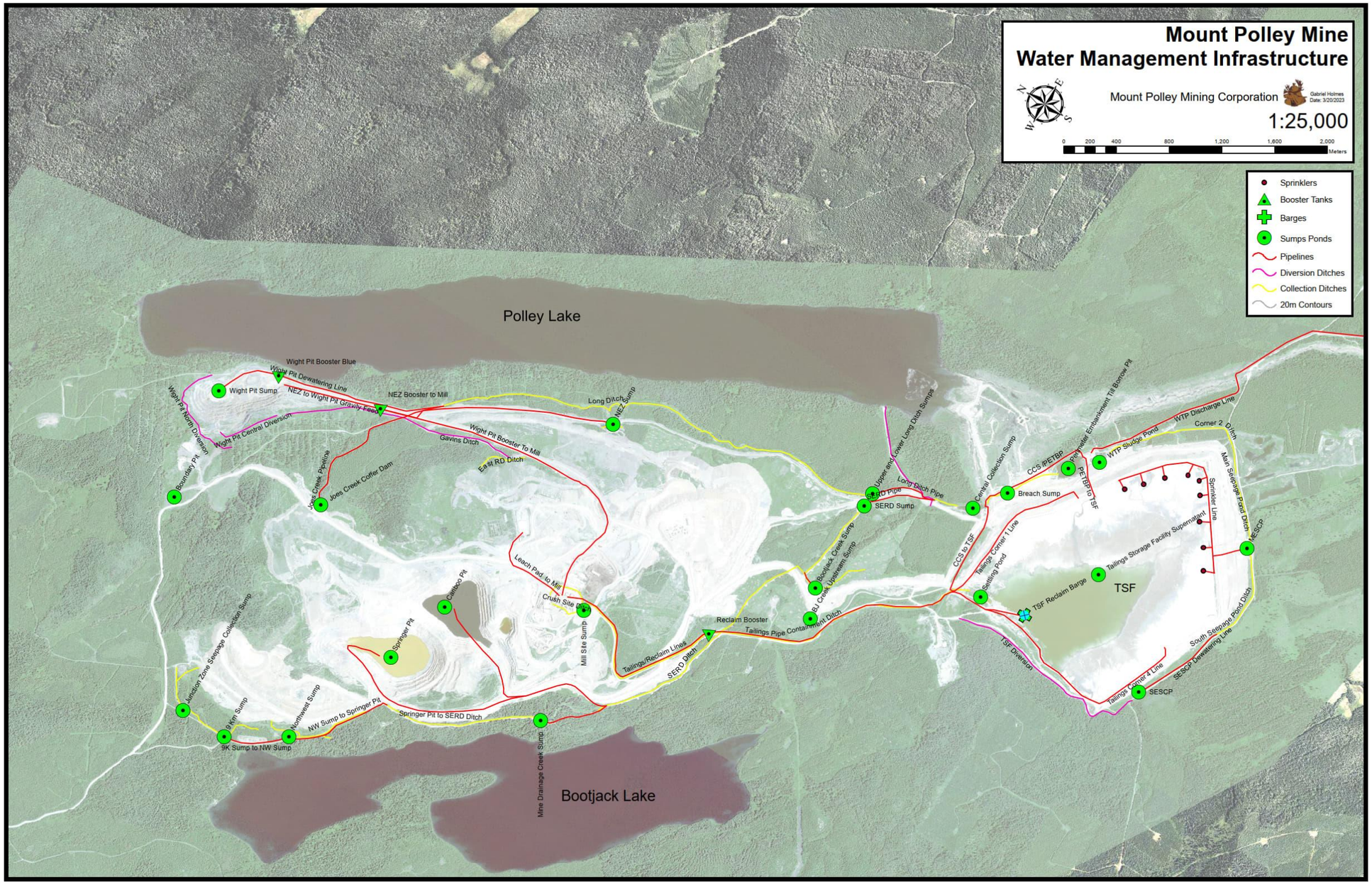


Figure 5.1 Mount Polley Mine water management system

An on-line turbidity meter measures the turbidity every minute where the WTP human-machine interface calculates the total suspended solids (TSS) using a calibrated factor based on a site-specific correlation between turbidity and TSS for the treated effluent. If the calculated on-line TSS is greater than the assigned set points an alarm sounds to alert the operator and the WTP automatically goes into recirculation mode and ceases discharge.

Treated water from the WTP is discharged, by gravity, to Quesnel Lake via a pipeline (installed as of November 2017) connected to two submerged diffusers. Effluent discharge to the Hazeltine Creek channel ceased as of September 30, 2017.

5.2 Sediment and Erosion Control Management Plan

MPMC has developed a RCP that has been submitted to EMLI, formerly EMPR, under the *Mines Act* Permit M-200. This plan includes several Environmental Management Plans including a Sediment and Erosion Control Plan.

5.3 Invasive Plant Management Plan

MPMC developed an Invasive Plant Management Plan in 2010 and has regularly updated this plan to include newly disturbed areas and to follow the Cariboo Regional District Strategic Plan for Invasive Plant Management. This plan is included in the RCP.

5.4 Dust Management Plan

MPMC maintains a Dust Management Plan that is also included in the RCP.

5.5 Project Environmental Monitoring Plans

MPMC develops project specific Environmental Monitoring Plans (EMPs) for any development project that has potential to impact the environment. The requirement for these EMPs is outlined in the Erosion and Sediment Control Plan (Section 5.2).

5.6 Waste Management

MPMC recognizes the value of responsible waste management and recycling. MPMC Recycling and Waste Management Awareness presentations are given to Mount Polley employees annually and MPMC promotes several recycling programs for used materials including waste oil, scrap steel, batteries, plastic pails, electronic waste, light bulbs and associated fixtures, paper, cardboard, and beverage containers. Waste management information is also presented to employees and contractors during site orientation. Each year, Mount Polley donates the funds generated by its beverage container recycling program to local charities.

In the course of its ongoing operations, Mount Polley utilizes potentially hazardous chemicals, reagents, and other products. GFL Environmental Inc. routinely removes and disposes of these waste products in an environmentally safe manner compliant with all relevant waste management legislation. Products removed include: aerosol cans; contaminated gasoline and diesel; waste oil (in drums); waste oil filters; waste grease

fuel or oil-soaked rags, debris, and floor dry; and leachable liquid toxic waste, such as glycol/anti-freeze mix. The site waste oil tanks are emptied and the oil removed from site by a third-party contractor. MPMC is registered (BCG-01559) with the ENV under the *Hazardous Waste Regulation* for generation and temporary storage of these materials.

5.7 INCIDENT REPORTING

All non-compliance incidents are reported to the Director or to Emergency Management BC. All incidents are recorded and tracked, and are included in the AER. As outlined in the Communication Plan (see Section 3.3) and required by Section 4.4. of the permit, incidents or emergencies that have the potential to have adverse impacts on the environment will be reported to the XFN, WLFN and Public Liaison Committee.

5.8 INSPECTIONS

MPMC Environmental Department staff conduct weekly inspections on the site with a focus toward regulatory compliance and waste management (Section 5.6). These inspections are documented and communicated regularly to the site management and their respective departments. Guidance is provided by the Environmental Department for proper internal reporting and follow-up. The goal of these inspections is to provide all departments the capability to engage in proper environmental management practices and open lines of communication with the Environmental Department.

6 MONITORING

The subsections below outline general procedures at MPMC for scheduling of environmental monitoring and data review and management. Field methods, laboratory analysis, data quality control and objectives, as well as data analysis methods are included in the following sections with their respective monitoring components. Note that frequencies may change due to weather conditions or construction work and will be dependent on accessibility and, most importantly, safety of the field crews. Declarations of Competency for relevant Qualified Professionals are provided in Appendix E.

6.1 SCHEDULING

To coordinate sampling and schedule all planned monitoring, as per the CEMP, MPMC prepares internal monthly sampling schedules. An example monthly sampling schedule has been included as Appendix C.

6.2 FIELD METHODS

Monitoring procedures that will be used in carrying out the CEMP are consistent with the *BC Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples* (2013 or most recent version, herein referred to as the "BC Field Sampling Manual"; MoE 2013a). As appropriate, monitoring procedures will also be consistent with the *Metal Mining Technical Guidance for Environmental Effects Monitoring* (Environment Canada 2012) and the *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (MoE 2012). MPMC's procedures are also consistent with applicable sections of the *British Columbia Environmental Laboratory Manual* (MoE 2020), such as sample collection and preservation requirements.

Quality assurance/quality control (QA/QC) methods will follow procedures outlined in the *MPMC Environmental Department QA/QC Manual* (most recent version: MPMC 2021, herein referred to as the "QA/QC Manual", developed for the Mount Polley Mine. This manual provides detailed Standard Operating Procedures (SOPs) and Work Methods (WMs) of the protocols for environmental monitoring at MPMC and is a requirement of the Permit (December 1, 2022: Section 3.8). Procedures described in the manual are consistent with the BC Field Sampling Manual (MoE 2013a). The QA/QC Manual is reviewed and updated as appropriate (at minimum annually) to reflect changes to the ENV procedures and recommendations, and industry best practices. Should the manual be updated, the ENV Environmental Protection Division will be notified within 30 days of implementation as required by the Permit.

The QA/QC Manual protocols include collection of samples by trained personnel using standardized procedures, and use of field notebooks and chain of custody forms for sample documentation and tracking. These protocols are summarized for the different CEMP monitoring components below, where appropriate.

6.3 LABORATORY ANALYSIS

Sample analysis will be conducted at a laboratory registered for the designated parameter under the *Environmental Data Quality Assurance Regulation*. MPMC will participate in QA audits as required by the regulation.

6.4 Data Quality Review and Data Management

A data quality review of results will be conducted, including screening of laboratory QA/QC data, sample integrity issues, detection limits achieved, and metadata accuracy, as well as potential outliers/extreme values. This information will be catalogued in the MPMC sample tracking spreadsheets and the laboratory is contacted if any problem is identified. Water, soil, sediment, and tissue chemistry data as well as weather station data will be uploaded into the MP-5 database using files generated by the analytical laboratory. Accompanying field data will be manually entered and uploaded into the MP-5 database. Original laboratory-produced results files are filed on the MPMC network by date, and are linked to the data stored in the MP-5 database. Field data undergo a QC screening prior to upload and parameter restrictions are in place to reduce the likelihood of a typographical or laboratory reporting error being uploaded.

Non-chemistry data, including toxicity testing results, benthic invertebrate and plankton taxonomy data, and hydrology data (logger downloads and FlowTracker exports) are filed according to year and site on the MPMC network.

6.5 Climate Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.5.1 Section Authors and Study Component Design Professionals

This section was written by MPMC and is guided by Section 3.6 of the Permit (December 1, 2022).

6.5.2 Monitoring Objectives

The objective of the climate monitoring program is to track site weather data to support maintenance of the site water balance, water flow and accumulation predictions, and the design of water management infrastructure. Climate data are also considered important basic site characterization information that inform a number of other activities, such as reclamation revegetation prescriptions or building snow load requirements. Climate monitoring is also required under the Permit Section 3.6 (December 1, 2022).

6.5.3 Monitoring Overview

MPMC maintains two automated Onset HOBO weather stations. Both stations are connected via telemetry allowing semi-real time viewing of weather conditions. Four snow course sites are located around the mine site to target different exposure conditions. Table 6.1 provides an overview of the climate monitoring. Further details of monitoring sites, including site access descriptions, access or safety concerns, and a brief rationale for monitoring, is provided in the Site Matrix in Appendix D. Figure 6.1 shows monitoring locations of the meteorological monitoring locations.

Table 6.1 Climate monitoring overview

Station Name	EMS Code	Description	Frequency	Parameters Measured	Guidelines
Weather Station #1	N/A	Continuous monitoring weather station beside tree plots near Mill Site	Logged every 5 minutes	Temperature, wind speed and direction, solar radiation, relative humidity, rainfall	N/A
Weather Station #2	N/A	Continuous monitoring weather station adjacent to the TSF	Logged every 5 minutes	Temperature, wind speed and direction, solar radiation, relative humidity, rainfall	N/A
JCP	N/A	Snow course site located east of the start of the Long Ditch in a clearing	Minimum of once per month when snow is present	Snow depth, snow volume	N/A
Weather Station #1	N/A	Snow course site located near Weather Station #1	Minimum of once per month when snow is present	Snow depth, snow volume	N/A
PAG Stockpile	N/A	Snow course site located beside the NW sump	Minimum of once per month when snow is present	Snow depth, snow volume	N/A
TSF	N/A	Snow course site located near Weather Station #2, near the TSF	Minimum of once per month when snow is present	Snow depth, snow volume	N/A

Notes: N/A: not applicable, TSF: tailings storage facility, JCP: Joe's Creek Pipe, PAG: potentially acid generating; NW: Northwest

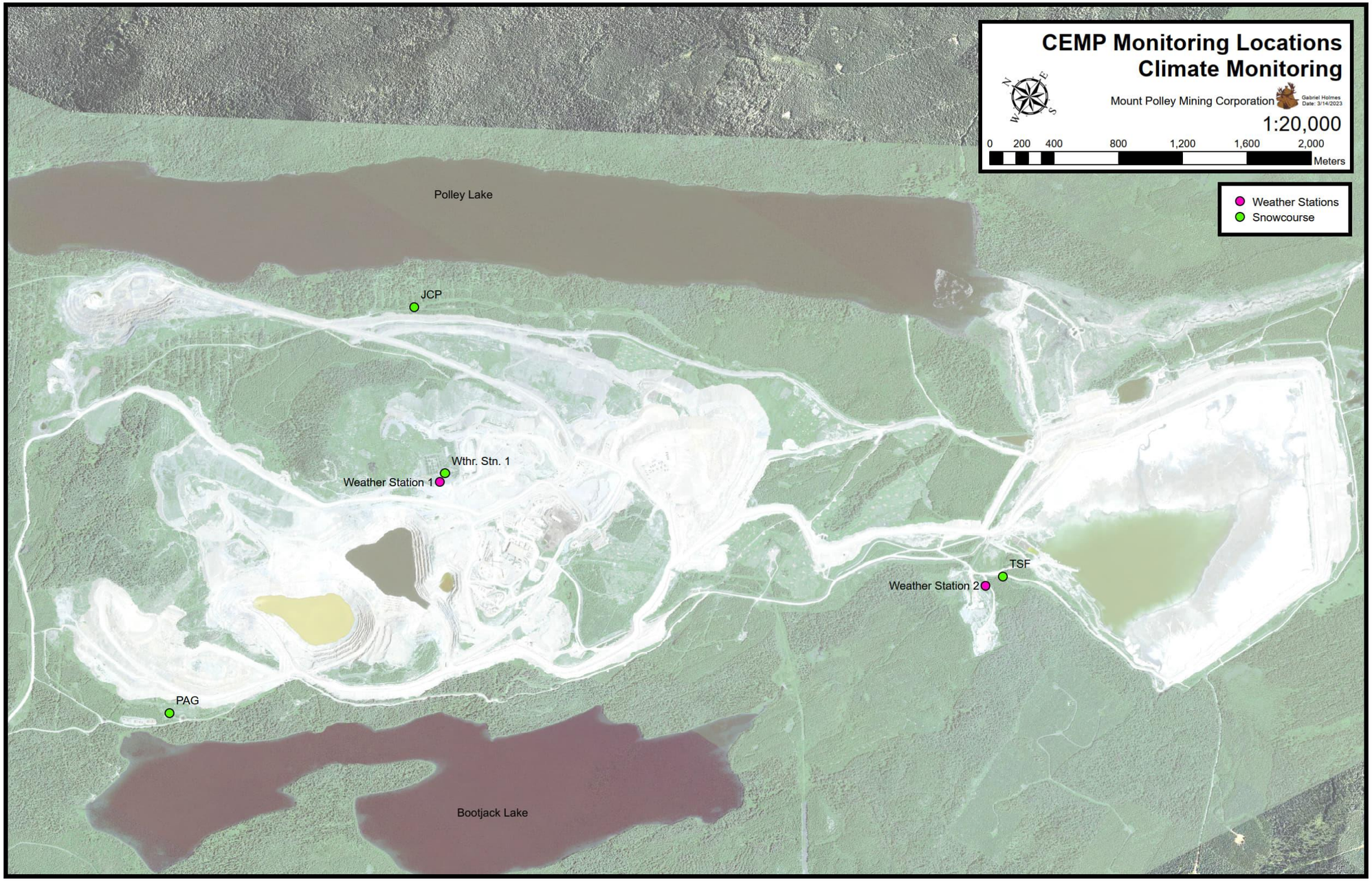


Figure 6.1 CEMP monitoring locations: Climate monitoring

6.5.4 High-Level Monitoring Design Description

Meteorological monitoring will occur as per the SOPs and WMs for Meteorological Data Collection and Snowpack Measurements in the QA/QC Manual. There are two automated Onset HOBO weather stations located on the mine site that continuously record wind speed and direction, precipitation, solar radiation, relative humidity, and temperature. Evaporation is calculated based on data collected from these stations. The data are downloaded from the automated weather stations monthly or as required by remote radio telemetry. If necessary, data are also stored on the weather logger and can be downloaded manually using a data shuttle.

Table 6.2 is a summary of previous climate monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.2 Summary of climate monitoring

Summary of Monitoring and Findings	**Monitoring Objective**		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	Two weather stations collect temperature, wind speed and direction, solar radiation, and precipitation data. Snowpack data was collected at four representative snow course sites. The weather and snow course stations are situated to encompass the topographical and geographic range of the mine site.	N/A	N/A
Summary of findings	Weather data collected were compared to site averages. Evaporation was calculated using measured parameters.	N/A	N/A
Recommendations for 2023-2025 monitoring	The program continued unchanged because the two current weather stations and snow course sites provide adequate information for the conditions on site.	N/A	N/A

Notes: N/A – not applicable

6.5.5 Data Quality Control, Objectives, and Review

Data ranges are set in the MP-5 database to detect erroneous data collected during station malfunctions. Weather station data that are erroneous (e.g., sensor malfunctions) will be investigated.

6.5.6 Laboratory Analysis

No laboratory analysis is required for climate monitoring.

6.5.7 Data Analysis and Reporting

Climate statistics, including mean, minimum, and maximum temperature, will be calculated and reviewed monthly. Daily evaporation is calculated using the Penman-Monteith equation for open water in the WaSIM software (developed by Cranfield University), based on data collected from the weather stations and site-specific factors, such as weather station elevation. These data are reported annually in the AER and ARR.

6.6 Surface Water Monitoring

Surface water monitoring is characterised below into the following locations: Hazeltine Creek, streams and creeks adjacent to the mine site (receiving environment of the mine site), Bootjack Lake, Polley Lake, Edney Creek, Quesnel Lake, and Quesnel River.

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.6.1 Section Authors and Study Design Professionals

The mine site environmental monitoring was developed during the Environmental Assessment process in 1995, which included input from several QPs. For the purpose of the CEMP, MPMC will continue to monitor with the understanding that this program is well-established to monitor any mine-related effects. The mine site monitoring described below was written by MPMC.

6.6.2 Monitoring Objectives

The objective of water chemistry monitoring in Hazeltine Creek is to evaluate the Hazeltine Creek aquatic environment following the TSF embankment breach and track changes to the aquatic environment over time and/or as a result of implementation of rehabilitation and sediment and erosion control work.

The objective of water chemistry monitoring in streams and creeks adjacent to the mine site, as well as Bootjack Lake and Polley Lake, is to identify water quality changes in waterbodies that run through or are adjacent to the mine site to assess efficacy of the mine water management systems and to stimulate applicable management actions.

The objective of water chemistry monitoring in Polley Lake, Quesnel Lake, and Quesnel River is to support ongoing evaluation of water chemistry following the TSF embankment breach in the downstream environments.

The objective of water chemistry monitoring in Quesnel Lake at the boundary of the initial dilution zone (IDZ) is to verify that the discharge of treated effluent is not causing an exceedance of the applicable ambient BC Water Quality Guidelines at the edge of the IDZ, as required by the Permit, and to verify the discharge model, as described in the ADP.

Monitoring of the far-field receiving environment in Quesnel Lake in the West Basin will be carried out downstream and upstream (for reference) of the mouth of Hazeltine Creek for the verification of the discharge model as described in the ADP.

6.6.3 MONITORING OVERVIEW

Table 6.3 summarizes the parameters analysed for surface water quality. The lake field parameters are measured at each sampling depth and for each limnological profile (excluding Secchi depth, which is taken from the surface of each lake sampling point). Table 6.4 provides an overview of the surface water monitoring. The location "Mine Site" refers to the streams and creeks adjacent to the mine site. Further details of monitoring sites, including site access descriptions, access or safety concerns, and a brief rationale for monitoring, is provided in the Site Matrix in Appendix D. Figure 6.2 shows monitoring locations of the surface water sampling locations.

Table 6.3 Surface water chemistry parameters

Parameter	LOR	Unit
Field Parameters - Lake		
pH	-	pH
Specific conductance	-	µS/cm
Temperature	-	°C
Turbidity	-	NTU
Dissolved oxygen	-	%, mg/L
Secchi depth	-	m
Field Parameters - General		
pH	-	pH
Conductivity	-	µS/cm
Temperature	-	°C
Turbidity	-	NTU
Physical Tests		
Conductivity	2	µS/cm
Hardness (as $CaCO_3$)	0.5	mg/L
pH	0.1	pH
Total Suspended Solids	1	mg/L
Total Dissolved Solids	10	mg/L
Turbidity	0.1	NTU
Anions and Nutrients		
Alkalinity, Total (as $CaCO_3$)	1	mg/L
Ammonia, Total (as N)	0.005	mg/L
Chloride (Cl)	0.5	mg/L
Fluoride (F)	0.02	mg/L
Nitrate and Nitrite (as N)	0.003	mg/L
Nitrate (as N)	0.001	mg/L
Nitrite (as N)	0.005	mg/L
Total Nitrogen	0.03	mg/L
Orthophosphate-Dissolved (as P)	0.001	mg/L
Phosphorus (P)-Total Dissolved	0.002	mg/L
Phosphorus (P)-Total	0.002	mg/L
Sulfate (SO_4)	0.3	mg/L
Organic / Inorganic Carbon		
Dissolved Organic Carbon	0.5	mg/L

Parameter	LOR	Unit
Total and Dissolved Metals		
Aluminum (Al)	0.003	mg/L
Antimony (Sb)	0.0001	mg/L
Arsenic (As)	0.0001	mg/L
Barium (Ba)	0.0001	mg/L
Beryllium (Be)	0.0001	mg/L
Bismuth (Bi)	0.00005	mg/L
Boron (B)	0.01	mg/L
Cadmium (Cd)	0.000005	mg/L
Calcium (Ca)	0.05	mg/L
Chromium (Cr)	0.0005	mg/L
Cobalt (Co)	0.0001	mg/L
Copper (Cu)	0.0005	mg/L
Iron (Fe)	0.03	mg/L
Lead (Pb)	0.00005	mg/L
Lithium (Li)	0.001	mg/L
Magnesium (Mg)	0.1	mg/L
Manganese (Mn)	0.0001	mg/L
Molybdenum (Mo)	0.00005	mg/L
Nickel (Ni)	0.0005	mg/L
Potassium (K)	0.05	mg/L
Selenium (Se)	0.00005	mg/L
Silicon (Si)	0.1	mg/L
Silver (Ag)	0.00001	mg/L
Sodium (Na)	0.05	mg/L
Strontium (Sr)	0.0002	mg/L
Thallium (Tl)	0.00001	mg/L
Tin (Sn)	0.0001	mg/L
Titanium (Ti)	0.01	mg/L
Uranium (U)	0.00001	mg/L
Vanadium (V)	0.0005	mg/L
Zinc (Zn)	0.003	mg/L
EEM Parameters		
Mercury (Hg)-Total	0.000005	mg/L

Notes: LOR: Limit of Reporting; EEM: Environmental Effects Monitoring

Table 6.4 Surface water monitoring overview

Location	Station Name	EMS Code	Description	Frequency	Depths	Parameters Measured	Guidelines
Mine Site	W1	E225084	Morehead Creek	Quarterly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W1b	E291449	Morehead Creek	Quarterly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W4a	E298551	North Dump Creek below Wight Pit Road	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W5	E208039	Bootjack Creek Above Hazeltine Creek	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W8	E216743	NE Edney Creek Tributary	Quarterly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W8Z	E223292	SW Edney Creek Tributary	Quarterly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W10	E291209	Lower Edney Creek (upstream of breach impact)	Semi-annually[1]	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W12	E216744	6 km Creek at Road	Quarterly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Mine Site	W20	E297070	W20 Creek Tributary to Bootjack Lake	Semi-annually	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Edney Creek	EDC-01a		Lower Edney Creek (remediated reach)	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Hazeltine Creek	HAC-10	E303010	Upper Hazeltine Creek at Polley Lake outlet	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Hazeltine Creek	HAC-13	E304810	End of Reach 1 in Hazeltine Creek	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Hazeltine Creek	HAC-14	pending	Middle Hazeltine Creek upstream of the canyon	Monthly[2]	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Hazeltine Creek	HAC-05a	E304510	Upper Hazeltine Creek at Gavin Lake FSR Bridge	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL

Location	Station Name	EMS Code	Description	Frequency	Depths	Parameters Measured	Guidelines
Hazeltine Creek	HAC-08	E303013	Lower Hazeltine Creek at Ditch Road Bridge	Monthly	Surface	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Bootjack Lake	B1	E207975	Bootjack Lake deepest area at north end	Semi-annually[3]	Surface (0 m), 1 m above thermocline (AT) and 1 m below thermocline (BT) OR mid-depth if no thermocline (MID), bottom (B)	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
				Monthly[4]	Limnological profile	Field parameters - lake	BC WQG - AL
Bootjack Lake	B2	E215897	Bootjack Lake deepest area at south end	Semi-annually[3]	Surface (0 m), 1 m above thermocline (AT) and 1 m below thermocline (BT) OR mid-depth if no thermocline (MID), bottom (B)	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
				Monthly[4]	Limnological profile	Field parameters - lake	BC WQG - AL
				Three times annually [10]	Limnological profile, surface	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Bootjack Lake	B4	E216744	Bootjack Lake (potential zone of influence from seepage from Springer Pit)	For closure only[5]	For closure only[5]	For closure only[5]	-
Polley Lake	P1	E207974	Polley Lake deepest area at north end	Spring overturn, twice in summer, fall overturn, once under ice[6]	Surface (0 m), 1 m above thermocline (AT) and 1 m below thermocline (BT) OR mid-depth if no thermocline (MID), bottom (B)	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
				Monthly[4]	Limnological profile	Field parameters - lake	BC WQG - AL
Polley Lake	P2	E207975	Polley Lake deepest area at south end	Spring overturn, twice in summer, fall overturn, once under ice[6]	Surface (0 m), 1 m above thermocline (AT) and 1 m below thermocline (BT) OR mid-depth if no thermocline (MID), bottom (B)	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
				Monthly[4]	Limnological profile	Field parameters - lake	BC WQG - AL
				Three times annually [10]	Limnological profile, surface	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Quesnel Lake	QUL-58	E304876	Quesnel Lake discharge IDZ	Four times annually[7, 11, 12]	Limnological profile, If plume detected: middle of plume (MP), 5 m above (AP), 5 m below plume (BP) If plume not detected: surface (S), 1 m above thermocline (AT) and 1 m below thermocline (BT) OR mid-depth if no thermocline (MID), bottom (B)	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals, EEM parameter (total mercury)[8]	BC WQG - AL
Quesnel Lake	QUL-57	E304874	Quesnel Lake IDZ	Four times annually[7, 11, 12]	Limnological profile, same sample depths as for QUL-58, if possible[13]	Field parameters - lake	BC WQG - AL
Quesnel Lake	QUL-59	E304875	Quesnel Lake IDZ	Four times annually[7, 11, 12]	Limnological profile, same sample depths as for QUL-58, if possible[13]	Field parameters - lake	BC WQG - AL
Quesnel Lake	QUL-18	E303019	Quesnel Lake far-field, downstream of Hazeltine Creek	Four times annually[7, 11]	Limnological profile, 0 m, 20 m, 50 m, 100 m[9]	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Quesnel Lake	QUL-120a	E303022	Quesnel Lake station east of Cariboo Island (reference)	Four times annually[7, 11]	Limnological profile, If Lake is stratified:0 m, 40 m, 80 m, 120 m, 140 m; If lake is well-mixed: 0 m, 80 m, 190m	Field parameters - lake, physical tests, anions and nutrients, DOC,	BC WQG - AL

Location	Station Name	EMS Code	Description	Frequency	Depths	Parameters Measured	Guidelines
						total and dissolved metals, EEM parameter (total mercury)[8]	
Quesnel Lake	QUL-ZOO-1	E306455	Quesnel Lake in centre of West Basin (zooplankton station)	Three times annually [10, 11]	Limnological profile, surface	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL
Quesnel Lake	QUL-ZOO-7	E306456	Quesnel Lake near Cariboo Island (reference zooplankton station)	Three times annually [10, 11]	Limnological profile, surface	Field parameters - lake, physical tests, anions and nutrients, DOC, total and dissolved metals	BC WQG - AL

Notes: [1] In June and October due to access; [2] May to November only due to restricted access in winter; [3] At spring overturn and late summer; [4] Between spring and fall overturn; [5] Monitoring will depend on closure conditions; [6] if ice and weather conditions meet safety requirements; [7] Taken at evenly spaced time series plus or minus one month; [8] Total mercury will be collected at MID or BT for QUL-58 and at 40 m for QUL-2a as part of EEM four times per year (no less than 1 month apart). Parameter only reported to MDMER; [9] QUL-18 is approximately 110 m deep. 100 m sample depth is collected for historical consistency; [10] Taken in conjunction with plankton sampling (see Section 6.14); [11] When sampling is less frequent than monthly, sampling at Quesnel Lake operational surface water monitoring stations (as identified in Table 6.6) will be undertaken when effluent discharge to Quesnel Lake is discharging. In the event of an unexpected shutdown of the water treatment plant, reasonable efforts will be made to re-sample within the timeframe of the quarterly or other specified time period sampling upon restart of effluent discharge to Quesnel Lake; [12] Samples will be taken at HAD-3 on the same day as samples collected from QUL-57, -58, and -59; [13] Sample depths at QUL-57 and QUL-59 will be consistent with those at QUL-58, when possible

DOC: dissolved organic carbon; BC WQG: British Columbia Water Quality Guidelines; AL: aquatic life; FSR: Forest Service Road; EEM: Environmental Effects Monitoring; IDZ: initial dilution zone

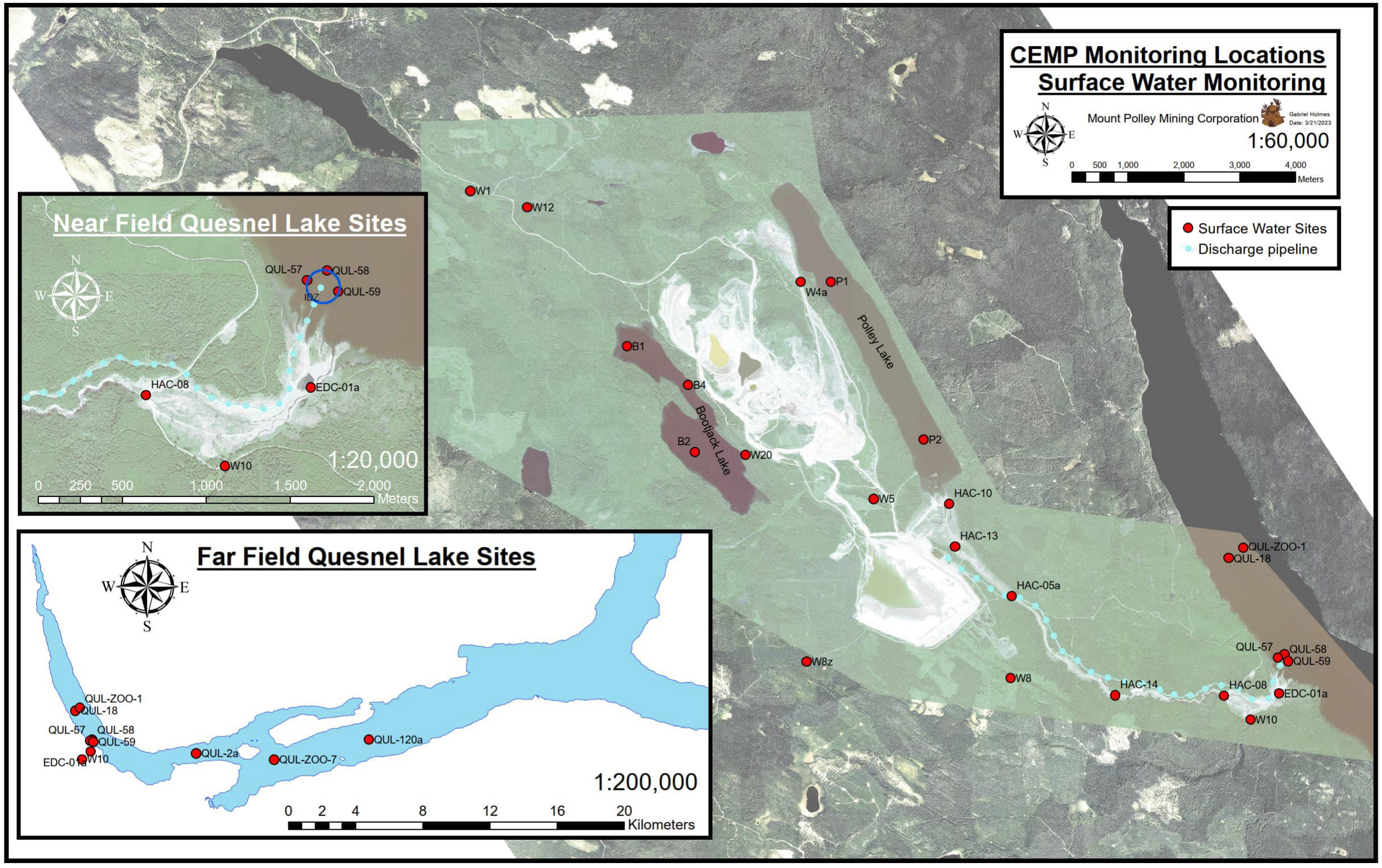


Figure 6.2 CEMP monitoring locations: Surface water monitoring

6.6.4 HIGH-LEVEL MONITORING DESIGN DESCRIPTION

Field parameter collection, sample collection, preparation, and shipping will be conducted following the SOPs and WMs for the associated field meters, Surface Water Quality Monitoring and Lake Water Monitoring, as appropriate as described in the QA/QC Manual. These procedures include use of lab-verified clean or appropriately rinsed sampling bottles and steps to reduce risk of sampling contamination. *In-situ* parameters will be measured when samples for chemistry are collected. Water samples will be analyzed as described in Section 6.6.3. Limnological profiles of field parameters will be conducted where described in Table 6.4.

For the edge of the IDZ sampling, limnological profiles of field parameters (specific conductance, temperature, and turbidity) will be carried out in an attempt to identify the location of the plume from the outfall (i.e., direction of flow). MPMC is committed to spending a reasonable level of effort and time to detect the plume and direction of flow. The reasonable level of effort and time will vary depending on the health and safety risks associated with the weather conditions and season. Vertical profiles of field measurements and water chemistry samples will be taken at the inferred centerline of the plume at the edge of the IDZ (station QUL-58).

A plume dispersion model was developed by Golder for the nearfield (i.e., in the vicinity of the IDZ), and a hydrodynamic model of Quesnel Lake has been developed and calibrated by Tetra Tech EBA to predict effluent transfer throughout the West Basin of Quesnel Lake and potential for buildup (Golder 2015b). Further dilution modelling work was conducted in 2021 by DWB Consulting Services Ltd. and is informing this plan. Monitoring at the near-field station, along with monitoring of other Quesnel Lake receiving environment stations, will be used to verify the near-field and lake-wide hydrodynamic models. It should be noted that the nearfield and the hydrodynamic models, as described in the Long Term Water Management Plan, serve as the basis for the Trigger Response Plan incorporated into the 2022ADP.

Table 6.5 is a summary of previous surface water monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.5 Summary of surface water monitoring

Summary of Monitoring and Findings	Monitoring Objective		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	Monitoring included streams adjacent to the mine site to determine if there are any changes in water quality. Bootjack and Polley lakes were monitored as receiving environment of the mine. Bootjack Lake was monitored to evaluate potential for exfiltration from Springer Pit. The monitoring sites in Bootjack Lake were moved to two deeper monitoring locations in 2017, as described in the 2016 AERR. For the discharge receiving environment, Quesnel Lake and Quesnel River were monitored.	Post-breach monitoring overlapped with operational monitoring in Polley Lake, Quesnel Lake, and Quesnel River. Monitoring occurred at sites selected to capture major inputs and mixing of Hazeltine Creek. Supplemental sampling of 3 stations flowing into Hazeltine Creek in the Polley Flats area was undertaken to support a geochemical conceptual model in 2016 (SRK and Minnow 2016).	N/A
Summary of findings	The results for the creeks and lakes from 2016-2017 identified no significant trends. No indication of exfiltration from the Springer Pit was found in Bootjack Lake.	Results from Quesnel River show no indications of further effects post-breach since 2016. The 2016 and 2017 results showed that the lower sedimentation pond was effective at decreasing the TSS concentration of Hazeltine Creek. The modelling concluded that 93 to 99% of copper was organically complexed and generally not bioavailable.	N/A
Recommendations for 2023-2025 monitoring	A summary of all changes from the 2016 CEMP is provided in Section 6.6.4.1.	A summary of changes from the 2016 CEMP is provided in Sections 6.6.4.1 and 6.6.4.2.	N/A

Notes: AERR: Annual Environmental and Reclamation Report; N/A: not applicable; TSS: total suspended solids

6.6.4.1 OPERATIONAL MONITORING

Table 6.6 summarizes all changes in operational surface water monitoring from the 2016 CEMP.

Table 6.6 Operational monitoring changes since the 2016 CEMP

Sample Site(s)	Change from 2016 CEMP	Purpose/Justification
W1	Reduced frequency from monthly to quarterly	W1 monitors water quality in Morehead Creek, the outflow of Bootjack Lake. As of time of writing, Springer Pit water level is below 990 masl and no indication of exfiltration from the Springer Pit was found in Bootjack Lake. The monitoring frequency will be reviewed by a QP if Bootjack Lake shows any mine-related changes in the future.
W10	Reduced frequency from monthly to semi-annually (in June and October)	The monitoring of this site overlaps with Post-Breach Monitoring as it acts as a reference location for the remediated section of Edney Creek. The reduced frequency aligns with frequency of EDC-01 (see Section 6.6.4.2).
W20	Reduced frequency from quarterly to semi-annually	This creek is not directly influenced by mine activities as mine-affected water is diverted away from this creek catchment. Less intense monitoring is required. The frequency will be reviewed by a QP if Bootjack Lake water quality shows any mine-related changes.
QUL-58	Reduced frequency from monthly to 4 times per year (taken at evenly spaced time series plus or minus one month)	Monitoring as per the ADP, QUL-58 monitoring is for model verification.
QUL-57	Reduced frequency from monthly to 4 times per year (taken at evenly spaced time series plus or minus one month)	As per the ADP, QUL-57 monitoring is for model verification.
QUL-59	Reduced frequency from monthly to 4 times per year (taken at evenly spaced time series plus or minus one month)	As per the ADP, QUL-59 monitoring is for model verification.
QUL-18	Reduced frequency from monthly to 4 times per year (taken at evenly spaced time series plus or minus one month)	As per the ADP, QUL-18 monitoring is for model verification.
QUL-2a	Reduced frequency from monthly to 4 times per year (taken at evenly spaced time series plus or minus one month) Considered Quesnel Lake reference site	As per the ADP, QUL-2a monitoring is for model verification.

Sample Site(s)	Change from 2016 CEMP	Purpose/Justification
QUL-120a	Increased frequency from semi-annually to 4 times per year (taken at evenly spaced time series plus or minus one month) Considered Quesnel Lake reference site	As per the ADP, QUL-120a monitoring is for model verification and is considered the Quesnel Lake reference site.
QUR-1	Continuous monitoring removed	Continuous monitoring was conducted at this site from August 12, 2014 to May 30, 2016. In consultation with ENV, given the lack of variation in the results, continuous monitoring was deemed to be no longer necessary.
QUR-11	Removed	This site is regularly monitored by the provincial and federal government agencies with financial support from MPMC. An annual side-by-side sample will be collected by MPMC at the request of the regulator.
P1, P2	Reduced sampling from monthly to spring overturn, twice in summer, fall overturn, and once in winter under ice Change in sampling depths	The monitoring of these sites overlaps with Post-Breach Monitoring. The reduction in monitoring frequency (both sampling and limnological profiles) is because the water quality in Polley Lake appears to be stable. If changes are observed in water quality reflecting breach- or mine-related impacts, frequency of monitoring will be reviewed by a QP. These sample depths align with pre-breach monitoring as agreed upon with ENV staff biologist.
B1, B2	Reduced monitoring of limnological profile from semi-monthly to monthly Change in sampling depths	The reduction in monitoring frequency is because the water quality in Bootjack Lake appears to be stable. If changes are observed in water quality reflecting mine-related impacts, frequency of monitoring will be reviewed by a QP. These sample depths align with pre-breach monitoring as agreed upon with ENV staff biologist.

Notes: CEMP: Comprehensive Environmental Monitoring Plan; masl: meters above sea level; QP: Qualified Professional; ADP: Annual Discharge Plan

6.6.4.2 POST-BREACH MONITORING

Table 6.7 summarizes all changes in operational surface water monitoring from the 2016 CEMP.

Table 6.7 Post-breach monitoring changes since the 2016 CEMP

Sample Site(s)	Change from 2016 CEMP	Purpose/Justification
HAC-13	Reduced from weekly to monthly	This site used to be upstream of the Hazeltine Creek Discharge and was monitored under the EEM. Currently, this site monitors water quality in Hazeltine Creek after Reach 1. Monitoring frequency has been reduced to align with other Hazeltine Creek samples.
HAC-14	Added	This site was added to monitor effects of remediation activities on Hazeltine Creek water quality. The frequency aligns with other Hazeltine Creek samples.
HAC-12	Removed	In consultation with ENV (C. Danyluk, personal communication, February 8, 2018), this site has been removed as it is no longer necessary with the connection of the pipeline from the WTP to the diffusers.
HAC-01c	Added, removed following the 2020 construction season	This site represented Hazeltine Creek water quality before entering Quesnel Lake. The frequency aligned with other Hazeltine Creek samples. Remedial construction in 2020 resulted in the realignment of Hazeltine Creek and the elimination of HAC-01c. Site EDC-01a will be sampled monthly to capture creek water quality prior to entering Quesnel Lake.
EDC-01	Reduced from monthly to semi-annually, removed following the 2020 construction season	No significant trends had been identified at EDC-01. Because of reduced site access in winter and stable water quality, sampling frequency was reduced to semi-annually. Remedial construction in 2020 resulted in the realignment of Edney Creek and elimination of EDC-01. EDC-01a will be sampled monthly to capture creek water quality prior to entering Quesnel Lake.
EDC-01a	Added following the 2020 construction season	Remedial construction in 2020 resulted in the realignment of Edney Creek and elimination of EDC-01. EDC-01a is located within 150 m of EDC-01 and captures creek water quality prior to entering Quesnel Lake.

Notes: CEMP: Comprehensive Environmental Monitoring Plan; EEM: Environmental Effects Monitoring; ENV: BC Ministry of Environment and Climate Change Strategy; WTP: Water Treatment Plant

6.6.5 Data Quality Control, Objectives, and Review

For water chemistry, QC samples will be collected as a component of the monitoring program as per the MPMC QA/QC Manual. A combined QC schedule for all surface water monitoring (i.e., operational, post-breach, reclamation) is summarized in Table 6.8.

Table 6.8 Water chemistry QC sample frequencies for surface water monitoring

QC Samples	Frequency
Duplicate samples	10% of surface water samples
Equipment blanks	Monthly per piece of equipment (when used)
Trip blanks	Twice per month
Field blanks	Twice per month
Filter blanks	Quarterly
Deionized water blanks	Annually
Laboratory replicate[1]	Annually

Note: [1] Split sample

For results greater than five times the method detection limit (MDL), a relative percent difference (RPD) will be used to identify differences between original and duplicate samples. These data quality objectives (DQOs) are the same as the RPDs used by the lab. If one or both results are less than five times the MDL, a difference between original and duplicate samples greater than two times the MDL is used to identify differences. Blanks in which any parameters exceed the reported MDL will be flagged.

6.6.6 Laboratory Analysis

Samples will be submitted to and processed by a Canadian Association of Laboratory Accreditation (CALA) accredited analytical laboratory, typically ALS Environmental Inc. in Burnaby, BC, where standard testing procedures will be used as specified in the most recent editions of the *BC Environmental Laboratory Manual* (MoE 2020).

Laboratory precision will be assessed on the basis of laboratory duplicate results and laboratory accuracy will be assessed using certified reference materials (CRMs) and matrix spikes. Potential laboratory contamination will be assessed using a DQO of ≤ 2 times the laboratory MDL in laboratory method blank results.

6.6.7 Data Analysis and Reporting

In Hazeltine Creek, data analysis and interpretation for reporting purposes will include calculation of summary statistics (e.g., mean, minimum, maximum, and 95th percentile values over the period of interest) and evaluation of any spatial (e.g., down the creek) and temporal changes or trends. Results will also be compared to the BC aquatic life WQGs.

In the other surface water monitoring sites, statistical analysis will be carried out to compare data to reference sites and to assess trends over time. Results will also be compared to the BC aquatic life WQGs.

6.7 HYDROLOGY MONITORING

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.7.1 SECTION AUTHORS AND STUDY DESIGN PROFESSIONALS

This section was written by MPMC, and is guided by Section 3.4 of the Permit (December 1, 2022).

6.7.2 MONITORING OBJECTIVES

The objective of hydrological monitoring in Hazeltine Creek is to characterize the hydrology of the Hazeltine Creek system, assess fish habitat (only in reaches accessible to fish), interpret water quality and water balance, and evaluate changes over time as rehabilitation works are carried out and system recovery occurs (e.g., establishment of riparian vegetation).

The objective of hydrological monitoring in Edney Creek is to characterize the hydrology of Edney Creek in the remediated section, assess fish habitat, interpret water quality, and evaluate changes over time as rehabilitation works are carried out and system recovery occurs (e.g., establishment of riparian vegetation).

The objective of the hydrological monitoring of the streams and creeks that run through or adjacent to the mine site is to characterize the hydrology of the drainages, interpret water quality, and evaluate any changes over time.

6.7.3 MONITORING OVERVIEW

MPMC maintains eight hydrology stations as required by the Permit. Table 6.9 provides an overview of the hydrology monitoring. No large changes have been made from the 2016 CEMP, but wording has been changed to more align with the wording in Section 3.4 in the Permit. Station H3 was relocated as a result of 2020 remedial construction and the realignment of Hazeltine and Edney Creeks, and is now referred to as H3a. Further details of monitoring sites, including site access descriptions, access or safety concerns, and a brief rationale for monitoring, is provided in the Site Matrix in Appendix D. Figure 6.3 shows monitoring locations of the hydrology monitoring locations.

Staff gauges will be benchmarked (calibrated) once per year between June 15 and August 31, as defined by the Permit. Staff gauge readings will be recorded during water chemistry sampling events at the associated stations and each manual flow measurement. Continuous stage monitoring equipment (pressure transducers) will be installed at hydrometric locations specified in Table 6.9 during non-freezing conditions.

Manual flow gauging will be conducted at all sites during high, moderate, and low flows in non-freezing conditions and when the sites are accessible. These measurements will be conducted at minimum three times per year for validation of the stage-discharge rating curves. A new stage-discharge curve will be established for H3a. If stage-discharge stability is not demonstrated, the frequency of monitoring will be

increased to five times per year during the non-freezing period (across the spectrum of high to low flows) and when accessible to meet Resources Information Standards Committee Grade A standards for hydrometric monitoring (MoE 2009). Due to site characteristics and difficult operating conditions, often the sites meet Grade B/C standards. MPMC will continue to work with a QP to move toward meeting Grade A standards for all hydrological stations. A stage discharge curve that encompasses the non-freezing period flows will be maintained for all hydrological stations with staff gauges.

Table 6.9 Hydrology monitoring overview

Station Name	EMS Code	Description	Frequency	Parameters Measured	Guidelines
H4	-	Upper Hazeltine Creek at Polley Lake outlet	Continuous[1]	Water head pressure, temperature	N/A
			Weekly (daily during high runoff periods)	Stage (staff gauge)	Permit 11678
			Monthly[1]	Manual flow gauging	
H1	-	Upper Hazeltine Creek hydrometric station (at Gavin Lake FSR Bridge)	Continuous[1]	Water head pressure, temperature	Permit 11678
			Monthly[1]	Stage (staff gauge)	
			Monthly[1]	Manual flow gauging	
H2	-	Lower Hazeltine Creek hydrometric station (downstream of the Ditch Road Bridge)	Continuous[1]	Water head pressure, temperature	Permit 11678
			Monthly[1]	Stage (staff gauge)	
			Monthly[1]	Manual flow gauging	
W1b	E291449	Morehead Creek	When flows are measured[1]	Stage (staff gauge)	Permit 11678
			High, moderate and low flows[1]	Manual flow gauging (3 time/year; 5 times if rating curve stability not demonstrated)	
W4a	E298551	North Dump Creek below Wight Pit Road	Monthly[1]	Manual flow gauging	Permit 11678
W5	E208039	Bootjack Creek Above Hazeltine Creek	When flows are measured[1]	Stage (staff gauge)	Permit 11678
			High, moderate, and low flows[1]	Manual flow gauging (3 time/year; 5 times if rating curve stability not demonstrated); only when sufficient flow	

Station Name	EMS Code	Description	Frequency	Parameters Measured	Guidelines
W12	E216744	6 km Creek at Road	When flows are measured[1]	Stage (staff gauge)	Permit 11678
			High, moderate and low flows[1]	Manual flow gauging (3 time/year; 5 times if rating curve stability not demonstrated)	
H3a	-	Lower Edney Creek	Continuous[1]	Water head pressure, temperature	N/A
			When flows are measured[1]	Stage (staff gauge)	Permit 11678
			High, moderate and low flows[1]	Manual flow gauging (3 time/year; 5 times if rating curve stability not demonstrated)	

Notes: [1] In non-freezing conditions and when the sites are accessible; N/A: not applicable

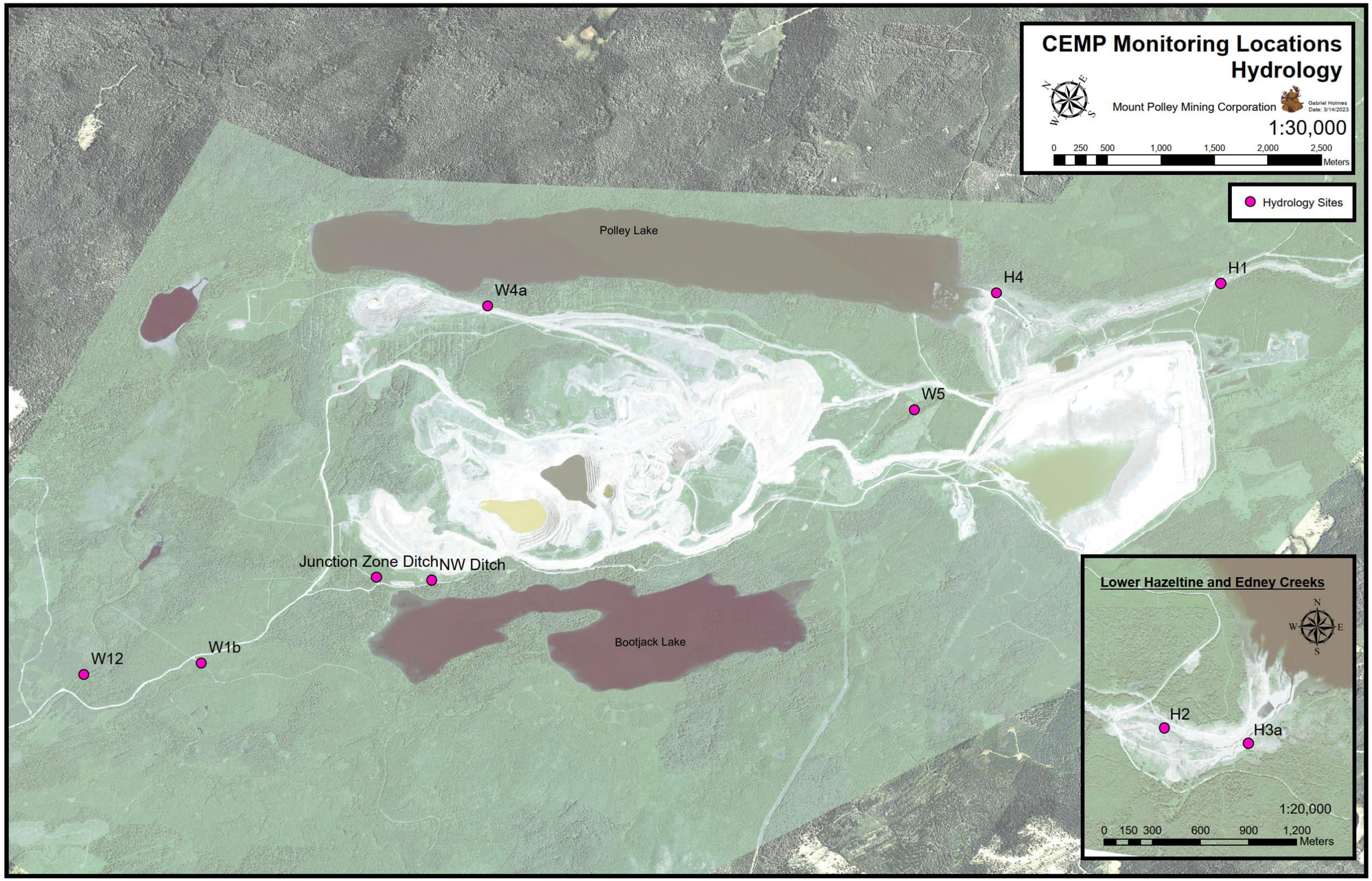


Figure 6.3 CEMP monitoring locations: Hydrology monitoring

6.7.4 HIGH-LEVEL MONITORING DESIGN DESCRIPTION

Hydrological monitoring will be conducted as per the SOPs and WMs for Hydrological Monitoring (which includes installing and downloading continuous loggers) and Benchmarking, as well as the specific WM for operating the FlowTracker acoustic Doppler velocity meter.

Note that some streams do not flow year-round; if there is no flow and a sample or measurement cannot be taken as scheduled, the attempt will be documented in the field notebook.

To verify the accuracy of established rating curves (i.e., confirm that the channel morphology at the station and outflow control point have not changed) and, where possible, extend the upper and lower bounds of the curves, manual flow gauging will be taken according to Table 6.9 in non-freezing conditions and when the sites are accessible. Manual flow monitoring requirements will be re-evaluated each year, following refinement of the stage-discharge rating curves.

Table 6.10 is a summary of previous hydrology monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.10 Summary of hydrology monitoring and findings

Summary of Monitoring and Findings	**Monitoring Objective**		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	W1b, W5, and W12 were established prior to 2014. W4a was established in 2014. More detail for each site is provided in Section 6.7.4.1.	H1 and H2 hydrology sites were established in 2015, when channeling of Hazeltine Creek was completed. H4 hydrology site was established in 2016 in the remediated section of upper Hazeltine Creek. H3 hydrology site in the remediated section of Edney Creek was established in 2015. More detail of each station is provided in Section 6.7.4.2.	N/A
Summary of findings	Manual measurements were used to confirm and refine rating curves.	Manual measurements confirmed the rating curves for H1, H2, and H3. Increased manual measurements for H4 will confirm the ratings curve.	N/A

Summary of Monitoring and Findings	Monitoring Objective		
	Operational	Post-Breach	Reclamation
Recommendations for 2023-2025 monitoring	Manual measurements will be collected to confirm the rating curves. One hydrology station is not configured for staff gauge and its establishment will be explored. A new stage-discharge curve will be established for the H3a hydrology site.	Continuous monitoring of levels will continue using the established rating curve. Manual measurements will be collected to confirm the rating curves.	N/A

Notes: N/A: not applicable

6.7.4.1 Operational Monitoring

Table 6.11 summarizes the operational hydrology sites. Flows around the MPMC site are freshet driven; therefore, many hydrology stations are low flow during the rest of the year and cannot be measured. No continuous monitoring devices are installed at these sites due to the very low flow nature of the creeks.

Table 6.11 Summary of operational hydrology sites

Site	Comment
W1b	Site W1b was established in 2012. Benchmarking of this station has occurred annually. In 2016, WaterSmith made significant changes to the site and a new stage-discharge curve was developed. MPMC will continue to conducted manual measurements to confirm the rating curve.
W4a	Site W4a was established downstream, and replaced site W4 in 2014. Manual bucket flow measurements and staff gauge readings are recorded from a constructed pipe weir at this site.
W5	Site W5 at Bootjack Creek was re-established in 2008. Benchmarking of this station has occurred annually. A new staff gauge was installed in 2016 by WaterSmith and a new stage-discharge curve was developed. MPMC will continue to conducted manual measurements to confirm the curve.
W12	Site W12 was established in 1990. Benchmarking of this station has occurred annually. A new stage-discharge curve was developed in 2016. MPMC will continue to conducted manual measurements to confirm the curve.

Notes: WaterSmith: WaterSmith Research Inc.; MPMC: Mount Polley Mining Corporation

6.7.4.2 Post-Breach Monitoring

Table 6.12 summarizes the post-breach hydrology sites.

Table 6.12 Summary of post-breach monitoring hydrology sites

Site	Comment
H1	Site H1 was established in upper Hazeltine Creek in 2015. Benchmarking of this station has occurred annually. A new stage-discharge curve was developed in 2016. A continuous monitoring device will be installed at this station to provide continuous water head pressure measurements during non-freezing periods and when the site is accessible. In addition, MPMC will continue to conducted manual measurements to confirm the rating curve.
H2	Site H2 was established in upper Hazeltine Creek in 2015. Benchmarking of this station has occurred annually. A new stage-discharge curve was developed in 2016. A continuous monitoring device will be installed at this station to provide continuous water head pressure measurements during non-freezing periods and when the site is accessible. In addition, MPMC will continue to conducted manual measurements to confirm the rating curve.
H3	Site H3 was established in the remediated area of lower Edney Creek in 2015. Benchmarking of this station has occurred annually. A new stage-discharge curve was developed in 2016. A continuous monitoring device will be installed at this station to provide continuous water head pressure measurements during non-freezing periods and when the site is accessible. Following the 2020 construction season and realignment of Hazeltine and Edney Creeks, hydrology site H3 was relocated and is now referred to as H3a.
H3a	Site H3a was established in lower Edney Creek in 2020 following the remedial construction season to replace site H3. A new stage-discharge curve will be developed and benchmarking will occur annually. A continuous monitoring device will be installed at this station to provide continuous water head pressure measurements during non-freezing periods and when the site is accessible. In addition, MPMC will conduct manual measurements to confirm the curve.
H4	Site H4 was established in upper Hazeltine Creek at the Polley Lake Weir in 2016. Benchmarking of this station has occurred annually. A new stage-discharge curve was developed in 2016. A continuous monitoring device will be installed at this station to provide continuous water head pressure measurements during non-freezing periods and when the site is accessible. In addition, MPMC will continue to conducted manual measurements to confirm the curve.

Notes: MPMC: Mount Polley Mining Corporation

6.7.5 Data Quality Control, Objectives, and Review

The FlowTracker has built in error messages associated with measurements that are outside of set QC bounds, and reports an International Standard Calculation error and statistical (US Geological Survey calculation) error output following each discharge measurement as a QC measure.

Benchmarking, as described above and as per the protocol in the QA/QC Manual, will occur annually between June 15 and August 31 as per the Permit, or as described by the Permit.

Routine monitoring includes inspections of equipment, including stilling wells and loggers (e.g., to identify sedimentation inside the stilling well or debris build up in logger ports). Identification of potential station changes or issues also occurs through data analysis when data are inconsistent or unusual in comparison with previously collected data.

6.7.6 Laboratory Analysis

No laboratory analysis is required for hydrology monitoring.

6.7.7 Data Analysis and Reporting

Data analysis will include building and validating the stage-discharge rating curves, as well as production of annual hydrographs. These will be presented in the AER and ARR.

6.8 Groundwater Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.8.1 Section Authors and Study Design Professionals

This section was written by MPMC.

6.8.2 Monitoring Objectives

The primary objective of the groundwater monitoring program on the mine site is to determine the direction, volume, and quality of groundwater flow from the mine site and other disturbed areas to receiving environment.

6.8.3 Monitoring Overview

Groundwater monitoring wells around the mine site are installed in the area around the TSF, the Springer Pit, downstream of waste rock dumps and haul roads, and in other areas on or surrounding the mine. The monitoring program was developed on the recommendation of the groundwater program review by Golder conducted in March 2016. This review was submitted to ENV on March 31, 2016. An annual review of the groundwater monitoring program was also conducted by Golder in March 2017 and was submitted as Appendix F in the 2017 AERR (MPMC 2018). Recommendations from the 2017-2022 reviews have been incorporated into the monitoring program outlined below. Sampling events at times of maximum and minimum hydrologic conditions to account for seasonal variability will be conducted when appropriate (i.e., spring and late summer/fall). Static water level (SWL) of all wells will be monitored on the same day at minimum once annually to allow for comparison across the site.

Groundwater monitoring wells were also installed along the Hazeltine Creek in 2015 and 2016. From Golder (2017), groundwater "was not screened for the terrestrial risk assessment because wildlife do not consume groundwater". Monitoring of surface water in Hazeltine Creek captures the potential effects of groundwater discharged to the Hazeltine Channel system (Golder 2017; see Section 6.6). No further monitoring is planned at these groundwater wells.

Table 6.13 summarizes the parameters analysed for groundwater quality. Table 6.14 provides an overview of the groundwater monitoring. Further details of monitoring sites, including site access descriptions, access or safety concerns, and a brief rationale for monitoring, is provided in the Site Matrix in Appendix D. Figure 6.4 shows monitoring locations of the groundwater sampling locations.

Table 6.13 Groundwater chemistry parameters

Parameter	LOR	Unit
Field Parameters		
pH	-	pH
Conductivity	-	µS/cm
Temperature	-	°C
Physical Tests		
Conductivity	2	µS/cm
Hardness (as $CaCO_3$)	0.5	mg/L
pH	0.1	pH
Turbidity	0.1	NTU
Anions and Nutrients		
Alkalinity, Total (as $CaCO_3$)	1	mg/L
Ammonia, Total (as N)	0.005	mg/L
Chloride (Cl)	0.5	mg/L
Fluoride (F)	0.02	mg/L
Nitrate and Nitrite (as N)	0.003	mg/L
Nitrate (as N)	0.001	mg/L
Nitrite (as N)	0.005	mg/L
Total Nitrogen	0.03	mg/L
Phosphorus (P)-Total Dissolved	0.002	mg/L
Phosphorus (P)-Total	0.002	mg/L
Sulfate (SO_4)	0.3	mg/L

Parameter	LOR	Unit
Dissolved Metals		
Aluminum (Al)	0.003	mg/L
Antimony (Sb)	0.0001	mg/L
Arsenic (As)	0.0001	mg/L
Barium (Ba)	0.0001	mg/L
Beryllium (Be)	0.0001	mg/L
Bismuth (Bi)	0.00005	mg/L
Boron (B)	0.01	mg/L
Cadmium (Cd)	0.000005	mg/L
Calcium (Ca)	0.05	mg/L
Chromium (Cr)	0.0005	mg/L
Cobalt (Co)	0.0001	mg/L
Copper (Cu)	0.0005	mg/L
Iron (Fe)	0.03	mg/L
Lead (Pb)	0.00005	mg/L
Lithium (Li)	0.001	mg/L
Magnesium (Mg)	0.1	mg/L
Manganese (Mn)	0.0001	mg/L
Molybdenum (Mo)	0.00005	mg/L
Nickel (Ni)	0.0005	mg/L
Potassium (K)	0.05	mg/L
Selenium (Se)	0.00005	mg/L
Silicon (Si)	0.1	mg/L
Silver (Ag)	0.00001	mg/L
Sodium (Na)	0.05	mg/L
Strontium (Sr)	0.0002	mg/L
Thallium (Tl)	0.00001	mg/L
Tin (Sn)	0.0001	mg/L
Titanium (Ti)	0.01	mg/L
Uranium (U)	0.00001	mg/L
Vanadium (V)	0.0005	mg/L
Zinc (Zn)	0.003	mg/L

Notes: LOR: Limit of Reporting

Table 6.14 Groundwater monitoring overview

Station Name	EMS Code	Description	Frequency	Parameters Measured	Guidelines
GW96-2a	E229681	Tailings Impoundment East Well (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW96-2b	E229682	Tailings Impoundment East Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW96-3a	E229683	Tailings Impoundment SE Well (deep)	Annually[1]	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Quarterly[1]	SWL	N/A
GW96-4a	E229685	Tailings Impoundment SW Well (deep)	Annually[1]	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Quarterly[1]	SWL	N/A
GW96-4b	E229686	Tailings Impoundment SW Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW96-7	E229690	SE Sed Pond Well	Annually[1]	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Quarterly[1]	SWL	N/A
GW00-1a	E242385	Tailings Impoundment West Well (deep)	Annually[1]	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Quarterly[1]	SWL	N/A
GW00-1b	E242384	Tailings Impoundment West Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW00-2a	E242387	Tailings Impoundment West Well (deep)	Annually[1]	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Quarterly[1]	SWL	N/A
GW00-3a	E242389	Tailings Impoundment West Well (deep)	Annually[1]	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Quarterly[1]	SWL	N/A
GW00-3b	E242388	Tailings Impoundment West Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
95-R-5	E229695	Lower SERDS Well (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW05-01	E258923	Wight Pit/Polley Lake Interface Well	Quarterly[2]	Field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW11-1a	E291210	Below Temporary PAG Dump (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW11-1b	E291211	Below Temporary PAG Dump (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW11-2a	E291212	Below SERDS (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW11-2b	E291213	Below SERDS (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW12-1a	E291969	NW of Temporary PAG Dump (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW12-1b	E291970	NW of Temporary PAG Dump (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW12-2a	E291971	Springer Pit Well (deep)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Continuous when Springer Pit Water elevation exceed 1035 masl	SWL (level logger installed in well)	N/A
GW12-2b	E291972	Springer Pit Well (shallow)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Continuous when Springer Pit Water elevation exceed 1035 masl	SWL (level logger installed in well)	N/A
GW12-3a	E291973	Below Waste Haul Road (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW12-3b	E291974	Below Waste Haul Road (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW12-4a	E291976	Below NEZ Dump (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW12-4b	E291977	Below NEZ Dump (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW12-5a	E291978	Below Wight Pit Road (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW12-5b	E291979	Below Wight Pit Road (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW14-1	E301973	Groundwater well at New Orica Site	Quarterly[2]	Field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW15-1a	E303210	Springer Pit Well North (deep)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards

Station Name	EMS Code	Description	Frequency	Parameters Measured	Guidelines
			Continuous when Springer Pit Water elevation exceed 1035 MASL	SWL (level logger installed in well)	N/A
GW15-1b	E303211	Springer Pit Well North (shallow)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Continuous when Springer Pit Water elevation exceed 1035 masl	SWL (level logger installed in well)	N/A
GW15-2a	E303212	Springer Pit Well South (deep)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Weekly	SWL (if the water level in the Springer Pit is over 1025 masl)	N/A
GW15-2b	E303213	Springer Pit Well South (shallow)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Weekly	SWL (if the water level in the Springer Pit is over 1025 masl)	N/A
GW16-1a	E308529	Below SERDS (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW16-1b	E308530	Below SERDS (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW16-2a	E308531	Tailings Impoundment North Well (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Quarterly	SWL	N/A
GW16-2b	E308532	Tailing Impoundment North Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW16-3a	E308533	Tailings Impoundment SE Well (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Quarterly	SWL	N/A
GW16-3b	E308534	Tailings Impoundment SE Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW16-4a	E308535	Tailings Impoundment S Well (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Quarterly	SWL	N/A
GW16-4b	E308536	Tailings Impoundment S Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW16-5a	E308537	Tailings Impoundment W Well (deep)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
			Quarterly	SWL	N/A
GW16-5b	E308538	Tailings Impoundment W Well (shallow)	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW16-6a	E308539	West of Cariboo Pit (deep)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW16-6b	E308540	West of Cariboo Pit (shallow)	Quarterly	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW16-7	E308541	Between Wight Pit and Polley Lake	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards
GW16-8	E308542	Between Wight Pit and Polley Lake	Semi-annually	SWL, field parameters, physical tests, anions and nutrients, dissolved metals, DOC	CSR Schedule 3.2 AL Standards

Notes: [1] Wells show stable chemistry. If an unexpected change in SWL is observed, well water will be sampled; [2] Well provided domestic water for infrastructure in Wight Pit but is only used for monitoring purposes now; SWL: static water level; CSR: Contaminated Sites Regulations; AL: aquatic life;

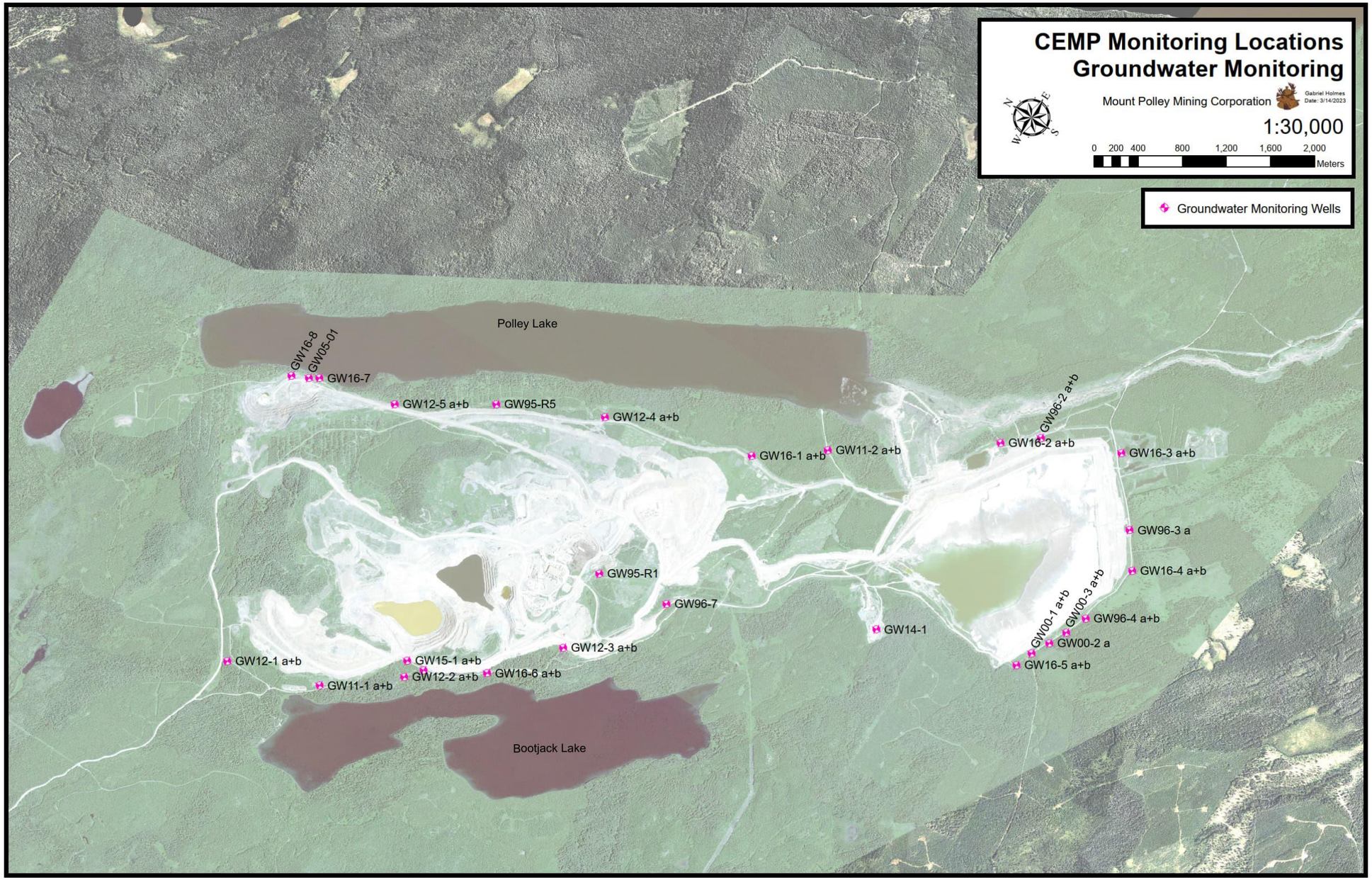


Figure 6.4 CEMP monitoring locations: Groundwater monitoring

6.8.4 HIGH-LEVEL MONITORING DESIGN DESCRIPTION

As outlined in the SOPs, groundwater monitoring involves use of an automated depth to water meter to measure SWL and a submersible pump powered by a generator for sampling. These protocols also require routine inspections of the well housing.

Sample collection, preparation, and shipping will be conducted following the SOPs and WMs for Groundwater Monitoring and use of associated field meters in the QA/QC Manual. These procedures include use of lab-verified clean or appropriately rinsed sampling bottles and steps to reduce risk of sampling contamination. *In-situ* parameters will be measured when samples for chemistry are collected. Water samples will be analyzed as described in Section 6.8.3.

Table 6.15 is a summary of previous groundwater monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.15 Summary of groundwater monitoring and findings

Summary of Monitoring and Findings	Monitoring Objective		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	Groundwater locations in both shallow and deep bedrock downstream of mine activities. Higher frequency monitoring occurred at wells near the Springer Pit in 2015, 2016, and 2017 because the pit water level was above 1025 masl. Dredging of the Springer Pit commenced in 2017, and the water level in the pit is less than 1000 masl at the time of writing.	An updated groundwater program was implemented for the ERA (Golder 2017). Wells installed in 2015 were resampled and additional wells were installed along the creek in 2016. Groundwater was analyzed for dissolved metals, TSS, pH, anions, nutrients, hardness and acidity.	N/A
Summary of findings	Monitoring of the groundwater wells near the Springer Pit showed exfiltration from the Springer Pit towards Bootjack Lake occurred during 2016. This exfiltration was reversed after the Springer Pit was dewatered, which was confirmed by continued monitoring of these wells. No groundwater leakage from Springer Pit to Bootjack Lake in 2107 was inferred based on the levels measured. No significant changes to groundwater quality were identified in the 2017 annual groundwater review (MPMC 2018).	Although copper was the primary metal of concern in the tailings outwash material deposited in Hazeltine Creek, groundwater copper concentrations were lower than the CSR standard. Other substances that exceeded CSR standards are believed to be associated with natural conditions and were not derived from the tailings.	N/A
Recommendations for 2023-2025 monitoring	New groundwater wells were drilled at the end of 2016 as per recommendations in the Groundwater Program Review. These wells were incorporated into the current program in 2017. One pair of wells was removed due to likely contamination and were replaced (see Golder 2016c). See Section 6.8.4.1 for more detail on the recommendations for future monitoring. Continuous SWL monitoring when Springer Pit Water elevation exceed 1035 masl. Inclusion of DOC in analysis.	No further sampling is planned for groundwater in Hazeltine Creek. If the water quality declines in the creek, monitoring of these wells will be reviewed and considered.	N/A

Notes: masl: metres above sea level; CSR: Contaminated Sites Regulation; ERA: ecological risk assessment; TSS: total suspended solids; SWL: Static water level; DOC: dissolved organic carbon

6.8.4.1 OPERATIONAL MONITORING

The monitoring frequencies of the Springer Pit wells were decreased from monthly to quarterly due to the ongoing dewatering at Springer Pit, which has resulted in a significant drop in water levels in some of these wells. For example, dataloggers have been removed from GW15-1a and b as these wells are now dry (J. Foley, personal communication, August 10, 2018). According to J. Foley, "due to the ongoing dewatering at Springer Pit, Golder would consider it acceptable to move to quarterly monitoring, if groundwater is present within the wells." Once dewatering stops and the pit is refilled, consideration to move back to monthly monitoring for a period of time will be given.

A further change to the recommendations put forth in Appendix F of MPMC (2018) is that "quarterly groundwater monitoring should continue at GW16-6 a and b, but semi-annual monitoring can be completed at the remaining GW16 well series. Note that some of the remaining 2016 well series (other than GW16-6 a/b) were monitored one to three times in the 2017 calendar year" (J. Foley, personal communication, August 10, 2018).

Additionally, the 2020 groundwater program review recommended that dissolved organic carbon be added to the required analytes and has been included in the program's routine sampling.

6.8.5 DATA QUALITY CONTROL, OBJECTIVES, AND REVIEW

For water chemistry, QC samples will be collected as a component of the monitoring program as per the MPMC QA/QC Manual. A combined QC schedule for all the groundwater monitoring is summarized in Table 6.16.

Table 6.16 Water chemistry QC sample frequencies for groundwater water monitoring

QC Samples	Frequency
Duplicate samples	10% of groundwater samples
Equipment blanks	Quarterly per piece of equipment (when used)
Trip blanks	Quarterly/semi-annually[1]
Field blanks	Quarterly/semi-annually[1]

Notes: [1] Quarterly for quarterly groundwater samples, semi-annually for semi-annual groundwater samples (i.e., six per year)

For results greater than five times the MDL, an RPD will be used to identify differences between original and duplicate samples. These DQOs are the same as the RPDs used by the lab. If one or both results are less than five times the MDL, a difference between original and duplicate samples greater than two times the MDL is used to identify differences. Blanks in which any parameters exceed the reported MDL will be flagged.

6.8.6 Laboratory Analysis

Samples will be submitted to and processed by a CALA accredited analytical laboratory, typically ALS Environmental Inc. in Burnaby, BC for chemistry samples, where standard testing procedures will be used as specified in the most recent editions of the *BC Environmental Laboratory Manual* (MoE 2020).

Laboratory precision will be assessed on the basis of laboratory duplicate results and laboratory accuracy will be assessed using certified reference materials (CRMs) and matrix spikes. Potential laboratory contamination will be assessed using a DQO of ≤ 2 times the laboratory MDL in laboratory method blank results.

6.8.7 Data Analysis and Reporting

Data analysis and interpretation for reporting purposes will include calculation of summary statistics (e.g., mean, minimum, maximum, and 95th percentile values over the period of interest) and evaluation of water chemistry or water level changes and/or trends. Groundwater chemistry will be compared to the Schedule 3.2, Column 3 (Aquatic Life) standards in the ENV Contaminated Sites Regulation (CSR) under the *EMA*, and BC WQGs per Technical Guidance 15 (MOE 2017a). These data will also be used by a third-party qualified professional for the three-year groundwater monitoring program review, and updates to hydrogeological models, including the Springer Pit groundwater model. Hazeltine Creek groundwater data will be used to support the geochemical characterization of materials in the Hazeltine Creek corridor.

6.9 Contact Water Quality Monitoring

Monitoring in this subsection falls under BC *Mines Act* M-200 and is only described here for completeness. Monitoring is summarized and changes will be presented in the CEMP, but changes to this monitoring are subject to BC *Mines Act* Permit M-200 and not Section 7 in the CEMP or Section 5 in the CEMP TOR (Appendix A).

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.9.1 Section Authors and Study Design Professionals

This section was written by MPMC.

6.9.2 Monitoring Objectives

The objective is to monitor trends in contact water quality on site, including runoff and mill process water, specifically at locations that represent the WTP source water. These data are applied to understand trends in site water chemistry and inform water management planning, including water discharge strategies.

6.9.3 MONITORING OVERVIEW

Table 6.17 summarizes the parameters analysed for contact water quality. Table 6.18 provides an overview of the contact water monitoring. Figure 6.5 shows monitoring locations of the contact water sampling locations.

Table 6.17 Contact water chemistry parameters

Parameter	LOR	Unit
Field Parameters - General		
pH	-	pH
Conductivity	-	µS/cm
Temperature	-	°C
Turbidity	-	NTU
Physical Tests		
Conductivity	2	µS/cm
Hardness (as $CaCO_3$)	0.5	mg/L
pH	0.1	pH
Total Suspended Solids	1	mg/L
Total Dissolved Solids	10	mg/L
Turbidity	0.1	NTU
Anions and Nutrients		
Alkalinity, Total (as $CaCO_3$)	1	mg/L
Ammonia, Total (as N)	0.005	mg/L
Chloride (Cl)	0.5	mg/L
Fluoride (F)	0.02	mg/L
Nitrate and Nitrite (as N)	0.003	mg/L
Nitrate (as N)	0.001	mg/L
Nitrite (as N)	0.005	mg/L
Total Nitrogen	0.03	mg/L
Orthophosphate-Dissolved (as P)	0.001	mg/L
Phosphorus (P)-Total Dissolved	0.002	mg/L
Phosphorus (P)-Total	0.002	mg/L
Sulfate (SO_4)	0.3	mg/L
Organic / Inorganic Carbon		
Dissolved Organic Carbon	0.5	mg/L

Parameter	LOR	Unit
Total and Dissolved Metals		
Aluminum (Al)	0.003	mg/L
Antimony (Sb)	0.0001	mg/L
Arsenic (As)	0.0001	mg/L
Barium (Ba)	0.0001	mg/L
Beryllium (Be)	0.0001	mg/L
Bismuth (Bi)	0.00005	mg/L
Boron (B)	0.01	mg/L
Cadmium (Cd)	0.000005	mg/L
Calcium (Ca)	0.05	mg/L
Chromium (Cr)	0.0005	mg/L
Cobalt (Co)	0.0001	mg/L
Copper (Cu)	0.0005	mg/L
Iron (Fe)	0.03	mg/L
Lead (Pb)	0.00005	mg/L
Lithium (Li)	0.001	mg/L
Magnesium (Mg)	0.1	mg/L
Manganese (Mn)	0.0001	mg/L
Molybdenum (Mo)	0.00005	mg/L
Nickel (Ni)	0.0005	mg/L
Potassium (K)	0.05	mg/L
Selenium (Se)	0.00005	mg/L
Silicon (Si)	0.1	mg/L
Silver (Ag)	0.00001	mg/L
Sodium (Na)	0.05	mg/L
Strontium (Sr)	0.0002	mg/L
Thallium (Tl)	0.00001	mg/L
Tin (Sn)	0.0001	mg/L
Titanium (Ti)	0.01	mg/L
Uranium (U)	0.00001	mg/L
Vanadium (V)	0.0005	mg/L
Zinc (Zn)	0.003	mg/L

Notes: LOR: Limit of Reporting

Table 6.18 Contact water monitoring overview

Station Name	EMS Code	Description	Drainage	Inspection Frequency	Sample Frequency	Parameters Measured	Guidelines	Permit[1]
E1a	E225309	TSF Supernatant	Tailings slurry, seepage collection ponds	Daily	Quarterly[2]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
Long Ditch	-	Long Ditch	East RDS, NEZ Dump, SERDS, Wight Pit dewatering	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
SERDS Ditch	-	SERDS Ditch	SERDS, West Ditch, MDC Sump	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
E13	-	NW Sump	Temporary NW PAG Stockpile	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
E14	-	Mine Drainage Creek Sump	Upper Mine Drainage Creek, West Ditch	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
E15	-	Bootjack Creek Culvert Sump	TSF Haul Road, Upper Bootjack Creek	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
E17	-	9km Sump	Temporary NW PAG Stockpile	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
E4	-	Main Embankment Seepage Collection Pond	MTD, STD, Main Embankment foundation drains	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
E18	-	Central Collection Sump	Long Ditch, SERDS Ditch	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
East MTD	-	East Main Toe Drain	East TSF Main Embankment toe drain	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
West MTD	-	West Main Toe Drain	West TSF Main Embankment toe drain	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
STD	-	South Toe Drain	TSF South Embankment toe drain	Monthly	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	BC *Mines Act* Permit M-200
Gavin's Ditch	-	-	Undisturbed area east of Polley Mountain	Semi-annually	Semi-annually[3]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	Permit 11678[4]
TSF Clean Water Diversion	-	-	Undisturbed area west of TSF	Semi-annually	Semi-annually[3]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	Permit 11678[4]
Wight Pit Clean Water Diversion	-	-	Undisturbed area north of Wight Pit	Semi-annually	Semi-annually[3]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A	Permit 11678[4]

Notes: [1] Permit regulating the sample; [2] When reclaim water is sourced from TSF; [3] In spring and fall, coinciding with ditch inspections; [4] Under Section 2.4.1 of Permit 11678, surface runoff from undisturbed areas must be diverted away from mine workings. These clean water ditches are monitored to ensure water quality is maintained; N/A: not applicable; TSF: Tailings Storage Facility; PAG: potentially acid generating

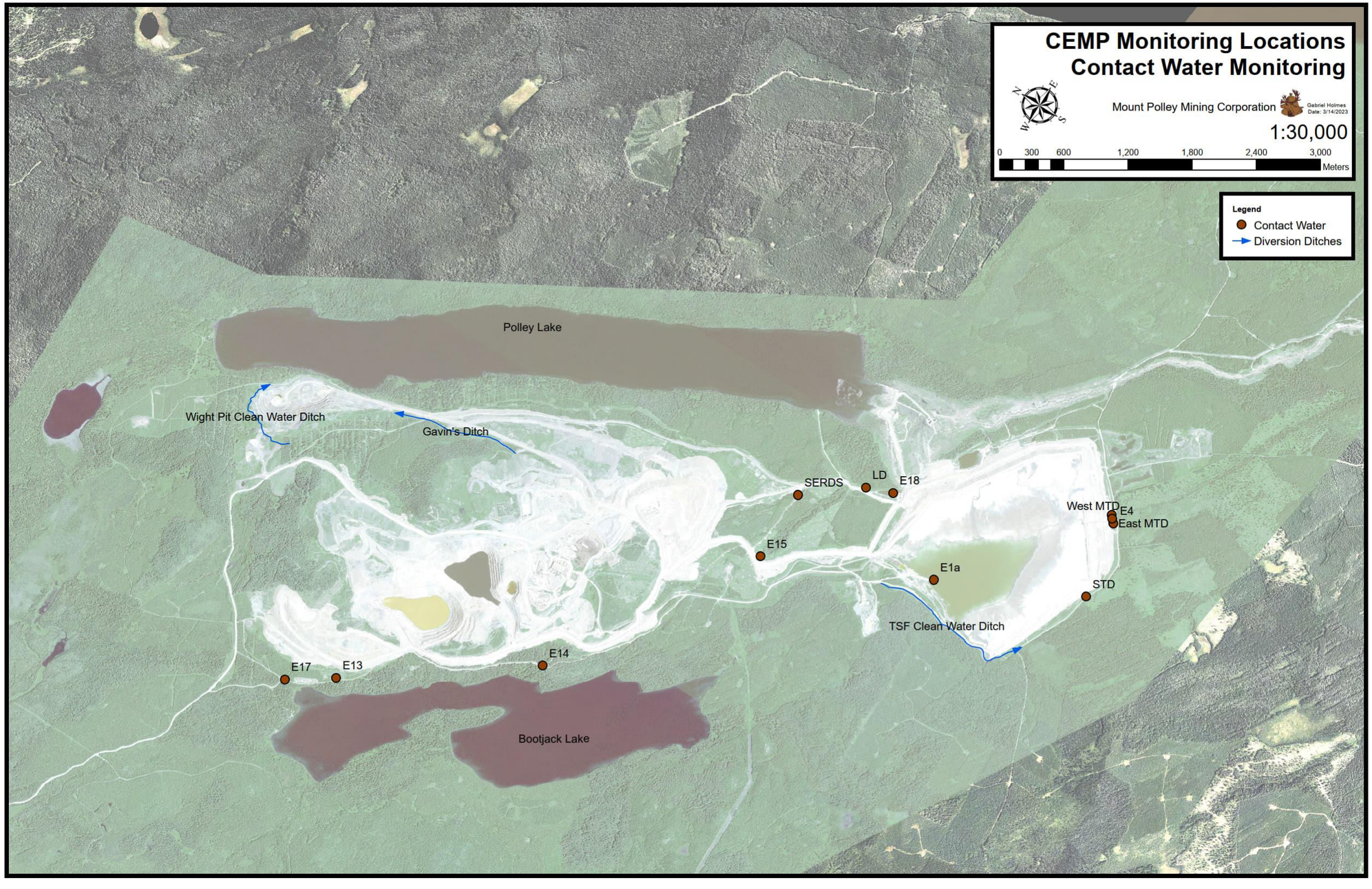


Figure 6.5 CEMP monitoring locations: Contact water monitoring

6.9.4 HIGH-LEVEL MONITORING DESIGN DESCRIPTION

Sample collection, preparation, and shipping will be conducted following the SOPs and WMs for Surface Water Quality Monitoring, and use of associated field meters in the QA/QC Manual. These procedures include use of lab-verified clean or appropriately rinsed sampling bottles and steps to reduce risk of sampling contamination. *In-situ* parameters will be measured when samples for chemistry are collected. Water samples will be analyzed as described in Section 6.9.3.

Table 6.19 is a summary of previous contact water monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.19 Summary of contact water monitoring and findings

Summary of Monitoring and Findings	**Monitoring Objective**		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	Sumps that collect and temporarily store water as well as ditches that convey water from many different sources were monitored.	N/A	N/A
Summary of findings	There were no notable trends in 2017 contact water monitoring that suggested the monitoring program needs to be changed.	N/A	N/A
Recommendations for 2023-2025 monitoring	The Springer Pit Sump (E11) is no longer representative of the pit lake water quality therefore, these sites have been removed from monitoring under the Permit; E11 continues to be monitored under the *Mines Act* Permit M-200 (see Section 6.10).	N/A	N/A

Notes: N/A: not applicable; WTP: Water Treatment Plant

6.9.5 DATA QUALITY CONTROL, OBJECTIVES, AND REVIEW

For water chemistry, QC samples will be collected as a component of the monitoring program as per the MPMC QA/QC Manual. A combined QC schedule for all contact water monitoring is summarized in Table 6.20. For results greater than five times the MDL, an RPD will be used to identify differences between original and duplicate samples. These DQOs are the same as the RPDs used by the lab. If one or both results are less than five times the MDL, a difference between original and duplicate samples greater than two times the MDL is used to identify differences. Blanks in which any parameters exceed the reported MDL will be flagged.

Table 6.20 Water chemistry QC sample frequencies for contact water monitoring

QC Samples	Frequency
Duplicate samples	10% of contact water samples
Trip blanks	Combined with surface water QC schedule
Field blanks	Combined with surface water QC schedule

6.9.6 Laboratory Analysis

Samples will be submitted to and processed by a CALA accredited analytical laboratory, typically ALS Environmental Inc. in Burnaby, BC, where standard testing procedures will be used as specified in the most recent editions of the *BC Environmental Laboratory Manual* (MoE 2020).

Laboratory precision will be assessed on the basis of laboratory duplicate results and laboratory accuracy will be assessed using certified reference materials (CRMs) and matrix spikes. Potential laboratory contamination will be assessed using a DQO of ≤ 2 times the laboratory MDL in laboratory method blank results.

6.9.7 Data Management and Analysis

Data analysis and interpretation for reporting purposes will include calculation of summary statistics (e.g., mean, minimum, maximum, and 95th percentile values over the period of interest). These data, including spatial and temporal trends in relation to mine features and their geochemistry, will be used in long-term water management planning (Section 5.1).

6.10 Seep Monitoring

Monitoring included in this subsection fall under BC *Mines Act* Permit M-200 and is only described here for completeness. Monitoring is summarized and changes will be presented in the CEMP, but changes to this monitoring are subject to BC *Mines Act* Permit M-200 and not Section 7 in the CEMP or Section 5 in the CEMP TOR (Appendix A).

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.10.1 Section Authors and Study Design Professionals

This section was written by MPMC.

6.10.2 Monitoring Objectives

An important component in determining and monitoring long-term chemical stability of drainage from the pits and waste rock dumps is water quality monitoring. The seep sampling is conducted under the BC *Mines Act* Permit M-200.

6.10.3 MONITORING OVERVIEW

Under the BC *Mines Act* Permit M-200 seepage monitoring program, monitoring of waste rock dump seepages is conducted under a bi-annual seep survey program of all waste rock dumps on site, with representative seeps being monitored more frequently when possible (numerous seeps stop flowing during dry periods). Table 6.21 summarizes the parameters analysed for seepage water quality. A list of dumps and pits that are sampled, along with the representative sample locations, is provided in Table 6.22 and Table 6.23, respectively. Figure 6.6 shows monitoring locations of the seepage sampling locations.

Table 6.21 Seepage water chemistry parameters

Parameter	LOR	Unit
Field Parameters - General		
pH	-	pH
Conductivity	-	µS/cm
Temperature	-	°C
Turbidity	-	NTU
Physical Tests		
Conductivity	2	µS/cm
Hardness (as $CaCO_3$)	0.5	mg/L
pH	0.1	pH
Total Suspended Solids	1	mg/L
Total Dissolved Solids	10	mg/L
Turbidity	0.1	NTU
Anions and Nutrients		
Alkalinity, Total (as $CaCO_3$)	1	mg/L
Ammonia, Total (as N)	0.005	mg/L
Chloride (Cl)	0.5	mg/L
Fluoride (F)	0.02	mg/L
Nitrate and Nitrite (as N)	0.003	mg/L
Nitrate (as N)	0.001	mg/L
Nitrite (as N)	0.005	mg/L
Total Nitrogen	0.03	mg/L
Orthophosphate-Dissolved (as P)	0.001	mg/L
Phosphorus (P)-Total Dissolved	0.002	mg/L
Phosphorus (P)-Total	0.002	mg/L
Sulfate (SO_4)	0.3	mg/L
Organic / Inorganic Carbon		
Dissolved Organic Carbon	0.5	mg/L

Parameter	LOR	Unit
Total and Dissolved Metals		
Aluminum (Al)	0.003	mg/L
Antimony (Sb)	0.0001	mg/L
Arsenic (As)	0.0001	mg/L
Barium (Ba)	0.0001	mg/L
Beryllium (Be)	0.0001	mg/L
Bismuth (Bi)	0.00005	mg/L
Boron (B)	0.01	mg/L
Cadmium (Cd)	0.000005	mg/L
Calcium (Ca)	0.05	mg/L
Chromium (Cr)	0.0005	mg/L
Cobalt (Co)	0.0001	mg/L
Copper (Cu)	0.0005	mg/L
Iron (Fe)	0.03	mg/L
Lead (Pb)	0.00005	mg/L
Lithium (Li)	0.001	mg/L
Magnesium (Mg)	0.1	mg/L
Manganese (Mn)	0.0001	mg/L
Molybdenum (Mo)	0.00005	mg/L
Nickel (Ni)	0.0005	mg/L
Potassium (K)	0.05	mg/L
Selenium (Se)	0.00005	mg/L
Silicon (Si)	0.1	mg/L
Silver (Ag)	0.00001	mg/L
Sodium (Na)	0.05	mg/L
Strontium (Sr)	0.0002	mg/L
Thallium (Tl)	0.00001	mg/L
Tin (Sn)	0.0001	mg/L
Titanium (Ti)	0.01	mg/L
Uranium (U)	0.00001	mg/L
Vanadium (V)	0.0005	mg/L
Zinc (Zn)	0.003	mg/L

Notes: LOR: Limit of Reporting

Table 6.22 Seep monitoring overview

Waste Rock Dump	Representative Sample	Representative Sample Frequency	Parameters Measured	Guidelines
North Bell Dump	Joe's Creek Pipe	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
Boundary Dump	Boundary Seep 2	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
East RDS	-	-	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
NEZ Dump	NEZ Seep 1	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
Waste Haul Road	Mine Drainage Creek Culvert (MDC)	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
Temporary NW PAG Dump	PAG Seep 15	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
TSF Haul Road	-	-	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
SERDS	SERD Seep 13	Quarterly	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A

Table 6.23 Pit seepage monitoring overview

Pit	Station Name	Sample Frequency	Parameters Measured	Guidelines
Cariboo Pit	E8	Semi-annually[1]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
Wight Pit	E10	Semi-annually[1]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
Springer Pit	E11	Semi-annually[1]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
Boundary Pit	Boundary Pit	Semi-annually[1]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A

Notes: [1] When pit is not storing water from other sources on site

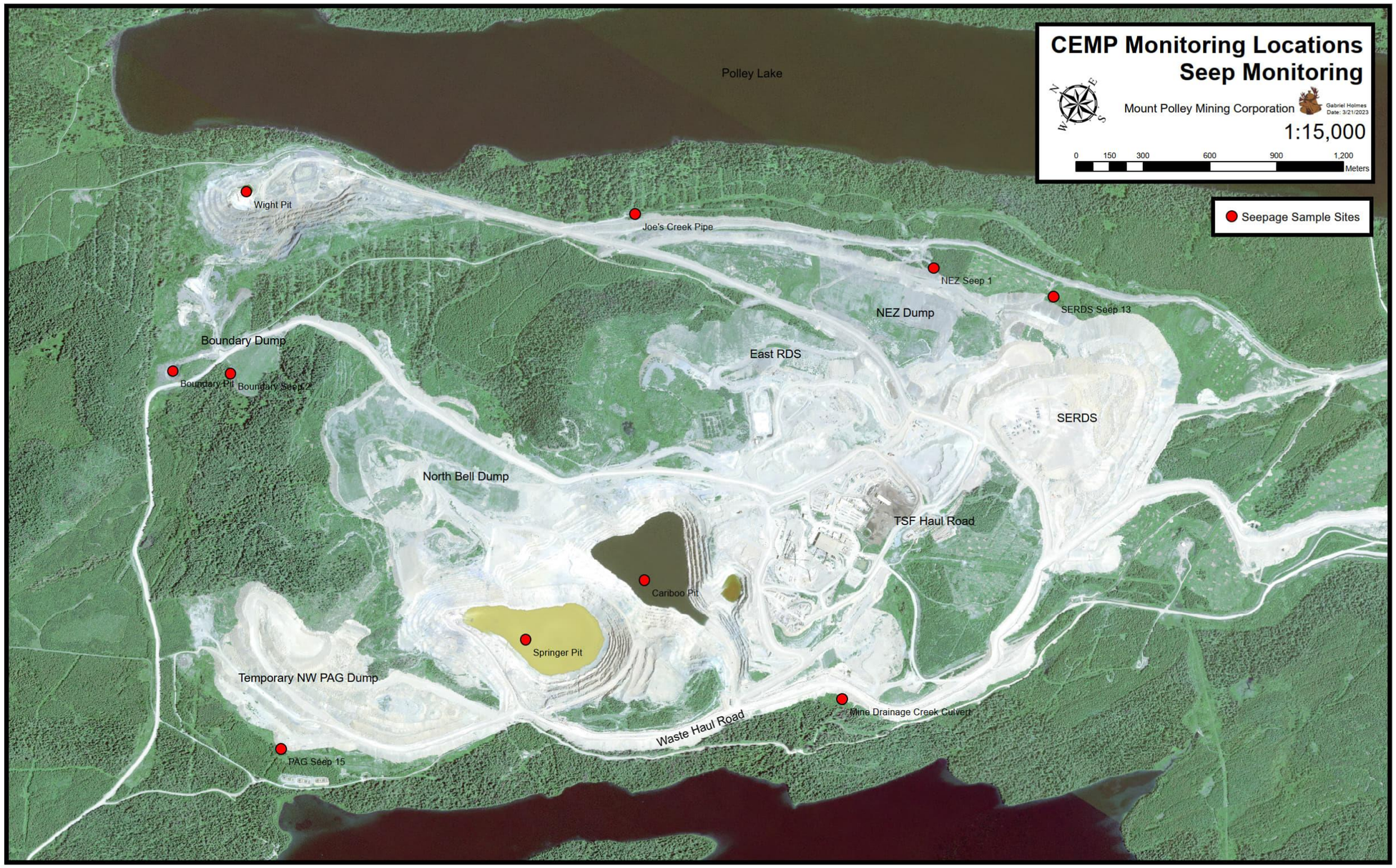


Figure 6.6 CEMP monitoring locations: Seep monitoring

6.10.4 High-Level Monitoring Design Description

Sample collection, preparation, and shipping will be conducted following the SOPs and WMs for Surface Water Quality Monitoring, and use of associated field meters in the QA/QC Manual. These procedures include use of lab-verified clean or appropriately rinsed sampling bottles and steps to reduce risk of sampling contamination. *In-situ* parameters will be measured when samples for chemistry are collected. Water samples will be analyzed as described in Section 6.10.3.

Table 6.24 is a summary of previous seep monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.24 Summary of seep monitoring and findings

Summary of Monitoring and Findings	Monitoring Objective		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	N/A	N/A	Seeps were sampled at the toe of waste rock piles and from pits that are not storing water from other locations.
Summary of findings	N/A	N/A	The results are used to inform long-term planning for reclamation and closure. It has been identified that two seeps from the NEZ Dump have elevated metal concentrations. See Section 6.10.4.1 for more detail.
Recommendations for 2023-2025 monitoring	N/A	N/A	The program will continue unchanged because bi-annual monitoring (i.e., in spring and fall) captures representative conditions.

Notes: N/A: not applicable; NEZ: North-East Zone

6.10.4.1 Reclamation and Closure Monitoring

NEZ Seep 1 and NEZ Seep 2 have elevated metal concentrations compared to other seeps on site. To address this, research into the source of the elevated metals has been conducted, as well as possible treatment options. A collection system for these two seeps has been constructed to isolate the water from the mine site collection infrastructure; this water will be pumped to the mill for use in processing and further research will be conducted.

6.10.5 Data Quality Control, Objectives, and Review

For water chemistry, QC samples will be collected as a component of the monitoring program as per the MPMC QA/QC Manual. A combined QC schedule for all seep monitoring is summarized in Table 6.25.

Table 6.25 Water chemistry QC sample frequencies for seep monitoring

QC Samples	Frequency
Duplicate samples	10% of seep monitoring samples
Trip blanks	Quarterly/Semi-annually[1]
Field blanks	Quarterly/Semi-annually[1]

Notes: [1] Quarterly for quarterly sampling events; semi-annually for semi-annual sampling events

For results greater than five times the MDL, an RPD will be used to identify differences between original and duplicate samples. These DQOs are the same as the RPDs used by the lab. If one or both results are less than five times the MDL, a difference between original and duplicate samples greater than two times the MDL is used to identify differences. Blanks in which any parameters exceed the reported MDL will be flagged.

6.10.6 Laboratory Analysis

Samples will be submitted to and processed by a CALA accredited analytical laboratory, typically ALS Environmental Inc. in Burnaby, BC, where standard testing procedures will be used as specified in the most recent editions of the *BC Environmental Laboratory Manual* (MoE 2020).

Laboratory precision will be assessed on the basis of laboratory duplicate results and laboratory accuracy will be assessed using certified reference materials (CRMs) and matrix spikes. Potential laboratory contamination will be assessed using a DQO of ≤ 2 times the laboratory MDL in laboratory method blank results.

6.10.7 Data Analysis and Reporting

Collection of this data is used in long-term effluent water quality predictions. These results are presented in the AER and ARR, and are applied to understand long-term ML/ARD potential, develop site source terms, and inform water management planning.

6.11 Effluent Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.11.1 Section Authors and Study Design Professionals

This section was written by MPMC.

6.11.2 MONITORING OBJECTIVES

The objective of the effluent monitoring program is to verify the water chemistry complies with the applicable regulatory limits at the point of discharge (MDMER Schedule 4 and the Permit limits in Table 6.26; see Section 1.2.4 in the Permit), and that the discharge flow rate does not exceed the permitted rates of a maximum of 52,000 m^3/day and an annual average of 29,000 m^3/day (see Sections 1.2.1 and 1.2.2 in the Permit). The influent is also sampled to allow for analysis of treatment efficacy.

6.11.3 MONITORING OVERVIEW

The flow rate, temperature, and TSS of the effluent will be continuously monitored and recorded in the Veolia WTP HMI. MPMC may consider less frequent sampling (MDMER minimum is quarterly) if the monthly mean concentrations of parameters are <10% of the MDMER guidelines for 12 months, as described in Section 13 (1) of the MDMER. To make this change if these conditions are met, MPMC will follow the process outlined in Section 7. Table 6.27 summarizes the parameters analysed for effluent quality and Table 6.28 provides an overview of the effluent monitoring. Further details of monitoring sites, including site access descriptions, access or safety concerns, and a brief rationale for monitoring, is provided in the Site Matrix in Appendix D. Figure 6.7 shows monitoring locations of the effluent sampling locations. Reporting of the monitoring data is outlined in Section 9.

Table 6.26 Permit 11678 and MDMER Schedule 4 treated effluent compliance limits for direct discharge to Quesnel Lake

		Permit Limit	MDMER Schedule 4: Authorized Limits	
Constituent	**Units**	**Treatment Plant Outlet**	**MAX Monthly Mean**	**MAX Grab Sample**
Non-Metal Constituents				
pH	pH	6.0 - 9.5	6.0 - 9.5	6.0 - 9.5
Total Suspended Solids	mg/L	15 (mean)/30 (max)	15	30
Total Sulphate	mg/L	1,100	-	-
Total Ammonia	mg/L (as N)	1.3	-	-
Un-ionized Ammonia	mg/L (as N)	-	0.5	1
Total Nitrate	mg/L (as N)	34.0	-	-
Total Nitrite	mg/L (as N)	0.78	-	-
Total Phosphorus	mg/L	0.09	-	-
Fluoride	mg/L	17		
Cyanide [1]	mg/L	-	0.5	1
Radium 226 [2]	Bq/L	-	0.37	1.11
Total Metals				
Arsenic	mg/L	0.028	0.1	10.2
Chromium	mg/L	0.004	-	-
Copper	mg/L	0.033	0.1	0.2
Iron	mg/L	1	-	-
Lead	mg/L	-	0.08	0.16
Manganese	mg/L	3.4	-	-
Molybdenum	mg/L	0.36	-	-
Nickel	mg/L	-	0.25	0.5
Selenium	mg/L	0.075	-	-
Silver	mg/L	0.00024	-	-
Zinc	mg/L	0.059	0.4	0.8
Dissolved Metals				
Aluminum	mg/L	0.75	-	-
Cadmium	mg/L	0.00034	-	-
Iron	mg/L	0.35	-	-
96h LC50 Rainbow Trout	Mortality in 100% effluent	50%	-	LC50 >100%
48h LC50 *D. magna*		50%	-	LC50 >100%

Notes: [1] MDMER requirement only; if cyanide is not used in the mining/milling process, then it does not have to be analysed. Since cyanide is not used in the mining/milling process at Mount Polley, the effluent is not analysed for cyanide; [2] MDMER requirement only; if 10 consecutive samples show radium 226 as less than 0.037 Bq/l then frequency of sampling for radium 226 can be reduced to once a quarter. This has been satisfied, and radium 226 analysis is currently conducted quarterly.

Table 6.27 Effluent chemistry parameters

Parameter	LOR	Unit
Field Parameters - General		
pH	-	pH
Conductivity	-	µS/cm
Temperature	-	°C
Turbidity	-	NTU
Physical Tests		
Conductivity	2	µS/cm
Hardness (as $CaCO_3$)	0.5	mg/L
pH	0.1	pH
Total Suspended Solids	1	mg/L
Total Dissolved Solids	10	mg/L
Turbidity	0.1	NTU
Anions and Nutrients		
Alkalinity, Total (as $CaCO_3$)	1	mg/L
Ammonia, Total (as N)	0.005	mg/L
Chloride (Cl)	0.5	mg/L
Fluoride (F)	0.02	mg/L
Nitrate and Nitrite (as N)	0.003	mg/L
Nitrate (as N)	0.001	mg/L
Nitrite (as N)	0.005	mg/L
Total Nitrogen	0.03	mg/L
Orthophosphate-Dissolved (as P)	0.001	mg/L
Phosphorus (P)-Total Dissolved	0.002	mg/L
Phosphorus (P)-Total	0.002	mg/L
Sulfate (SO_4)	0.3	mg/L
Organic / Inorganic Carbon		
Dissolved Organic Carbon	0.5	mg/L

Notes: LOR: Limit of Reporting

Parameter	LOR	Unit
Total and Dissolved Metals		
Aluminum (Al)	0.003	mg/L
Antimony (Sb)	0.0001	mg/L
Arsenic (As)	0.0001	mg/L
Barium (Ba)	0.0001	mg/L
Beryllium (Be)	0.0001	mg/L
Bismuth (Bi)	0.00005	mg/L
Boron (B)	0.01	mg/L
Cadmium (Cd)	0.000005	mg/L
Calcium (Ca)	0.05	mg/L
Chromium (Cr)	0.0005	mg/L
Cobalt (Co)	0.0001	mg/L
Copper (Cu)	0.0005	mg/L
Iron (Fe)	0.03	mg/L
Lead (Pb)	0.00005	mg/L
Lithium (Li)	0.001	mg/L
Magnesium (Mg)	0.1	mg/L
Manganese (Mn)	0.0001	mg/L
Molybdenum (Mo)	0.00005	mg/L
Nickel (Ni)	0.0005	mg/L
Potassium (K)	0.05	mg/L
Selenium (Se)	0.00005	mg/L
Silicon (Si)	0.1	mg/L
Silver (Ag)	0.00001	mg/L
Sodium (Na)	0.05	mg/L
Strontium (Sr)	0.0002	mg/L
Thallium (Tl)	0.00001	mg/L
Tin (Sn)	0.0001	mg/L
Titanium (Ti)	0.01	mg/L
Uranium (U)	0.00001	mg/L
Vanadium (V)	0.0005	mg/L
Zinc (Zn)	0.003	mg/L

Table 6.28 Effluent monitoring overview

Station Name	EMS Code	Description	Frequency	Parameters Measured	Guidelines
E19	E305050	WTP influent	Weekly[1]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals	N/A
HAD-03	E304230	WTP treated effluent	Continuous[1]	TSS (calculated), temperature, flow rate	Permit 11678
			Weekly[1]	Field parameters, physical tests, anions and nutrients, DOC, total and dissolved metals, radium 226[2], total mercury[3]	Permit 11678; MDMER; EEM
			Monthly	Acute toxicity tests: - Rainbow trout: *Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout* (Reference Method EPS1/RM/13) - Daphnia Magna: *Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Daphnia magna* (Reference Method EPS1/RM/14) - or most recent methods, as per MDMER	Permit 11678; MDMER[4]
			Semi-annually[5]	Chronic toxicity tests: - Biological Test Method: *Toxicity Tests Using Early Life Stages of Salmonid Fish* (Rainbow Trout) (Reference Method EPS 1/RM/28) - Invertebrate species: *Biological Test Method: Test of Reproduction and Survival Using the Cladoceran Ceriodaphnia dubia* (Report EPS 1/RM/21) - Plant species: *Biological Test Method: Test for Measuring the Inhibition of Growth Using the Freshwater Macrophyte, Lemna minor* (Reference Method EPS 1/RM/37) - Algal species: *Biological Test Method: Growth Inhibition Test Using a Freshwater Alga* (Report Method EPS 1/RM/25)	MDMER

Notes: [1] Only when discharging; [2] MDMER requirement only; if 10 consecutive samples show radium 226 as less than 0.037 Bq/l then frequency of sampling for radium 226 can be reduced to once a quarter. This has been satisfied and radium 226 analysis is currently conducted quarterly; [3] EEM requirement only; can be discontinued if concentration is less than 0.10 µg/L in 12 consecutive samples. This has been satisfied and mercury analysis has been discontinued; [4] MDMER June 2018 Part 2 Division 2 16 (1): frequency may be reduced to quarterly if discharge is determined not to be acutely lethal for 12 consecutive months; [5] Chronic/sub-lethal toxicity tests are conducted semi-annually for 3 years. MDMER June 2018 Schedule 5, 6 (1-3): after 3 years, frequency will be increased to once per calendar quarter on the sub lethal species whose results of sub lethal tests produce the lowest geometric mean, taking into account the inhibition concentration that produces a 25% effect or effective concentration of 25%; N/A: not applicable; TSS: total suspended solids; DOC: dissolved organic carbon; MDMER: Metal and Diamond Mining Effluent Regulations; EEM: Environmental Effects Monitoring

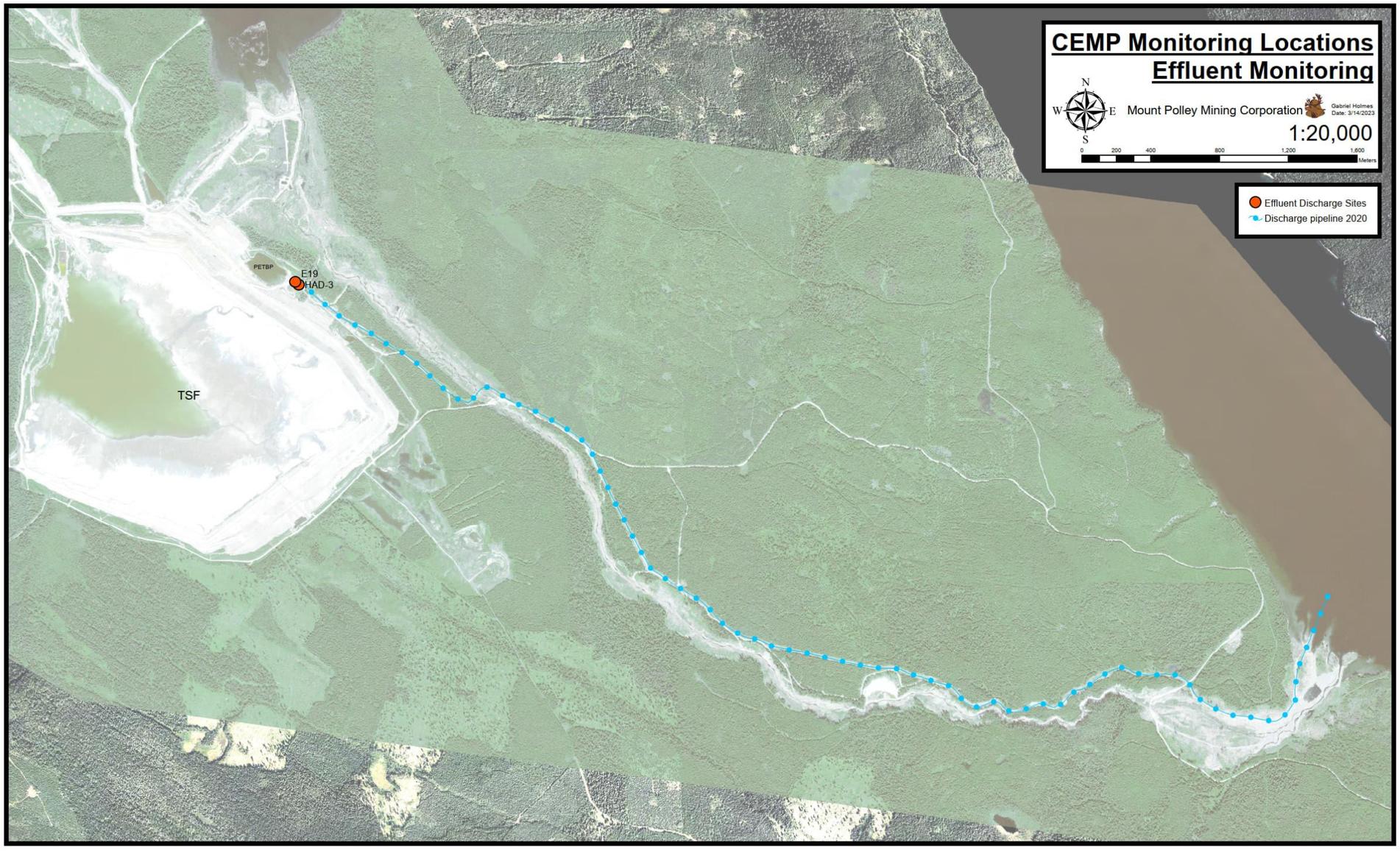


Figure 6.7 CEMP monitoring locations: Effluent monitoring

6.11.4 High-Level Monitoring Design Description

Sample collection, preparation, and shipping will be conducted following the SOPs and WMs for Surface Water Quality Monitoring, and use of associated field meters in the QA/QC Manual. These procedures include use of lab-verified clean or appropriately rinsed sampling bottles and steps to reduce risk of sampling contamination. *In-situ* parameters will be measured when samples for chemistry are collected. Water samples will be analyzed for the parameters described in Section 6.11.3.

Table 6.29 is a summary of previous effluent monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.29 Summary of effluent monitoring and findings

Summary of Monitoring and Findings	Monitoring Objective		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	Discharge monitoring included the influent and treated effluent.	N/A	N/A
Summary of findings	The majority of all samples to date were at or below the permit limits. When samples did not meet permit limits, ENV was notified and an investigation into the cause was undertaken. Comparing the influent concentrations to treated effluent concentrations verified reduction in parameters interest. See Section 6.11.4.1 for more details.	N/A	N/A
Recommendations for 2023-2025 monitoring	Monitoring of the influent (E19) will continue to be conducted weekly to align with monitoring of HAD-03 for better efficiency analysis of the WTP.	N/A	N/A

Notes: N/A: not applicable; ENV: Ministry of Environment and Climate Change Strategy; WTP: water treatment plant

Should there be an extreme weather event or equipment failure in the WTP that could affect water quality in the effluent, MPMC has the ability to request rush analysis from the analytical lab (ALS). MPMC maintains an Emergency Response Plan for the effluent discharge as required by the MDMER and the Permit.

6.11.4.1 Operational Monitoring

MPMC conducts routine water chemistry monitoring weekly and acute toxicity tests monthly for LC50 Rainbow trout and LC50 *Daphnia magna*. Under the new MDMER, *D. magna* is now a compliance parameter. MPMC will continue to conduct these acute lethality tests as required.

MDMER has changed the frequency of acute toxicity tests for effluent discharge. In accordance with Part 2, Division 2, paragraph 16 (1), acute lethality tests at the final discharge point (HAD-03) will become quarterly if the effluent is determined to be non-lethal for 12 consecutive months (Government of Canada 2018). Effluent at HAD-03 since discharge has started (December 2015) has been shown to be non-lethal.

MPMC has conducted chronic toxicity tests on the effluent discharge since December 7, 2015 on a quarterly and semi-annual basis. Under MDMER requirements, after three years (after December 2018 at HAD-03), the chronic toxicity tests results will be reviewed by a QP and will be streamlined to one test only. This test will be based on the most sensitive organism to the effluent according to historical geometric means and will be tested quarterly. The reduction of frequency from the 2016 CEMP for the chronic toxicity tests, as described in Table 6.28, aligns with the MDMER, as no actionable effects have been recorded at HAD-03 and the MDMER protocol is established to characterise the impacts on the most sensitive aquatic life.

6.11.5 Data Quality Control, Objectives, and Review

For water chemistry, QC samples will be collected as a component of the monitoring program as per the MPMC QA/QC Manual. Effluent monitoring samples are combined in the surface water QC schedule (see Section 6.6.5), as laid out in Table 6.8.

6.11.6 Laboratory Analysis

Samples will be submitted to and processed by a CALA accredited analytical laboratory, typically ALS Environmental Inc. in Burnaby, BC for chemistry samples and Nautilus Environmental in Burnaby, BC for toxicity testing, where standard testing procedures will be used as specified in the most recent editions of the *BC Environmental Laboratory Manual* (MoE 2020) and the MDMER (where applicable; i.e., discharge water toxicity testing).

Laboratory precision will be assessed on the basis of laboratory duplicate results and laboratory accuracy will be assessed using certified reference materials (CRMs) and matrix spikes. Potential laboratory contamination will be assessed using a DQO of ≤ 2 times the laboratory MDL in laboratory method blank results.

QC monitoring for toxicity testing will be carried out at the laboratory, as per the test methods, with requirements to meet criteria such as test organism health history, and control acceptability. Uncertainty associated with test results will be described by the standard deviation around the mean and/or the confidence limits around the point estimate.

6.11.7 Data Analysis and Reporting

Data analysis and interpretation for reporting purposes will include calculation of summary statistics (e.g., mean, minimum, max, and 95th percentile values over the period of interest) and screening of results against applicable regulatory benchmarks (see Table 6.26). Screening will include evaluation of results at the treated effluent discharge against MDMER and the Permit limits. Alerts are set up in the MP-5 database so that MPMC Environmental Department staff receives an email if specified benchmarks are exceeded.

6.12 Sediment Quality Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description;

data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.12.1 Section Authors and Study Design Professionals

This section was written by MPMC, and is a summary of the study design and *Proposed Revisions to the Comprehensive Environmental Monitoring Program (CEMP)* provided by Minnow Environmental Inc. (Minnow). The detailed study design and *Proposed Revisions to the Comprehensive Environmental Monitoring Program (CEMP)* are provided in Appendices B.1.1 and B.1, respectively. Golder prepared the study design for selecting an alternate reference lake for Polley Lake (Appendix B.4).

6.12.2 Monitoring Objectives

As outlined in Appendix B.1.1, the objectives of sediment quality monitoring are to:

- "Evaluate the influence of mine activities on the receiving environments (e.g., Hazeltine Creek, Polley Lake, and Quesnel Lake) in comparison to baseline and/or reference conditions";
- "Determine potential implications to aquatic life by applying a variety of interpretive tools";
- "Provide data to support exposure assessment as part of the ERA and HHRA"; and
- "Provide supporting information for benthic invertebrate community monitoring".

6.12.3 Monitoring Overview

Sediment quality monitoring under the CEMP is proposed to meet the combined needs of:

1) Operational monitoring;
2) Monitoring of the impact of the 2014 perimeter embankment failure; and
3) Monitoring of response to reclamation activity following the perimeter embankment failure.

An overview of the proposed sediment quality monitoring program is provided in Table 2 and Figures 8 and 9 of the study design, and Table 1 of the proposed revisions document included in Appendices B.1.1 and B.1. Sediment quality monitoring is focused on Polley Lake, Hazeltine Creek, and Quesnel Lake, with reference areas identified for each mine-influenced sampling area (i.e., Bootjack Lake for Polley Lake, unaffected areas of Quesnel Lake for impacted areas of Quesnel Lake). Table 3 in Appendix B.1.1 summarizes the analytes and laboratory reporting limits for the sediment quality monitoring program.

The monitoring program is divided into lake monitoring and creek monitoring and will include physical and chemical characterisation of deposited sediments. Sediment quality sampling will be supported by measurements of temperature, dissolved oxygen, pH, and specific conductance near the sediment-water interface at all sampling stations, and at shallow areas will be supported by toxicity testing using *Hyalella azteca*. More detail is provided in Appendix B.1.1.

6.12.4 High-Level Monitoring Design Description

Appendix B.1.1 provides a summary of sediment monitoring history previously conducted in the vicinity of the mine in the surrounding lakes and creeks, including baseline, and pre- and post-breach monitoring. The sample collection methods are also summarized in Appendix B.1.1 for lake and creek sediment sampling. A study design for evaluating alternate reference lakes for Polley Lake is provided in Appendix B.4.

6.12.5 Data Quality Control, Objectives, and Review

Appendix B.1.1 summarizes the QAQC program for the sediment monitoring plan. It includes specific QA/QC protocols, including collection of QC samples and collection of replicate samples to allow for statistical calculations and to capture within-area variability. As described in Appendix B.1.1, "comparisons between duplicate samples will be made by calculating the RPD between concentrations of paired duplicates. If the RPD <30% for concentrations that are >5 times the detection limit, then the duplicate sample results will be considered acceptable. Analyte concentrations in laboratory blank samples will be evaluated in relation to their respective detection limits." See Appendix B.1.1 for more details.

6.12.6 Laboratory Analysis

Chemical analyses will be completed at a CALA accredited analytical laboratory and will include moisture content, pH, particle size distribution, total organic carbon (TOC), total nitrogen, total sulphur, and total metal concentrations, as summarized in Table 3 in Appendix B.1.1.

Toxicity testing will be conducted at a CALA accredited testing laboratory using a 14 day test of the survival and growth of *Hyalella azteca*, which is described in detail in Appendix B.1.1 in Section 4.3.

6.12.7 Data Analysis and Reporting

As described in Appendix B.1.1, data will be provided to the QP and summarized by calculating mean, median, standard deviation, minimum, maximum, and 95th percentile for each analyte for all replicated data. Appendix B.1.1 describes how "sediment quality data will then be evaluated in comparison to British Columbia Working Sediment Quality Guidelines for the protection of aquatic life (BCWSQGs; MOE 2021) and reference concentrations. Reference 95th percentile values will be used to screen exposed-area mean concentrations to efficiently identify analytes with concentrations that are beyond the range of reference.

"The overall interpretation of sediment quality data will include integration of a weight-of-evidence that includes other components of the MPMC CEMP (e.g., water quality data, periphyton data for creeks, benthic invertebrate community data for lakes and creeks). Thus, within the CEMP, sediment quality data interpretation will specifically include the integration of data on sediment quality and the results of bio-assessment (e.g., sediment toxicity testing and benthic invertebrate communities). "

"An interpretive report based on the sediment quality data will be prepared to be integrated into the AER for the Mount Polley Mine that is prepared annually by MPMC (see Section 9.3). The interpretive report will provide all data in an Appendix and will include the data quality review, the results of the screening against

BCWSQG, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots."

6.13 BENTHIC INVERTEBRATE MONITORING

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.13.1 SECTION AUTHORS AND STUDY DESIGN PROFESSIONALS

This section was written by MPMC, and is a summary of the study design and *Proposed Revisions to the Comprehensive Environmental Monitoring Program (CEMP)* provided by Minnow. The detailed study design and *Proposed Revisions to the Comprehensive Environmental Monitoring Program (CEMP)* are provided in Appendices B.1.2 and B.1, respectively. Golder prepared a study design for selecting an alternate reference lake for Polley Lake (Appendix B.4).

6.13.2 MONITORING OBJECTIVES

As outlined in Appendix B.1.2, the objectives of benthic invertebrate monitoring are to:

- "Evaluate the influence of Mount Polley Mine activities on benthic invertebrate communities, productivity, and tissue quality in receiving environments (e.g., Polley Lake, Hazeltine Creek, Edney Creek, and Quesnel Lake) in comparison to baseline and/or reference conditions";
- "Determine potential implications to aquatic life (e.g., through assessment of benthic invertebrate community and productivity endpoints, and comparison of benthic tissue quality results to available guidelines; MoE 2014) and to aquatic ecosystem health by providing supporting information for the assessment of potential effects to higher trophic levels (e.g., fish and fish habitat quality; Section 6.16)"; and,
- "Provide data to support exposure assessment as part of the ERA and HHRA and to support the evaluation of fish habitat productivity identified as a monitoring objective by the Habitat Remediation Working Group (HRWG) for remediated creek areas".

6.13.3 MONITORING OVERVIEW

Benthic invertebrate monitoring under the CEMP is designed to meet the combined needs of:

1) Operational monitoring;
2) Monitoring of the impact of the 2014 TSF embankment breach; and
3) Monitoring of the response to reclamation activity following the TSF embankment breach.

An overview of the proposed benthic invertebrate monitoring program is provided in Table 3 of the study design, and Table 1 of the proposed revisions document included in Appendix B.1, and includes benthic invertebrate community, productivity, and tissue quality. Benthic invertebrate monitoring is focused on

Polley Lake, Hazeltine Creek, lower Edney Creek, Quesnel Lake, and associated reference areas (Figures 7 and 8 of Appendix B.1.2). Table 4 in Appendix B.1.2 summarizes the analytes and laboratory reporting limits for the benthic invertebrate monitoring program.

6.13.4 High-Level Monitoring Design Description

Appendix B.1.2 provides a summary of benthic invertebrate monitoring history previously conducted in the vicinity of the mine in the surrounding lakes and creeks, including baseline, and pre- and post-breach monitoring. The sample collection methods are also summarized in Appendix B.1.2 for community and productivity sampling, and tissue quality sampling. A study design for evaluating alternate reference lakes for Polley Lake is provided in Appendix B.4.

6.13.5 Data Quality Control, Objectives, and Review

Appendix B.1.2 summarizes the QAQC program for the benthic invertebrate monitoring plan. It includes specific QA/QC protocols, including collection of QC samples and collection of replicate samples to allow for statistical calculations and to capture within-area variability. As stated in Appendix B.1.2, "for benthic invertebrate tissue quality samples, comparisons between duplicate samples will be made by calculating the RPD between concentrations of paired duplicates. If the RPD <30% for concentrations that are >5 times the detection limit, then the duplicate sample results will be considered acceptable. Results for laboratory blanks, precision, and accuracy will be evaluated relative to Data Quality Objectives (DQO) established by the analytical laboratory that performed the analyses. Analyte concentrations in laboratory blank samples will be evaluated in relation to their respective detection limits."

"For benthic invertebrate community samples, reanalysis for quality control endpoints (organism sorting efficiency, subsampling precision and accuracy error, and taxonomic identification error) will be performed on 10% of samples, and results of quality control measures will be evaluated relative to pre-established DQOs." See Appendix B.1.2 for more details.

6.13.6 Laboratory Analysis

As described in Appendix B.1.2, "taxonomic identification of benthic invertebrate community samples will be completed by a qualified laboratory certified under the Taxonomic Certification Program of the Society for Freshwater Science (SFS). Benthic invertebrate tissue quality samples will remain frozen until overnight shipment on ice with completed COCs to ALS Environmental, Burnaby BC, which is an analytical laboratory accredited by the CALA."

6.13.7 Data Analysis and Reporting

As described in Appendix B.1.2, data will be provided to the QP and summarized by calculating mean, median, standard deviation, minimum, and maximum for each endpoint for all replicated data. Data analysis will be completed for each monitoring component (community, productivity, and tissue quality). More detail for each monitoring component is provided in Section 4.5 of Appendix B.1.2.

As stated in Appendix B.1.2, "an interpretive report based on the benthic invertebrate data will be prepared to be integrated into the AER for the Mount Polley Mine that is prepared annually by MPMC (see Section 9.3). The interpretive report will provide all data in an appendix and will include the date quality review, the results of the screening against BCWQG, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots."

6.14 PLANKTON AND CHLOROPHYLL *A* MONITORING

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.14.1 SECTION AUTHORS AND STUDY DESIGN PROFESSIONALS

This section was written by MPMC, and is a summary of the study design and *Proposed Revisions to the Comprehensive Environmental Monitoring Program (CEMP)* provided by Minnow. The detailed study design and *Proposed Revisions to the Comprehensive Environmental Monitoring Program (CEMP)* are provided in Appendices B.1.3 and B.1, respectively.

6.14.2 MONITORING OBJECTIVES

As outlined in Appendix B.1.3, the objectives of plankton monitoring are to:

- "Evaluate the influence of Mount Polley Mine activities on phytoplankton (community and productivity) and zooplankton monitoring (community, productivity, and tissue quality) in receiving environments (Polley Lake and Quesnel Lake) in comparison to reference conditions";
- "Determine potential implications to aquatic life (e.g., through assessment of plankton community and productivity endpoints, and comparison of zooplankton tissue quality results to available guidelines; MoE 2014) and to aquatic ecosystem health by providing supporting information for the assessment of potential effects to higher trophic levels (e.g., fish and fish habitat quality; Section 6.16)"; and,
- "Provide data to support exposure assessment as part of the ERA and HHRA".

6.14.3 MONITORING OVERVIEW

Plankton monitoring under the CEMP is designed to meet the combined needs of:

1) Operational monitoring;
2) Monitoring of the impact of the 2014 TSF embankment breach; and
3) Monitoring of the response to reclamation activity following the TSF embankment breach (via potential effects downstream to Quesnel Lake).

An overview of the proposed plankton monitoring program is provided in Table 4 of the study design, and included in Appendix B.1.3, and includes phytoplankton and zooplankton community and productivity, and

zooplankton tissue quality. Plankton monitoring is focused on Polley Lake and Quesnel Lake and associated reference areas (Figure 8 of Appendix B.1.3). Table 5 in Appendix B.1.3 summarizes the analytes and laboratory reporting limits for the plankton monitoring program.

6.14.4 High-Level Monitoring Design Description

Appendix B.1.3 provides a summary of plankton monitoring history previously conducted in the vicinity of the mine in the surrounding lakes, including baseline, and pre- and post-breach monitoring. The sample collection methods are also summarized in Appendix B.1.3 for phytoplankton and zooplankton community and productivity sampling, and zooplankton tissue quality sampling.

6.14.5 Data Quality Control, Objectives, and Review

Appendix B.1.3 summarizes the QAQC program for the plankton monitoring plan. It includes specific QA/QC protocols, including collection of QC samples and collection of replicate samples to allow for statistical calculations and to capture within-area variability. As stated in Appendix B.1.3, "comparisons between duplicate samples will be made by calculating the relative percent difference (RPD) of analyte concentrations between paired duplicates. If the RPD is < 30% for concentrations that are > 5 times the LRL (for chlorophyll-a, tissue quality, and water quality samples), then the duplicate sample results will be considered acceptable. Results for laboratory blanks, precision, and accuracy will be evaluated relative to Data Quality Objectives (DQO) established by the analytical laboratory that performed the analyses. Analyte concentrations in laboratory blank samples will be evaluated in relation to their respective LRLs."

"For plankton community samples, reanalysis for subsampling error and enumeration precision will be performed on 10% of samples, and results of quality control measures will be evaluated relative to pre-established DQOs. Evaluation of subsampling error provides a measure of analytical accuracy by comparing the plankton densities determined by analysis of at least two sub-samples, and of analytical precision by comparing sub-sample derived plankton community numbers with the densities determined for whole plankton community samples. An error of < 20% will be considered acceptable for subsampling." See Appendix B.1.3 for more details.

6.14.6 Laboratory Analysis

Plankton taxonomy samples will be shipped to the following laboratories for processing[2]:

- Biologica environmental Services Ltd., Victoria, BC: plankton taxonomy.
- ALS Environmental Inc., Burnaby, BC[3] – chlorophyll *a* and zooplankton tissue chemistry.

6.14.7 Data Analysis and Reporting

As described in Appendix B.1.3, data will be provided to the QP and summarized by calculating mean, median, standard deviation, minimum, and maximum for each endpoint for all replicated data. Data analysis will be completed for each monitoring component (community, productivity, and tissue quality). More detail for each monitoring component is provided in Section 4.5 of Appendix B.1.3.

[2] No accreditation program exists for plankton taxonomy

[3] Accredited by the Canadian Association of Laboratory Accreditation (CALA)

As stated in Appendix B.1.3, "an interpretive report based on the plankton data will be prepared to be integrated into the AER for the Mount Polley Mine that is prepared annually by MPMC (see Section 9.3). The interpretive report will provide all data in an appendix and will include the date quality review, the results of the screening against BCWQG, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots."

6.15 PERIPHYTON MONITORING

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.15.1 SECTION AUTHORS AND STUDY DESIGN PROFESSIONALS

This section was written by MPMC, and is a summary of the study design and *Proposed Revisions to the Comprehensive Environmental Monitoring Program (CEMP)* provided by Minnow. The detailed study design and *Proposed Revisions to the Comprehensive Environmental Monitoring Program (CEMP)* are provided in Appendices B.1.4 and B.1, respectively.

6.15.2 MONITORING OBJECTIVES

As outlined in Appendix B.1.4, the objectives of periphyton monitoring are to:

- "Evaluate the influence of Mount Polley Mine activities on periphyton productivity in receiving environments (Hazeltine Creek and Edney Creek) in comparison to baseline and/or reference conditions";
- "Determine potential implications to aquatic life through comparison to available guidelines (i.e., chlorophyll-a; MoE 2021) and to literature-based criteria";
- "Support the evaluation of aquatic ecosystem health by providing information for the assessment of potential effects to higher trophic levels (e.g., benthic invertebrates [Section 6.13], fish, and fish habitat quality [Section 6.16])"; and
- "Provide data to support exposure assessment as part of the ERA and HHRA and to support the evaluation of fish habitat productivity identified as a monitoring objective by the HRWG for remediated creek areas."

Periphyton monitoring will include assessment of productivity, with comparison to previous and/or reference conditions, to applicable guidelines (i.e., chlorophyll *a*; MoE 2021), and to literature-based criteria (or classification ranges).

6.15.3 MONITORING OVERVIEW

Periphyton monitoring under the CEMP is proposed to meet the combined needs of:

1) Operational monitoring;

2) Monitoring of the impact of the 2014 TSF breach; and
3) Monitoring of the response to reclamation activity following the TSF breach.

An overview of the proposed periphyton monitoring program is provided in Table 3 and Figure 7 of the study design. Periphyton monitoring is focused on Hazeltine Creek and lower Edney Creek with reference areas identified for each mine-influenced sampling area (i.e., upper Edney Creek and Frypan Creek for upper Hazeltine Creek, and an unaffected area of lower Edney Creek for rehabilitated areas of lower Edney Creek and lower Hazeltine Creek). Table 4 in Appendix B.1.4 summarizes the analytes and laboratory reporting limits for the periphyton monitoring program.

6.15.4 High-Level Monitoring Design Description

Appendix B.1.4 provides a summary of periphyton monitoring history previously conducted in the vicinity of the mine in the surrounding creeks, including pre- and post-breach monitoring. The sample collection methods are also summarized in Appendix B.1.4 for biomass and chlorophyll *a* sampling.

6.15.5 Data Quality Control, Objectives, and Review

Appendix B.1.4 summarizes the QAQC program for the periphyton monitoring plan. It includes specific QA/QC protocols, including collection of replicate samples to allow for statistical calculations and to capture within-area variability. As stated in Appendix B.1.4, the QA/QC review "will confirm that all requested laboratory analyses are complete, that acceptable detection limits have been achieved relative to established targets and relative to relevant British Columbia guidelines (i.e., chlorophyll *a*; MoE 2021), and that the data meets Data Quality Objectives (DQO) established by the analytical laboratory, including laboratory blanks, precision, and accuracy." See Appendix B.1.4 for more details.

6.15.6 Laboratory Analysis

The laboratory responsible for the physical or chemical analyses will be accredited by the CALA for these analyses.

6.15.7 Data Analysis and Reporting

For all replicated periphyton productivity data (typically based on a sample size of five stations per area), data will be provided to the QP and summarized by calculating mean, median, standard deviation, minimum, and maximum for each analyte. More detail for each monitoring component is provided in Section 4.5 of Appendix B.1.4.

As outlined in Appendix B.1.4, "an interpretive report based on the periphyton monitoring data will be prepared to be integrated into the AER for the Mount Polley Mine that is prepared annually by MPMC (see Section 9.3). The interpretive report will provide all data in an appendix and will include the data quality review, the results of the screening against BCWSQG and other guidelines or classification schemes, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots."

6.16 FISH MONITORING

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.16.1 SECTION AUTHORS AND STUDY DESIGN PROFESSIONALS

This section was written by MPMC, and is a summary of the study design and *Proposed Revisions to the Comprehensive Environmental Monitoring Program (CEMP)* provided by Minnow. The detailed study design and *Proposed Revisions to the Comprehensive Environmental Monitoring Program (CEMP)* are provided in Appendices B.1.5 and B.1, respectively.

6.16.2 MONITORING OBJECTIVES

As outlined in Appendix B.1.5, the objectives of fish monitoring are to:

- "Evaluate the influence of Mount Polley Mine activities on fish communities, populations, and tissue quality in receiving environments (Hazeltine Creek, Polley Lake, and Quesnel Lake) in comparison to baseline and/or reference conditions";
- "Determine potential implications to aquatic ecosystem health and human health (e.g., relative to available fish tissue quality guidelines [MoE 2014; CFIA 2015])";
- "Provide data to support exposure assessment as part of the ERA and HHRA"; and,
- "Document fish habitat utilization in creek and lake areas that were physically impacted by the TSF breach (most notably Hazeltine Creek and the lower segment of Edney Creek), thereby addressing fish and fish habitat monitoring objectives identified and reviewed by the HRWG for the remediated creek areas".

From Appendix B.1.5, the evaluation of selenium in fish tissues is triggered under the MDMER EEM (Environment Canada 2012) on the basis of current selenium concentrations in effluent. "The objective of the MDMER EEM fish tissue selenium monitoring program is to evaluate fish tissue selenium concentrations in comparison to reference conditions and to determine potential implications to aquatic ecosystem health and human health (e.g., relative to available fish tissue quality guidelines [MoE 2014; CFIA 2015])."

6.16.3 MONITORING OVERVIEW

Fish monitoring under the CEMP is designed to meet the combined needs of:

1) Operational monitoring (including the discharge of treated effluent to Quesnel Lake);
2) Monitoring of the impact of the 2014 TSF embankment breach; and
3) Monitoring of the response to remediation following the TSF embankment breach.

As previously indicated, fish monitoring includes fish tissue quality monitoring, sentinel fish population monitoring, fish habitat characterization and fish usage monitoring, and fish community monitoring. An

overview of the proposed fish monitoring program is provided in Table 8 and Figures 7 and 8 of the study design Table 9 in Appendix B.1.5 summarizes the fish tissue analytes and laboratory reporting limits for the fish monitoring program.

6.16.4 High-Level Monitoring Design Description

Appendix B.1.5 provides a summary of fish monitoring history previously conducted in the vicinity of the mine in the surrounding creeks, including baseline monitoring, and pre- and post-breach monitoring. The sample collection methods and monitoring are also summarized in Appendix B.1.5 for tissue sampling, sentinel fish population monitoring, fish community monitoring, and fish habitat characterization and usage monitoring.

6.16.5 Data Quality Control, Objectives, and Review

Appendix B.1.5 summarizes the QAQC program for the fish monitoring plan. It includes specific QA/QC protocols, including collection of QC samples and collection of replicate samples to allow for statistical calculations and to capture within-area variability. For fish tissue samples, comparisons between duplicate samples will be made by calculating the RPD between concentrations of paired duplicates. If the RPD <30% for concentrations that are >5 times the detection limit, then the duplicate sample results will be considered acceptable. Specific QC samples will include laboratory blanks, laboratory replicates, and laboratory accuracy samples (i.e., matrix spikes, laboratory control samples, and/or certified reference materials). The QC sample results will be assessed as part of the data quality review. See Appendix B.1.5 for more details.

6.16.6 Laboratory Analysis

All chemical analyses will be completed by a laboratory that is accredited by CALA, and will be required to include specific QC samples and report associated results.

6.16.7 Data Analysis and Reporting

Catch-per-unit-effort and summary statistics for meristic measurements taken in the field will be calculated. Although community and population data are collected during every phase or component of the fish monitoring program, the sample size will be defined by the study objectives and may be insufficient to address corollary questions. For example, the sample size required for tissue quality analyses (n = 8) is not large enough to support formal contrasts of population endpoints. To this end, evaluation of fish community data in these instances (e.g., associated with tissue quality monitoring objectives) will rely on qualitative comparisons. Data collected for the assessment of fish community and population in Polley Lake, Hazeltine Creek, and Edney Creek will include a level of replication that enables formal statistical comparisons of fish health endpoints (as described in Appendix B.1.5). These statistical comparisons will include evaluation of body size (fork length and body weight), energy storage (as condition [weight-at-length], and length-frequency distributions. Summary statistics, including mean, median, minimum, maximum, standard deviation, and sample size, will be calculated for fish age, fork length, total length, and body weight by area, species, and year.

"For the fish tissue data sets, statistical comparisons of age, length, weight, and concentrations of metals in fish tissues (n = 8) will be completed among years and locations. The sample size, mean, median, standard deviation, minimum, and maximum will be calculated for each analyte. Means will be calculated using the Kaplan-Meier (K-M) method. The standard deviation and the median for each analyte will also be calculated using the K-M method. When a standard deviation cannot be estimated (i.e., when an analyte has a high proportion of censored values), it will be reported as "not calculated".

"Results of the fish habitat characterizations for Upper Hazeltine, Lower Hazeltine, and Lower Edney creeks will be summarized, along with fish usage results, according to season (spring, summer, and fall) and year. Fish habitat characterization measures will be summarized by season, reach, and area (rehabilitated and reference), with summary statistics (mean and standard deviation) calculated for all numerical parameters."

More detail for each monitoring component is provided in Section 4.5 of Appendix B.1.5.

An interpretive report based on the fish monitoring data was prepared to be integrated into the AER for the Mount Polley Mine that is prepared annually by MPMC (see Section 9.3). The interpretive report will provide all data in an appendix and will include the data quality review, the results of the screening against BCWQGs, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots.

A summary of historical results regarding Hazeltine Creek spawning surveys can be found in Section 2 of the study design.

6.17 WILDLIFE MONITORING

Wildlife monitoring described below includes observational monitoring and monitoring using wildlife cameras. A study design for wildlife monitoring in the Hazeltine Creek corridor was provided in 2020 and updated in 2021. See Appendix B.2 for updated wildlife monitoring study designs.

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.17.1 SECTION AUTHORS AND STUDY DESIGN PROFESSIONALS

This section was written by MPMC (wildlife observations), DWB (small and large mammals) and Golder (tissue collection and food chain model – related to follow up tasks for the ERA).

6.17.2 MONITORING OBJECTIVES

The current objective of the wildlife monitoring is to document the presence of mammals and birds using or migrating through the mine site and adjacent areas and seeks to develop a quantitative monitoring methodology to specifically address the Technical Working Group comments in Condition 18 (Re: Approval of the Comprehensive Environmental Monitoring Plan, dated October 31, 2019, ENV 2021). This information

is used to monitor the potential for effects of mine-related activities on animals in the area and evaluate wildlife recovery by area and reclamation type.

The study design concept in Appendix B.2 focuses on reducing the sources of uncertainty from the terrestrial ERA (Golder 2017). The study design concept in Appendix B.2 focuses on usage and recovery in areas affected by the TSF dam failure.

6.17.3 Monitoring Overview

Wildlife occurrences will be recorded throughout the year by MPMC Environmental Department staff, and by other MPMC employees and contractors, when possible. Observations will include wildlife sightings and evidence of wildlife, such as tracks and droppings. Documentation will include the date, initials of the observer, location of the observation, wildlife observed, and comments (such as size of group, sex, or activity of an animal).

Data files from wildlife cameras installed in target areas (Hazeltine Creek, Mine Site, Reference site) are downloaded and reviewed periodically. Any changes to the location of the cameras are documented. Details including frequency of use by wildlife near each camera and variety of wildlife are documented. These details will be included in the AER.

6.17.4 High-Level Monitoring Design Description

Table 6.30 is a summary of previous wildlife monitoring undertaken and includes recommendations for future monitoring. Further rationale is provided in the following sub-sections, if appropriate, and is referenced in the table where applicable.

Table 6.30 Summary of wildlife monitoring and findings

Summary of Monitoring and Findings	Monitoring Objective		
	Operational	**Post-Breach**	**Reclamation**
Previous monitoring undertaken	General wildlife observations (animals, scat, and tracks) documented.	N/A	N/A
Summary of findings	734 observations of wildlife were documented in 2017.	N/A	N/A
Recommendations for 2023-2025 monitoring	General wildlife observations will continue to be made per Permit requirements. Continue to implement large and small mammal studies.	Reconnaissance-level field surveys to support updated food chain modelling for potential bioaccumulation in wildlife.	N/A

Notes: N/A: not applicable

6.17.4.1 POST-BREACH MONITORING

In 2018, a reconnaissance-level survey was undertaken to support an update of the food chain model first presented in the ERA. Soil sampling is presented in Section 6.19, soil invertebrate sampling in Section 6.20, and vegetation monitoring in Section 6.21. An additional component considered in the food chain model was flying insects.

Samples of flying invertebrates (bees/wasps [order Hymenoptera], moths [order Lepidoptera], and crickets/grasshoppers [order Orthoptera]) were collected from the impacted area and background areas. Information about the tissue chemistry of this important food item for insectivorous birds and bats was not previously available in Golder (2017). The samples were collected through a combination of manual foraging and trapping. Manual foraging generally involved surveying flowering plants for bees or the ground surface for grasshoppers and using a sweep net to capture target invertebrates. Moths were predominantly collected using black light traps. Terrestrial invertebrate trapping was conducted using methods adapted from the RISC guidelines for terrestrial arthropod inventory (RIC 1998), guidance from the Biological Survey of Canada (Marshall et al. 1994; Danks 1996) and the US Department of Agriculture (Schauff 1998). Terrestrial invertebrate trapping methods employed on the Site included malaise traps, black light traps, pan/window traps and Berlese funnels.

Irrespective of the specific capture method, the following steps consistent with the *BC Field Sampling Manual* (BC ENV 2013) were followed to process the flying invertebrate samples:

- Samples were collected using nitrile gloves and transferred to clean Ziploc bags.
- Flying invertebrates of the same order from a single sample location (limited to 25 meters squared [m2]) were composited.
- Flying invertebrates were left in sample containers stored at ambient temperature overnight to allow samples to depurate.
- Flying invertebrate samples were rinsed using DI water and blotted dry with lint-free wipes before being transferred to clean Ziploc bags.
- Samples were transferred to a freezer to kill the invertebrates.
- Samples were kept frozen until they were submitted to the laboratory for analysis.

The invertebrate tissue samples were submitted for analysis of metals and moisture content, and the data were used, with other data collected as part of the reconnaissance survey, to update the food chain model developed to evaluate the potential for bioaccumulation of metals in wildlife. The food chain model update is described in Section 6.17.7.

6.17.5 DATA QUALITY CONTROL, OBJECTIVES, AND REVIEW

Wildlife observations data will undergo a QC screening prior to upload to the network.

Twelve duplicate flying invertebrate samples were collected and laboratory QC samples consisted of duplicates, method and equipment blanks, and certified reference materials. RPDs exceeded DQOs for most metals in at least one duplicate sample. A higher variability in flying invertebrate samples is expected because the field duplicates are not splits of a composite—they are two composites of different individual organisms. In terms of copper, RPDs of 58 and 86% were noted in two of twelve duplicate pairs for wet weight concentrations and in one of twelve (RPD = 50%) of dry weight concentrations. For vanadium, RPDs of 65 to 126% were noted in three of twelve duplicate sample pairs for wet weight concentrations and in zero of twelve duplicate sample pairs for dry weight. The data were considered reliable and suitable for their intended purpose.

6.17.6 Laboratory Analysis

Laboratory analyses of the invertebrate tissue samples were undertaken by a CALA-accredited laboratory.

6.17.7 Data Analysis and Reporting

The number of wildlife observations will be tabulated and reported in the AER.

The flying insect chemistry data (Golder 2019a) and updated food chain model (Golder 2019b) were submitted to ENV as an attachment to the 2018 Environmental and Reclamation Report (the "2018 Annual Report").

The wildlife food chain model presented in the ERA (Golder 2017) provided screening-level risk estimates for receptors exposed to copper and vanadium (the only contaminants of concern identified in the ERA), which were based on calculated area-weighted hazard quotients (HQs) of <1 to 2.8, and a maximum HQ of 5.1 (for masked shrew in the Polley Flats area). Although the HQs were considered not to represent an unacceptable risk to wildlife, the food chain model was refined in 2018 by:

- Adding bats (*Myotis* sp.) as a receptor.
- Improving the quality of information with respect to tissue concentrations in invertebrates and plants by expanding the existing bioaccumulation sampling (as part of the reconnaissance-level survey conducted in 2018).
- Replacing the conservative assumption that flying insects have the same tissue concentrations as soil-dwelling insects by collecting site-specific data (as part of the reconnaissance-level survey conducted in 2018).
- Refining the toxicity reference values (i.e., the denominator in the HQ) to consider more than a highly conservative threshold.

Revised screening-level risk estimates resulted in lower HQs. Screening-level HQs were <1 for all receptors except robin, shrew, and bat exposed to copper. The aggregate area-weighted HQs for those three receptors ranged from 1.0 to 1.7, and the maximum observed HQ for a sub-area was 2.1 for robin in the Polley Flats area. When a refined TRV was used to provide an additional level of protection to listed species, no HQs greater than 1 were identified and therefore, risks to wildlife associated with copper and vanadium in soils at the site are considered to be acceptable.

6.18 AMPHIBIAN AND REPTILE MONITORING

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.18.1 SECTION AUTHORS AND STUDY DESIGN PROFESSIONALS

This section was written by Golder. The detailed study design concept is provided in Appendix B.3. Note that Appendix B.3 is a study design concept; a study design may be submitted at a later date depending on results of a preliminary review (Steps 1 and 2 as outlined in Figure 1 in Appendix B.3).

6.18.2 MONITORING OBJECTIVES

The study design concept in Appendix B.3 focuses on reducing the sources of uncertainty from the terrestrial ERA (Golder 2017). As outlined in Appendix B.3, the objectives of amphibian monitoring will be to "continue the risk assessment process by proceeding through tiers to the point needed to support an informed risk management decision". More detail is provided in Appendix B.3.

6.18.3 MONITORING OVERVIEW

A tiered approach has been recommended, as outlined in Appendix B.3. Only Steps 1 and 2 will be completed as part of the current CEMP, with Step 1 undertaken in 2018. If risks are found to be unacceptable at the end of Step 2, further investigation following the proposed tiered approach described in Appendix B.3 will be conducted, which may include a development of a study design.

6.18.4 HIGH-LEVEL MONITORING DESIGN DESCRIPTION

In 2018, Step 1 of the study design concept was undertaken, specifically, a hazard evaluation. Existing soil, sediment and surface water chemistry data were screened for different habitat units against a conservative amphibian-specific screening value, as follows:

1. Review of existing guidelines: the purpose of the review was to determine if existing guidelines, criteria or standards contained sufficient amphibian-specific data to allow their use as a screening value for this assessment.
2. Derivation of screening values: the existing guidelines were determined to be unsuitable for the amphibian hazard assessment, and therefore screening values were developed through the review of scientific literature. Toxicity testing data were compiled, an uncertainty analysis was conducted on the compiled data, and safety factors were applied as applicable to mitigated identified uncertainties.
3. Application of derived screening values to site data: site monitoring data for water, sediment and soils were compared to the screening values for water and hydric soils/sediment.

6.18.5 Data Quality Control, Objectives, and Review

The study was a desktop review of guideline derivation documents and scientific literature.

6.18.6 Laboratory Analysis

No laboratory analysis were undertaken as part of the amphibian hazard assessment.

6.18.7 Data Analysis and Reporting

The amphibian hazard assessment (Golder 2019c) was submitted to ENV as an attachment to the 2018 Annual Report, prepared in fulfillment of *Mines Act* Permit M-200, and *EMA* Permit 11678. In summary, a toxicity reference value of 0.018 mg/L dissolved copper was derived for evaluating hazards associated with surface water, and 800 mg/kg copper for evaluating hazards associated with hydric soils or sediment. The available surface water and soil data for the Mount Polley site were compared to these conservative screening values, and overall, there was no evidence that environmental concentrations were routinely or notably higher than those screening value on a site-wide basis. Hazards to amphibians as a result of exposure to soil or surface water are considered to be low under these circumstances.

6.19 Soil Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.19.1 Section Authors and Study Design Professionals

This section was written by Golder, and the detailed study design concept is provided in Appendix B.2.

6.19.2 Monitoring Objectives

The study design concept in Appendix B.2 focuses on reducing the sources of uncertainty from the terrestrial ERA (Golder 2017). As outlined in Appendix B.2, the objective of soil monitoring will be to "refine site-specific relationships between copper concentrations in soil and copper concentrations in various soil invertebrate and plant tissues". More detail is provided in Appendix B.2.

6.19.3 Monitoring Overview

Monitoring of soil stockpiles on the mine site for reclamation and closure is outlined in the Soil Management Plan included in the RCP. It is covered under BC *Mines Act* Permit M-200.

In 2018, Task 1A of the study design concept was undertaken, specifically, a reconnaissance-level sampling program.

6.19.4 High-Level Monitoring Design Description

Operational Sampling - Monitoring of soil stockpiles on the mine site for reclamation and closure is outlined in the Soil Management Plan included in the RCP. It is covered under BC *Mines Act* Permit M-200.

Supplemental Sampling - Soil samples were collected from 69 locations (co-located with tissue samples – described in Sections 6.20 and 6.21) to refine the exposure estimate for post-breach rehabilitated areas. The soil chemistry data were used, with other data collected as part of the reconnaissance survey, to update the food chain model developed to evaluate the potential for bioaccumulation of metals in wildlife. The food chain model update is described in Section 6.17.

Each sample was a composite of three aliquots of soil collected from within a 5 m radius of the tissue sample. The aliquots were collected from the top 20 cm of soil using a hand shovel, and then homogenized in a stainless-steel bowl prior to transfer to clean, laboratory-supplied 125-mL, glass sample jars with Teflon™ lined lids. Samples were kept on ice in a cooler after collection and kept cool until submitted to ALS for analysis of metals and pH.

6.19.5 Data Quality Control, Objectives, and Review

Supplemental soil sampling was undertaken using methods consistent with those used for the HHRA and ERA. Eight field duplicates were collected and laboratory QC consisted of duplicates, method blanks and matrix spike recovery. Copper and vanadium (the metals of interest for the food chain model) met the field DQOs. The soil sample results met the laboratory DQOs for precision, accuracy, method blanks, duplicate sample analysis and matrix spike recovery, with the exception of a method blank that had a detected concentration of copper. This could be a potential bias in samples that are near the limit of reporting but was not an issue in the current samples because all copper results were substantially higher than detection limits. Overall, the data were considered representative and suitable for their intended use.

6.19.6 Laboratory Analysis

Laboratory analyses were undertaken by a CALA-accredited laboratory.

6.19.7 Data Analysis and Reporting

The results of the reconnaissance survey (Golder 2019a) were submitted to ENV as an attachment to the 2018 Annual Report. Data from the 2018 soil sampling were integrated with the relevant historical data to update the soil concentrations used in the food chain model. All samples were compared to the applicable CSR standards, and an overview of those findings is provided below for each of the different rehabilitated areas that were sampled in Tables 1 through 3. Overall, the results of the soil chemistry were consistent with results from previous sampling in those areas and no new contaminants of concern were identified. The use of the soil chemistry data is further discussed in Section 17 (vis-à-vis the food chain model update).

6.20 SOIL INVERTEBRATE MONITORING

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description; data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.20.1 SECTION AUTHORS AND STUDY DESIGN PROFESSIONALS

This section was written by Golder, and the detailed study design concept is provided in Appendix B.2.

6.20.2 MONITORING OBJECTIVES

The study design concept in Appendix B.2 focuses on reducing the sources of uncertainty from the terrestrial ERA (Golder 2017). As outlined in Appendix B.2, the objectives of soil invertebrate monitoring will be to:

- "Focus on establishing a long-term trend analysis of soil invertebrate community rather than to support a multitude of pair-wise comparisons that would have limited value for making site management decisions";
- "Refine site-specific relationships between copper concentrations in soil and copper concentrations in various soil invertebrate tissues"; and,
- "Improve the quality of data with respect to tissue concentrations in invertebrates, particularly for flying insects."

6.20.3 MONITORING OVERVIEW

In 2018, Task 2A of the study design concept was undertaken, specifically, a reconnaissance-level sampling program.

6.20.4 HIGH-LEVEL MONITORING DESIGN DESCRIPTION

Additional sampling was conducted to improve the spatial coverage of soil invertebrate samples, and to obtain sufficient samples of each main invertebrate type from the range of soil concentrations present at the site. Invertebrate (i.e., ants, beetles, spiders and worm) samples were collected through a combination of manual foraging and trapping. Manual foraging involved surveying the ground surface and searching below woody debris. Sampling was conducted if sufficient volume of soil invertebrates were noted or if a larger soil invertebrate (e.g., a large beetle) was found.

Terrestrial invertebrate trapping was conducted using methods adapted from the RISC guidelines for terrestrial arthropod inventory (RIC 1998), guidance from the Biological Survey of Canada (Marshall et al. 1994; Danks 1996) and the US Department of Agriculture (Schauff 1998). These documents guided the selection of the trapping method, locations of samples, sampling design and trapping protocols. Terrestrial invertebrate trapping methods employed on the Site included pitfall traps and Berlese funnels. Irrespective of the specific capture method, the following steps consistent with the *BC Field Sampling Manual* (BC ENV 2013) were followed to process the soil invertebrate samples:

- Samples were collected using nitrile gloves and transferred to either clean, laboratory supplied glass jars or clean Ziploc bags.
- Invertebrates of the same order from a single sample location (limited to 25 m^2) were composited.
- Soil invertebrates were left in partially open sample containers stored at ambient temperature overnight to allow samples to depurate.
- Invertebrate samples were rinsed using DI water and blotted dry with lint-free wipes before being transferred to clean Ziploc bags.
- Samples were transferred to a freezer to kill the invertebrates.
- Samples were kept frozen until they were submitted to the laboratory for analysis.

The soil invertebrate tissue samples were submitted for analysis of metals and moisture content, and the data were used, with other data collected as part of the reconnaissance survey, to update the food chain model developed to evaluate the potential for bioaccumulation of metals in wildlife. The food chain model update is described in Section 6.17.

6.20.5 Data Quality Control, Objectives, and Review

Soil invertebrate sampling were undertaken using methods consistent with those used for the HHRA and ERA. Eight field duplicates were collected and laboratory QC consisted of duplicates, method blanks and certified reference materials. RPDs were greater than 50% for most metals in at least one duplicate sample. A higher variability in soil invertebrate samples is expected because the field duplicates are not splits of a composite—they are two composites of different individual organisms. In terms of copper, an RPD of 65% was noted for the wet weight concentration in one duplicate pair, but the dry weight data had an acceptable RPD (48%). There was less variability in copper results than most other metals, and Golder concludes that the data are reliable and suitable for its intended purpose. RPDs of 55 to 106% were noted in four of eight duplicate sample pairs for wet weight concentrations and in two of eight duplicate sample pairs for dry weight with respect to vanadium. However, this variability does not impact the overall conclusion that vanadium bioaccumulation is limited, nor does it change the conclusion that vanadium risks to wildlife from consumption of dietary items was low. The tissue samples met the laboratory DQOs with respect to copper and vanadium (the parameters of interest for the food chain model).

6.20.6 Laboratory Analysis

Laboratory analyses were undertaken by a CALA-accredited laboratory.

6.20.7 Data Analysis and Reporting

The results of the reconnaissance survey (Golder 2019a) were submitted to ENV as an attachment to the 2018 Annual Report. The use of the soil chemistry data is further discussed in Section 17 (vis-à-vis the food chain model update).

6.21 Vegetation Monitoring

The following sections give a synopsis of the objectives; sample locations along with parameters measured, site description, sampling frequency, and applicable guidelines; a high-level monitoring design description;

data quality control, objectives, and review; laboratory analysis; and data analysis and reporting, where applicable.

6.21.1 Section Authors and Study Design Professionals

This section was written by MPMC, and is a summary of the study design concept provided by Golder. The detailed study design concept is provided in Appendix B.2. Note that Appendix B.2 is a study design concept; a study design was submitted in December 2019 after completion of tasks outlined in Figure 2 in Appendix B.2. The detailed study design for terrestrial wildlife monitoring is provided in Appendix B.2.

6.21.2 Monitoring Objectives

The study design concept in Appendix B.2 focuses on reducing the sources of uncertainty from the terrestrial ERA (Golder 2017). As outlined in Appendix B.2, the objectives of vegetation monitoring will be to:

- "Focus on establishing a long-term trend analysis of plant community rather than to support a multitude of pair-wise comparisons that would have limited value for making site management decisions"; and,
- "Refine site-specific relationships between copper concentrations in soil and copper concentrations in various plant tissues."

More detail is provided in Appendix B.2.

6.21.3 Monitoring Overview

In 2018, Task 2A of the study design concept was undertaken, specifically, a reconnaissance-level sampling program.

6.21.4 High-Level Monitoring Design Description

Samples of the edible portions of plants (were collected following the same approach used in 2015 and 2016. The focus of plant sampling was on rehabilitated areas to increase sample density in these areas and to provide more information about plants growing in soils that have lower copper concentrations than the non-reclaimed areas. The following plant tissue samples were collected in 2018:

- Berry—Berry samples were collected from raspberry [*Rubus occidentalis]*, high bush cranberry [*Viburnum trilobum*], and thimbleberry [*Rubus parviflorus*]) plants that were rooted in soil.
- Leaf—Willow (*Salix* sp.) and alder (*Alnus crispa*) leaf samples were collected from shrubs planted in the impacted area. Only shrubs planted in the floodplain before spring 2016 were sampled. Plants sampled included willow planted in lower Hazeltine Channel in early 2015, above the canyon in late 2015, and in upper Hazeltine Channel late 2015 (near Gavin Lake Bridge).
- Grass— Slender wheatgrass *(Elymus trachycaulus*) samples were collected from a variety of areas. The objective of the sampling was to reduce the uncertainty in the existing soil-to-grass bioaccumulation relationship, and therefore, sampling was limited to a single species which was

commonly found across the entire site. Only the edible, above-ground portion of grass was collected.

Sampling methods were consistent with the *BC Field Sampling Manual* (MoE 2013) and consisted of the following steps:

- Plant tissue was hand-picked by field staff using nitrile gloves from an area of 25 m^2 or less. Plant tissue was composited from multiple plants within the area if sufficient volume could not be collected from one plant.
- Plant samples were rinsed using DI water and blotted dry with lint-free wipes before being transferred to clean Ziploc bags.
- Samples were placed in a cooler containing ice until they could be transferred to a freezer for storage prior to shipping to the laboratory for analysis.

The plant tissue samples were submitted for analysis of metals and moisture content, and the data were used, with other data collected as part of the reconnaissance survey, to update the food chain model developed to evaluate the potential for bioaccumulation of metals in wildlife. The food chain model update is described in Section 6.17.

6.21.5 Data Quality Control, Objectives, and Review

Vegetation sampling was undertaken using methods consistent with those used for the HHRA and ERA. Five replicate plant samples were collected and laboratory QC consisted of duplicates, method blanks and certified reference materials. Data quality objectives were met for copper and vanadium (the parameters of interest for the food chain model) in vegetation samples for both field and laboratory QC samples.

6.21.6 Laboratory Analysis

Laboratory analyses were undertaken by a CALA-accredited laboratory.

6.21.7 Data Analysis and Reporting

The results of the reconnaissance survey (Golder 2019a) were submitted to ENV as an attachment to the 2018 Annual Report. The use of the soil chemistry data is further discussed in Section 17 (vis-à-vis the food chain model update).

6.22 Biosolids Monitoring

MPMC is in possession of an *EMA* permit (15968) for the use of biosolids. This permit requires that MPMC retain the services of a qualified professional to develop a monitoring plan for the biosolids application program. MPMC will submit this plan to ENV and EMLI prior to any land application of biosolids at the mine site.

7 CEMP UPDATES AND REVISIONS

When possible, MPMC will provide written notice of planned changes to the CEMP to the ENV Director a minimum of 30 days prior to implementation to allow for review and feedback on the revision. Proposed changes will be shared with First Nations and stakeholders, as per MPMC's Communication Plan (MPMC 2016d). Additionally, changes that occur but are unplanned, such as the collection of additional samples, will be discussed with the ENV Director as soon as possible after the sampling occurs. When changes are made to the monitoring, this amended plan (or relevant replacement pages) will be resubmitted to the Director.

Given the dynamic nature of environmental investigation, rehabilitation, and water management plan development at Mount Polley Mine, it is anticipated that the CEMP will evolve in alignment with site activities and findings, as described in Section 2.3, and will be updated as required. It is anticipated that larger CEMP revisions in response to these activities and findings will be made with consideration of maintaining continuity in spatial and temporal coverage to meet the global objectives of the CEMP, as described in Section 1.1.

As required by the Permit, following the three-year detailed monitoring program interpretive report to the Director, MPMC will submit a summary of proposed changes to the CEMP to the Director by April 30 of that year (one month following the interpretive report deadline). In order to incorporate recommended changes in a timely fashion, MPMC would appreciate feedback on the proposed changes from the ENV by May 31 of that year.

8 RECLAMATION AND REMEDIATION

Rehabilitation of the aquatic and terrestrial receiving environments that were impacted by the TSF embankment breach and associated remediation activities is continuing as outlined in the Remediation Plan, Mount Polley Mine Perimeter Embankment Breach (Golder, 2019). Overview as follows:

- The Remediation Plan identifies the proposed remedial options, and it outlines the rationale to select the preferred options where those have not already been selected during previous or ongoing work (e.g., by the HRWG). The Remediation Plan is a requirement of the Ministry of Environment & Climate Change Strategy (ENV) Pollution Abatement Order (107461) which requires a Remediation Plan that:
    - Summarizes the remedial planning basis.
    - Summarizes remedial actions that have already been carried out, including a description of the process and criteria that were used to evaluate options for remedial work that has been undertaken.
    - Identifies the proposed remedial actions based on the results, conclusions and recommendations from the detailed site investigation, the human health risk assessment, and ecological risk assessment as delineated by area as defined in the Update Report: Post-Event Environmental Impact Assessment Report.
    - Summarizes consultation on the remedial objectives and how the feedback received from that consultation has been accommodated within the remedial planning basis.
    - Provides an implementation schedule.
    - Provides a monitoring and reporting framework that will be integrated into the CEMP that is required in accordance with Permit 11678.

Monitoring associated with the Hazeltine Creek channel rehabilitation construction activity has concluded and was undertaken under the *Post-Breach Rehabilitation Work Environmental Management Plan* (Golder 2015f), which pertains to monitoring of any construction works and associated construction specifications, and the Remediation Plan (Golder, 2019).

As Hazeltine Creek is rehabilitated and returned to fish-bearing status, this environmental management plan will be phased out and be replaced by routine monitoring for evaluating performance of the works as a component of the CEMP.

The steps in the aforementioned terrestrial rehabilitation plan include establishment of permanent monitoring plots for ongoing assessment, feedback (to inform adaptive management) and demonstration. As terrestrial rehabilitation works progress, monitoring to this end will be implemented.

9 REPORTING

9.1 MONTHLY REPORTING

As required by Section 4.1 in the Permit (December 1, 2022) a monthly report will be submitted to the Director in each month that discharge occurs. The report will summarize the volume of treated effluent

discharged, a summary of continuous turbidity readings of the treated effluent discharged, and the most recently available water quality results for the effluent discharged, including a summary of acute and/or chronic toxicity testing results. A statement outlining the number of exceedances of permitted discharges that occurred during the reporting period, the dates of each exceedance, an explanation as to the cause of the exceedances, and a description of the measures taken to rectify the cause of each such exceedance will also be included in the report.

9.2 Quarterly Reporting

All data and information collected under the CEMP will be provided to the Director, in electronic format, on a quarterly basis or as required by the Permit.

9.3 Annual Reporting

As required by the Permit Section 4.2, MPMC will continue to submit an AER to ENV on or before March 31 of each year. In addition, an ARR, as required under the M-200 permit, will be prepared and submitted to EMLI on or before March 31 of each year. These reports will include the details required by the permit, as well as an analysis of the linkages between program components, where appropriate. MPMC will refer to *Technical Guidance 4, Environmental Monitoring under the Environmental Management Act* such that the ENV's expectations for reporting are achieved.

The AER will continue to be in a format suitable for public release and will be deposited at the Cariboo Regional District Library as well as submitted to the XFN and WLFN within 30 days of being submitted to the ENV.

As required by the Permit (December 1, 2022), MPMC will continue to review annually the Environmental Emergency Response Plan and Annual Discharge Plan and will submit any changes to the Director.

9.4 Three-Year Reports

Under the Permit, a detailed monitoring program interpretive report is required every three years with the next report due on March 31, 2025 and every three years thereafter. the first report was submitted in March 2019 and included data collected in 2016, 2017, and 2018. The next report will be completed by one or more qualified professionals and will be more comprehensive than the synoptic review of data presented in the annual reports. It will include recommendations for changes to the CEMP.

In addition, a groundwater monitoring program review including, but not limited to, sampling, well locations, site water balance, interpretation of data trends, and suitable recommendations is required every three years, with the first presented in March 2016. The next report will be submitted on March 31, 2025. Monitoring data and the analysis of those data presented in the report will be reviewed by a third party qualified professional.

10 FUTURE OUTLOOK

This CEMP represents a unique and specialized variation of a typical mine environmental monitoring plan. This plan seeks to integrate all environmental monitoring programs that are carried out on the Mount Polley mine site and in the local area related to:

(a) Ongoing mine operations (including *EMA* and *Mines Acts* permit requirements and MDMER requirements of the *Fisheries Act*);
(b) TSF embankment breach-related impacts and remediation; and,
(c) Reclamation and closure planning (*Mines Act* permit requirement).

The overall goals of this CEMP are to provide science-based evidence: for evaluation of environmental impacts of mine operations; for evaluation of the effects of any ongoing impacts of, and remediation measures undertaken in response to, the TSF embankment breach; and to inform ongoing reclamation and closure planning. These goals are guided by an intent to return the impacted areas of the mine site and its surroundings to viable and diverse ecosystems that reflect pre-breach land uses, or those identified by Communities of Interest as representing values of importance. These values of importance are identified through ongoing consultation with local Communities of Interest.

Mount Polley fosters a culture of research and innovation. In addition to the extensive monitoring and research work that was undertaken as part of the impact and risk assessments of the TSF embankment breach, there are a number of research projects underway (and several recently completed) that the mine has supported. The results of these projects may contribute directly to improving the mine's understanding of breach impacts (Cuervo et al, 2017; Garris et al, 2018; Byrne et al, 2018), new approaches to remediation, reclamation and closure (McMahen, PhD UBC; Litke MASc, UBC), and to mitigating environmental impacts of ongoing operations.

With respect to mitigating environmental impacts of ongoing operations and planning for reclamation and closure, Mount Polley is embarking on passive water treatment research and pilot projects to test the suitability of constructed wetland water treatment systems for dispersed water treatment and discharge on the mine site. These research projects may include lab and site testing, monitoring of water quality, vegetation, and microbial communities, and will be reported annually in the AER or in a technical memo.

As the results of monitoring programs and environmental research projects are generated, analyzed, and interpreted, this CEMP will be reviewed and updated where warranted. MPMC will aim to review the requirements of the CEMP on a quarterly basis and will submit a list of proposed changes based on the review to the Director within 45 days from the end of the quarter.

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Appendix A

CEMP Terms of Reference – 4 July 2017

Mount Polley Mining Corporation

Mount Polley Mining Corporation
an Imperial Metals company

Terms of Reference

Comprehensive Environmental Monitoring Plan – 4 July 2017

1 BACKGROUND AND CONTEXT

Mount Polley Mining Corporation (MPMC) is the owner and operator of the Mount Polley Mine, a property comprising, among other things, a copper-gold mine and mill complex located near Likely, British Columbia (BC).

MPMC is authorized by the BC Ministry of Environment (MoE) to discharge effluent to the land and to surface water from the Mount Polley Mine, subject to the terms and conditions of *Environmental Management Act* (*EMA*) Permit 11678. *EMA* Permit 11678 was originally issued to MPMC by the MoE on 30 May 1997, and has been the subject of numerous amendments since.

As is typical of owners of mines in BC, MPMC undertakes extensive environmental monitoring for a variety of purposes and objectives. In many instances, data collected as part of one monitoring program are beneficial to other programs, even though programs may have been established specifically for unique purposes.

Under Section 3.2 of *EMA* Permit 11678, MPMC is required to implement a Comprehensive Environmental Monitoring Plan (CEMP). In previous versions of *EMA* Permit 11678, MPMC was required to implement a number of individually defined monitoring plans for various aspects of Mount Polley Mine operations to which this MoE authorization was subject. As stated in Section 3.2 of *EMA* Permit 11678, the CEMP is intended to consolidate and integrate all such pre-existing monitoring programs.

2 OBJECTIVES AND DRIVERS

As described in Section 3.2 of *EMA* Permit 11678, the objective of the CEMP is to evaluate the effects of mining-related activities on the physical, chemical and biological characteristics of Hazeltine Creek, Edney Creek, Bootjack Lake, Morehead Creek, Polley Lake, Quesnel Lake, Quesnel River, and associated riparian and upland areas.

Environmental monitoring has the broad objective of verifying that environmental controls are in place that protect the environment and are sufficient to confirm compliance with applicable statutory requirements to which operations are subject. Environmental monitoring also has the broad objective of providing data to support evidence-based communication to parties who might be affected by the Mount Polley Mine.

For the Mount Polley Mine, the main drivers (which govern the objectives) are:

- Regulatory Drivers;
    - Federal (e.g., *Metal Mining Effluent Regulation* [MMER])
    - Provincial (e.g., *EMA, Mines Act*)
- MPMC Commitments:
    - The respective Participation Agreements (PAs) that MPMC have in place with the Soda Creek Indian Band (SCIB; Xatśūll First Nation) and the Williams Lake Indian Band (WLIB).

Subject to the requirements of the various drivers, the CEMP is intended to be an adaptive plan. This means that the CEMP is anticipated to change over time, as it is informed by findings obtained from preceding stages of work.

3 SCOPE AND CONTENT

The scope of the CEMP will be built around the Objectives and Drivers, will provide an appropriate level of scientific robustness, and will utilize provincially and federally acknowledged methodology. It is noted that failing to utilize methods common to the various objectives undermines the value of a comprehensive monitoring program. The scope of the CEMP will not include studies of general research (e.g., academic), nor will it include collection of regional data that are not directly linked to the Objectives and Drivers.

As per Section 3.2 of *EMA* Permit 11678, the scope of the CEMP must be such that it consolidates and integrates monitoring programs that are being conducted in the vicinity of the Mount Polley Mine site. At minimum, the CEMP must consider programs addressing surface water (quality and quantity), groundwater (characterization and interactions with surface water), sediments, soils, periphyton, phytoplankton, benthic invertebrates, zooplankton, fish, floodplain and upland vegetation, and wildlife.

As described in Section 3.2 of *EMA* Permit 11678, the CEMP must address, at minimum, a three-year time span, as well as, at minimum, include all sampling sites, frequency of sampling, variables to be analyzed, method detection limits, sampling methods, sample analysis methods, and data analysis methods.

As noted in the Background and Context of this Terms of Reference, environmental monitoring is a tool used by mining companies (and others) to inform them (and other parties), of the adequacy of their source control efforts. The content of the CEMP will be reflective of its use as such a monitoring tool. The CEMP will serve as the document that provides the context and linkages demonstrating how the monitoring program developed provides an appropriate mechanism by which to meet the Objectives and Drivers of the CEMP. In providing this purpose, the CEMP's content is anticipated to provide: a statement of its objectives; an overview of its subject (the Mount Polley Mine); a discussion of the various components that comprise environmental management in the context of the Mount Polley Mine; presentation of monitoring procedures and considerations (e.g., previous data) specific to each environmental monitoring component; and, an outline for control of the CEMP (e.g., updating and revising) and its reporting outputs.

A comprehensive monitoring plan requires a response framework as the monitoring program is the linkage between monitoring plan design, implementation, and effective use. The level and urgency

of response will have due regard to the level of potential risk to the environment (which includes people). The CEMP response framework will be updated in parallel with the CEMP, or as otherwise appropriate.

4 DEPENDENCIES AND ASSUMPTIONS

The CEMP is intended to support an interdependent program. The dependencies across the monitoring programs will be evaluated with the benefit of a conceptual site model (CSM). The CSM will aid in understanding and addressing the dependencies by allowing a visual representation of release and transport mechanisms (e.g., sources and water flow) and exposure by environmental receptors. The CEMP is predicated on the understanding that people (i.e., humans) are part of the environment. The CEMP response framework will have due regard to linkages and dependencies, and the CSM.

The CSM will be reviewed for dependencies in the context of:

- The Objectives and Drivers and Scope for the CEMP, as described in this Terms of Reference.
- The basal understanding of sources, pathways, contaminants of potential concern (COPC), and receptors.
- An analysis of the linkages between program components, in a tabular format.
    - Linkages will include a rationalization of methods used across program components to make the methodology as consistent as possible.
- Current and planned activities at the Mount Polley Mine site, especially how those activities might impact on the CSM.

The following assumptions guide the continued development and implementation of the CEMP required under Section 3.2 of *EMA* Permit 11678:

- The CEMP is developed, reviewed and revised by Qualified Professionals (QPs), QPs being as defined by the Province of BC (e.g., R.P.Bio.).
    - MPMC notes that there are certain aspects of CEMP scoping (particularly in defining the objectives and drivers), where a QP is not necessary. For example, the reasonable study questions from members of the public are outside of the domain of expertise for a QP who would develop a CEMP; however, the scientific approach by which those questions would be answered are within the QP's domain of expertise.
- The CEMP will be based on information that is available, verifiable and can be relied upon by a QP.
- With the exception of regulatory requirements, a pattern of decrease or stasis in environmental condition is a suitable basis for gradual decrease in monitoring locations, frequencies, or parameters.

5 REVISION

The Mount Polley Mine is an operating site, changes to which are anticipated to transpire as development and closure activities co-occur; thus, an adaptive approach is both necessary and appropriate for documents such as the CEMP. Review of the CEMP content is an integral aspect of its effectiveness. In this application, 'effectiveness' means that the CEMP delivers on the regulatory drivers, some of which have rigid statutory obligations (e.g., MMER), satisfies the Objectives and Drivers for the CEMP, and undertakes that work with due regard to financial impact (without limiting the ability to meet the Objectives and Drivers established) and the adaptive nature of the CEMP.

To fulfill the adaptive approach, the CEMP will be reviewed and revised considering data collected in previous years (as interpreted by QPs). Such data will include that collected and interpreted directly under the CEMP, or as may be available from other assessments, studies or reports commissioned by MPMC as relating to the Objectives and Drivers for the CEMP. In the case of the latter, the CEMP will be modified, as appropriate, in consideration of the results and recommendations of such assessments, studies or reports. Based on collected data (and subsequent interpretation by QPs), the CEMP will include rationale for existing monitoring as well as any changes to the monitoring plan. It is anticipated that larger CEMP revisions in response to these activities will be made with consideration of maintaining continuity in spatial and temporal coverage to meet the Objectives and Drivers of the CEMP.

When possible, MPMC will provide written notice of planned changes to the CEMP to the MoE Director a minimum of 30 days prior to implementation to allow for review and feedback on the revision. Such written notice shall describe the planned changes as well as the rationale for the changes, including a summary of relevant data considered.

Under Section 3.2 of *EMA* Permit 11678, MPMC must submit a three-year detailed monitoring program interpretive report and updated CEMP to the MoE Director, for approval, by 31 March 2019, and every three years thereafter. Following the three-year detailed monitoring program interpretive report to the Director, MPMC will submit a summary of proposed changes to the CEMP to the MoE Director by April 30 of that year (one month following the interpretive report deadline).

A key component of the CEMP will be the monitoring program itself. The monitoring program will be designed, reviewed and revised by QPs such that, in their professional opinion, it satisfies the Objectives of the Drivers for the CEMP and allows MPMC to be informed of the adequacy of their source control efforts. Changes to the monitoring program that occur but are unplanned, such as the collection of additional samples, will be formally submitted with the MoE Director as soon as possible after the sampling occurs. Such written notice shall describe the planned changes as well as the rationale for the changes.

Notification of any CEMP or CEMP monitoring program changes must be provided to the MoE Director in writing for approval.

Notwithstanding the above, as per Section 3.2 of *EMA* Permit 11678, the MoE Director may require revisions to the CEMP or monitoring program based on review of monitoring data and/or any other relevant information.

6 CONSTRAINTS AND PROJECT RISKS

In the context of the CEMP and the content of this Terms of Reference, the following constraints and project risks have been identified by MPMC:

- The Mount Polley Mine, and by it, MPMC as owner and operator of the mine, is constrained to comply with applicable laws and statutory requirements.
- The health and safety of persons engaged in the monitoring work is a paramount consideration. Samples that cannot be obtained safely, using practical methods, will not be obtained. Certain seasonal conditions may preclude safe sampling.
- MPMC has voluntarily entered into (respective) PAs with the SCIB and the WLIB. MPMC will honour the respective PAs in full, and expects the SCIB and WLIB to reciprocate. Certain aspects of the CEMP pertain to subjects that fall within the bounds of the PAs.

7 ROLES AND RESPONSIBILITIES

In the context of the CEMP and the content of this Terms of Reference, the following roles and responsibilities are established:

- The MPMC Environmental Superintendent (or designate) will be responsible for implementing the CEMP, and revising it as appropriate.
    - Deliverables will be prepared by, or under the direct supervision of, QPs.
- Monitoring that is part of the CEMP will be coordinated by MPMC.
- All parties' reviewers of technical elements of the CEMP are required to be QPs if they are providing recommendations on the content or implementation of its subject matter.
- Participants involved in the design and review of the CEMP acknowledge that study designs, monitoring methods, and interpretation will be carried out in accordance with federal and provincial laws, policy and guidance.

Appendix B.1

Proposed CEMP Revisions

Minnow Environmental

minnow
environmental inc.
A Trinity Consultants Company
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Victoria, British Columbia
V8V 3K4
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November 9, 2020

Mr. Gabriel Holmes
Environmental Technician
Mount Polley Mine
PO Box 12
Likely, British Columbia
V0L 1N0

Re: Proposed Revisions to the Comprehensive Environmental Monitoring Program (CEMP)

Dear Mr. Holmes,

At your request, Minnow Environmental Inc. (Minnow) is pleased to provide an overview of aquatic environmental monitoring in the vicinity of the Mount Polley Mine in 2021 and recommendations for monitoring program revision. In October, Minnow prepared a budget estimate for 2021 (Minnow 2020a) that encompassed monitoring proposed to fulfil the requirements of:

1. the Comprehensive Environmental Monitoring Plan (CEMP);
2. Phase 2 Environmental Effects Monitoring (EEM); and
3. the reopening of Hazeltine Creek as fish habitat (under the mandate of the Habitat Remediation Working Group; HRWG).

The 2021 budget estimate provided by Minnow (Minnow 2020a) for the CEMP focused on sediment, benthic invertebrate, periphyton, and fish monitoring components. At your request, Minnow has prepared this brief letter to provide recommendations regarding potential revisions to monitoring requirements for 2021.

A revised version of the CEMP was submitted to the British Columbia Ministry of Environment and Climate Change Strategy (ENV) on October 31, 2019. This version of the CEMP is pending approval from ENV and encompasses monitoring from 2018 to 2020. Study designs produced by Minnow were included as appendices of the CEMP (Appendix B.1: Sediment Monitoring; Appendix B.2: Benthic Invertebrate Monitoring; Appendix B.3: Periphyton Monitoring; and Appendix B.4 Fish Monitoring). These are outdated and due to be updated to cover monitoring in the next three years (2021 to 2023). The purpose of this memorandum is to propose changes to sediment, benthic invertebrate, periphyton, and fish monitoring for the next cycle of the CEMP (2021 to 2023) prior to implementation of the 2021 field campaign. The recommended changes

are based on results from 2018 to 2020 and exclude revisions to the EEM because this monitoring is federally prescribed.

The sections below outline the monitoring requirements of the current CEMP, proposed revisions to the monitoring requirements (where appropriate) and the rationale for the proposed revisions. These are also summarized in Table 1. The following sections are organised to follow the structure of the CEMP.

1) Sediment

a) Lakes-Deep Areas

i) Current CEMP:

Monitoring every three years at Polley Lake (POL-P1, POL-P2) and reference (BOL-B2), Quesnel Exposed (QUL-PNF, QUL-PFF1) and reference (QUL-PREF1; next monitoring would occur in 2021; Table 1).

ii) *Proposed CEMP revisions:*

None.

iii) *Description/Rationale:*

The estimated sediment deposition rates in Polley Lake and Quesnel Lake are low (4.7 mm/year and 1.5 mm/year average, respectively; Minnow 2019). Based on this, a monitoring frequency of every three years is more than adequate to track temporal changes in sediment quality that are measured in top three centimeters of surficial sediment (an average accumulation of 1.4 cm and 0.45 cm of sediment is estimated over a three-year period in Polley Lake and Quesnel Lake, respectively). Sediment quality and toxicity were monitored at deep monitoring areas most recently in 2018. As such, it is recommended that monitoring be completed in 2021 consistent with the three-year monitoring frequency outlined in the current CEMP (MPMC 2019). If stability or improvement in sediment quality is demonstrated between 2018 and 2021, further reduction in monitoring frequency may be proposed. Sediment monitoring is also used as a supporting measure for benthic invertebrate monitoring. Benthic invertebrate monitoring is recommended for 2021 (see Section 3a below), therefore sediment monitoring in 2021 would coincide with this.

Table 1: Overview of Current Comprehensive Environmental Monitoring Program (CEMP) Monitoring Requirements and Proposed CEMP Revisions

CEMP Component	Sampling Details				Current CEMP		Proposed CEMP Revision		
	Area Type		Waterbody	Parameter(s)	Frequency	Next Sampling Event	Change to current CEMP proposed?	Frequency	Next Sampling Event
Sediment	Lakes	Deep Areas	Polley Lake and Reference; Quesnel Lake and Reference	Chemistry, Toxicity	Every 3 years	2021	No	-	-
		Shallow Areas		Chemistry, Toxicity	None [1]	-	No	-	-
	Creeks		Upper and Lower Hazeltine Creek and Reference	Chemistry	Annual	2021	Yes	Discontinuation of monitoring recommended. If monitoring is continued, sample every 2 years. [2]	- (2022 if monitoring is continued)
DGTs [3]	Lakes	Deep Areas	Polley Lake and Reference; Quesnel Lake and Reference	DGT-labile metals	Annual	2021	Yes	Every 3 years	2021 [4]
		Shallow Areas		DGT-labile metals	None [1]	-	No	-	-
Benthic Invertebrates	Lakes		Polley Lake and Reference; Quesnel Lake and Reference	Community	Every 3 years	2021	No	-	-
	Creeks		Upper and Lower Hazeltine Creek and Reference	Community and Productivity	Upper Creek Areas: Annual; Lower Creek Areas: Every 2 years	2021 (Upper and Lower Areas)	Yes	Upper Creek Areas: Every 2 years [5]; Lower Creek Areas: Annual; Eliminate single-taxon tissue chemistry monitoring	2022 (Upper Areas); 2021 (Lower Areas)
				Chemistry	Annual	2021	Yes	Every 2 years	2022
Plankton and Chlorophyll-a	Lakes		Polley Lake and Reference; Quesnel Lake and Reference	Community, Productivity, Chemistry	Annual	2021	No	-	-
Periphyton	Creeks		Upper and Lower Hazeltine Creek and Reference	Community and Productivity	Upper Creek Areas: Annual; Lower Creek Areas: Every 2 years	2021 (Upper and Lower Areas)	Yes	Upper Creek Areas: Every 2 years [5]; Lower Creek Areas: Annual	2022 (Upper Areas); 2021 (Lower Areas)
				Chemistry	Annual	2021	Yes	Every 2 years	2022
Fish	Lakes		Polley Lake and Reference; Quesnel Lake and Reference	Fish Tissue Quality	Annual	2021	Yes	Every 3 years	2023
			Quesnel River		Annual	2021	No	-	-
			Polley Lake	Fish Population and Community	Annual	2021	No	-	-
	Creeks		Lower Edney Creek	Fish Habitat and Usage	Every 2 years	2021	No	-	-
				Spawning Surveys	Annual	2021	No	-	-
			Hazeltine Creek	Fish Habitat and Usage	Annual	2021	No [6]	-	-
				Spawning Surveys	Annual	2021	No [6]	-	-

Notes: CEMP = Comprehensive Environmental Monitoring Program; DGTs = Diffusive Gradients in Thin-Films; HRWG = Habitat Remediation Working Group
Revisions to the current CEMP are proposed for this monitoring component.

[1] There are no current requirements for monitoring of shallow lake areas in the CEMP (October 31, 2019 version; MPMC 2019). Requirements for sediment and DGT monitoring of shallow lake areas were included in the CEMP Conditional Approval Letter dated March 14, 2019 (BCMOECCS 2019a) which was superseded by an updated version of Permit 11678 dated February 1, 2020 (BCMOECCS 2020). The revised Permit 11678 does not specify monitoring requirements beyond the scope of the CEMP (which does not include monitoring of shallow lake areas).

[2] A discontinuation of sediment monitoring in creek habitats is recommended (see Section 3c of memorandum for rationale). A middle ground would be to reduce monitoring frequency to every two years.

[3] DGTs are included as a supporting measure for sediment monitoring in the CEMP (October 31, 2019 version; MPMC 2019).

[4] DGT monitoring was completed most recently in deep lake areas in 2019. At a monitoring frequency of every three years the next event would occur in 2022. Completing DGT monitoring in 2021 instead of 2022 would allow alignment with sediment sampling, which is required as a supporting measure for the DGT evaluation.

[5] Monitoring in upper creek areas is used to support the evaluation of the reopening of Hazeltine Creek as fish habitat. Although the proposed reduction in monitoring frequency to every 2 years is adequate for the evaluation of benthic invertebrate community recovery, this frequency may need to be more frequent (annual) to meet HRWG requirements for evaluation of fish habitat.

[6] The monitoring frequency for the evaluation of fish habitat and usage of Hazeltine Creek is dictated by discussions with the HRWG. Our understanding from discussions with MPMC is that a continued annual monitoring is currently recommended.

b) Lakes-Shallow Areas

i) *Current CEMP:*

There is no requirement in the current CEMP (MPMC 2019) for sediment monitoring in shallow lake areas.

ii) *Proposed CEMP revisions:*

None.

iii) *Description/Rationale:*

There are no current requirements for sediment monitoring of shallow lake areas in the current CEMP (MPMC 2019), but requirements for this monitoring were outlined in the CEMP Conditional Approval Letter dated March 14, 2019 (BCMOECCS 2019a). These included sediment quality and toxicity monitoring at the shallow impacted areas of Polley Lake and Quesnel Lake which could be discontinued if no effect to *H. azteca* was detected in toxicity tests completed in 2019 (BCMOECCS 2019a). Toxicity tests of the shallow sediments from Polley in 2019 met this criterion (Minnow 2020b), therefore sediment monitoring in this monitoring area was discontinued in 2020 while monitoring in the shallow areas of Quesnel Lake was continued.

The CEMP Conditional Approval Letter (BCMOECCS 2019a) was superseded by an updated version of Permit 11678 issued on February 1, 2020 (BCMOECCS 2020). The revised Permit 11678 does not specify monitoring requirements beyond the scope of the current CEMP (MPMC 2019; which does not include monitoring of shallow lake areas as outlined above). It is therefore understood that although sediment monitoring in the shallow impacted area of Quesnel Lake has not satisfied the criterion of the CEMP Conditional Approval Letter (BCMOECCS 2019a), sediment monitoring in this area is no longer a CEMP requirement.

c) Creeks

i) *Current CEMP:*

Annual monitoring at upper Hazeltine Creek (HAC-U) and reference (EDC-U), and lower Hazeltine Creek areas (HAC-D) and reference (EDC-D).

ii) *Proposed CEMP revisions:*

Consider discontinuing sediment monitoring in creek habitats (Table 1). A middle ground would be to reduce monitoring frequency to every two years (next monitoring

would occur in 2022; Table 1) with subsequent consideration of further reduction in monitoring frequency.

iii) *Description/Rationale:*

Sediment in upper and lower Hazeltine Creek and associated reference areas has been monitored annually since 2018. Although significant temporal changes in sediment metal concentrations have been observed between 2018 and 2019, these were likely related to variation in sediment physical characteristics between years rather than a mine-related influence. For instance, concentrations of copper and manganese increased significantly between 2018 and 2019 in upper Hazeltine Creek but this was likely related to increased total organic carbon (TOC), total nitrogen, and fines (silt and clay) content (Minnow 2020b). In lower Hazeltine Creek, sediment concentrations of copper and iron decreased significantly from 2018 to 2019, but this change was likely related to a decrease in sediment TOC and total nitrogen content (Minnow 2020b).

Few areas of sediment deposition exist in Hazeltine Creek or associated reference areas, which are primarily erosional habitat. Therefore, sediment samples consist of fines deposited in boulder interstices or in small backwater locations. The limited availability of sediment in these areas dictates the physical characteristics of sediment that can be sampled (i.e., sediment with specific physical characteristics cannot be targeted for sampling if it is not present). Given that the variability in physical characteristics of creek sediments is so highly influenced by uncontrollable factors (i.e., availability of sediment) that confound controlled spatial and temporal comparison, a discontinuation of sediment monitoring in creek habitats is recommended. The continued sampling of creek sediments will contribute little to furthering the understanding of a potential mine-related influence on aquatic biota. Instead, monitoring efforts should be focused on continued periphyton and benthic invertebrate tissue quality monitoring which provides a direct means of evaluating a potential mine-influence on the chemistry of aquatic biota. A middle ground would be to reduce monitoring frequency to every two years (next monitoring would occur in 2022; Table 1) with subsequent consideration of further reduction in monitoring frequency.

2) Diffusive Gradients in Thin-films (DGTs)

a) Lakes-Deep Areas

i) Current CEMP:

Annual monitoring at Polley Lake (POL-P2) and reference (BOL-B2), and Quesnel Exposed (QUL-PNF) and reference (QUL-PREF1).

ii) *Proposed CEMP revisions:*

Reduce the monitoring frequency to every three years (next monitoring would occur 2021; Table 1)[1] with subsequent consideration of further reduction in monitoring frequency.

iii) *Description/Rationale:*

Diffusive Gradients in Thin-films devices (DGTs) are small devices that are designed to accumulate free metals, dissolved inorganic metal complexes, and labile organic metal complexes by diffusion. These metal fractions are considered to be readily bioavailable and are good indicators of the potential toxicity to aquatic life. As such, DGT devices have been deployed annually in deep areas of impacted lakes (and reference) to address a critical CEMP question – is there any evidence of temporal change in the mobility or bioavailability of metals associated with the Tailings Storage Facility (TSF) breach?

DGT monitoring was initiated in 2015 and continued annually in deep impacted areas of lakes (and reference) until 2019. At the deep impacted area of Quesnel Lake (QUL-PNF), DGT-labile concentrations of copper and most other analytes have demonstrated stability over this period (Minnow 2020b). At the deep areas of Polley Lake, DGT-labile concentrations of most analytes have also been stable or have decreased over time (on an absolute basis and relative to reference), except copper. DGT-labile concentrations of copper increased significantly in Polley Lake between 2016 and 2018 but decreased significantly from 2018 to 2019 (on an absolute basis and relative to reference). These changes in DGT-labile copper concentrations were consistent with changes in total and dissolved copper concentrations (measured by conventional water chemistry; Minnow 2020b).

[1] DGT monitoring was completed most recently in deep lake areas in 2019. At a monitoring frequency of every three years the next event would occur in 2022. Completing DGT monitoring in 2021 instead of 2022 would allow alignment with sediment sampling, which is required as a supporting measure for DGT evaluation.

A reduction in monitoring frequency from annually to every three years is recommended based on the observed stability (or decrease) in the majority of DGT-labile analyte concentrations in impacted areas, and the recent decrease in DGT-labile copper concentrations in Polley Lake. This proposed monitoring frequency aligns with sediment and benthic invertebrate community monitoring to provide opportunity for integration of these results (sediment quality data is used in the interpretation of DGT-labile concentrations).

b) Lakes-Shallow Areas

i) Current CEMP:

There is no requirement in the current CEMP (MPMC 2019) for DGT monitoring in shallow lake areas.

ii) *Proposed CEMP revisions:*

None.

iii) *Description/Rationale:*

Although there are no current requirements for DGT monitoring of shallow lake areas in the current CEMP (MPMC 2019), requirements for this monitoring were outlined in the CEMP Conditional Approval Letter dated March 14, 2019 (BCMOECCS 2019a). These included DGT monitoring at the shallow impacted areas of Polley Lake and Quesnel Lake (BCMOECCS 2019a). The CEMP Conditional Approval Letter was superseded by an updated version of Permit 11678 issued on February 1, 2020 (BCMOECCS 2020). The revised Permit 11678 does not specify monitoring requirements beyond the scope of the current CEMP (MPMC 2019; which does not include monitoring of shallow lake areas). It is therefore understood that DGT monitoring in shallow lake habitats is no longer a monitoring requirement of the CEMP.

An important benefit of DGT monitoring in the shallow lake areas is to provide a line of evidence to counter potentially unusual sediment toxicity results that may be artifacts of sediment toxicity testing methodology (i.e., disturbance at test setup resulting in much higher metal concentrations in test water than in-situ). Since sediment quality and toxicity monitoring is not required for these shallow areas (see Section 1b), DGT monitoring is also not necessary as a supporting measure.

3) Benthic Invertebrates

a) Lakes

i) *Current CEMP:*

Monitoring every three years at Polley Lake (POL-P1 and POL-P2) and reference (BOL-B2), and Quesnel Exposed (QUL-PNF and QUL-PFF1) and reference (QUL-PREF1; next monitoring would occur in 2022; Table 1).

ii) *Proposed CEMP revisions:*

None.

iii) *Description/Rationale:*

Benthic invertebrate community monitoring is a key component in evaluating aquatic ecosystem health and is highly valuable tool used to monitor the natural recovery of the waterbodies impacted by the TSF breach. Benthic invertebrate community was monitored at all deep lake areas most recently in 2018. Results of this monitoring indicated that benthic invertebrate density at the most impacted areas of Polley Lake (POL-P2) and Quesnel Lake (QUL-PNF) increased significantly after 3 years of recovery (between 2015 and 2018; Minnow 2019). This timing aligns with the current frequency of monitoring every three years. Given this documented rate of recovery and the importance of benthic invertebrate community as monitoring tool, continuation of this frequency in these deep lake areas is recommended to adequately track recovery.

b) Creeks

i) Current CEMP:

Annual monitoring at upper Hazeltine Creek areas (HAC-R1 and HAC-U) and reference (EDC-U) for benthic invertebrate community, productivity, and tissue quality. Monitoring every two years at remediated lower Hazeltine Creek (HAC-D) and Edney Creek (E1) areas and reference (EDC-D) for benthic invertebrate community and productivity. Annual monitoring at upper and lower Hazeltine Creek areas (and references) for benthic invertebrate tissue quality.

ii) *Proposed CEMP revisions:*

Reduce the monitoring frequency of benthic invertebrate community and productivity in upper Hazeltine Creek and reference areas to every two years (next monitoring

would occur in 2022[2]; Table 1). Temporarily increase the monitoring frequency of benthic invertebrate community and productivity in lower Hazeltine Creek and reference areas to annually (next monitoring would occur in 2021; Table 1). Reduce the monitoring frequency of benthic invertebrate tissue quality at upper and lower Hazeltine Creek and lower Edney Creek (and associated references) to every two years and discontinue single-taxon tissue quality monitoring (next monitoring would occur in 2022; Table 1). Consider further reduction in the monitoring frequency of both benthic invertebrate community and tissue quality if recovery/stability of these components continues to be demonstrated.

iii) *Description/Rationale:*

As outlined for lakes, benthic invertebrate community monitoring is a highly valuable tool for evaluating the recovery of aquatic ecosystem health in creek habitats impacted by the TSF breach and subsequent remediation works. The benthic invertebrate community in upper Hazeltine Creek (Reaches 1 and 2) has recovered substantially since remediation was completed in these areas in 2016 and 2017, respectively. Organism density has recovered to similar to pre-breach (and has been since 2018) and several measures of community composition recovered significantly between 2018 despite remaining differences from pre-breach conditions (taxon richness, Simpson's Diversity, and proportions of sensitive taxa; Minnow 2020b). These significant improvements in density and community composition clearly indicate that recovery remains ongoing. The remaining differences relative to pre-breach are not unexpected given the physical differences relative to pre-breach, including the absence of riparian cover. Further recovery of the benthic invertebrate community is linked to the recovery of riparian cover which is a long-term process. As such, the continued recovery of the benthic invertebrate community is also expected to be a long-term process and a monitoring frequency of every 2 years will be sufficient to track this recovery. Further reduction in monitoring frequency may be considered if the benthic invertebrate community continues to demonstrate recovery to conditions that are more similar to pre-breach and reference.

Final remediation works in lower Hazeltine Creek and lower Edney Creek were completed in September 2020, which included complete reconstruction of the creek

[2] Benthic invertebrate community and productivity monitoring in Hazeltine Creek is used to support the evaluation of the reopening of Hazeltine Creek as fish habitat. Although the proposed reduction in monitoring frequency to every 2 years is adequate for the evaluation of benthic invertebrate community recovery in upper Hazeltine Creek, this frequency may need to be more frequent (annual) to meet HRWG requirements for evaluation of fish habitat.

channels. The frequency for benthic invertebrate community and productivity monitoring in lower Hazeltine and Edney creeks (and reference) was previously every two years because these areas had been undisturbed since 2015 and the benthic invertebrate community had demonstrated recovery (MPMC 2019). A short-term increase in monitoring frequency from every 2 years to annually is recommended to better track recovery of the benthic invertebrate community following the recent reconstruction of these areas. Based on the recovery of the benthic invertebrate community in these lower creek areas following initial remediation works (Minnow 2020b), it is anticipated that a reduction in monitoring frequency to every two years could be considered after three years of annual monitoring (if recovery of the benthic invertebrate community has been observed).

Benthic invertebrate tissue quality monitoring has included evaluation of two sample types; composite-taxa samples (that are proportionally representative of the community and a measure of fish dietary exposure) and single-taxon samples (that provide a more temporally-consistent sample type). Although the concentrations of some metals have differed slightly between the two sample types, the trophic transfer functions (TTF; the relationships between metal concentrations in periphyton and those in benthic invertebrates) for a given metal were generally similar between the two sample types. TTFs are a key tool used to evaluate the bioavailability and potential bioaccumulation of metals between trophic levels. Since the TTFs are generally the same for both composite-taxa and single-taxon sample types, there is no benefit to continuing to monitor both sample types. Composite-taxa benthic invertebrate tissue samples provide information about the dietary exposure of fish that single-taxon samples cannot provide (because fish feed on the entire benthic community). As such, discontinuation of single-taxon sampling is recommended.

Temporal evaluations have indicated that concentrations of metals in benthic invertebrate tissue from upper and lower Hazeltine Creek in 2019 were generally consistent with those observed prior to 2018, despite significant elevation of several metals relative to 2018 (Minnow 2020b). Evaluation of TTFs in 2019 indicated moderately higher bioavailability and/or trophic transfer of selenium in upper and lower Hazeltine Creek relative to reference and of copper in upper Hazeltine Creek. Despite this, concentrations of selenium in benthic invertebrates from both upper and lower Hazeltine Creek were below the BC interim guideline (BCMOE 2014) indicating that no selenium-associated effects to aquatic life would be expected (Minnow 2020b). Benthic invertebrate tissue quality in the remediated area of lower Edney Creek showed no evidence of a mine-related influence (Minnow 2020b). Based on the

general stability of benthic invertebrate metal concentrations (i.e., there is no evidence of an increasing trend) and observed selenium concentrations that are below the BC interim guideline (BCMOE 2014) in all impacted areas, a reduction in monitoring frequency to every two years is recommended. This frequency should be adequate to track potential further changes in tissue quality. Further reduction in monitoring frequency may be considered if continued stability in benthic invertebrate tissue quality is demonstrated.

4) Plankton and Chlorophyll-a

i) Current CEMP:

Annual monitoring at Polley Lake (POL-P2) and Reference (BOL-B2), and Quesnel Exposed (QUL-ZOO-1) and Reference (QUL-ZOO-7; next monitoring would occur in 2021; Table 1).

ii) *Proposed CEMP revisions:*

None.

iii) *Description/Rationale:*

A revised CEMP plankton monitoring program was developed by Minnow in 2019 and program revisions approved by ENV were incorporated into the CEMP conditional approval letter dated July 15, 2019 (BCMOECCS 2019b). The revised monitoring program was implemented throughout the 2019 season and includes sampling three times per year (June, July, and August) with replication (n = 5 at each monitoring area) during one of the sampling events (July). The addition of replication to the monitoring program enables robust spatial and temporal statistical comparisons which were previously not possible. Monitoring under the revised program should continue annually for at least three years (until 2021) until sufficient data are available to evaluate the temporal stability of the plankton community, productivity, and tissue chemistry results. The monitoring frequency may then be reduced if temporal stability is observed.

5) Periphyton

i) Current CEMP:

Annual monitoring at upper Hazeltine Creek areas (HAC-R1 and HAC-U) and reference (EDC-U) for periphyton community, productivity, and tissue quality. Monitoring every two years at lower Hazeltine Creek (HAC-D) and Edney Creek (E1)

areas and reference (EDC-D) for periphyton community and productivity, and annual monitoring for benthic invertebrate tissue quality.

ii) *Proposed CEMP revisions:*

Reduce the monitoring frequency of periphyton community and productivity in upper Hazeltine Creek and reference areas to every two years (next monitoring would occur in 2022[3]; Table 1). Temporarily increase the monitoring frequency of periphyton community and productivity in lower Hazeltine Creek and reference areas to annually (next monitoring would occur in 2021; Table 1). Reduce the monitoring frequency of periphyton tissue quality at upper and lower Hazeltine Creek areas (and associated references) to every two years. Consider further reduction in the monitoring frequency of both periphyton community and tissue quality if recovery/stability of these components continues to be demonstrated.

iii) *Description/Rationale:*

Periphyton community and productivity has recovered significantly in upper Hazeltine Creek since the completion final remediation works. Specifically, periphyton productivity and periphyton community (measured in terms of density, total and diatom richness) recovered significantly between 2018 and 2019 to conditions similar to or greater than reference (Minnow 2020b). Productivity as measured by chlorophyll-a concentrations remained below the British Columbia Water Quality Guideline (BCWQG) in 2019 (Minnow 2020b). Given the demonstrated recovery in periphyton community and productivity (while remaining below the BCWQG), a monitoring frequency of every two years would be sufficient to continue to track the continued recovery of periphyton community composition. Further reduction in monitoring frequency may be considered if continued stability of recovered endpoints is demonstrated.

As described in Section 3b (benthic invertebrates – creeks), final remediation works in lower Hazeltine Creek and Edney Creek were completed in September 2020. As such, a short-term increase in monitoring frequency from every 2 years to annually is recommended to track recovery of periphyton community and productivity in these areas following the recent reconstruction. This frequency will also align with benthic invertebrate community and productivity monitoring in these lower creek areas. There

[3] Periphyton productivity monitoring in Hazeltine Creek is used to support the evaluation of the reopening of Hazeltine Creek as fish habitat. Although the proposed reduction in monitoring frequency to every 2 years is adequate for the re-evaluation of periphyton community and productivity recovery in upper Hazeltine Creek, this frequency may need to be more frequent (annual) to meet HRWG requirements for evaluation of fish habitat.

are currently insufficient periphyton community and productivity data from the lower creek areas (monitoring was initiated in 2019; MPMC 2020) to comment on the anticipated rate of periphyton recovery in these areas. However, a reduction in monitoring frequency to every two years could be considered after three years of annual monitoring (if recovery of the periphyton community has been observed) to align with benthic invertebrate monitoring frequency

Periphyton tissue quality monitoring is used to support the evaluation of metal bioavailability and trophic transfer. In general, concentrations of metals in periphyton tissue have either decreased relative to previous results (2018 and earlier) or remained stable (Minnow 2020b). Evaluation of BCFs in 2019 indicated moderately higher bioavailability of copper in upper Hazeltine Creek relative to reference (similar to benthic invertebrates, see Section 3b), but the bioavailability of selenium in upper and lower Hazeltine Creek and copper in lower Hazeltine Creek was lower than reference (as measured by BCFs; Minnow 2020b). Periphyton tissue quality in the remediated area of lower Edney Creek showed no evidence of a mine-related influence (Minnow 2020b). Based on the general temporal stability of periphyton metal concentrations (i.e., there is no evidence of an increasing trend) and limited evidence of increased bioavailability at remediated areas, a reduction in monitoring frequency to every two years is recommended. This aligns with the recommended benthic invertebrate tissue quality monitoring frequency to allow for the intended purpose of periphyton tissue quality monitoring (i.e., the evaluation of trophic transfer of metals between periphyton and benthic invertebrates). Further reduction in monitoring frequency may be considered if continued stability in periphyton tissue quality is demonstrated.

6) Fish

a) Fish Tissue Quality

i) Current CEMP:

Annual spring monitoring of female rainbow trout and longnose sucker from Polley Lake and reference (Bootjack Lake). Annual fall monitoring of lake trout, peamouth chub, and northern pikeminnow from exposed and reference areas of Quesnel Lake and rainbow trout from Quesnel River.

ii) *Proposed CEMP revisions:*

Reduce the monitoring frequency to every 3 years (next monitoring would occur in 2023; Table 1) for Polley Lake and Quesnel Lake (and reference)[4]. Maintain an annual monitoring frequency for Quesnel River (rainbow trout monitoring).

iii) *Description/Rationale:*

Fish tissue quality monitoring in Polley Lake (and reference) and in Quesnel Lake has demonstrated limited evidence of a mine-related influence. Specifically, in the tissues of fish from Polley Lake (muscle, liver, kidney, and ovary), selenium was the only metal to show a pattern of potential mine-related influence that was not equivocal. Fish tissue quality monitoring in Polley Lake was initiated in baseline (1995), completed again in 2009 and 2012, and completed annually between 2015 and 2020. This amount of historical data enables accurate comparison between pre-breach and post-breach conditions as well as an estimation of variability in tissue quality results both within and among years (variability among years has been limited since 2015; Minnow 2020b). The latter is useful in determining recommended monitoring frequencies that are adequate to track potential changes in tissue quality.

Selenium concentrations in fish tissues from Polley Lake increased in response to the uncontrolled surface runoff (2006 to 2009) and have remained elevated relative to reference but generally have not increased further (Minnow 2020b). Mercury and selenium concentrations of fish muscle from Polley Lake were below the guidelines for the protection of human health (i.e., that fish are fully usable for moderate human consumption). Mean selenium concentrations in rainbow trout ovary tissue (the tissue most valuable in the assessment of potential selenium-associated effects on fish) exceeded the BC interim guideline in 2019 but were below the threshold for reproductive effects indicating that no selenium-associated effects on reproduction are expected (Minnow 2020b).

In tissues of fish from Quesnel Lake and River, copper and selenium showed a somewhat equivocal pattern of potential mine-related influence in a small number of species-tissue combinations while other metals showed no pattern. For-instance, copper and selenium concentrations in lake trout ovary tissues in 2019 were significantly higher than prior years (relative to reference), but this was not corroborated by other tissue types, or by zooplankton tissue and water quality

[4] A reduction to monitoring every three years is recommended, but ENV may prefer to reduce monitoring frequency to every two years which would be a middle ground.

monitoring results (Minnow 2020b). Mercury and selenium concentrations of fish muscle from Quesnel Lake and River in 2019 were below the guidelines for the protection of human health except for four lake trout from the reference area (Minnow 2020b). Although selenium concentrations of the ovary tissue from a small number individuals in 2019 exceeded the BC interim guideline for aquatic life (BCMOE 2014), all ovary selenium concentrations were well below the threshold for reproductive effects indicating that no selenium-associated effects on reproduction are expected (Minnow 2020b).

A reduction in fish tissue quality monitoring frequency to every three years is recommended for Polley Lake and Quesnel Lake (and associated references) based on: 1) the absence of an evident pattern of mine-related influence on metal concentrations in fish tissues from exposed areas; 2) the recent temporal stability of metal concentrations that do demonstrate a mine-related influence; 3) concentrations of mercury and selenium that have consistently met the human health guidelines in most fish muscle samples; and 4) selenium concentrations in ovary tissue that are consistently below the threshold for reproductive effects in all exposed individuals. Given the limited evidence of a mine-influence and the demonstrated temporal stability, a monitoring frequency of every three years will be sufficient to track potential changes in fish tissue quality in these exposed areas.

A continued annual frequency is recommended for tissue quality monitoring of rainbow trout from the Quesnel River. Rainbow trout from the Quesnel River are monitored to evaluate potential human exposure through consumption of sport fish. Previous monitoring results have generally demonstrated temporal stability in rainbow trout tissue quality (from 2015 to 2019; Minnow 2020). Despite this, continued annual monitoring of rainbow trout tissue quality from Quesnel River is recommended to address potential community concerns over the safety of consuming fish from Quesnel Lake and Quesnel River. This monitoring represents a more cost-effective means of continuing to address questions from the community regarding sport fish consumption than monitoring other sport fish species (i.e., lake trout) on a more frequent basis.

b) <u>Polley Lake Fish Population and Community</u>

i) Current CEMP:

Annual monitoring of rainbow trout, longnose sucker, and redside shiner population health in Polley Lake.

ii) Proposed CEMP revisions:

Maintain annual monitoring frequency but focus monitoring on rainbow trout and discontinue evaluation of longnose sucker and redside shiner.

iii) *Description/Rationale:*

Fish community and population health assessments have been undertaken annually to continue to document the influence of the temporary loss of Hazeltine Creek due to the TSF breach (August 2014 to April 2018), which previously supported the majority of fish recruitment to Polley Lake. Results from spring 2019 indicated that rainbow trout catch was higher than the previous two years but was still much lower than 2016, consistent with loss of recruitment and natural mortality of older fish since the TSF breach. Despite this, more smaller rainbow trout were caught in 2019 than in 2018 or 2016 (Minnow 2020b). In addition, several 1+ rainbow trout were captured in 2019, confirming the recruitment of rainbow trout to Polley Lake and overwintering survival following the reopening of Hazeltine Creek as fish habitat in 2018. Evaluation of longnose sucker results indicated no evidence of loss of recruitment due to the breach (Minnow 2020b).

This monitoring is central to the continued evaluation of rainbow trout recruitment and population health for Polley Lake. Monitoring is recommended to continue annually to satisfy interest expressed by the HRWG in the continued evaluation of rainbow trout population health in Polley Lake and to support the evaluation of the success of Hazeltine Creek as spawning and rearing habitat. It is recommended that the continued fish population health monitoring focus on rainbow trout and that evaluation of the population health of longnose sucker and redside shiner be discontinued. This recommendation is based on the absence of evidence that recruitment of these two species was lost due to the TSF breach (Minnow 2020). A reduction in monitoring frequency may considered once a full cohort structure of the rainbow trout population is established (i.e., individuals present all size/age classes), conditional on approval from the HRWG.

c) <u>Fish Usage and Habitat – Edney Creek</u>

i) Current CEMP:

Annual visual spawning surveys and monitoring every two years of fish habitat and usage for remediated and reference areas of lower Edney Creek (next monitoring would occur in 2021; Table 1).

ii) *Proposed CEMP revisions:*

None.

iii) *Description/Rationale:*

Final remediation of lower Edney Creek was completed in September 2020 which included the complete reconstruction of the creek channels and the joining of lower Edney Creek and Hazeltine Creek channels which were historically joined (pre-breach) but separated following initial remediation works. Evaluation of fish habitat and usage of this newly remediated area is planned for 2021, consistent with the current CEMP and with discussions with MPMC. Assessment of the success of fish habitat in lower Hazeltine Creek falls under the mandate of HRWG. As such, the continued monitoring frequency may be adjusted depending on HRWG monitoring requirements. It is recommended that a reduction of monitoring frequency be considered after two monitoring events (4 years) have demonstrated successful usage of the remediated area by the majority of fish species that have been historically documented in lower Edney Creek.

d) <u>Fish Usage and Habitat – Hazeltine Creek</u>

i) Current CEMP:

Annual spring visual spawning surveys, fish habitat, and fish usage monitoring in Hazeltine Creek areas reopened as fish habitat (Reaches 1, 2, 3, and 5; next monitoring would occur in 2021; Table 1).

ii) *Proposed CEMP revisions:*

None.

iii) *Description/Rationale:*

Assessment of the success of Hazeltine Creek as fish habitat falls under the mandate of the HRWG. The current monitoring frequency is annual and continued annual monitoring is planned according to HRWG requirements and discussions with MPMC. This frequency may be adjusted depending on continued HRWG monitoring requirements.

Sincerely,

Minnow Environmental Inc.

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cc: Don Parsons, Chief Operating Officer Imperial Metals
Mathieu O'Leary, Technical Services Superintendent

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Appendix B.1.1

Sediment Quality Monitoring Plan

Minnow Environmental

Sediment Quality Monitoring Plan

Prepared for:
Mount Polley Mining Corporation
Likely, British Columbia

Prepared by:
Minnow Environmental Inc.
Victoria, British Columbia

March 2023

Sediment Quality Monitoring Plan

Katharina Batchelar, M.Sc., R.P. Bio.
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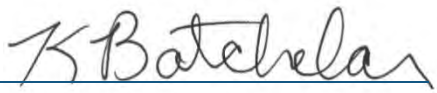

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ACRONYMS AND ABBREVIATIONS

ANOVA - Analysis of Variance
BC - British Columbia
BCMOE - British Columbia Ministry of Environment
BCMOECCS - British Columbia Ministry of Environment and Climate Change Strategy
CALA - Canadian Association for Laboratory Accreditation
CASQO - California Sediment Quality Objectives
CCME - Canadian Council of Ministers of the Environment
CEMP - Comprehensive Environmental Monitoring Program
COC - Chain of Custody
CRC-ICP-MS - Collision Cell Inductively Coupled Plasma-Mass Spectrometry
CVAAS - Cold Vapor Atomic Absorption Spectrophotometry
DFO - Fisheries and Oceans Canada
DGT - Diffusive Gradients in Thin Films
DQR - Data Quality Review
EDD - Electronic Data Deliverable
EEM - Environmental Effects Monitoring
ERA - Ecological Risk Assessment
GPS - Global Positioning System
HHRA - Human Health Risk Assessment
HR-ICP-MS - (High Resolution Inductively Coupled Plasma-Mass Spectrometry
HRWG - Habitat Remediation Working Group
IP - Indicator Parameters
LRL - Laboratory Reporting Limits
MDMER - Metal and Diamond Mining Effluent Regulations
MPMC - Mount Polley Mining Corporation
MS - Microsoft
PCA - Principal Components Analysis
PDF - Portable Document Format
QA/QC - Quality Assurance/Quality Control
QC - Quality Control
QP - Qualified Professional
RPD - Relative Percent Difference
SCCWRP - Southern California Coastal Water Research Project
SEM/AVS - Simultaneously Extracted Metals to Acid Volatile Sulphides

WSQG - British Columbia Working Sediment Quality Guidelines

TOC - Total Organic Carbon

TSF - Tailings Storage Facility

USEPA - United States Environmental Protection Agency

WSQG - Working Sediment Quality Guidelines

1 INTRODUCTION

1.1 Background

Sediment is an important sink and potential source of metals, metalloids, and nutrients[1] in aquatic environments (e.g., Horowitz 1991; Ingersoll et al. 1997; Simpson and Batley 2016). Sediment quality of receiving environments adjacent to mine sites can be influenced by the direct input of solids as well as by the introduction of dissolved constituents (e.g., metals) into water that subsequently associate with reactive materials on sediment surfaces (e.g., oxides, organic carbon) by surface complexation (Santschi et al. 1990; Stumm and Morgan 1996; Sposito 2004). Sediment also represents a pathway for the exposure of aquatic life to metals and other substances (e.g., nutrients, organic substances). Therefore, sediment quality is an important monitoring component that has been incorporated into the Mount Polley Mining Corporation (MPMC) Comprehensive Environmental Monitoring Program (CEMP).

The influence of the Mount Polley Mine on sediment quality can occur (or has occurred) by several key mechanisms: 1) general mine influence from physical impingement, dustfall, and/or uncontained surface or groundwater flows; 2) direct discharge of mine effluent to Hazeltine Creek (April to August 2014) and Quesnel Lake (December 2015 to present)[2]; 3) the Tailings Storage Facility (TSF) embankment breach ("the breach") on August 4, 2014; and 4) remediation activities following the TSF embankment breach (via potential effects downstream in Quesnel Lake). Potential effects associated with effluent discharge are chemical, while those associated with general mine influence, the TSF embankment breach, and subsequent remediation can be both physical and chemical.

The geomorphology of the entirety of Hazeltine Creek (from Polley Lake to Quesnel Lake) was substantially altered by the TSF embankment breach, and a portion of lower Edney Creek was also impacted by the breach. Hazeltine Creek was delineated into upper (Reach 1 [HAC-R1], Reach 2 [HAC-R2], and Reach 3 [HAC-R3]) and lower (Reach 5 [HAC-R5] and Reach 6 [HAC-R6]) reaches for remediation efforts. These upper and lower areas of Hazeltine Creek have always been separated by a canyon in Reach 4 (HAC-R4) which acts as a permanent barrier to upstream fish passage. Remediation of upper Hazeltine Creek was initiated in 2014 following the breach (Golder 2017a), and completed at HAC-R1, HAC-R2, and HAC-R3 in 2016, 2017

[1] Through the remainder of this section, the term "metals" will be used to include metals, metalloids, and nutrients for ease of communication

[2] Treated effluent was discharged to Quesnel Lake via Hazeltine Creek from December 2015 to December 2017. During this period, treated effluent flowed into a settling pond in Hazeltine Creek located at the edge of Quesnel Lake prior to final discharge into Quesnel Lake via diffusers. From 2018 to present, treated effluent was conveyed to the diffusers in Quesnel Lake via a direct pipeline.

(Golder 2017b,c), and 2019 (Golder 2020), respectively. Interim remediation efforts in lower Hazeltine Creek and lower Edney Creek were initiated in 2015 with the temporary reconstruction of the two creeks as two separate watercourses. Final remediation in these lower creek areas was initiated in 2020, including the reconnection of the two watercourses, and was completed in autumn 2020 except for two sections in which final works were completed in summer 2021 (Minnow 2021b).

Sediment quality in waterbodies adjacent to the Mount Polley Mine has been monitored since baseline investigations in 1989, 1995, and 1996 (Imperial Metals 1990; HKP 1996, 1997). Results of sediment quality monitoring are reviewed in Section 2 and provide context for this CEMP Sediment Quality Monitoring Plan. This study design is guided by a combination of historical findings, representative locations downstream of Mount Polley Mine operations, representative reference locations, and considerations for a statistically-based design that will facilitate the detection of spatial and temporal differences in addition to providing data to evaluate concentrations relative to effects-based guidelines (e.g., British Columbia Working Sediment Quality Guidelines [WSQG]; BCMOECCS 2021a,b). Sediment quality monitoring in Quesnel Lake was previously required to support benthic invertebrate community monitoring conducted as part of Environmental Effects Monitoring (EEM) under the Metal and Diamond Mining Effluent Regulations (MDMER) of the federal *Fisheries Act* (Government of Canada 2022). Previous monitoring and modelling has demonstrated that the Mount Polley Mine effluent discharge in Quesnel Lake does not meet the criterion for requiring a benthic invertebrate community study under the MDMER EEM (DWB 2021, Minnow 2022c). Therefore, supporting sediment quality data is no longer required under the MDMER EEM for the Mount Polley Mine effluent discharge and will not be discussed further within this CEMP Sediment Monitoring Plan.

The following sections of the CEMP Sediment Quality Monitoring Plan provide the objectives of sediment quality monitoring from 2023 to 2025, a summary of historical sediment quality findings, an overview of the CEMP study design and associated rationale (including sampling locations, replication, frequency, and analytes), and detailed methodology for sediment quality monitoring (quality assurance/quality control [QA/QC], sample collection methods, sample handling and laboratory analysis, data quality review, data handling, interpretation, and reporting).

1.2 Monitoring Objective

The objective of sediment quality monitoring is to evaluate the influence of Mount Polley Mine activities on receiving environments (Hazeltine Creek, Polley Lake, and Quesnel Lake) in comparison to baseline and/or reference conditions, and to determine potential implications to aquatic life by applying a variety of interpretive tools (e.g., Working Sediment Quality Guidelines [BCMOECCS 2021a,b], biological assessment). Sediment quality monitoring also provides

supporting information for benthic invertebrate community monitoring, supports exposure assessment as part of Ecological Risk Assessment (ERA) and Human Health Risk Assessment (HHRA), and supports the evaluation of fish habitat quality identified as a monitoring objective by the Habitat Remediation Working Group[3] (HRWG) for remediated creek areas.

[3] The HRWG was established at the request of Fisheries and Oceans Canada (DFO; April 9, 2015), in response to regulatory requirements set out in Section 38(6) of the *Fisheries Act*. Members of the working group include: DFO, British Columbia Ministry of Environment (BCMOE), British Columbia Ministry of Forest Lands and Natural Resource Operations and Rural Development (FLNRORD), Soda Creek Indian Band, Williams Lake Indian Band, and Mount Polley Mining Company.

2 SUMMARY OF HISTORICAL FINDINGS

Sediment has been monitored in the vicinity of the Mount Polley Mine since 1989, with most of the sediment quality samples collected in Polley Lake, Bootjack Lake, Hazeltine Creek, and Edney Creek (Table 1). Hazeltine Creek and Edney Creek are primarily comprised of erosional habitat, with few locations of sediment deposition. This has made sediment sampling challenging relative to lake environments, and some unconventional methodologies were applied in baseline studies.

Sediment quality sampling in the vicinity of the Mount Polley Mine has spanned four distinct time periods:

1. Baseline monitoring (1989, 1995, 1996);
2. Pre-breach operational monitoring (1999, 2009, 2012);
3. Post-breach operational monitoring (2014, 2015); and
4. Post-breach and post-discharge monitoring (2016, 2018, 2019, 2020, 2021, 2022[4]).

Data collected prior to the breach were summarized in an Aquatic Environmental Description Report prepared concurrent with an application for water discharge to Polley Lake in 2014 (Minnow 2014), and general findings of the historical sampling, as well as sediment monitoring data collected from 2014 to present, are provided, by sampling area to support the design of the CEMP Sediment Quality Monitoring Plan.

2.1 Polley Lake

2.1.1 Pre-Breach

Baseline sediment quality of Polley Lake was characterized by concentrations of a number of metals that were naturally elevated above sediment quality guidelines (WSQG), including arsenic, chromium, copper, iron, manganese, nickel, and selenium (Minnow 2014). Concentrations of copper, iron, and manganese were particularly elevated, with concentrations naturally exceeding the upper WSQG in some samples (HKP 1996, 1997).

Sediment quality monitoring in Polley Lake during operations but before the TSF embankment breach in 2014 indicated that concentrations of most of the elevated analytes remained similar to baseline. One apparent exception was selenium, which increased from 1.7 to 2.6 milligrams

[4] Sediment quality monitoring was also completed in 2022 but reporting of these results is in progress, with submission of an interpretive report that includes these results required by March 31, 2023. The 2022 sediment quality results are therefore excluded from the present document.

Table 1: History of Sediment Quality Monitoring in Waterbodies in the Vicinity of the Mount Polley Mine

A) Lakes

Year	Locations	Report
1989	Polley Lake, Bootjack Lake	Imperial Metals 1990
1995	Polley Lake, Bootjack Lake	HKP 1996
1996	Polley Lake, Bootjack Lake	HKP 1996
1999	Polley Lake, Bootjack Lake	Beak 2000
2007	Quesnel Lake	Minnow 2009
2009	Polley Lake, Bootjack Lake, Frypan Lake, Trio Lake	Minnow 2011
2012	Polley Lake	Minnow 2013a
2014	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2015a
2015	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2015b
2016	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2016a, 2016e
2018	Polley Lake, Bootjack Lake, Jacobie Lake, Quesnel Lake	Minnow 2019a, 2019c
2019	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2020a
2020	Quesnel Lake	Minnow 2021a
2021	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2022a, 2022c

B) Creeks

Year	Locations	Report
1995	Upper Hazeltine, Lower Hazeltine, Edney Creeks	HKP 1996
1996	Upper Hazeltine, Lower Hazeltine, Edney Creeks	HKP 1997
1999	Upper Hazeltine, Lower Hazeltine, Edney Creeks	Beak 2000
2007	Upper Hazeltine, Lower Hazeltine Creeks	Minnow 2009
2009	Upper Hazeltine Creek	Minnow 2011
2010	Upper Hazeltine, Lower Hazeltine Creeks	Minnow 2011
2011	Edney Creek	Minnow 2012
2012	Upper Hazeltine, Lower Hazeltine, Edney Creeks	Minnow 2013a
2013	Upper Hazeltine Creek	Minnow 2013b
2014	Upper Hazeltine, Lower Hazeltine Creeks	Minnow 2015a
2015	Sedimentation Pond	Minnow 2015b
2016	Sedimentation Pond	Minnow 2016c
2018	Upper Hazeltine, Lower Hazeltine, Edney Creeks	Minnow 2019a, 2019b
2019	Upper Hazeltine, Lower Hazeltine, Edney Creeks	Minnow 2020a, 2020b
2020	Upper Hazeltine, Lower Hazeltine, Edney Creeks	Minnow 2021a, 2021b
2021	Upper Hazeltine, Lower Hazeltine, Edney Creeks	Minnow 2022a, 2022b

per kilogram dry weight (mg/kg dw) in baseline to 2.5 to 3.7 mg/kg dw in 2009, and 5.0 to 6.9 mg/kg dw in 2012 (Minnow 2014). This increase was considered to be due to uncontrolled surface runoff from a north waste rock dump which reported to Polley Lake via North Dump Creek. This runoff contained elevated concentrations of selenium from 2006 until control in 2009 with the construction of the Long Ditch.

2.1.2 Post-Breach (Deep Areas)

Following the TSF embankment breach, sediment quality monitoring in the deep basins of Polley Lake indicated that concentrations of arsenic and copper were elevated at one or more deep monitoring locations relative to the WSQG and baseline/reference concentrations (Minnow 2015a). Changes in sediment quality were greatest for copper, with concentrations increasing from a baseline range of 262 to 370 mg/kg dw to 630 to 722 mg/kg dw in September 2014 (Minnow 2015a). Due to very low organic content of the breach-derived materials, sediment organic carbon content was also lower following the breach (Minnow 2015a). Sediment quality monitoring from 2015 to 2021 for the deep basins of Polley Lake has indicated very temporally consistent results over this period. Specifically, arsenic (mean: 10.5 to 12.7 mg/kg dw; 2014 to 2021) and copper (mean: 526 to 823 mg/kg dw; Figure 1) have consistently been the only two analytes in sediments from these deep areas (POL-P1 and POL-P2) with concentrations greater than pre-breach/reference concentrations and the WSQG since 2014 (Minnow 2022a). Concentrations of these two analytes have either remained stable (copper; Figure 1) or have decreased since 2014 (arsenic) relative to reference (Minnow 2022a). Similarly, total organic carbon (TOC; mean: 5.1 to 11.3 %) content of sediments has showed no significant change from 2014 to 2021 relative to reference conditions (Figure 1; Minnow 2022a), although slight non-significant increases were observed in 2021 compared to previous-post breach monitoring years (i.e., 2016 and 2018; Figure 1; Minnow 2022a). Overall, these deep sediment quality results from Polley Lake indicate that temporal changes in the physical and chemical characteristics of sediments in both the north and south basins of Polley Lake have been limited since the breach in 2014, but recovery may be occurring (Minnow 2022a). The low rate of change observed in sediment quality results is consistent with monitoring results that have indicated relatively low rates of sediment deposition in Polley Lake (average 0.66 mm/year.; 15 years for the accumulation of 1 cm of sediment; Minnow 2018a).

Toxicity testing of sediments from the deep basins of Polley Lake in 2014, 2016, 2018, and 2021 indicated no effects to survival or growth of *Chironomus dilutus* (Figure 2; Minnow 2015a, 2017a, 2019a, 2020a), but a moderate reduction in growth of *Hyallela azteca* was observed at mid-depth areas in 2014 (Minnow 2015a). The benthic invertebrate community of the two deep basins in Polley Lake showed consistent recovery from 2014 to 2021 to a condition similar to the reference

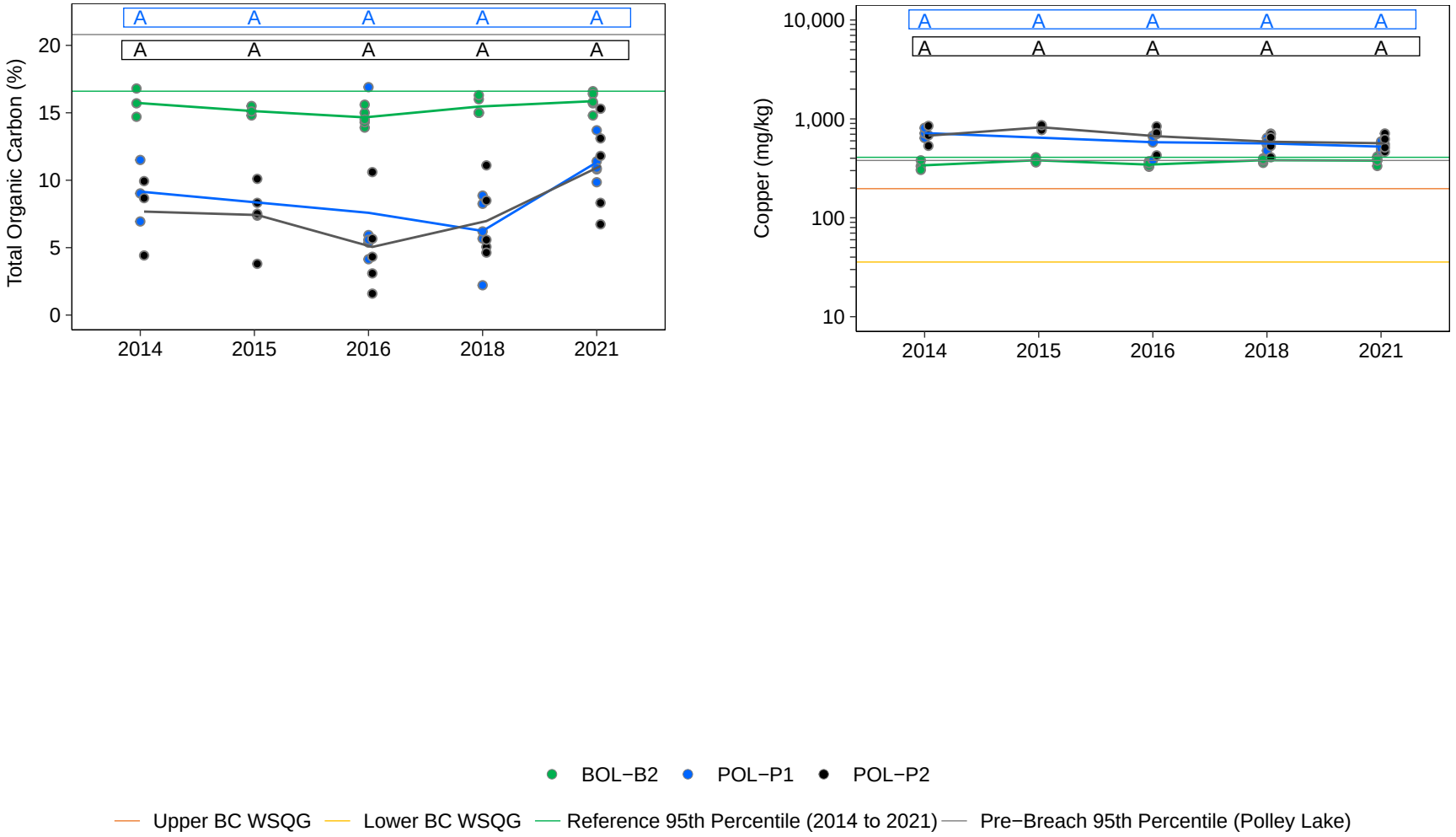


Figure 1: Concentrations of Copper and Total Organic Carbon in Sediment (<63 µm Fraction) from Deep Polley Lake (POL-P1, POL-P2) and Reference (Bootjack Lake; BOL-B2) Areas, 2014 to 2021

Notes: BC WSQG = British Columbia Working Sediment Quality Guideline (BCMOECCS 2021a). The reference 95th Percentile was calculated using data from 2014 to 2021. Green represents reference areas and other colours represent exposed areas. Individual samples are plotted and lines join the least squares estimated mean values for years included in the statistical analysis (i.e., not below the laboratory reporting limit). Statistical analyses were conducted using a two −way ANOVA with factors Area and Year and $\log_{10}$-transformed data for all analytes except Total Organic Carbon (TOC; no transformation). Years that share a letter (e.g., A,B,C) have ratios (or differences – TOC) of concentrations (Exposed:Reference) that do not differ significantly (p−value < 0.05) among years. Letter A was assigned to the year with the highest ratio (or difference) of concentrations (Exposed:Reference). Only years with samples from both reference and exposed areas are plotted.

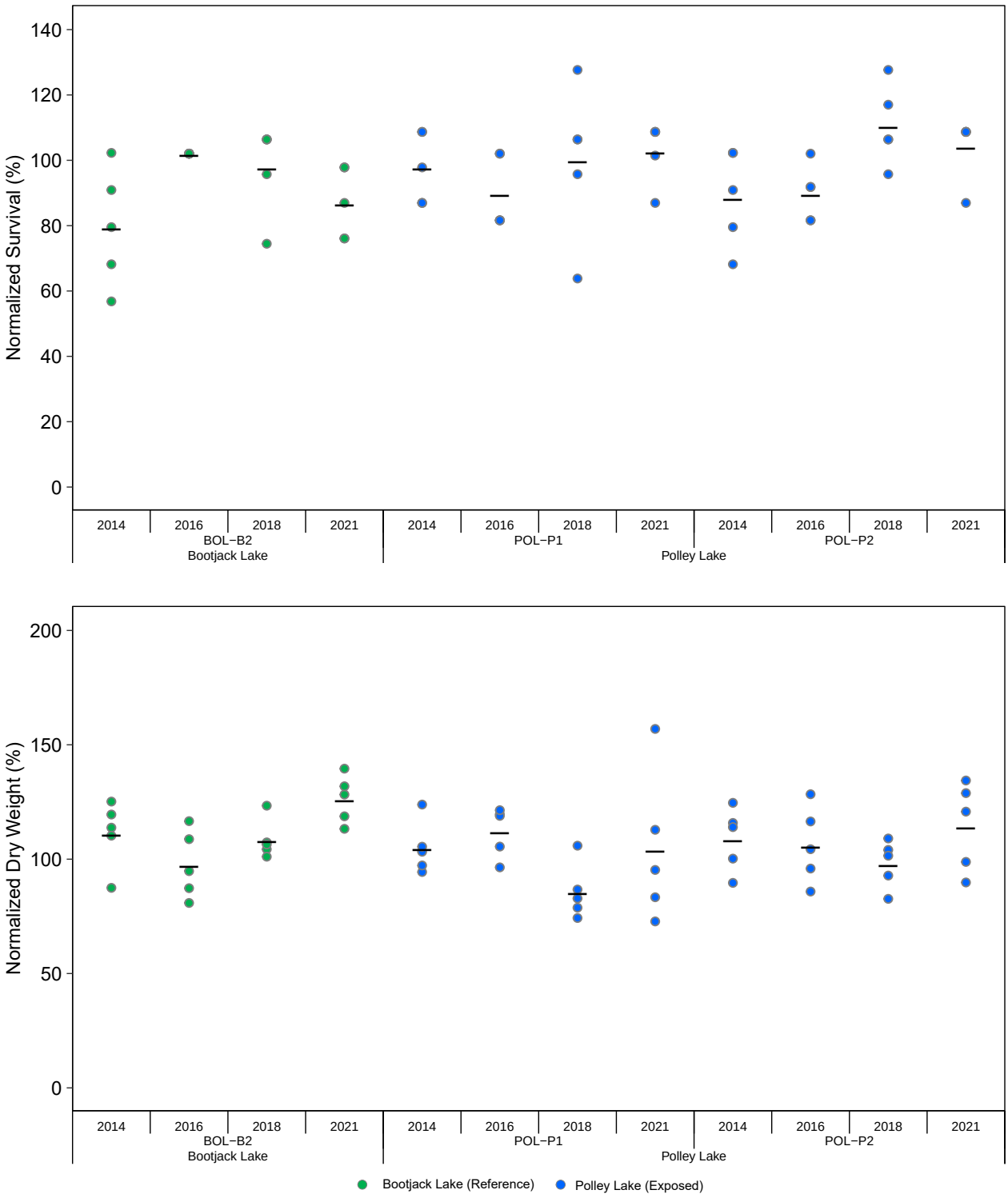


Figure 2: Control Normalized *Chironomus dilutus* Toxicity Test Results for Sediment from Deep Polley Lake (POL-P1, POL-P2; Exposed) and Bootjack Lake (BOL-B2; Reference) Areas, 2014 to 2021

Notes: Control-normalized survival and growth results are presented as a percentage of the test control performance (i.e., control-normalized results were calculated by dividing the test results by the concurrent average laboratory control result).

area in terms of density and richness and with densities similar or greater than pre-breach (Minnow 2022a). Lastly, a variety of sediment quality investigations conducted to characterize the potential mobility and bioavailability of sediment associated metals (humidity cell tests, shake flask tests, selective extractions, ratios of simultaneously extracted metals to acid volatile sulphides [SEM/AVS], porewater chemistry, and Diffusive Gradients in Thin Films [DGT] devices) have all supported low mobility and bioavailability of sediment-associated metals (e.g., SRK 2015a,b; Minnow 2015a, 2016c, 2016d, 2017b, 2017c, 2018b, 2019a, 2020a, 2022a). Combined, the low potential mobility and bioavailability of sediment-associated metals, the absence of sediment toxicity, and the recovery of the benthic invertebrate community to conditions largely similar to reference and/or pre-breach, indicates that the potential risk to aquatic life associated with breach-impacted sediments in deep Polley Lake areas is low.

2.1.3 Post-Breach (Shallow Areas)

Sediment quality monitoring of a shallow area of Polley Lake (POL-S) was initiated in 2019 in support of sediment toxicity monitoring at this area. Monitoring results indicated that concentrations of arsenic, copper, and iron were greater than the WSQG and reference concentrations. Specifically, mean arsenic (13.5 mg/kg dw) was greater than the lower WSQG by 2.3 times, while mean copper (767 mg/kg dw) and iron (137,000 mg/kg dw) concentrations exceeded the upper WSQG by 3.9 and 3.1 times, respectively. Copper concentrations in reference sediments also exceeded the lower WSQG by approximately 3.8 times (Minnow 2020a). Sediment toxicity testing of shallow Polley Lake sediments showed no unacceptable response to survival of *H. azteca* relative to reference, but a moderate reduction in survival when relative to the laboratory sand control) and no effects to growth (Minnow 2020a).

2.2 Hazeltine Creek

2.2.1 Pre-Breach

Baseline sediment quality of Hazeltine Creek was characterized in 1995 and 1996 (HKP 1996, 1997), but the latter included suspected errors (i.e., sampling in 1996 yielded unusually high concentrations of some metals [e.g., up to 22,000 mg/kg dw copper] that were not observed in 1995 and have not been observed since). Based on the sampling conducted in 1995 (HKP 1996) and consistency with sampling conducted in 1999 (Beak 2000), concentrations of arsenic, copper, iron, and manganese (although reported as much lower than in 1996) were naturally elevated above the lower WSQG (Minnow 2014).

Sediment quality monitoring in Hazeltine Creek during operations but before the TSF embankment breach in 2014 indicated concentrations of most of the elevated analytes remained similar to baseline. One possible exception was selenium, which, despite some uncertainty

associated with different sampling methods and locations, had concentrations that were slightly greater than the sediment quality guideline of 2 mg/kg dw (i.e., up to 3.14 mg/kg dw in a beaver pond in the fall of 2013; Minnow 2014). It is uncertain whether this difference was associated with the uncontrolled surface runoff that occurred from 2006 to 2009 (as described in Section 2.1) or if it was associated with the exclusive availability of fine sediment (that would naturally be expected to have higher metal concentrations) at a beaver pond sampled in 2013.

2.2.2 Post-Breach

Following the TSF embankment breach, sediment quality monitoring was conducted in Hazeltine Creek in 2014. This sampling was prior to substantial creek channel remediation efforts and represented breach-material, believed to be mostly tailings. Accordingly, these "sediments" had very low organic carbon content, concentrations of copper and iron greater than the upper WSQG and concentrations of arsenic, nickel, and manganese greater than the lower WSQG (Minnow 2015a). Sediment quality monitoring of the Hazeltine Creek upper sedimentation pond completed in 2015 and 2016 indicated that concentrations of arsenic and nickel occurred at concentrations greater than reference and the lower WSQG, and concentrations of copper and iron occurred at concentrations greater than reference and the upper WSQG (Minnow 2015b; 2016a).

Sediment quality monitoring completed in upper (HAC-R1 and HAC-U [HAC-R2]) and lower Hazeltine Creek (HAC-D [HAC-R5]) was completed annually starting in 2018. This monitoring documented the physical and chemical characteristics of sediments from limited locations of sparse accumulation in the primarily erosional habitats of upper and lower Hazeltine Creek. Sediments were characterized in 2021 by concentrations of several analytes that were greater than reference/pre-breach concentrations and the upper WSQG values: copper in upper Hazeltine Creek, and arsenic, copper, and iron in lower Hazeltine Creek. Mean concentrations of these analytes and the TOC content of sediments from upper and lower Hazeltine Creek areas have remained stable from 2019 to 2021, relative to reference, except for copper which was similar between 2018 and 2021 (Figure 3) and iron which decreased from 2018 to 2021 in lower Hazeltine Creek (Minnow 2022a). In both upper and lower Hazeltine Creek, copper was the most substantially elevated analyte from 2018 to 2021 (Figure 3; Minnow 2022a). The highest sediment copper concentrations in Hazeltine Creek from 2021 were collected from areas that were remediated within weeks prior to sampling and may have been influenced by highly inorganic (low TOC and total nitrogen) materials that were used or disturbed by the remediation project. Variability among years (2018 to 2021) in the analytes with sediment concentrations greater than reference/pre-breach concentrations and the lower or upper WSQG (Minnow 2019a, 2020a, 2021a, 2022a) has indicated that results are driven to a degree by

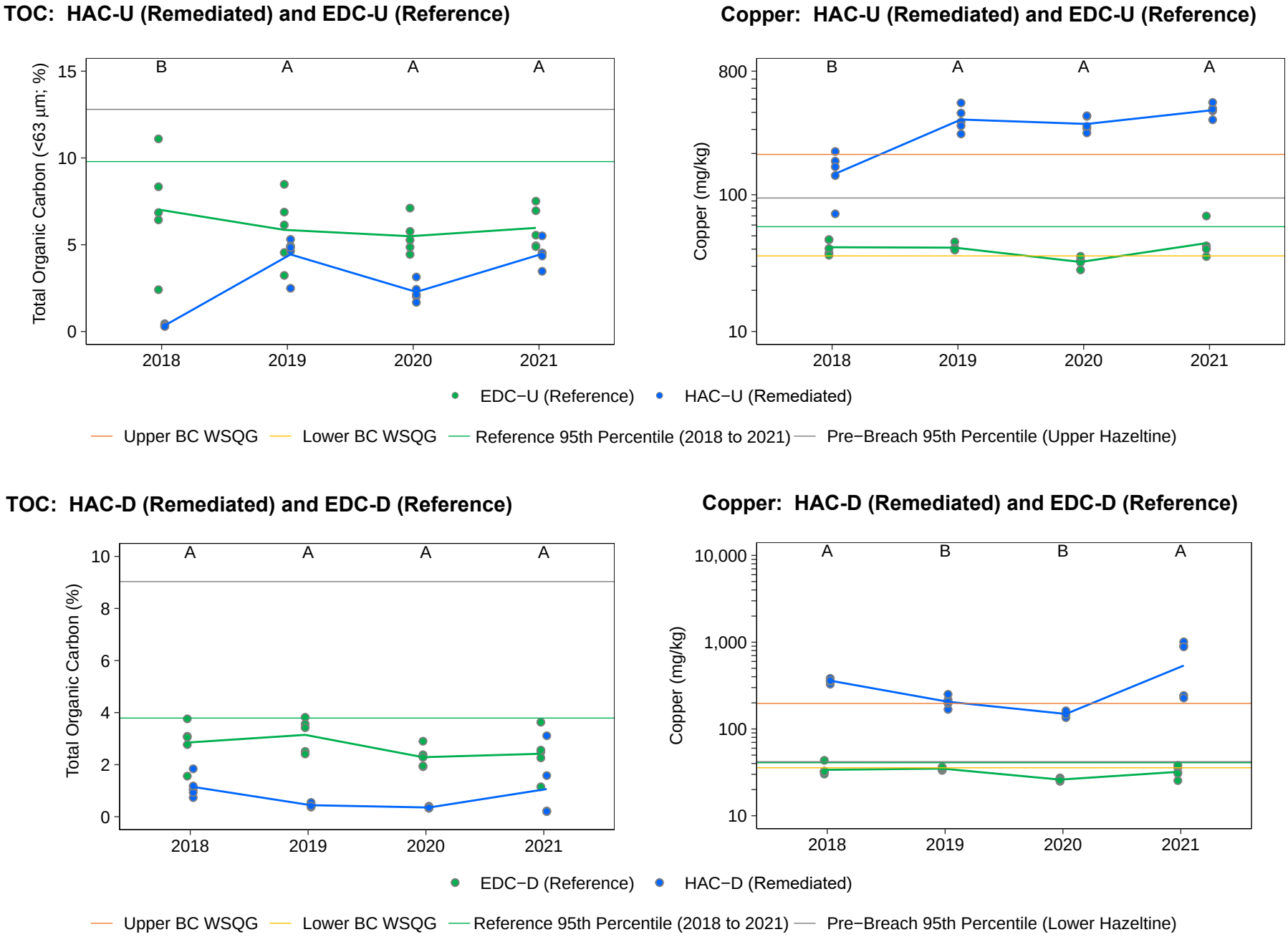


Figure 3: Concentrations of Copper and Total Organic Carbon in Sediment (<63 µm Fraction) from Hazeltine Creek (HAC-U, HAC-D; Remediated) and Edney Creek (EDC-U, EDC-D; Reference) Areas, 2018 to 2021

Notes: TOC = total organic carbon. Concentrations below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL. Individual samples are plotted and lines join the least−squares estimated mean values for years included in the statistical analysis (i.e., not <LRL). Statistical analyses were conducted using a two −way ANOVA with factors Area and Year. The models were fit using Maximum Likelihood Estimation with an assumed log−normal distribution. Years that share a letter (e.g., A,B,C) have differences in concentrations (Exposed − Reference) that do not differ significantly (p−value < 0.05) among years.

variable sediment physical characteristics related to the limited presence of sediment in the erosional habitat of Hazeltine Creek (and reference) and the unavoidable necessity for opportunistic sampling (Minnow 2022a).

2.3 Quesnel Lake

2.3.1 Pre-Breach

Sediment quality data for Quesnel Lake collected prior to the TSF embankment breach are limited to a few samples collected from shallow areas near the mouth of Hazeltine Creek in 2007 (Minnow 2009) and from the north arm near the mouth of the Mitchell River in 2012 (Minnow 2015a). These data documented a mean selenium concentration of 0.37 mg/kg dw in the north arm samples (only analyte measured; Minnow 2015a) and a mean copper concentration of 23.0 mg/kg dw in samples from near Hazeltine Creek (Minnow 2009).

2.3.2 Post-Breach (Deep Areas)

Sediment quality monitoring in Quesnel Lake was completed following the TSF embankment breach at impacted and reference areas. A total of 121 sediment samples were collected from deep habitat of Quesnel Lake and 60 sediment samples were collected from shallow habitat of Quesnel Lake between 2014 and 2016 to characterize sediment quality (Minnow 2015a, 2015b, 2016a). These sediment quality investigations indicated that the majority of breach-derived material was deposited to deep habitat. As with other habitats (i.e., Polley Lake and Hazeltine Creek), the chemical influence of the breach on these deep habitats was most evident in copper concentrations greater than reference and the upper WSQG in impacted areas. Arsenic, iron, and manganese in sediments from these deep areas were elevated to concentrations greater than the lower WSQG and reference concentrations. The influence of the breach was also evident in very low organic carbon content in impacted areas relative to reference.

Monitoring of deep near-field and far-field impacted sediments from 2015 to 2021 indicated temporal stability in the sediment quality conditions at these areas since 2014. Specifically, sediment concentrations of arsenic, copper, iron, and manganese continued to exceed reference conditions and the WSQG (the lower WSQG for arsenic and iron, the lower/upper WSQG for manganese depending on year, and the upper WSQG for copper) and copper continued to be the most substantially elevated analyte (Minnow 2022a). Concentrations of these analytes and TOC in the deep impacted sediments in 2021 remained similar to early post-breach values (i.e., 2014; Figure 4), relative to reference, with the exception of copper in far-field and manganese in near-field and far-field sediments which increased over the same period (Minnow 2022a). Concentrations of copper and manganese in the deep far-field

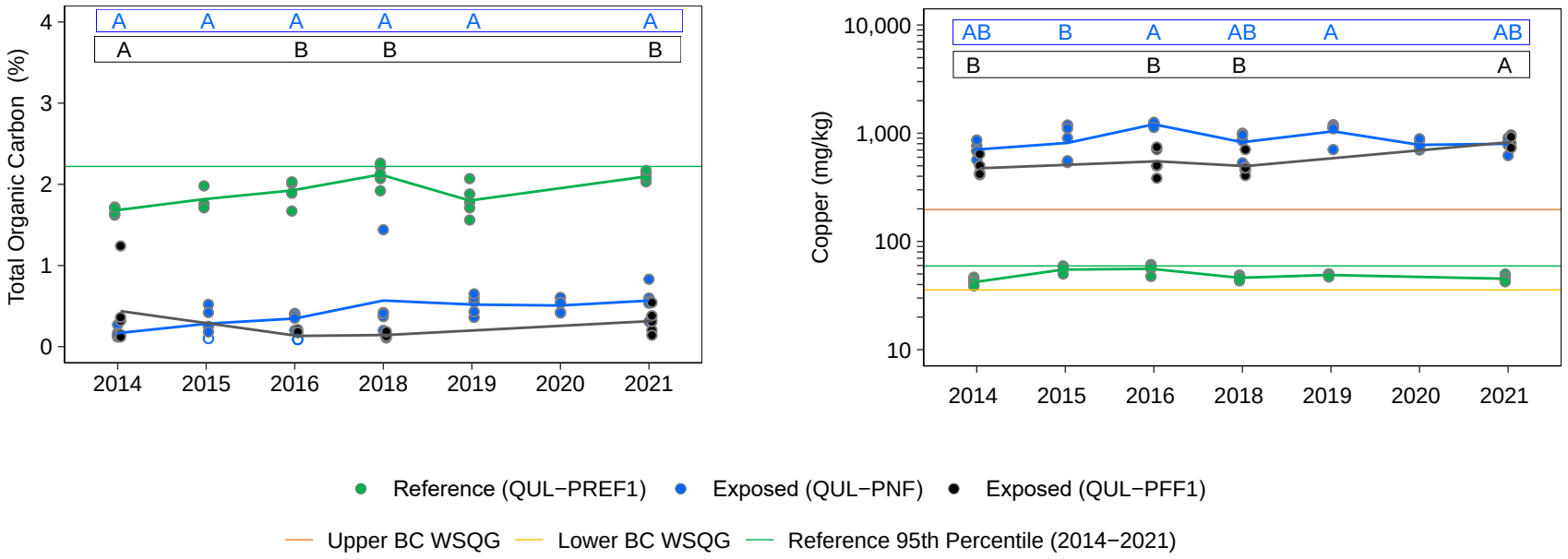


Figure 4: Concentrations of Copper and Total Organic Carbon in Sediment (<63 µm Fraction) from Deep Exposed (QUL-PNF, QUL-PFF1) and Reference (QUL-PREF1) Areas of Quesnel Lake, 2014 to 2021

Notes: BC WSQG = British Columbia Working Sediment Quality Guideline (BCMOECCS 2021a). The reference 95th Percentile was calculated using data from 2014 to 2021. Green represents reference areas and other colours represent exposed areas. Concentrations below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL and the open symbol represents one or more values reported below the LRL. Individual samples are plotted and lines join the least squares estimated mean values for years included in the statistical analysis (i.e., not <LRL). Statistical analyses were conducted using a two−way ANOVA with factors Area and Year and $\log_{10}$-transformed data for all analytes except Total Organic Carbon (TOC) (no transformation). Years that share a letter (e.g., A,B,C) have ratios (or differences – TOC) of concentrations (Exposed:Reference) that do not differ significantly ($p-value < 0.05$) among years. Letter A was assigned to the year with the highest ratio (or difference) of concentrations (Exposed:Reference). Only years with samples from both reference and exposed areas are plotted.

sediments were notably higher in 2021 than in the previous sampling year, 2018, relative to reference (Figure 4). This increase was likely driven by higher clay content of these sediments in 2021 compared to 2018 (31% higher; Minnow 2022a). Some sediment consolidation (i.e., compaction) appears to be occurring in Quesnel Lake. Temporal change is expected to be primarily associated with deposition (i.e., covering of impacted sediment with non-impacted sediment), and evaluation of sediment deposition rates have indicated relatively low rates of sediment deposition in Quesnel Lake (range 1.4 to 1.7 mm/yr; 6 to 7 years for the accumulation of 1 cm of sediment; Minnow 2018a).

Sediment toxicity testing completed in 2014, 2015, 2016, and 2021 for deep impacted sediments indicated no responses to *C. dilutus* survival, but clear reductions in growth in 2014 to 2016 (Minnow 2017a) and a moderate reduction in growth in 2021 compared to reference (but not compared to laboratory control; Figure 5; Minnow 2022a). Results in 2018 showed a moderate reduction in survival and a moderate (compared to laboratory control) or high (compared to reference) reduction in *C. dilutus* growth exposed to sediments from the deep near-field area (Minnow 2019a). Although results from toxicity testing with *C. dilutus* at the Quesnel Lake deep near-field area have varied temporally from 2014, normalized survival has been consistently above 60% and normalized growth was higher in 2021 than in previous years of testing (Figure 5; Minnow 2022a).

Evaluation of relationships between observed responses and sediment quality indicated that combinations of high copper concentrations and low sediment organic carbon content were the best determinants of the observed responses (Minnow 2017a) and provided stronger relationships with growth than with survival responses (Minnow 2022a). These relationships are consistent with a breach-related effect on *C. dilutus* growth that occurs due to a combination of low TOC and high concentrations of copper and the suite of breach-related analytes that correlate positively with copper (Minnow 2022a). The TOC concentrations of deep near-field sediments (mean = 0.17 to 0.57% in 2014 to 2021) are lower than the organic content at which intolerance to sediments by *C. tentans* (the commonly used former name of *C. dilutus*) has been reported (< 1%; Suedel et al. 1993) and similar to the TOC at which poor survival has been reported (0.5% or lower; Suedel and Rodgers 1994). Sediment copper concentrations also are greater than the upper WSQG (197 mg/kg dw; BCMOECCS 2021a) which is considered to represent a concentration that if exceeded will likely cause severe effects on aquatic life. Despite the observed responses in sediment toxicity tests, benthic invertebrate community monitoring, which is considered to be a measure of greater ecological relevance than toxicity testing (due to the fact that it evaluates *in situ* habitat use by site organisms), have indicated recovery of organism density and taxon richness in 2016 to 2021 compared to immediately following the breach (2014/2015; Minnow 2022a). These endpoints remain lower than reference, the exposed area

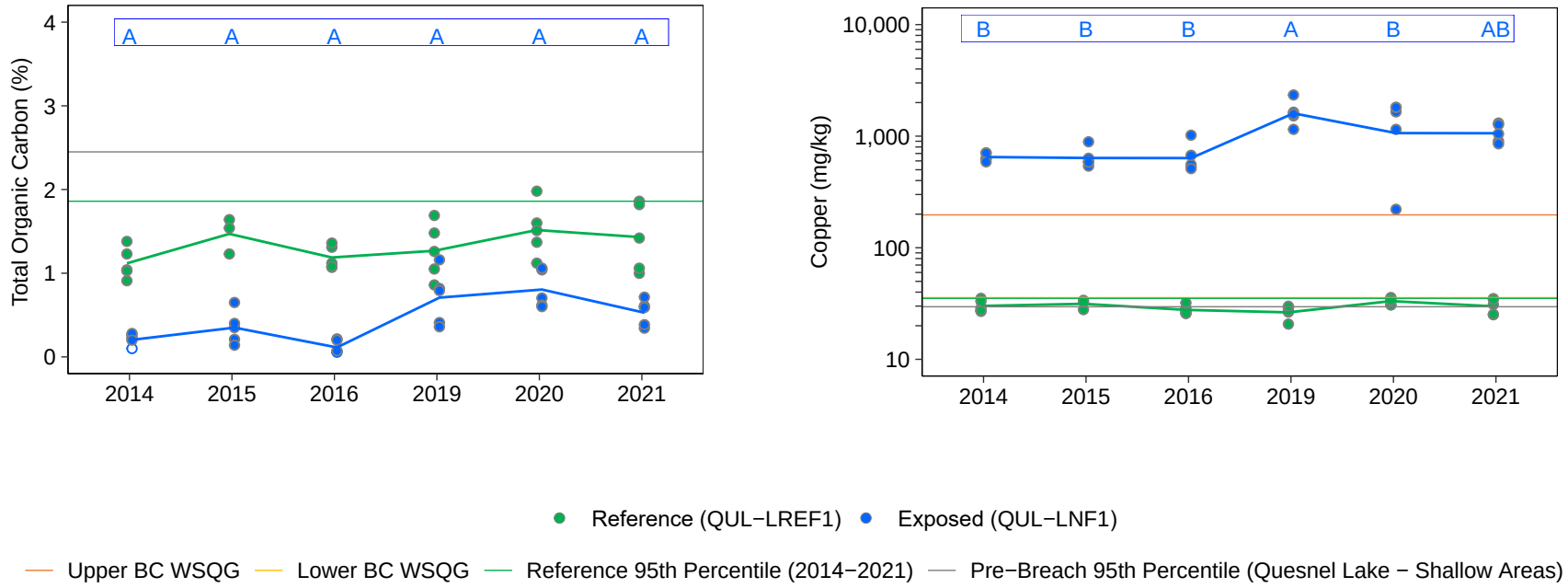


Figure 5: Concentrations of Copper and Total Organic Carbon in Sediment (<63 µm Fraction) from Shallow (QUL−LNF1; Exposed) and (QUL−LREF1; Reference) Areas of Quesnel Lake, 2014 to 2021

Notes: BC WSQG = British Columbia Working Sediment Quality Guideline (BCMOECCS 2021a). The reference 95th Percentile was calculated using data from 2014 to 2021. Green represents reference areas and other colours represent exposed areas. Individual samples are plotted and lines join the least squares estimated mean values for years included in the statistical analysis (i.e., not below the laboratory reporting limit). Statistical analyses were conducted using a two −way ANOVA with factors Area and Year and $\log_{10}$ -transformed data for all analytes except Total Organic Carbon (TOC; no transformation). Years that share a letter (e.g., A,B,C) have ratios (or differences – TOC) of concentrations (Exposed:Reference) that do not differ significantly (p−value < 0.05) among years. Letter A was assigned to the year with the highest ratio (or difference) of concentrations (Exposed:Reference). Only years with samples from both reference and exposed areas are plotted.

communities are not identical to reference, and no substantial change in community features has occurred from 2016 to 2021 (Minnow 2022a); however the increased density and richness since 2014 are indicative of some recolonization of these impacted areas. Lastly, a variety of sediment quality investigations conducted to characterize the potential mobility and bioavailability of sediment associated metals (humidity cell tests, shake flask tests, selective extractions, ratios of simultaneously extracted metals to acid volatile sulphides [SEM/AVS], porewater chemistry, and DGT devices) have supported low mobility and bioavailability of sediment-associated metals (e.g., SRK 2015a,b; Minnow 2015a, 2016c, 2017b, 2018b, 2019a, 2020a).

2.3.3 Post-Breach (Shallow Areas)

Shallow sediments impacted by the TSF embankment breach have been monitored since 2014 and at the shallow near-field area (QUL-LNF1) were characterized by high sand content from 2015 to 2021 (mean: >82%; Minnow 2020a). Immediately following the breach in 2014, arsenic, iron, and manganese concentrations in these shallow impacted sediments were elevated to concentrations greater than the lower WSQG and reference conditions (Minnow 2015a). Similar to the deep habitats, the chemical influence of the breach on these shallow impacted sediments was most evident in copper concentrations (which exceeded both reference conditions and the upper WSQG) and in the organic carbon content that was much lower than reference (Minnow 2015a). The TOC content of shallow near-field sediments was both temporally stable, relative to reference, and consistently lower than reference from 2014 to 2021 (Figure 6; Minnow 2022a). Concentrations of arsenic and copper also showed temporal stability, with results in 2021 similar to those reported in 2014 (Figure 6), while concentrations of iron and manganese increased between 2014 and 2021 but have been temporally stable relative to reference since 2015 and 2016, respectively (Minnow 2022a). The increase in iron and manganese concentrations relative to 2014 is likely related to the substantial decrease in sediment silt content and increase in sand content that occurred between 2014 and 2015 (Minnow 2015a, 2016a, 2022a). Silver concentrations in the shallow near-field sediment were higher than the lower WSQG and reference in 2019 to 2021, but concentrations in 2021 were similar to those reported in 2014, relative to reference, indicating relative temporal stability (Minnow 2022a).

Sediment toxicity testing of *H. azteca* for shallow near-field sediments resulted in no effect to survival in 2014, moderate survival responses in 2016, 2020, and 2021, and 0% survival in 2019. Growth of *H. azteca* exposed to these sediments showed moderate responses in 2014 and high growth responses in 2016 to 2021 (with no growth measures in 2019 due to 0% survival; Figure 7; Minnow 2015a, 2016b, 2020a, 2021a, 2022a). Concentrations of dissolved copper in overlying waters of the toxicity test vessels for the shallow near-field sediment were measured from 2019

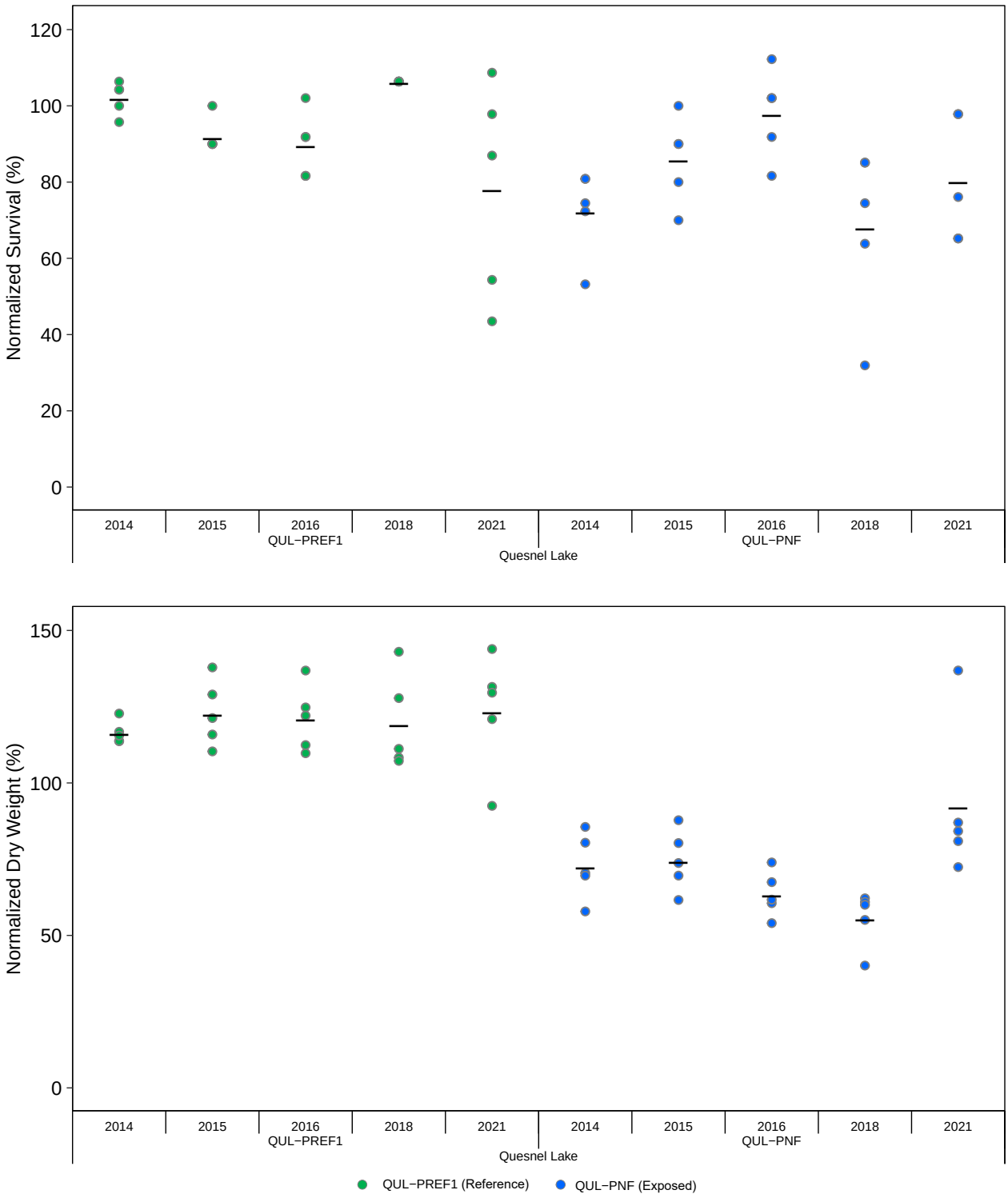


Figure 6: Control Normalized *Chironomus dilutus* Toxicity Test Survival and Growth Responses (10-day) for Sediment from Deep Exposed (QUL-PNF) and Reference (QUL- PREF1) Areas of Quesnel Lake, 2014 to 2021

Notes: Control-normalized survival and growth results are presented as a percentage of the test control performance (i.e., control-normalized results were calculated by dividing the test results by the concurrent average laboratory control result).

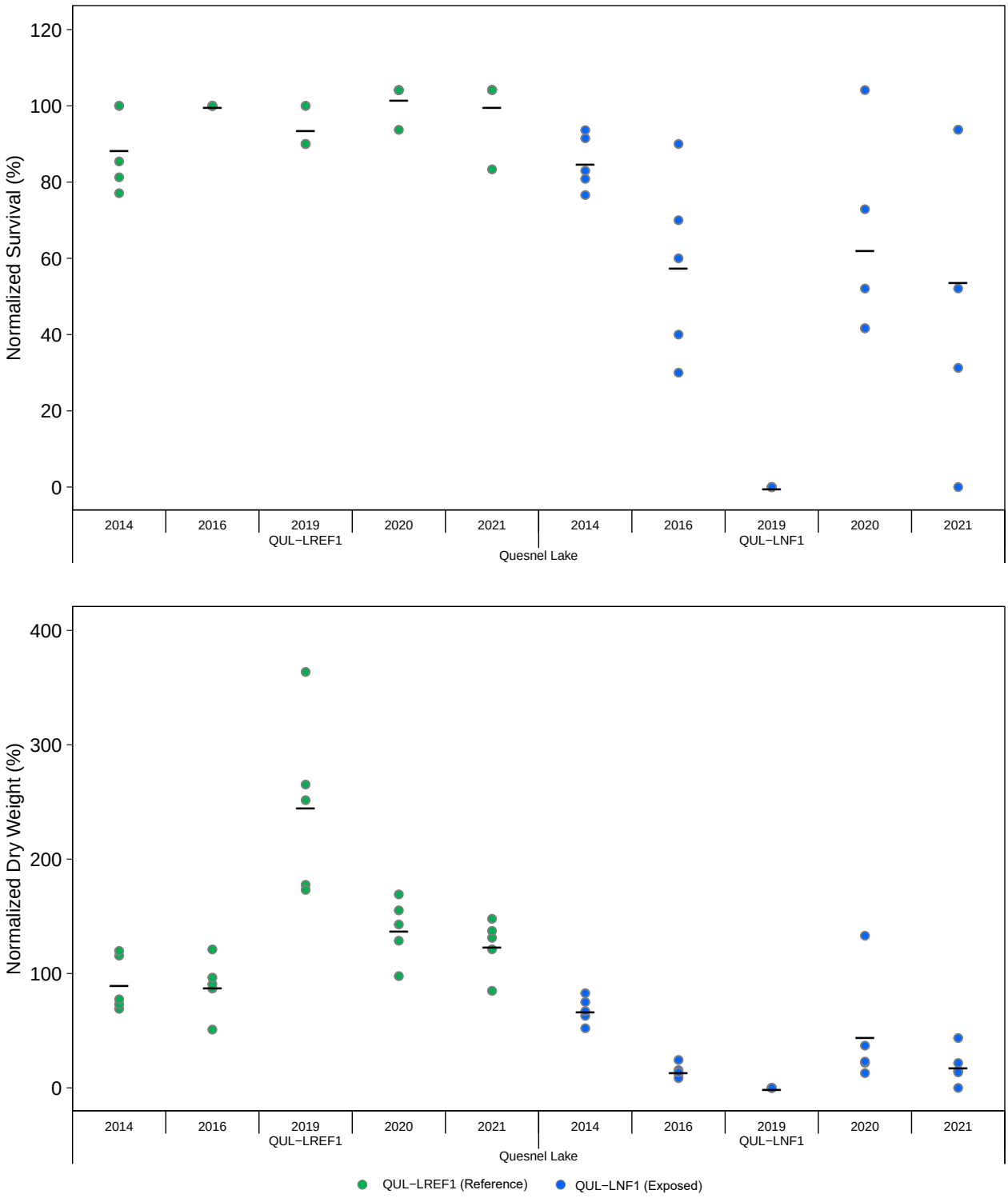


Figure 7: Control Normalized *Hyalella azteca* Toxicity Test Survival and Growth Responses (14-day) for Sediment from Shallow Exposed (QUL-LNF1) and Reference (QUL-LREF1) Areas of Quesnel Lake, 2014 to 2021

Notes: Control-normalized survival and growth results are presented as a percentage of the test control performance (i.e., control-normalized results were calculated by dividing the test results by the concurrent average laboratory control result).

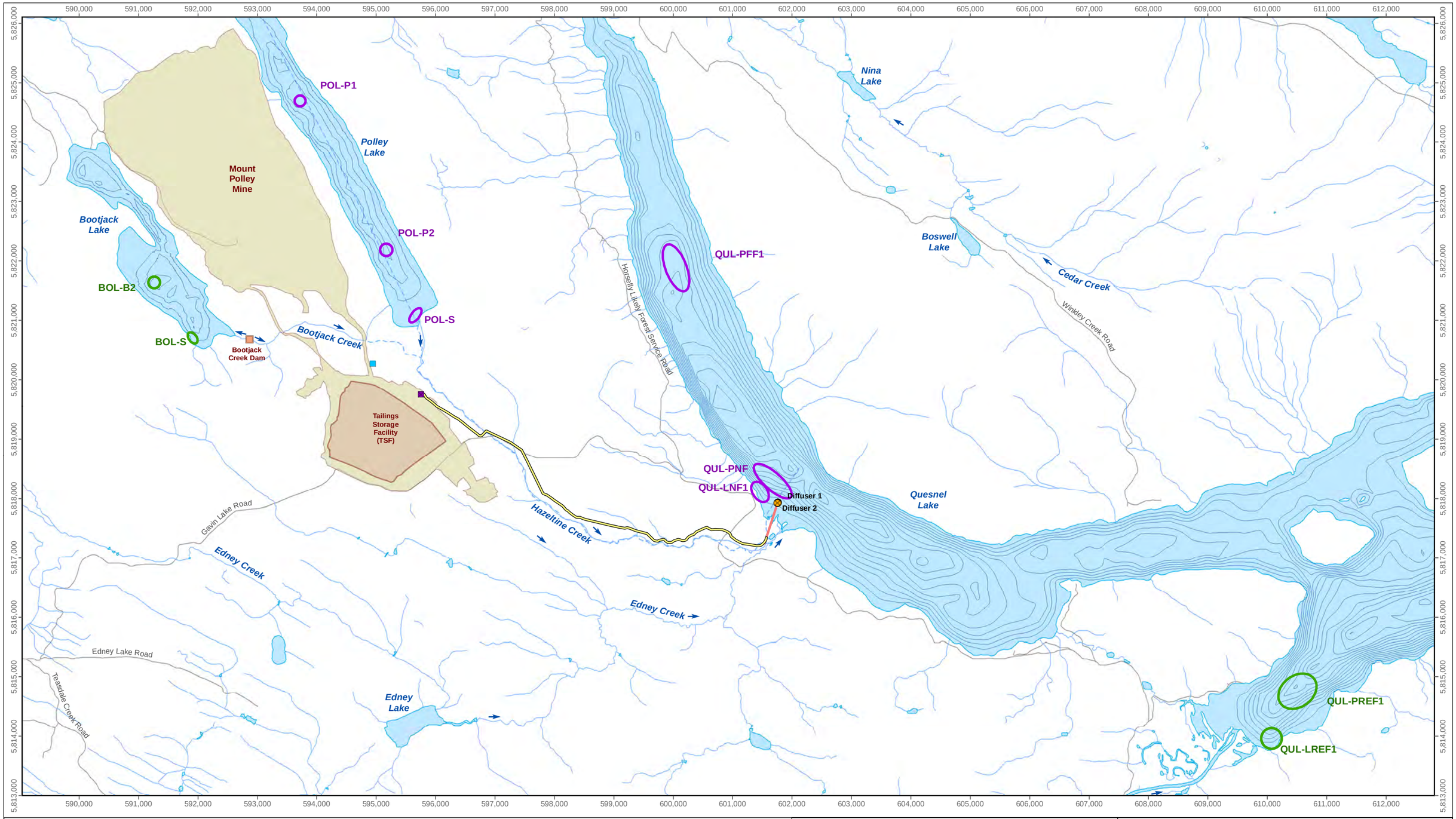
to 2021, and in all three years were highly dissimilar from those documented at these sites in field-collected water supporting the sediment sampling (i.e., mean ranging from 74- to 175-times greater in the test vessels than *in situ*; Minnow 2020a, 2021a, 2022a). This strongly suggests copper mobilization in the static test setup that has either not occurred *in situ* or has attenuated over time *in situ*. To better understand the evolution of dissolved copper to overlying toxicity test waters for these shallow sediments, additional toxicity tests using static-renewal methods were conducted in 2021 (Minnow 2022a). The static-renewal test method provides more environmentally relevant testing conditions than the standard static testing methods but is still highly dissimilar from *in situ* field conditions. Although dissolved copper concentrations in overlying waters of static-renewal tests were significantly lower than the static tests, growth and survival results for *H. azteca* between the test types were similar (Minnow 2022a). Survival in *H. azteca* testing was higher in both 2020 and 2021 than in 2019 when 0% survival occurred (Figure 7). The survival response in 2019 was associated with dissolved copper concentrations in overlying test waters that were 175-times higher than those observed *in situ*, while in 2020 and 2021 copper concentrations were 74- and 114- times higher in test overlying water than *in situ* results, respectively (Minnow 2020a, 2021a, 2022a). The decreased survival response in 2020 and 2021 relative to 2019, observed in concert with increase dissolved copper concentrations in test waters, further corroborates the observation that toxicity responses of *H. azteca* are consistent with dissolved copper concentrations in overlying test water. Overall, temporal trends of *H. azteca* toxicity test results suggest a residual breach-related influence on *H. azteca* toxicity for both growth and survival within the small “shallow near-field area” near the mouth of Hazeltine Creek. However, the toxicity test results from this small area cannot be reliably extrapolated to the field because chemical conditions created in the laboratory are highly dissimilar from those in the field.

3 STUDY DESIGN AND RATIONALE

Sediment quality monitoring under the CEMP is designed to meet the combined needs of: 1) operational monitoring; 2) monitoring of the impact of the 2014 TSF embankment breach; and 3) monitoring of the response to remediation activities following the TSF embankment breach. An overview of the proposed sediment quality monitoring program for 2023 to 2025 is provided in Figures 8 and 9 and Table 2. This CEMP Sediment Monitoring Plan includes revisions to the study design (i.e., updates to monitoring frequency, locations, endpoints, and methodologies) relative to the previous study design (MPMC 2019), with revisions that are based on a Qualified Professional (QP) review of existing data. This section details the updated study design, outlines revisions compared to the previous study design (MPMC 2019), and provides the rationale associated with the proposed study design revisions.

Sediment quality monitoring will continue to focus on Polley Lake, Hazeltine Creek, and Quesnel Lake, with reference areas identified for each mine-influenced sampling area (i.e., Bootjack Lake for Polley Lake, unaffected areas of Edney Creek for Hazeltine Creek, and unaffected areas of Quesnel Lake for impacted areas of Quesnel Lake; Figures 8 and 9, Table 2). In Polley Lake, sediment sampling will continue to include the two basins (deepest locations in Polley Lake, representing locations of sediment accumulation/fate; POL-P1, POL-P2), with the deepest location in Bootjack Lake (BOL-B2) serving as reference. Sediment sampling in Polley Lake will also include a shallow area (POL-S) with a shallow area of Bootjack Lake (BOL-S) serving as reference. In Quesnel Lake, sediment quality monitoring will continue to include deep near-field and far-field areas (QUL-PNF1, QUL-PFF1) and a suitable deep reference area (QUL-PREF1; Figure 8, Table 2). Sediment sampling in Quesnel Lake will also include a shallow near-field area (QUL-LNF1) with a shallow unaffected area of Quesnel Lake (QUL-LREF1) serving as reference. The deep monitoring areas of Polley Lake (with Bootjack Lake as reference) and Quesnel Lake are consistent with the previous study design, however the shallow monitoring areas of these waterbodies were not included in the previous study design (MPMC 2019). These shallow areas have been monitored since 2019 in Polley Lake (and reference) and since 2014 in Quesnel Lake, and their inclusion in the present study design is specifically for the purpose of meeting the monitoring requirements outlined in BCMOECCS (British Columbia Ministry of Environment and Climate Change Strategy; 2021c)[5]. Sediment quality monitoring in

[5] The requirements for sediment monitoring in shallow areas of Polley Lake and Quesnel Lake outlined in BCMOECCS (2021c) are as follows: “Regarding the update of Condition 11) of the approval letter of November 09, 2018 in the approval letter of March 14, 2019, the Director approves discontinuation of the *Hyalella azteca* toxicity testing using sediment of shallow habitat from Polley Lake. However, the 14-day sediment toxicity test on *H. azteca* must be conducted every three years (i.e., next in 2022) using sediment of shallow habitat from Polley Lake unless MPMC can



LEGEND

- Exposed Area
- Reference Area
- Diffuser (Treated Effluent Discharge, December 2015 to present)
- Effluent Discharge Pipeline (January 2018 to present)
- Discharge to Diffusers (2015 to present)
- Water Treatment Plant (WTP)
- Central Collection Sump
- Historic Watercourse

Please note: Quesnel Lake bathymetry lines are an approximate representation only and may not precisely delineate accurate depths at larger scales.

0 1 2 4 km

N W E S

Projection: North American Datum 1983 UTM Zone 10U

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Mount Polley CEMP Sediment Monitoring Locations, Lakes

Date: January 2023
Project: 227202.0029

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Figure 8

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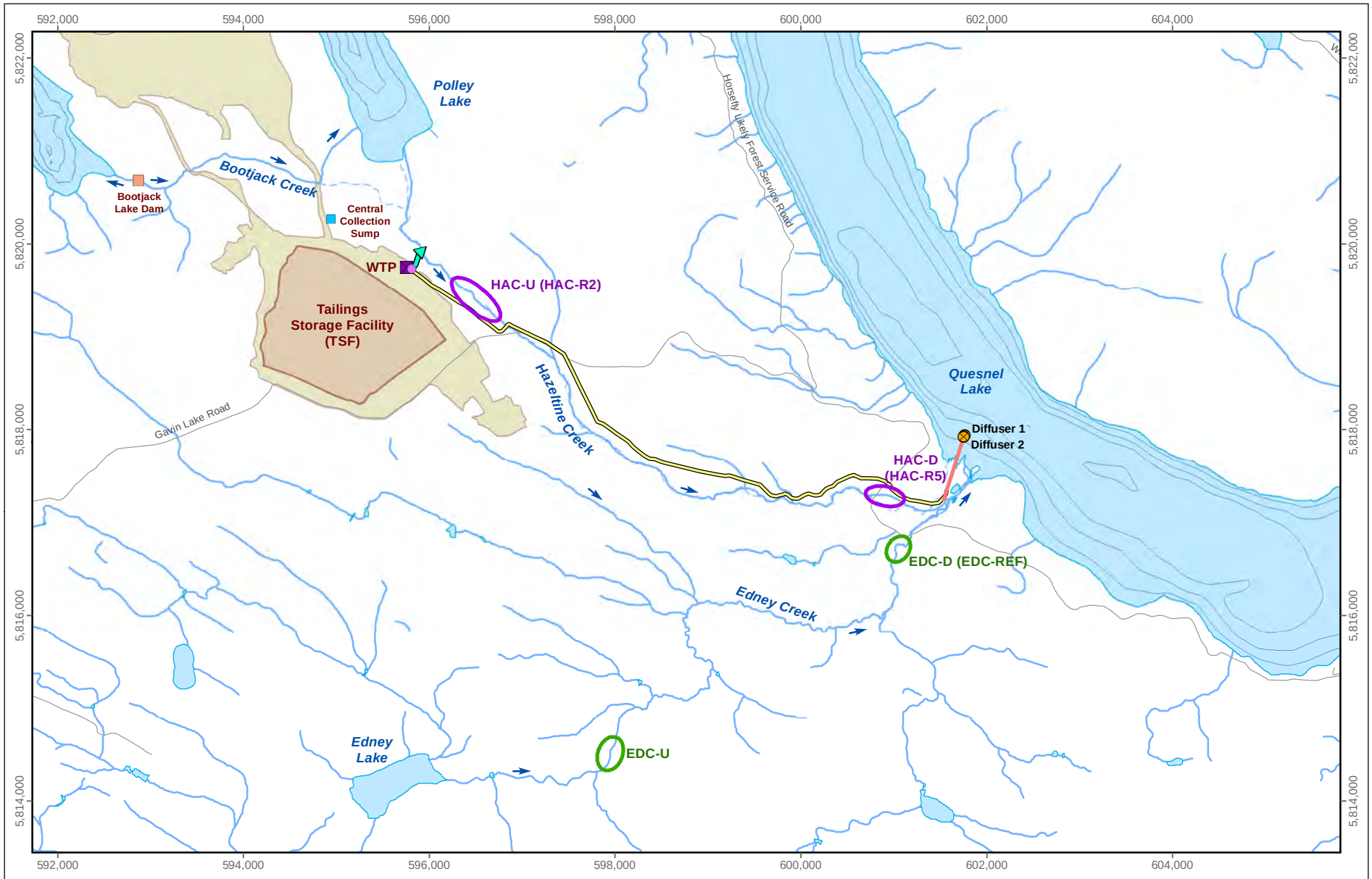

LEGEND

- Exposed Area
- Reference Area
- Discharge to Diffusers (2015 to present)
- Discharge to Hazeltine Creek (Apr 10 2014 to Aug 14 2014 and Nov 29 2015 to Sept 30 2017)
- Effluent Discharge Pipeline (January 2018 to present)
- Diffuser (Treated Effluent Discharge, December 2015 to present)
- Central Collection Sump
- Effluent Mixing Tank
- Historic Watercourse

0 0.75 1.5 3 km

N W E S

Projection: North American Datum 1983 UTM Zone 10U

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Mount Polley CEMP Sediment Monitoring Locations, Creeks

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Figure 9

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Table 2: Mount Polley CEMP Sediment Quality Monitoring Program Overview

A) Lakes

Water Body		Sampling Area	Type	Monitoring Frequency	Components [a]	Replication [b]	Rationale
Polley Lake	Shallow	POL-S [c]	Exposed	Every 3 years [c]	C, T	5	immediately adjacent to mine and breach-influenced
	Deep	POL-P1 (Northwest Basin)	Exposed	Every 5 years	C	5	immediately adjacent to mine and breach-influenced
		POL-P2 (Southeast Basin)	Exposed	Every 5 years	C	5	immediately adjacent to mine and breach-influenced
Bootjack Lake	Shallow	BOL-S [c]	Reference	Every 3 years [c]	C, T	5	reference for Polley Lake [d]
	Deep	BOL-B2 (Southeast Basin)	Reference	Every 5 years	C	5	reference for Polley Lake [d]
Quesnel Lake	Shallow	QUL-LNF1 [c]	Exposed	Annual [c]	C,T	5	breach-influenced shallow habitat
		QUL-LREF1 [c]	Exposed	Annual [c]	C,T	5	breach-influenced shallow habitat
	Deep	QUL-PNF	Exposed	Every 5 years	C	5	breach-influenced deep habitat
		QUL-PFF1	Exposed	Every 5 years	C	5	breach influenced deep habitat
		QUL-PREF1	Reference	Every 5 years	C	5	reference for exposed deep habitat areas of Quesnel Lake

[a] Sediment monitoring components: C = chemistry (see Table 3 for analytes) and T = toxicity (14-day test with *Hyallela azteca*).

[b] Number of replicate stations within the specified sampling area.

[c] Inclusion of sediment quality and toxicity sampling at a frequency of every three years in Polley Lake (with Bootjack Lake as reference), and at an annual frequency in Quesnel Lake, is to meet the monitoring requirements outlined in the BCMOECCS Approval of the CEMP (dated February 10, 2021; BCMOECCS 2021c).

[d] Bootjack Lake is retained as the reference for Polley Lake due to the fact that it has not been notably affected by the mine, there is a long-term dataset available for it, and its watershed includes similar geology to Polley lake. The latter is not true for other potential reference areas.

B) Creeks

Water Body		Sampling Area	Type	Monitoring Frequency	Components [a]	Replication [b]	Rationale
Hazeltine Creek	Upper	HAC-U (HAC-R2)	Exposed	Every 3 years	C	5	immediately adjacent to mine and breach-influenced
	Lower	HAC-D (HAC-R5)	Exposed	Every 3 years	C	5	immediately adjacent to mine and breach-influenced
Edney Creek	Upper	EDC-U	Reference	Every 3 years	C	5	reference for HAC-U (HAC-R2)
	Lower	EDC-D	Reference	Every 3 years	C	5	reference for HAC-D (HAC-R5)

[a] Sediment monitoring components: C = chemistry (see Table 3 for analytes).

[b] Number of replicate stations within the specified sampling area

creek habitats will continue will focus on areas of upper (HAC-U [HAC-R2]) and lower (HAC-D [HAC-R5]) Hazeltine Creek with areas of upper (EDC-U) and lower (EDC-D) Edney Creek serving as reference (Figure 9, Table 2), consistent with the previous study design (MPMC 2019). Hazeltine Creek is an erosional creek; therefore, sediment sampling will continue to be opportunistic and focused on the collection of fines deposited on the declining hydrograph.

Sediment quality monitoring will include an evaluation of sediment physical and chemical characterization at each proposed sampling area, and supporting sediment toxicity testing will also be completed at a subset of areas (Table 2). Sediment quality monitoring will include measures of particle size distribution, organic matter content, nutrients, and metals in the <63 µm fraction in accordance with BCMOE (2016) (see Section 4.2 below for greater detail). Sediment toxicity testing (shallow exposed areas of Polley Lake and Quesnel Lake, and associated references; Figure 8, Table 2) will focus on the epi-benthic amphipod *H. azteca*. Data interpretation will be based on a combination of: 1) statistical comparison to previous conditions; 2) statistical comparison to reference conditions; and 3) concentrations relative to the WSQG (BCMOECCS 2021a,b). Accordingly, five stations per area will be sampled to provide replication for the statistical contrasts (Table 2). Sediment quality and toxicity sampling will be supported by sampling depth, Secchi depth, *in situ* measurements of temperature, dissolved oxygen, pH, and specific conductance near the sediment-water interface, Global Positioning System (GPS) coordinates, and supporting photographs of the sampling location and samples at each monitoring station. Overlying *in situ* water quality samples will also be collected from the sediment-water interface of each monitoring station where sediment toxicity testing is completed (shallow exposed areas of Polley Lake and Quesnel Lake, and associated references; Table 2).

The sediment quality monitoring and supporting measures detailed herein are consistent with the previous approved CEMP Sediment Monitoring Plan (MPMC 2019), while the proposed sediment toxicity monitoring endpoints differ from the previous study design. Specifically, sediment toxicity monitoring of deep sediments using the 10-day test of *Chironomus dilutus* is no longer included in the study design. The removal of *C. dilutus* toxicity testing of deep exposed sediments from Polley Lake and Quesnel Lake is recommended based on the absence or relative stability of sediment toxicity testing effects at these areas. Toxicity testing of deep Polley Lake sediments has indicated no adverse effects to the survival or growth of *C. dilutus* since the initiation of testing

clearly show that copper concentrations in all Polley Lake shallow sediment samples are below the 95th percentile of the copper concentrations in the Bootjack Lake reference area shallow sediment samples. *H. azteca* toxicity testing using sediment from shallow areas of Quesnel Lake must be continued as stated in the March 14, 2019 approval letter. "No effect to *H. azteca*" in that letter shall mean "no unacceptable response" relative to the reference area, as defined on page 37 of "Mount Polley Comprehensive Environmental Monitoring Program 2019 – Sediment and Aquatic Life" (Minnow 2020; Appendix K to MPMC's 2019 Annual Environmental Report for the Mount Polley Mine)."

in 2014 (i.e., 2014 to 2021). In addition, the benthic invertebrate community at the deep areas of Polley Lake has showed consistent recovery to a condition in 2021 that was similar to the reference or pre-breach for most endpoints (see Section 2.1.2; Minnow 2022a). In Quesnel Lake, toxicity testing of the deep near-field sediments has indicated either no or moderate reductions in survival and moderate to high reductions in growth of *C. dilutus* exposed to these sediments in 2014 to 2021. However, normalized survival has been consistently above 60% and normalized growth was higher in 2021 than in previous years of testing (see Section 2.3.2; Minnow 2022a). In addition, benthic invertebrate community monitoring at the deep near-field area of Quesnel Lake has shown recovery of organism density and taxon richness from 2016 to 2021 compared to immediately following the breach (2014). This indicates some benthic invertebrate recolonization of this deep near-field area has occurred, although these endpoints remain lower than reference and unchanged from 2016 to 2021 (Minnow 2022a). Combined, the sediment toxicity and benthic invertebrate community monitoring results for the deep exposed areas of Polley Lake and Quesnel Lake support the proposed discontinuation of sediment toxicity monitoring for these areas. Continued benthic invertebrate community monitoring at these areas will provide a measure of benthic invertebrate community recovery that is of greater ecological relevance than toxicity testing (because it evaluates *in situ* habitat use by site organisms); see CEMP Section 6.13. Sediment toxicity testing of shallow sediments, which was not previously incorporated into the CEMP Sediment Monitoring Plan (MPMC 2019), is included the present study design for Polley Lake (and reference) and Quesnel Lake (exposed and reference areas) to satisfy the monitoring requirements for these areas outlined in BCMOECCS (2021c; see above).

Sediment sampling will be completed in August or September, consistent with previous data collections (HKP 1996, 1997; Beak 2000; Minnow 2015a,b, 2016a,e, 2019a,c, 2020a, 2021a, 2022a,c). The revised frequency of sediment quality monitoring in deep exposed areas of Polley Lake and Quesnel Lake (and associated reference areas) will be every five years (Table 2). This represents a decrease in frequency relative to the previous study design, which was every three years (MPMC 2019). Monitoring was completed at all Polley Lake and Quesnel Lake deep areas (and reference) most recently in 2021, therefore the next monitoring event would occur in 2026 under the revised monitoring frequency. This decrease in frequency is guided by previous results, which have shown temporal stability in sediment TOC and Analyte of Interest concentrations (i.e., analytes with mean concentrations greater than reference/pre-breach conditions and the WSQG; see Section 4.5) between 2014 and 2021 (i.e., 7 years) at the deep areas of Polley Lake (arsenic and copper) and at the deep near-field area of Quesnel Lake (arsenic, copper, and iron), relative to reference (Figures 1 and 4; see Section 2.3.2; Minnow 2022a). Sediment concentrations of copper and manganese increased at the Quesnel

Lake far-field area from 2018 to 2021, as did manganese concentrations at the near-field area from 2015 to 2018, relative to reference (Minnow 2022a). However, manganese concentrations at the near-field area have been temporally stable since 2016, and the increased analyte concentrations observed at the far-field area were likely due to an increase (by 31%) of the clay content of these sediments over this period that may potentially be related to sediment migration (Minnow 2022a). The stability in sediment quality results for most analytes from these deep areas is consistent with the relatively low rates of sediment deposition reported in Polley Lake (average 0.66 mm/yr; 15 years for the accumulation of 1 cm of sediment) and Quesnel Lake (range 1.4 to 1.7 mm/yr; 6 to 7 years for the accumulation of 1 cm of sediment; Minnow 2018a). It is anticipated that a monitoring frequency of every five years will be sufficient to track continued recovery of these areas, which will be associated with the deposition of approximately 3.3 mm of new sediment in Polley Lake and approximately 7.0 to 8.5 mm of new sediment in Quesnel Lake over the five-year period. Since sediment samples are composed of the top 3 cm (30 mm) of deposited sediment (to represent exposure to benthic organisms and consistent with technical guidance; BCMOE 2016), this is equivalent to approximately 11% and 23% of the sample volume being comprised of new material at a five-year monitoring frequency.

The frequency of sediment quality and toxicity monitoring for the shallow exposed area of Polley Lake (with Bootjack Lake as reference) is every three years, and the monitoring frequency for the shallow near-field and reference area of Quesnel Lake is annual (Table 2), as stipulated by BCMOECCS (2021c). Sediment quality and toxicity monitoring for the shallow area of Polley Lake (and reference) was completed most recently in 2022, therefore this monitoring would occur next in 2025 in accordance with BCMOECCS (2021c), "*unless MPMC can clearly show that copper concentrations in all Polley Lake shallow sediment samples are below the 95th percentile of copper concentrations in the Bootjack Lake reference area shallow sediment samples*" (BCMOECCS 2021c). Copper concentrations in shallow sediments from Polley Lake exceeded the reference (Bootjack Lake) 95th percentile in 2019 (2019; Minnow 2020a), indicating that continuation of this monitoring will be required (results for 2022 monitoring are in progress).

The revised frequency of sediment quality monitoring in Hazeltine Creek (with Edney Creek serving as reference) is every three years (Table 2). This represents a decrease in frequency from the previous study design which included annual monitoring of these creek areas (MPMC 2019). Monitoring was completed most recently in 2022, therefore would occur next in 2025 under the revised monitoring frequency. This decrease in frequency is guided by results, which have shown temporal stability in sediment TOC and most Analyte of Interest concentrations from 2019 to 2021 (i.e., 3 years), relative to reference (Figure 3; Section 2.2.2; Minnow 2022a). In lower Hazeltine Creek specifically, copper concentrations were similar in 2018 and 2021, and iron concentrations decreased from 2018 to 2021. Some variability among years in sediment

quality results from Hazeltine Creek has indicated that results are driven to a degree by variable sediment physical characteristics related to the limited presence of sediment in the erosional habitat of the creek, and the unavoidable necessity for opportunistic sampling of sediments deposited in quiescent areas on the lowering hydrograph (Minnow 2022a). Given the influence that opportunistic sampling has shown on sediment characteristics and the observed temporal stability for most analytes (relative to reference) despite this, it is anticipated that a monitoring frequency of every three years will be sufficient to track recovery now that final remediation works have been completed in upper and lower creek areas. The frequencies for all monitoring components and areas will be reviewed following interpretation of data collected in 2025, and design modifications (e.g., changes to monitoring frequency or locations) will be made based on a QP review of the data.

Sediments will be sampled, processed, analyzed, and associated data interpreted using methodology consistent with previous assessments at Mount Polley (e.g., Minnow 2015a,b, 2016a, 2019a, 2020a, 2021a, 2022a) and with technical guidance (e.g., Environment Canada 2012; BCMOE 2013, 2016), with one exception. Sediments from the deep areas of Polley Lake and reference (Bootjack Lake) have historically been collected using gravity coring methods (Beak 2000; Minnow 2011, 2013, 2015a, 2015b, 2016a, 2019a, 2022a) in accordance with provincial (BCMOE 2013) and federal technical guidance (Environment Canada 2012). In 2018, sediments from the deep areas of these lakes were collected using both gravity coring and grab sampling methods for the purpose of comparing sediment quality results based on these two different collection methods. Results of this comparison indicated that sediment metal concentrations measured using these two sampling methods (i.e., gravity coring and grab sampling) were very similar. Concentrations of all Analytes of Interest measured using the two collection methods either did not differ statistically between the methods, or if they did differ, the magnitude was small (< 20%; Minnow 2019a). These results indicated that grab sampling can be confidently used in Polley Lake and Bootjack Lake to provide sediment quality results that are directly comparable to those collected by coring (Minnow 2019a). The success rate for gravity coring methods tends to vary with sampling location and in accordance with sediment characteristics, and as a result, grab sampling methods are less time and labour intensive. Grab sampling methods for sediment collection in Polley Lake and Bootjack Lake have therefore been incorporated into the sample collection methods described herein. Detailed methodology is provided in Section 4, including: QA/QC, sample collection methods, sample handling and laboratory analysis, data quality review, data handling, interpretation, and reporting.

4 METHODOLOGY

4.1 Quality Assurance / Quality Control

All sampling will be performed by qualified field staff experienced in the implementation of sediment quality monitoring programs. All sample collection, quality assurance and quality control, and laboratory analysis methods will be implemented in accordance with technical guidance (BCMOE 2013, 2016; BCMOECCS 2020). Specifically, QA/QC measures will include program review prior to implementation, adequate resources for all field teams including field checklists and field data sheets, the availability and maintenance of clean sampling equipment and sampling containers, and sampling in a manner that minimizes any risk of sample contamination.

Quality control (QC) samples will be collected to support the sediment quality monitoring program. Five replicate samples (samples from 5 separate stations to represent the sampling area) will be collected from each sampling area to capture within-area variability. Specific field QC samples will include duplicates (i.e., splits) collected at a frequency of 10% of the total number of samples to assess field precision as part of the Data Quality Review (DQR; Section 4.4). Duplicate water samples will be collected at a frequency of 10% to assess field precision associated with the water samples that support sediment toxicity monitoring. Raw field data will be transcribed from field sheets into an electronic spreadsheet. Data will be checked by a separate individual for data entry errors as part of routine QA/QC procedures. In addition to field QA/QC, any laboratory conducting the physical or chemical analyses will be accredited by the Canadian Association for Laboratory Accreditation (CALA) for these analyses. Specific QC sampling and associated reporting will be requested of the analytical laboratory, including reagent blank results, laboratory replicate results, and laboratory accuracy results (i.e., matrix spikes, laboratory control samples, and/or certified reference materials). Laboratory Reporting Limits (LRLs) will also be evaluated in comparison to targets established by the analytical laboratory. These results will be assessed as part of the DQR (Section 4.4).

4.2 Sample Collection Methods

4.2.1 Lakes

Sampling of sediments from Quesnel Lake will be consistent with previous monitoring (Minnow 2015a,b; 2016a, 2019a, 2020a, 2021a, 2022a), while sediment sample collections from Polley Lake (and the associated reference, Bootjack Lake) will differ from previous monitoring methods (as outlined in Section 3). Briefly, sediments from the deep areas of Polley Lake and reference (Bootjack Lake) have historically been collected using gravity coring methods

(Beak 2000; Minnow 2011, 2013, 2015a,b, 2016a, 2019a, 2022a). Results of concurrent gravity coring and grab sampling methods in 2018 indicated that sediment metal concentrations measured using these two sampling methods were very similar and, grab sampling can confidently be used in these deep monitoring areas to provide results that are directly comparable to those collected by coring (Minnow 2019a). Grab sampling methods are therefore described herein for continued sediment quality monitoring in Polley Lake and Bootjack Lake.

Samples for sediment quality and toxicity analysis will be collected at five replicate stations per area using grab sampling methods. This will be completed using either a stainless-steel petite ponar (15.24 cm x 15.24 cm; 0.023 m^2 sampling area) or a stainless-steel standard ponar (22.86 cm x 22.86 cm; 0.052 m^2 sampling area) in accordance with federal and provincial technical guidance (Environment Canada 2012; BCMOE 2013). This grab sampling method will be applied at all lake sampling areas (Polley Lake, Bootjack Lake, and Quesnel Lake). Briefly the petite ponar and standard ponar are grab samplers with jaws that can be held open by shear-pressure on a spring-loaded pin. The grab sampler is lowered to the substrate at which point shear-pressure is eliminated and the pin springs out. Upon upward pull at the initiation of retrieval, the jaws of the ponar close to grab surficial sediment. Care must be taken to control the rate at which the ponar is lowered to allow appropriate sediment penetration and to minimize sediment disturbance. The ponar will be carefully retrieved to surface and each grab will be placed into a plastic tote and observed for completeness and any unusual characteristics. For deep areas of Quesnel Lake, samples will be retrieved with the assistance of a commercial line hauler (Ace Line Hauler - Brutus Plus 40). If the sample is deemed acceptable (i.e., the sampler is full to each end and is representative of surface sediment), surficial material to a depth of 3 cm will be transferred to a second tote using a stainless-steel spoon, and the remaining sediment discarded. At each station where toxicity testing is not required, one composite samples of the top three centimeters of surficial sediment from a minimum of three acceptable grabs (i.e., full to each edge of the sampler) will be collected at each station where toxicity testing is not required, and a composite from a minimum of five acceptable grabs will be collected at stations where toxicity testing is required. The sediment within the tote will then be homogenized using a stainless-steel spoon and transferred into 250 mL (for sediment quality) or 500 mL (for sediment toxicity) glass sampling jars labeled with the project number, sample location, and collection date. Sampling equipment will be rinsed between stations using site water. In addition, supporting information will be collected at each sampling site as outlined below. Samples will be kept on ice in the field then stored in a refrigerator until shipment (in a cooler with ice) to the analytical laboratory.

Supporting information collected at each lake sediment monitoring station will include GPS coordinates, sampling depth, Secchi depth, field meter measurements of temperature, specific

conductance, dissolved oxygen and pH, photographs of sediment samples, notes of the presence or absence of aquatic vegetation, and other physical observations (sediment texture, colour, density, etc.). In addition, one full vertical profile of *in situ* water quality measurements will be collected at a single station per area.

4.2.2 Creeks

Hazeltine Creek and the associated reference creek (Edney Creek) are predominantly erosional (HKP 1996, 1997; Minnow 2007, 2022a) and there are few locations of true sediment deposition. The limited sediment within these creeks tends to wash through during spring freshet and deposit as a thin layer of fines in quiescent areas on the lowering hydrograph. Thus, collection of true sediment (i.e., fines in the silt and clay size category) cannot be completed by conventional grab sampling as applied in lakes (as described above) and typically applied in depositional creeks (i.e., due to the dominant presence of sand, gravel, and cobble). An alternative method has been applied and will be applied for future monitoring – sampling by spoon. This sampling will target the fine sediment fraction (i.e., silt and clay). Sampling will be undertaken in late summer when low flows support some sediment deposition, even if only as a thin layer over sand, gravel, or cobble. As with lake sampling, sediments will be collected at five replicate stations per area. However, due to the non-uniform nature of sediment deposition in erosional creeks, the actual sampling stations will be determined opportunistically with each field sampling campaign and may vary slightly over time (i.e., a priority will be placed on the quality of the five replicate sediment samples collected within each area rather than the precise location of each sample within each area).

Sediment samples from creeks will be collected using a clean stainless-steel spoon. All samples will be collected from wetted sampling stations that support the accumulation of fine materials (i.e., small pools or backwaters). Sampling locations will be approached by foot in a manner that does not disturb sediment prior to sampling. At locations of sediment deposition, surficial sediment will be carefully collected by slowly placing the spoon on the sediment surface in a manner that minimizes disturbance. The spoon will then be inserted into the sediment to capture sediment to a depth of no greater than 3 cm and moved horizontally to fill the spoon. The collection depth may be much less than 3 cm, as fines often settle in a thin layer over coarser material (and sampling seeks to avoid coarse material as indicated above). The spoon will be slowly retrieved to surface to avoid sample washout. The content of the spoon will then be inspected to ensure that it represents fine sediment (i.e., is predominantly silt and clay) and, if accepted, will be placed into a 250 mL glass sampling jar labeled with the project number, sample location and collection date. This procedure will be repeated a minimum of four more times to form a composite sample representative of the sampling station and to collect sufficient sample

material for analysis. Sampling equipment will be rinsed between stations using site water. Duplicate sediment samples will be collected at a target frequency of 10% for QA/QC purposes (associated composite samples will be composed of twice the number of spoons to support the split samples). In addition, supporting information will be collected at each sampling site as outlined below. Samples will be kept on ice in the field then stored in a refrigerator until shipment (in a cooler with ice) to the analytical laboratory.

Supporting information collected at each of the creek sediment monitoring stations will include GPS coordinates, average water depth at the sample locations, average sediment depth collected, field meter measurements of temperature, specific conductance, dissolved oxygen and pH, photographs of sediment samples, notes of the presence or absence of aquatic vegetation, and other physical observations (sediment texture, colour, density, etc.).

4.3 Sample Handling and Laboratory Analysis

At the termination of the field program or at intervals of no more than seven days, sediment samples will be shipped (in a cooler with ice) to the analytical laboratory and/or toxicity testing laboratory with completed Chain of Custody (COC) forms.

Chemical and physical analyses will be completed at an analytical laboratory accredited by the CALA using methods that are consistent with those specified in the British Columbia Environmental Laboratory Manual (BCMOECCS 2020). Upon sample receipt, the laboratory will provide a sample receipt confirmation which will be reviewed to ensure that all samples are received and that the analytical requests are properly logged. These receipts will be reviewed to ensure that all samples are received and that the analytical requests are properly logged. Sediment chemical and physical analyses will include moisture content, pH, particle size distribution, total organic carbon (TOC), total nitrogen, total sulphur, and total metal concentrations (Table 3). Analyses except for moisture, pH, total nitrogen, total sulphur, and particle size distribution will be completed on the silt/clay fraction (<63 µm diameter) in accordance with recommendations (BCMOE 2016). In addition, sediment quality characterization conducted in 2014 indicated similar results in the <63 µm and <2 mm sediment fractions (Minnow 2015a). Analyses of pH will be completed by electrode, particle size analysis will be completed by sieve and pipette, total organic carbon will be completed by combustion and titration (total carbon minus total inorganic carbon), total nitrogen and total sulphur will be completed by combustion. Analysis of metals will be based on the BC Strong Acid Leachable Metals digestion (SALM; BCMOE 2016), with metals analyses will be completed by Collision Reaction Cell Inductively Coupled Plasma – Mass Spectrometry (CRC-ICP-MS United States Environmental Protection Agency [USEPA] Method 6020B; USEPA 2014]) and mercury

Table 3: Analytes and Laboratory Reporting Limits (LRLs) for Mount Polley CEMP Sediment Quality Monitoring

Analyte	Units	Target LRLs	Consensus LRLs[a]	British Columbia Sediment Quality Guidelines[b]	
				Lower	Upper
Physical Tests					
% Sand (2.0mm - 0.063mm)	%	1	1	-	-
% Silt (0.063mm - 4um)	%	1	1	-	-
% Clay (<4um)	%	1	1	-	-
Moisture	%	0.25	1	-	
pH (1:2 soil:water)	pH	0.1	-	-	-
Nitrogen and Carbon					
Total Nitrogen	%	0.02	-	-	-
Total Organic Carbon	%	0.05	0.05	-	-
Sulphur					
Sulphur	%	500	200	-	-
Metals					
Aluminum (Al)	mg/kg	50	100	-	-
Antimony (Sb)	mg/kg	0.1	0.1	-	-
Arsenic (As)	mg/kg	0.05	0.2	5.9	17
Barium (Ba)	mg/kg	0.5	1	-	-
Beryllium (Be)	mg/kg	0.1	0.1	-	-
Bismuth (Bi)	mg/kg	0.1	0.1	-	-
Boron (B)	mg/kg	5	5	-	-
Cadmium (Cd)	mg/kg	0.02	0.05	0.6	3.5
Calcium (Ca)	mg/kg	50	100	-	-
Chromium (Cr)	mg/kg	0.5	1	37.3	90
Cobalt (Co)	mg/kg	0.1	0.3	-	-
Copper (Cu)	mg/kg	0.5	0.5	35.7	197
Iron (Fe)	mg/kg	50	100	21,200	43,776
Lead (Pb)	mg/kg	0.1	0.1	35	91.3
Lithium (Li)	mg/kg	2	-	-	-
Magnesium (Mg)	mg/kg	10	10	-	-
Manganese (Mn)	mg/kg	0.2	0.2	460	1,100
Mercury (Hg)	mg/kg	0.005	0.05	0.17	0.486
Molybdenum (Mo)	mg/kg	0.1	0.1	-	-
Nickel (Ni)	mg/kg	0.5	0.8	16	75
Phosphorus (P)	mg/kg	50	10	-	-
Potassium (K)	mg/kg	100	100	-	-
Selenium (Se)	mg/kg	0.1	0.1	2	-
Silver (Ag)	mg/kg	0.05	0.1	0.5	-
Sodium (Na)	mg/kg	50	100	-	-
Strontium (Sr)	mg/kg	0.1	0.1	-	-
Thallium (Tl)	mg/kg	0.05	0.1	-	-
Tin (Sn)	mg/kg	0.2	0.2	-	-
Titanium (Ti)	mg/kg	1	1	-	-
Uranium (U)	mg/kg	0.05	0.05	-	-
Vanadium (V)	mg/kg	0.2	2	-	-
Zinc (Zn)	mg/kg	1	2	123	315
Zirconium	mg/kg	1	-	-	-

Primary Analyte.
Secondary Analyte.

Notes: "-" = no guideline available. mg/kg = milligrams per kilogram. % = percent.

[a] From Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators (BCMOE 2016)

[b] British Columbia Sediment Quality Guidelines; from British Columbia Working Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture (BCMOECCS 2021a,b).

analysis completed by Cold Vapor Atomic Absorption Spectrophotometry (CVAAS; USEPA Methods EPA 200.2/245.7; USEPA 1994, 2005).

Toxicity testing will be completed at a testing laboratory accredited by the CALA. Testing will be completed using a standard 14-day test of the survival and growth of *H. azteca* (an epi-benthic amphipod; Environment Canada 2017). In accordance with standard protocols for toxicity testing, five field-replicate test vessels per area will be tested (i.e., with each replicate representing a sampling station). In addition to the exposed area field replicates and the reference area field replicates, a laboratory control (beach sand in accordance with the standard biological test methods) will also be included (also to be set up with five laboratory replicates). A number of supporting measurements were collected within the toxicity test vessels during the test, including meter measurements of overlying water (temperature, dissolved oxygen, conductivity, and pH) and the collection of overlying water for analysis of ammonia (at test start and end) and dissolved copper at test completion.

Each of the laboratories will provide a sample receipt confirmation when the samples are received and logged. These receipts will be reviewed to ensure that all samples are received and that the analytical requests are properly logged. Upon completion of the analyses, each laboratory will provide a data report in Microsoft (MS) Excel™ and as an Adobe Acrobat Portable Document Format (PDF). Reporting will include the results of the laboratory QC sample results.

4.4 Data Quality Review

Upon receipt of sediment quality data and supporting water quality data from the analytical laboratory, a Data Quality Review (DQR) will be performed. The DQR will confirm that all requested analyses are complete, and that acceptable LRLs have been achieved. The LRLs will be evaluated relative to targets established for the analytes, to “consensus” LRLs (Table 3), and to the applicable WSQGs (BCMOECCS 2021a,b). The DQR will also include an evaluation of differences between duplicate (i.e., split) samples as well as the QA/QC data reported by the laboratory. Completion of the DQR promptly following receipt of the sediment quality data will ensure timely communication with the laboratory should any issues be identified.

Comparisons between duplicate samples will be made by calculating the relative percent difference (RPD) of concentrations measured in paired duplicates. If the RPD is <30% for concentrations that are > 5 times the LRL, then the duplicate sample results will be considered acceptable. Analyte concentrations in laboratory blank samples will be evaluated in relation to their respective LRLs, and the results will be used to identify potential contamination associated with equipment (e.g., cleanliness) and sample collection and handling procedures (e.g., collection, shipping).

4.5 Data Handling and Interpretation

Upon receipt of data from the analytical laboratories, all laboratory data files will be managed by the Mount Polley Mining Corporation (MPMC) Environment Department. In addition, data provided by the primary analytical laboratories as an Electronic Data Deliverable (EDD) will be imported directly into the MPMC's database.

Following completion of the DQR described above (Section 4.4), all sediment quality data and supporting data will be managed in MS Excel™ or R (R Core Team 2022). For all replicated data (typically based on a sample size of five stations per area), data will be provided to the QP and summarized by calculating mean, median, standard deviation, minimum, maximum for each endpoint and area. Th 5th percentile (for pH) and 95th percentile (for all other analytes) will also be calculated for reference and pre-breach data. Sediment quality data will then be evaluated in comparison to the WSQGs (BCMOECCS 2021a,b) and to reference and pre-breach concentrations. Reference and pre-breach 95th percentile values (calculated from all available data from a given area) will be used to screen exposed area mean concentrations to efficiently identify analytes with concentrations that are beyond the range of reference and pre-breach conditions (i.e., greater than both the reference and pre-breach 95th percentiles for a given analyte). If pre-breach data are not available, as is the case for the deep monitoring areas of Quesnel Lake, only the 95th percentile reference values will be used to screen mean analyte concentrations from associated exposed areas.

The WSQGs are numerical criteria that are protective of sediment-dwelling organisms based on long-term exposure (BCMOECCS 2021a,b). Most British Columbia WSQGs have been adopted from the Canadian Council of Ministers of the Environment (CCME; CCME 1999) or from Ontario (OMOE 1993) and have two levels – a Lower WSQG and an Upper WSQG. The Lower WSQG is intended to represent a concentration that will protect aquatic life from adverse effects of a toxic substance in most situations. The Upper WSQG is intended to represent a concentration that, if exceeded, will likely cause severe effects on aquatic life (BCMOECCS 2021a,b). However, WSQGs – even the Upper WSQGs - are often naturally exceeded in mineralized areas, as was the case for copper, iron, and manganese in Polley Lake (Section 2.1.1). In addition, the WSQGs were developed based on co-occurring bulk surficial sediment data and biological effect data (CCME 1995). Bulk sediment chemistry can differ substantially from the < 63 µm fraction, and this discrepancy between measurement (< 63 µm fraction) and exposure (to bulk sediment to which Sediment Quality Guidelines [SQGs] are most applicable) should be considered in interpretation as "caution should be used in interpreting the biological significance of chemical concentrations in sediments for different types based on these guidelines" (CCME 1995).

All analytes will be screened against the WSQG and reference and pre-breach 95th percentile values. This will include primary and secondary analytes identified in Minnow (2020a, 2021a, 2022a) as the focus for evaluation of chemical data[6] (Table 3). Analytes at exposed areas with mean concentrations that exceed all the following criteria will be the focus of more detailed analyses and interpretation (i.e., "Analytes of Interest"): 1) the WSQG, 2) the associated reference 95th percentile value, and 3) the associated pre-breach 95th percentile value (if available). Analytes of Interest will be determined separately for each monitoring area (i.e., separately for deep and shallow areas of Polley Lake, and deep and shallow areas of Quesnel Lake). Concentrations of these Analytes of Interest, along with TOC, will be the focus of more detailed interpretation which may include: graphical comparisons to reference, pre-breach, and historical data, graphical comparisons to all guidelines, and formal statistical contrasts to evaluate if mean analyte concentrations at the exposed area have changed over time relative to the reference area, and examination of relationships to physical and chemical sediment variables.

The formal statistical contrasts of sediment quality results at exposed versus reference areas over time will be conducted using a two-way ANOVA that assesses the exposed:reference ratio of results, with Area and Year as factors and assessing the interaction between Area and Year. If the Area×Year interaction term is significant ($\alpha = 0.05$), then the ratios of the concentrations from the exposed area to the reference area differ among years and pairwise contrasts will be completed among years (using $\alpha = 0.05$ to assess statistical significance). If the Area×Year interaction term is not significant ($\alpha = 0.05$), then the ratios of the concentrations from the exposed area to the reference area are consistent among years and no relative contrasts will be conducted. Temporal changes in the ratio of exposed:reference results will be quantified by calculating the difference between the value for the exposed area and the predicted value for the exposed area, assuming the same ratio (i.e., exposed:reference) from the baseline year (the first year the data were collected).

Multivariate statistical tools may also be applied to assist with sediment quality data interpretation. Specifically, ordination techniques such as Principal Components Analysis (PCA) may be applied to assist in the identification of key spatial or temporal differences in sediment chemistry. Perhaps more importantly, these techniques will be used in the analysis of potential physical and/or chemical causes of differences in biological metrics (e.g., benthic invertebrate community condition) as a means of reducing data to focus on a small list of key components for correlation analysis (see Section 6.13 – Benthic Invertebrate Monitoring).

[6] Primary analytes include arsenic, copper, iron, and selenium. Secondary analytes include barium, cadmium, calcium, cobalt, manganese, mercury, molybdenum, nickel, phosphorus, silver, sodium, strontium, tin, titanium, uranium, vanadium, and zinc.

Relationships between the analytes of interest and physical features (i.e., particle size) and other chemical variables (total organic carbon content) may be evaluated using Spearman correlation (often referred to a Spearman Rank-Order correlation). Following the derivation of correlation coefficients, a Bonferroni-type correction (i.e., p-value [0.05] divided by the total number of independent variables) will be applied to minimize the risk of declaring false positive correlations since at least 5% of derived correlations would be expected to occur by chance alone at an uncorrected p-value of 0.05. Any significant correlations found at the Bonferroni-adjusted p-value will be further investigated using scatter plots to determine if a continuous distribution of data was realized (possible causal relationships) or if these relationships were "leveraged" by outlying points (or groups of points).

Sediment toxicity test results (survival and growth of *H. azteca*) will be interpreted based on a combination of effect size and statistical contrasts. Results associated with each exposed area will be contrasted against the associated reference area and against the laboratory control. Results will then be evaluated using a stepwise procedure similar to that of Southern California Coastal Water Research Project (SCCWRP) California Sediment Quality Objectives (CASQO; Bay et al. 2014):

1. Mean responses (percent survival and growth [dry weight per surviving organism]) were expressed as a percentage of the mean laboratory control result and the mean field reference result.
2. Results of the statistical contrasts of mean responses in tests of impacted sediment against the laboratory control and the field reference sediment were compiled (i.e., the impacted area was identified as significantly different or not significantly different from the mean laboratory control result and the mean field reference result).
3. Results were categorized as follows:
    a. No unacceptable response was identified as a mean response within 20% of the mean laboratory control result and the mean field reference result (i.e., survival or growth were ≥ 80% of the control and field reference);
    b. Low to moderate response was identified as a mean response of between 20% and 50% of the mean laboratory control result and the mean field reference result (i.e., survival or growth were 50% to 80% of the control and field reference);
    c. High (large) response was identified as a mean response of >50% of mean laboratory control result and the mean field reference result (i.e., survival or growth were < 50% of the control and field reference).
4. Results that were in the low to moderate response category were subject to a further categorization step:

a. If the "low to moderate" response did not differ statistically from the laboratory control and the field reference, it was categorized as a low response;
b. If the "low to moderate" response differed statistically from the laboratory control and the field reference, it was categorized as a moderate response.

5. Where comparisons to mean laboratory control result and the mean field reference result did not fall into the same response category, the result was discussed relative to both the control and the field reference.

Application of a 20% reduction in survival relative to the field reference to define acceptability is consistent with thresholds used elsewhere (e.g., BCMELP 1998; Government of Canada 2010; Bay et al. 2014). If low, moderate, or high responses are observed in sediment toxicity testing, relationships between the effect endpoint (i.e., survival or growth) and overlying water and sediment quality will be evaluated in consideration of the WSQGs, effect thresholds, and the results of correlation analysis. Although it is recognized that a significant correlation or regression does not indicate causation (e.g., Norton et al. 2015), it is desirable to not only characterize the nature of a response (e.g., reduced survival or growth in sediment toxicity tests), but to also obtain evidence of cause. Correlation / regression analyses are commonly applied tools for identifying potential cause (e.g., Norton et al. 2015). Evidence of causation obtained from correlation or regression analysis will carefully consider the strength, range, and continuity of the relationships as well as mechanistic knowledge/understanding of potential cause.

The overall interpretation of sediment quality data will include integration of a weight-of-evidence that includes other components of the MPMC CEMP (e.g., water quality data, periphyton data for creeks, benthic invertebrate community data for lakes and creeks). Thus, within the CEMP, sediment quality data interpretation will specifically include the integration of data on sediment quality and the results of bio-assessment (e.g., sediment toxicity testing and benthic invertebrate communities).

An interpretive report based on the sediment quality data will be prepared to be integrated into the Annual Environmental Report for the Mount Polley Mine that is prepared annually by MPMC and submitted to the regulators and other stakeholders by March 31st of the following year. The interpretive report will provide all data in an appendix and will include the DQR, the results of the screening against the WSQG, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots.

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Appendix B.1.2

Benthic Invertebrate Monitoring Plan

Minnow Environmental

Benthic Invertebrate Monitoring Plan

Prepared for:
Mount Polley Mining Corporation
Likely, British Columbia

Prepared by:
Minnow Environmental Inc.
Victoria, British Columbia

March 2023

Benthic Invertebrate Monitoring Plan

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ACRONYMS AND ABBREVIATIONS

ANOVA – Analysis of Variance
BC – British Columbia
BCF – Bioconcentration Factors
BCMOE – British Columbia Ministry of Environment
BCMOECCS – British Columbia Ministry of Environment and Climate Change Strategy
BCWQG – British Columbia Water Quality Guidelines
CA – Correspondence Analysis
CABIN – Canadian Aquatic Biomonitoring Network
CALA – Canadian Association for Laboratory Accreditation
CEMP – Comprehensive Environmental Monitoring Program
COC – Chain of Custody
CRC-ICP-MS – Collision Cell Inductively Coupled Plasma-Mass Spectrometry
CVAAS – Cold Vapor Atomic Absorption Spectrophotometry
DFO – Fisheries and Oceans Canada
DGT – Diffusive Gradients in Thin Films
DQO – Data Quality Objective
DQR – Data Quality Review
EDD – Electronic Data Deliverable
EEM – Environmental Effects Monitoring
EPT – Ephemeroptera, Plecoptera, and Trichoptera
ERA – Ecological Risk Assessment
GPS – Global Positioning System
HHRA – Human Health Risk Assessment
HRWG – Habitat Remediation Working Group
LPL – Lowest Practical Level
LRL – Laboratory Reporting Limits
MAD – Mean Absolute Deviation
MDMER – Metal and Diamond Mining Effluent Regulations
MOD – Magnitude of Difference
MPMC – Mount Polley Mining Corporation
MS – Microsoft
PCA – Principal Components Analysis
PDF – Portable Document Format
PNAMP – Pacific Northwest Aquatic Monitoring Partnership

QA/QC – Quality Assurance/Quality Control

QC – Quality Control

RPD – Relative Percent Difference

SAFIT – Southwest Association of Freshwater Invertebrate Taxonomists

SFS – Society for Freshwater Science

TOC – Total Organic Carbon

TSF – Tailings Storage Facility

TTF – Trophic Transfer Factors

USEPA – United States Environmental Protection Agency

1 INTRODUCTION

1.1 Background

Benthic invertebrates are excellent biomonitors for assessing potential effects of physical and/or chemical habitat changes in aquatic systems (Barbour et al. 1999; Feltmate and Fraser 1999; Beatty et al. 2006). Due to the complexities of benthic invertebrate community structure and known tolerances and sensitivities to sediment and water quality (e.g., Barbour et al. 1999; Mandaville 2002), benthic invertebrate community analysis is typically a highly sensitive bio-indicator of aquatic ecosystems. Benthic invertebrates are sessile organisms and evaluation of benthic invertebrate tissue quality can provide an important measure of localized chemical conditions and of the spatial extent of an effect, as well as potential direct or indirect exposure of fish and wildlife to metals, metalloids, and nutrients[1]. Therefore, benthic invertebrate community and tissue quality are important monitoring components that have been incorporated into the Mount Polley Mining Corporation (MPMC) Comprehensive Environmental Monitoring Program (CEMP).

The influence of the Mount Polley Mine on benthic invertebrate community, productivity, and/or tissue quality can occur (or has occurred) by several key mechanisms: 1) general mine influence from physical impingement, dustfall and/or uncontained surface or groundwater flows; 2) direct discharge of mine effluent to Hazeltine Creek (April to August 2014) and Quesnel Lake (December 2015 to present)[2]; 3) the Tailings Storage Facility (TSF) embankment breach ("the breach") on August 4, 2014; and 4) remediation activities following the TSF embankment breach. Potential effects associated with effluent discharge are chemical, while those associated with general mine influence, the TSF embankment breach, and subsequent remediation can be both physical and chemical.

The geomorphology of the entirety of Hazeltine Creek (from Polley Lake to Quesnel Lake) was substantially altered by the TSF embankment breach such that Fisheries and Oceans Canada considered it not to be fish habitat (Golder 2015a). A portion of lower Edney Creek was also impacted by the breach. Fish access to the impacted creek areas was restricted by fish fence installations from August 2014 until channel remediation works were competed. Upper Hazeltine Creek (Reach 1 [HAC-R1], Reach 2 [HAC-R2], and Reach 3 [HAC-R3])

[1] Through the remainder of this section, the term "metals" will be used to include metals, metalloids, and nutrients for ease of communication.

[2] Treated effluent was discharged to Quesnel Lake via Hazeltine Creek from December 2015 to December 2017. During this period, treated effluent flowed into a settling pond in Hazeltine Creek located at the edge of Quesnel Lake prior to final discharge into Quesnel Lake via diffusers. From 2018 to present, treated effluent was conveyed to the diffusers in Quesnel Lake via a direct pipeline.

has always been isolated from lower Hazeltine Creek (Reach 5 [HAC-R5] and Reach 6 [HAC-R6]) and Edney Creek by a canyon in Reach 4 of Hazeltine Creek (HAC-R4) which acts as a permanent barrier to upstream fish passage. Remediation of upper Hazeltine Creek was initiated in 2014 following the breach (Golder 2017a), and completed at HAC-R1, HAC-R2, and HAC-R3 in 2016, 2017 (Golder 2017b,c), and 2019 (Golder 2020), respectively. Interim remediation efforts in lower Hazeltine Creek and lower Edney Creek were initiated in 2015 with the temporary reconstruction of the two creeks as two separate watercourses. Final remediation in these lower creek areas was initiated in 2020, including the reconnection of the two watercourses, and was completed in fall 2020 except for two sections in which final works were completed in summer 2021 (Minnow 2021b). Fish access was restored to upper Hazeltine Creek in spring 2018 for Reaches 1 and 2, and in spring 2020 for Reach 3. Fish access to lower Edney Creek was restored shortly after completion of the temporary remediation works in 2015 (Golder 2017a) while lower Hazeltine Creek remained inaccessible to fish until October 2020. Fish access was also temporarily restricted to lower creek work areas during final remediation works in 2020 and 2021 (Minnow 2021b).

Benthic invertebrate communities in waterbodies adjacent to the Mount Polley Mine have been monitored since baseline investigations in 1989, 1995, and 1996 (Imperial Metals 1990; HKP 1996, 1997). Benthic invertebrate tissue quality was monitored prior to the TSF embankment breach (2009, 2010, 2012, and 2013; Minnow 2011, 2013a,b). Results of benthic invertebrate community, productivity, and tissue quality monitoring are reviewed in Section 2 and provide context for this CEMP Benthic Invertebrate Monitoring Plan. This study design is guided by a combination of historical findings, representative locations downstream of Mount Polley Mine operations, representative reference locations, and considerations for a statistically-based design that will facilitate the detection of spatial and/or temporal differences in benthic invertebrate community, productivity, and/or tissue quality. Benthic invertebrate tissue selenium results will also be evaluated relative to effects-based guidelines (e.g., British Columbia Water Quality Guidelines [BCWQG]; BCMOE 2014). Fish and fish habitat monitoring objectives identified and reviewed by the Habitat Remediation Working Group[3] (HRWG) for remediated creek areas are addressed in part by the CEMP Benthic Invertebrate Monitoring Plan, through the evaluation of fish habitat productivity (e.g., benthic invertebrate community and productivity). In addition to monitoring required as part of the MPMC CEMP, benthic invertebrate community monitoring is a requirement of Environmental Effects Monitoring (EEM) under the Metal and

[3] The HRWG was established at the request of Fisheries and Oceans Canada (DFO; April 9, 2015), in response to regulatory requirements set out in Section 38(6) of the *Fisheries Act*. Members of the working group include: DFO, British Columbia Ministry of Environment (BCMOE), British Columbia Ministry of Forest Lands and Natural Resource Operations and Rural Development (FLNRORD), Soda Creek Indian Band, Williams Lake Indian Band, and Mount Polley Mining Company.

Diamond Mining Effluent Regulations (MDMER) of the federal *Fisheries Act* if effluent concentrations exceed 1% at 100 m from the point of discharge (Government of Canada 2022). Previous monitoring and modelling has demonstrated that the Mount Polley Mine effluent discharge in Quesnel Lake does not meet this criterion (DWB 2021), indicating that benthic invertebrate community monitoring is no longer required under the MDMER EEM for the Mount Polley Mine effluent discharge (Minnow 2022c). MDMER EEM monitoring will therefore not be discussed further within this CEMP Benthic Invertebrate Monitoring Plan.

The following sections of the CEMP Benthic Invertebrate Monitoring Plan provide the objectives of benthic invertebrate community, productivity, and tissue quality monitoring from 2023 to 2025, a summary of historical benthic invertebrate findings, an overview of the CEMP study design and associated rationale (including sampling locations, replication, frequency, and analytes), and detailed methodology for benthic invertebrate community, productivity, and tissue quality monitoring (quality assurance/quality control [QA/QC], sample collection methods, sample handling and laboratory analysis, data quality review, data handling, interpretation, and reporting).

1.2 Monitoring Objective

The objective of benthic invertebrate monitoring is to evaluate the influence of Mount Polley Mine activities on benthic invertebrate communities, productivity, and tissue quality in receiving environments (Polley Lake, Hazeltine Creek, Edney Creek, and Quesnel Lake) in comparison to baseline and/or reference conditions, and to determine potential implications to aquatic life (e.g., through assessment of benthic invertebrate community and productivity endpoints, and comparison of benthic tissue quality results to available guidelines; BCMOE 2014) and to aquatic ecosystem health by providing supporting information for the assessment of potential effects to higher trophic levels (e.g., fish and fish habitat quality; CEMP Section 6.16). Benthic invertebrate monitoring also provides data to support exposure assessment as part of the Ecological Risk Assessment (ERA) and Human Health Risk Assessment (HHRA) and supports the evaluation of fish habitat productivity identified as a monitoring objective by the HRWG for remediated creek areas.

2 SUMMARY OF HISTORICAL FINDINGS

Benthic invertebrate communities have been monitored in the vicinity of the Mount Polley Mine since 1989, and benthic invertebrate tissue quality has been monitored since 2009. The majority of benthic invertebrate community, productivity, and/or tissue quality samples have been collected from Polley Lake, Bootjack Lake, Quesnel Lake, Hazeltine Creek, and Edney Creek (Tables 1 and 2).

Benthic invertebrate sampling in waterbodies in the vicinity of the Mount Polley Mine has spanned the four distinct time periods listed below:

1. Baseline monitoring (1989, 1995, 1996);
2. Pre-breach operational monitoring (1999, 2007, 2009, 2010, 2012, 2013);
3. Post-breach operational monitoring (2014, 2015); and
4. Post-breach and post-discharge monitoring (2016, 2017, 2018, 2019, 2020, 2021, 2022 [4]).

Benthic invertebrate tissue quality sampling in the vicinity of the Mount Polley Mine has spanned operational time periods only (time periods 2 to 4). Data collected prior to the breach were summarized in a Technical Assessment Report (MPMC 2009) and an Aquatic Environmental Description Report (Minnow 2014a) prepared concurrently with applications for water discharge in 2009 and 2014, respectively. General findings associated with baseline, pre-breach, post-breach operational, and post-breach post-discharge monitoring are summarized, by sampling area, in the following sections.

2.1 Polley Lake

The benthic invertebrate community of Polley Lake during baseline studies in 1995 and 1996 (HKP 1996, 1997; Table 1) and pre-breach operational monitoring (1999; Beak 2000) was characterized by a dominance of Chironomidae (midges) and Oligochaeta (worms) in the two deep basins of the lake. A temporal increase in density and richness at these stations was observed between baseline period and pre-breach operational monitoring, but due to unavailability of detailed sample collection and laboratory methods for baseline studies (e.g., HKP 1996, 1997) the reason for this difference is not clear (Minnow 2014a).

[4] Benthic invertebrate monitoring was also completed in 2022 but reporting of these results is in progress, with submission of an interpretive report that includes these results required by March 31, 2023. The 2022 benthic invertebrate monitoring results are therefore excluded from the present study design.

Table 1: History of Benthic Invertebrate Community and Productivity Monitoring in Waterbodies in the Vicinity of the Mount Polley Mine

A) Lakes

Year	Locations	Report
1989	Polley Lake, Bootjack Lake	Imperial Metals 1990
1995	Polley Lake, Bootjack Lake	HKP 1996
1996	Polley Lake, Bootjack Lake	HKP 1997
1999	Polley Lake, Bootjack Lake, Jacobie Lake	Beak 2000
2007	Quesnel Lake	Minnow 2009
2014	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2015a
2015	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2016b
2016	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2016e, 2017a
2017	Quesnel Lake	Minnow 2018a
2018	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2019a, 2019c
2019	Quesnel Lake	Minnow 2020a
2020	Quesnel Lake	Minnow 2021a
2021	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2022a, 2022c

B) Creeks

Year	Locations	Report
1995	Bootjack Creek, Edney Creek, Edney Creek Tributaries, Hazeltine Creek	HKP 1996
1996	Bootjack Creek, Edney Creek, Edney Creek Tributary, Hazeltine Creek	HKP 1997
1999	Edney Creek, Edney Creek Tributary, Bootjack Creek, Jacobie Creek, Hazeltine Creek, Morehead Creek	Beak 2000
2002	Edney Creek	Morrow/Azimuth 2003
2007	Edney Creek, Edney Creek Tributary, Hazeltine Creek, Whiffle Creek, Cedar Creek	Minnow 2009
2013	Bootjack Creek	Minnow 2014b
2014	Blackwater Creek, Clearwater River, Cariboo River, Quesnel River	Minnow 2015a
2015	Edney Creek, Hazeltine Creek, Cariboo River, Quesnel River	Minnow 2016b
2016	Edney Creek	Minnow 2017a
2017	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2018a
2018	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2019a, 2019b
2019	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2020a, 2020b
2020	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2021a, 2021b
2021	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2022a, 2022b

Table 2: History of Benthic Invertebrate Tissue Chemistry Monitoring in Waterbodies in the Vicinity of the Mount Polley Mine

A) Lakes

Year	Locations	Report
2009	Main Embankment Seepage Pond, Polley Lake	Minnow 2011
2012	Bootjack Lake, Frypan Lake, Main Embankment Seepage Pond, Polley Lake, Quesnel Lake, Trio Lake	Minnow 2013a
2015	Bootjack Lake, Polley Lake, Quesnel Lake	Minnow 2016a
2016	Bootjack Lake, Polley Lake, Quesnel Lake	Minnow 2017b

B) Creeks

Year	Locations	Report
2009	Hazeltine Creek	Minnow 2011
2010	Hazeltine Creek, North Dump Creek	
2012	Hazeltine Creek, Edney Creek, North Dump Creek	Minnow 2013a
2013	Hazeltine Creek, Jacobie Creek, Morehead Creek, Trio Creek	Minnow 2013b
2014	Cariboo River, Blackwater Creek, Clearwater River, Quesnel River	Minnow 2015a
2015	Edney Creek, Hazeltine Creek, Cariboo River, Quesnel River	Minnow 2016a
2016	Edney Creek, Hazeltine Creek	Minnow 2017b
2017	Edney Creek, Hazeltine Creek	Minnow 2018b
2018	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2019a
2019	Edney Creek, Hazeltine Creek	Minnow 2020a
2020	Edney Creek, Hazeltine Creek	Minnow 2021a
2021	Edney Creek, Hazeltine Creek	Minnow 2022a

Following the TSF embankment breach, the benthic community in Polley Lake differed dramatically from conditions prior to the breach (1999; Beak 2000) and from reference in both deep basins of the lake (Figure 1). Specifically, no benthic organisms were present in the south basin (POL-P2) indicating an unequivocal impact, and organism density and taxon richness in the north basin (POL-P1) was substantially impacted (9 to 17 organisms/m^2; 1 to 2 taxa, respectively) relative to reference (1,431 to 2,551 organisms/m^2; 4 to 6 taxa, respectively) and pre-breach conditions (300 to 614 organisms/m^2, 10 to 15 taxa; Figure 1; Minnow 2015a).

Benthic invertebrate community monitoring completed between 2015 and 2021 showed substantial recovery at both deep basins of Polley Lake relative to 2014 conditions, with community composition in 2021 have mostly recovered to pre-breach conditions (Minnow 2022a). Benthic invertebrate densities at the two basins in 2021 (mean = 3,811 to 4,585 organisms/m^2) were higher than pre-breach and higher than those reported in 2014 to 2016 (Figure 1). Community structure reported in 2021 was similar to pre-breach with the exception of a slightly higher relative abundance of Chaoboridae at the south basin. The benthic invertebrate community in 2021 differed from reference (Bootjack Lake) with higher density and/or relative abundances of Arachnida (mites) and Chironomidae (non-biting midges), and lower density and/or relative abundances of Chaoboridae (phantom midges) and Oligochaeta (aquatic worms). The greater abundance of Chironomidae and lower abundance of Chaoboridae in Polley Lake compared to reference were consistent with pre-breach conditions (1999; Beak 2000). Although taxon richness in 2021 at the north basin (mean = 6 taxa) remained lower than pre-breach, richness at the south basin (mean = 7 taxa) was similar to pre-breach, and richness at both basins in 2021 was similar to reference since 2016 (north basin) and 2015 (south basin; Figure 1; Minnow 2022a). Overall, monitoring from 2015 to 2021 has indicated that the benthic invertebrate community of the deep basins in Polley Lake have largely recovered to conditions similar to reference and/or pre-breach (Minnow 2022a).

Benthic invertebrate tissue quality in Polley Lake was initiated in 2009 as selenium-specific monitoring after an uncontrolled surface runoff event (from 2006 to 2009) from the north waste rock dump which reported to Polley Lake via North Dump Creek (Minnow 2011; Table 2). Following the TSF embankment breach, benthic invertebrate tissue quality monitoring was completed in Polley Lake in 2015 and 2016 (Minnow 2016a, 2017b; Table 2). Diffusive Gradients in Thin Films (DGT) devices were used to monitor temporal changes in labile metal concentrations in Polley Lake from 2015 to 2021 rather than continued benthic invertebrate tissue quality monitoring (Minnow 2016d, 2017d, 2018f, 2019a, 2020a, 2022a). This was due to the uncertainties associated with depositional benthic invertebrate tissue monitoring (i.e., confounding influence of gut content on the determination of tissue metal concentrations in invertebrates) and similarities in the tissue quality results of other sampling endpoints

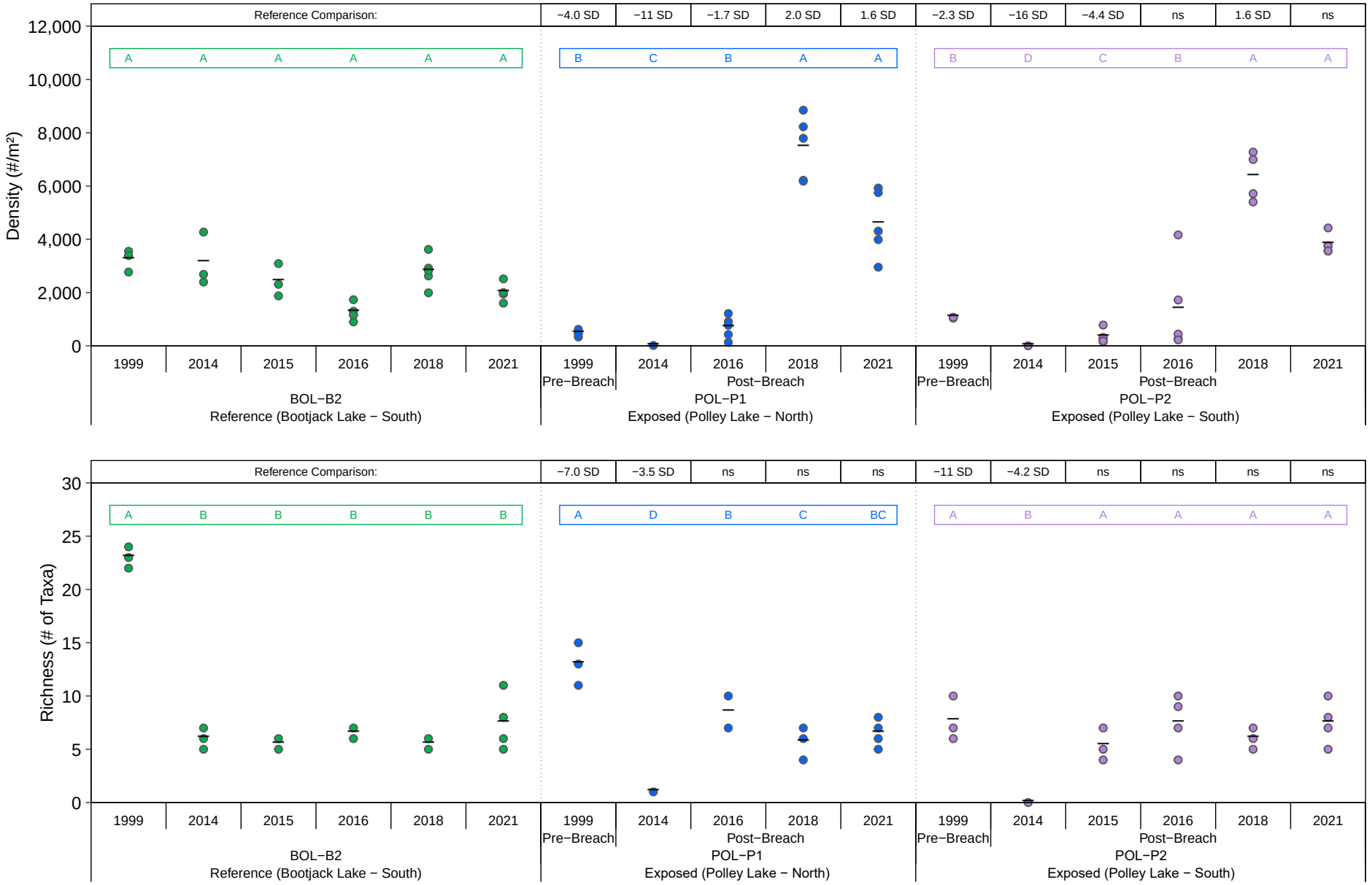


Figure 1: Benthic Invertebrate Community Endpoints in Deep Areas of Polley Lake (POL-P1, POL-P2; Exposed) and Bootjack Lake (BOL-B2; Reference), 1999 to 2021

Notes: Organisms were absent in replicate samples from POL-P2 in 2014. Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, $\log_{10}$− transformed or rank−transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. A number above the plot indicates significant exposed vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non−significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0.

(i.e., DGT devices). Benthic invertebrate tissue quality monitoring in Polley Lake was not included in the previous MPMC CEMP (MPMC 2019) and is also not included in this current CEMP Benthic Invertebrate Monitoring Plan.

2.2 Hazeltine and Edney Creeks

2.2.1 Community and Productivity

The benthic invertebrate community of Hazeltine Creek was relatively stable between baseline studies in 1995 and 1996 (HKP 1997, 1997), and operational monitoring in 1999 (Beak 2000) and 2007 (Minnow 2009), although unusual methodologies were applied to data collection in the 1996 baseline that appeared to affect results of certain endpoints such as density and the proportions of different taxon groups (MPMC 2009). Overall, benthic communities in both upper and lower Hazeltine Creek (with the exception of 1996 data) had high organism densities (25,000 to 43,000 and 6,000 to 33,000 organisms/m^2, respectively) and taxon richness (36 to 50 and 26 to 46 taxa, respectively) with a high proportion of metal sensitive taxa of the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT; mayflies, stoneflies, and caddisflies) indicating good ecosystem health (Minnow 2014a).

Post-breach benthic invertebrate community monitoring for upper Hazeltine Creek (HAC-R1 and HAC-U [HAC-R2]) from 2018 to 2021 has indicated considerable recovery in community structure and productivity following the completion of remediation efforts in these areas in 2016 (at HAC-R1) and 2017 (at HAC-U [HAC-R2]). Mean benthic invertebrate densities in upper Hazeltine Creek were similar to pre-breach conditions from 2018 to 2020 and also were temporally stable over this period (Figure 2; Minnow 2022a). Benthic invertebrate densities at these upper Hazeltine Creek areas decreased significantly between 2020 and 2021 at both areas, and from similar to pre-breach to significantly lower than pre-breach at HAC-R1 specifically. This decrease was potentially related to climatic conditions that occurred in 2021 (drought and higher summer temperatures; Minnow 2022a). Mean organism density at upper Hazeltine Creek area HAC-R3 also increased since the completion of remediation works in this area in 2019, with densities reported in 2021 that were higher than 2020, similar to pre-breach, and higher than the associated Frypan Creek reference area (Figure 2; Minnow 2022b). The monitoring area HAC-R3 and its associated reference area in FPC-R3 are monitored specifically to meet the fish and fish habitat monitoring objectives of the HRWG (see Section 1.1) and are included herein for the sake of completeness of this CEMP Benthic Invertebrate Monitoring Plan. Improvements to benthic invertebrate community structure since channel remediation works in upper Hazeltine Creek were further supported by taxon richness results, which improved significantly from 2018 to 2019 at HAC-R1 and HAC-U (HAC-R2) to richness results that were temporally stable and similar to reference (EDC-U) from 2019 to 2021, as well as similar to pre-breach conditions at HAC-R1

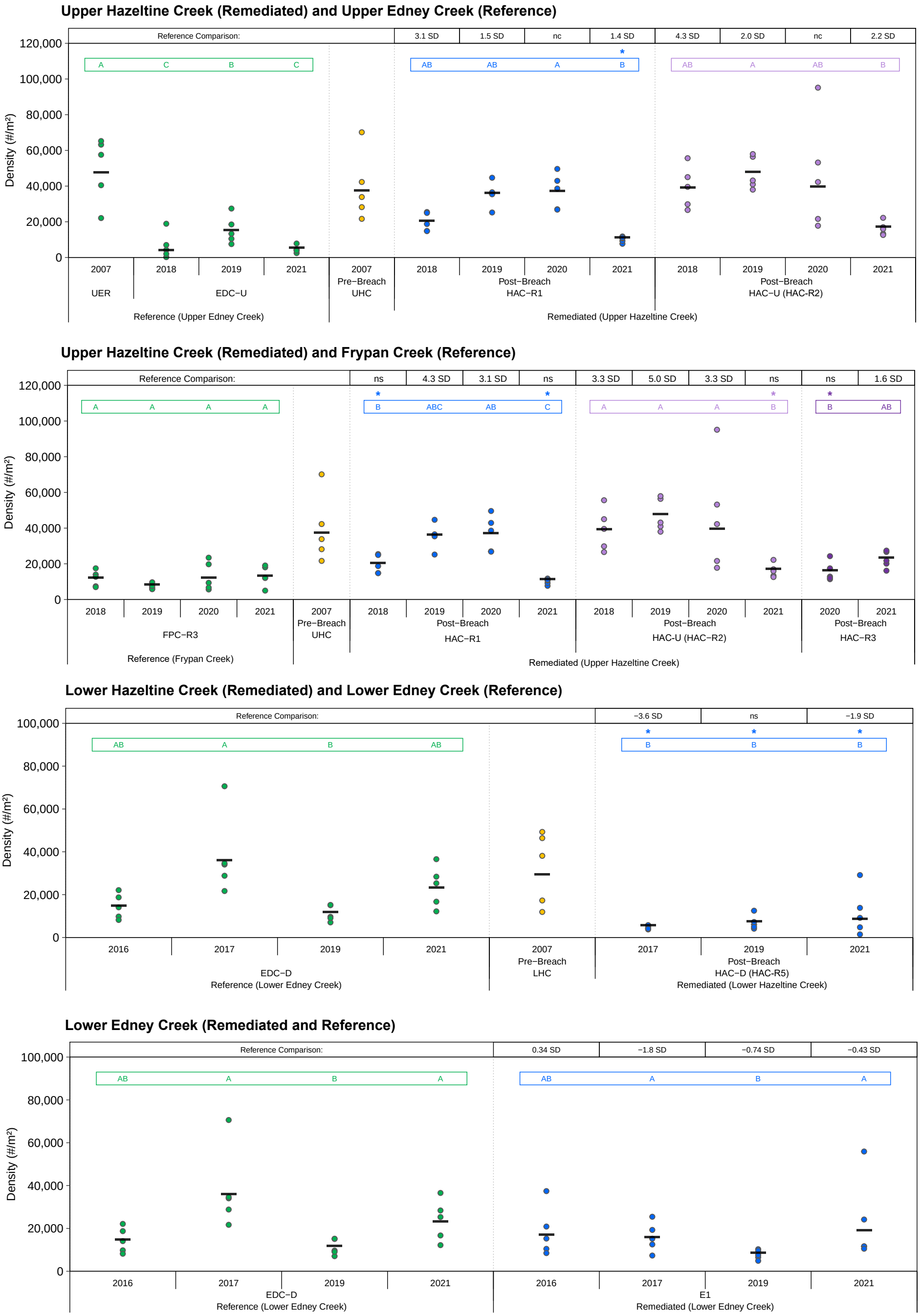


Figure 2: Benthic Invertebrate Density for Remediated (HAC-R1, HAC-U, HAC-R3, HAC-D, E1) and Reference (EDC-U, FPC-R3, EDC-D) Creek Areas, 2007 to 2021

Notes: Reference area EDC-U was not sampled in 2020 due to habitat differences (in water depth and flow) relative to the remediated areas HAC−R1 and HAC−U. Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, $\log_{10}$-transformed or rank −transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. An * indicates significant differences to UHC in 2007. A number above the plot indicates significant remediated vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non−significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0.

in 2021 (but not HAC-U [HAC-R2]; Figure 3; Minnow 2020a). Taxon richness at HAC-R3 was unchanged since initiation of monitoring in 2020, and consistently lower than reference and pre-breach conditions (Figure 3; Minnow 2020b).

Although the benthic invertebrate community of upper Hazeltine Creek has recovered considerably since the completion of remediation works, differences in community composition relative to pre-breach conditions remain, including higher and lower relative abundances of Arachnida and EPT[5] at HAC-R1, respectively, and lower and higher relative abundances of Arachnida and EPT at HAC-U (HAC-R2), respectively, compared to pre-breach. However, decreased relative abundance of Chironomidae (which tend to be tolerant of habitat disturbance) between 2018 and 2021 to proportions that were similar to pre-breach conditions is suggestive on-going habitat recovery. Similarly, densities and relative abundances of EPT taxa (which are sensitive to habitat disturbance and metal concentrations) were similar between the remediated and reference areas since 2018, suggesting limited chemical effect on recolonization (Minnow 2022a). Benthic invertebrate productivity at upper Hazeltine Creek areas (HAC-R1, HAC-U [HAC-R2]) increased from 2018 to 2019 and has been temporally stable since 2019, with dry weight biomass that was higher than the reference area (EDC-U) in each year (i.e., since 2018; Minnow 2022a). This combined with total organism abundances similar to reference and pre-breach in these remediated areas are indicative of a benthic community supportive of fish habitat productivity, the assessment of which is included to meet the fish and fish habitat monitoring objectives of the HRWG (Minnow 2022b).

Post-breach benthic invertebrate community monitoring in lower Hazeltine Creek (HAC-D [HAC-R5]) has shown more limited recovery in community endpoints since the completion of initial remediation works in this area in 2015 and final remediation works in 2020/2021 (see Section 1.1). Organism density in lower Hazeltine Creek remained consistently lower than pre-breach from 2017 to 2021, lower than reference in 2017 and 2021, and with no temporal increase over this period (Figure 2; Minnow 2022a). Taxonomic richness at HAC-D [HAC-R5] decreased significantly from similar to pre-breach in 2017 to lower than pre-breach in 2021 (Figure 3; Minnow 2022a). Similarly, the relative abundances of the EPT and Arachnida groups in 2021 were lower than pre-breach conditions and also the lowest observed since 2017, while the relative abundance of Chironomidae increased between 2017 and 2021 to a proportion that was higher than pre-breach (Minnow 2022a). Although no significant difference in benthic invertebrate productivity (dry weight biomass) was indicated at HAC-D from 2017 to 2021,

[5] EPT = Ephemeroptera, Plecoptera and Trichoptera

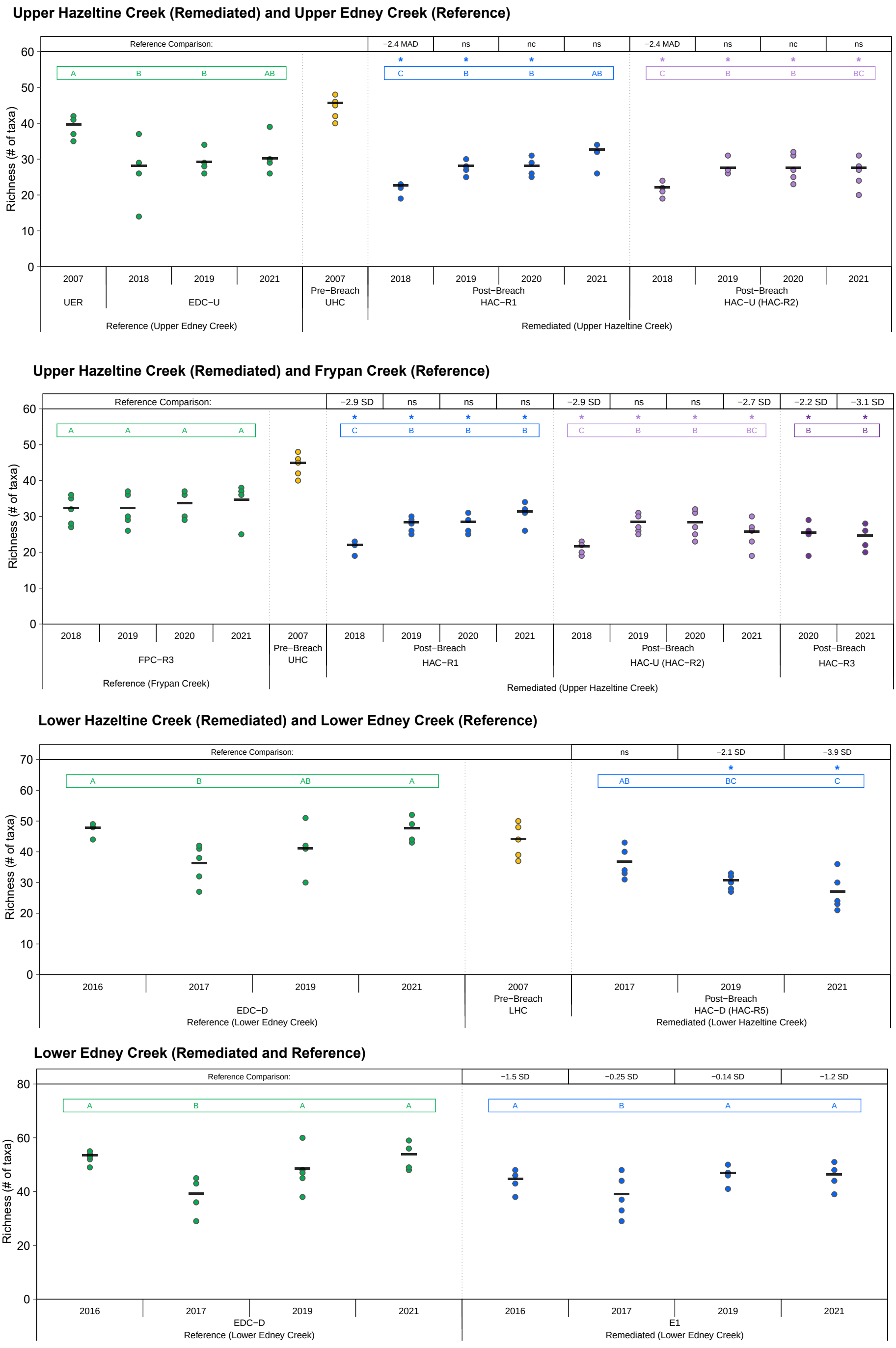


Figure 3: Benthic Invertebrate Taxon Richness for Remediated (HAC-R1, HAC-U, HAC-R3, HAC-D, E1) and Reference (EDC-U, FPC-R3, EDC-D) Creek Areas, 2007 to 2021

Notes: Reference area EDC-U was not sampled in 2020 due to habitat differences (in water depth and flow) relative to the remediated areas HAC−R1 and HAC−U. Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, $\log_{10}$-transformed or rank −transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. An * indicates significant differences to UHC in 2007. A number above the plot indicates significant remediated vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non−significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0.

biomass productivity was lowest in 2021 (Minnow 2022a). Collectively, the occurrence of lowest richness, biomass productivity, and relative abundances of EPT and Arachnida, and highest relative abundance of Chironomidae, in 2021 compared to pre-breach, and to 2017 and 2019 results, strongly suggested that the benthic invertebrate community at this area remained in a state of recovery in 2021 and that these temporal changes were related to the recent habitat disturbance associated in-stream remediation works that were completed at this area in September 2021 (just weeks prior to sampling; Minnow 2022a).

Similar to Hazeltine Creek, the benthic invertebrate community of Edney Creek was evaluated during baseline studies in 1995, 1996 (HKP 1996, 1997), and during the pre-breach operational time period in 1999 (Beak 2000), 2002 (Morrow/Azimuth 2003), and again in 2007 (Minnow 2009). Benthic invertebrate communities appeared to be relatively stable over this time (except for the 1996 data discussed above), with organism densities of 15,500 to 62,000 organisms/m^2 and taxon richness of 32 to 55 taxa, and a relatively high proportion of metal sensitive EPT taxa (Figures 2 and 3; MPMC 2009; Minnow 2014a).

Post-breach benthic invertebrate community monitoring in lower Edney Creek (E1) from 2016 to 2021 has shown relatively consistent community results since the completion of initial remediation works in this area in 2015 and final remediation works in 2020/2021 (see Section 1.1). Mean density at this remediated area was lower than reference from 2017 to 2021 and was temporally stable except for a decrease in 2019 compared to other years, which was mirrored at the reference area. Similarly, taxon richness was lower than reference in all years, and was temporally stable except for a decrease in 2019 compared to other years, which was also mirrored at the reference area (Figure 3; Minnow 2022a).

Community composition measured as the relative abundances of dominant taxonomic groups (i.e., EPT and Chironomidae) were relatively stable from 2016 to 2021 at the remediated area of Edney Creek, and any slight differences in these metrics over time were often mirrored at the reference area. These results indicated the benthic invertebrate community only differed slightly from reference in terms community composition, was similar to reference in terms of productivity (dry weight biomass) in all years and was responding to natural environmental conditions in a similar manner as the reference area among years, indicating rapid recovery since the recent completion of remediation works in 2020 and 2021 (Minnow 2022a).

2.2.2 Tissue Quality

Benthic invertebrate tissue quality monitoring in Hazeltine Creek was initiated in 2009 as part of the ongoing characterization of selenium incorporation into the aquatic food chain in the vicinity of the Mount Polley Mine. Throughout the pre-breach operational period (2009 to 2013) mean benthic invertebrate tissue selenium concentrations at erosional habitats in upper Hazeltine

Creek were higher than the BCWQG (4 mg/kg dw; BCMOE 2014) and generally higher than reference, while mean concentrations at erosional habitats in lower Hazeltine Creek were below the BCWQG (Minnow 2011, 2013a,b). In addition, selenium concentrations in benthic invertebrates from exposed erosional habitats were noted to be higher than those from nearby depositional areas (Minnow 2011, 2013b).

Effluent was discharged directly to Hazeltine Creek between November 2015 and September 2017; however, Hazeltine Creek was not considered to be fish habitat during this time by Fisheries and Oceans Canada (Golder 2015a) and was inaccessible to fish. Direct discharge of effluent to Quesnel Lake via a pipeline and diffusers was initiated in January 2018 prior to the reopening of upper Hazeltine Creek as fish habitat in spring 2018. Benthic invertebrate tissue quality monitoring was completed in 2015, 2016, and 2017 during the direct discharge of effluent to Hazeltine Creek (Minnow 2016a, 2017b, 2018b). The present historical summary for the post-breach period focuses on results collected from 2018 to 2021, during the direct discharge of effluent to Quesnel Lake via the pipeline, with data collected in 2015 to 2017 included where available.[6] From 2018 to 2021, one composite-taxa sample (containing a mixture of taxa that is proportional to biomass at the station), and one single-taxon sample (caddisfly) was collected at each station (Minnow 2019a, 2020a, 2021a, 2022a).

The evaluation of post-breach (i.e., 2018 to 2021) benthic invertebrate tissue quality results was focused on primary and secondary analytes identified in Minnow (2020a, 2021a, 2022a).[7] For most primary and secondary analytes evaluated, there was no evidence of increasing analyte concentrations in benthic invertebrate (composite-taxa or caddisfly) tissues from remediated areas of Hazeltine Creek or Edney Creek, relative to reference areas, during post-breach monitoring from 2018 to 2021 (Minnow 2022a). Copper and selenium were the only primary analytes in the remediated areas of Hazeltine Creek and Edney Creek with significantly higher benthic invertebrate tissue concentrations compared to reference for which the exposed-reference difference also increased significantly over time at one or more area (Figures 4 and 5; Minnow 2022a). Specifically, selenium concentrations in composite-taxa and caddisfly benthic invertebrate samples from upper Hazeltine Creek (HAC-R1 and HAC-U [HAC-R2]), and caddisfly tissue from lower Hazeltine Creek (HAC-D) increased over time relative

[6] Results collected from 2015 to 2017 were included in data analyses and interpretation if both exposed and associated reference results were available and if the tissue sample type was comparable to more recent monitoring results. In 2016 and 2017, stoneflies and caddisflies were sampled at reference and remediated areas (Minnow 2017b, 2018b), respectively, therefore could not be compared to the composite-taxa benthic invertebrate or caddisfly results collected since 2018 (Minnow 2019a, 2020a, 2021a, 2022a).

[7] Primary analytes include arsenic, copper, iron, and selenium. Secondary analytes include barium, cadmium, calcium, cobalt, manganese, mercury, molybdenum, nickel, phosphorus, silver, sodium, strontium, tin, titanium, uranium, vanadium, and zinc.

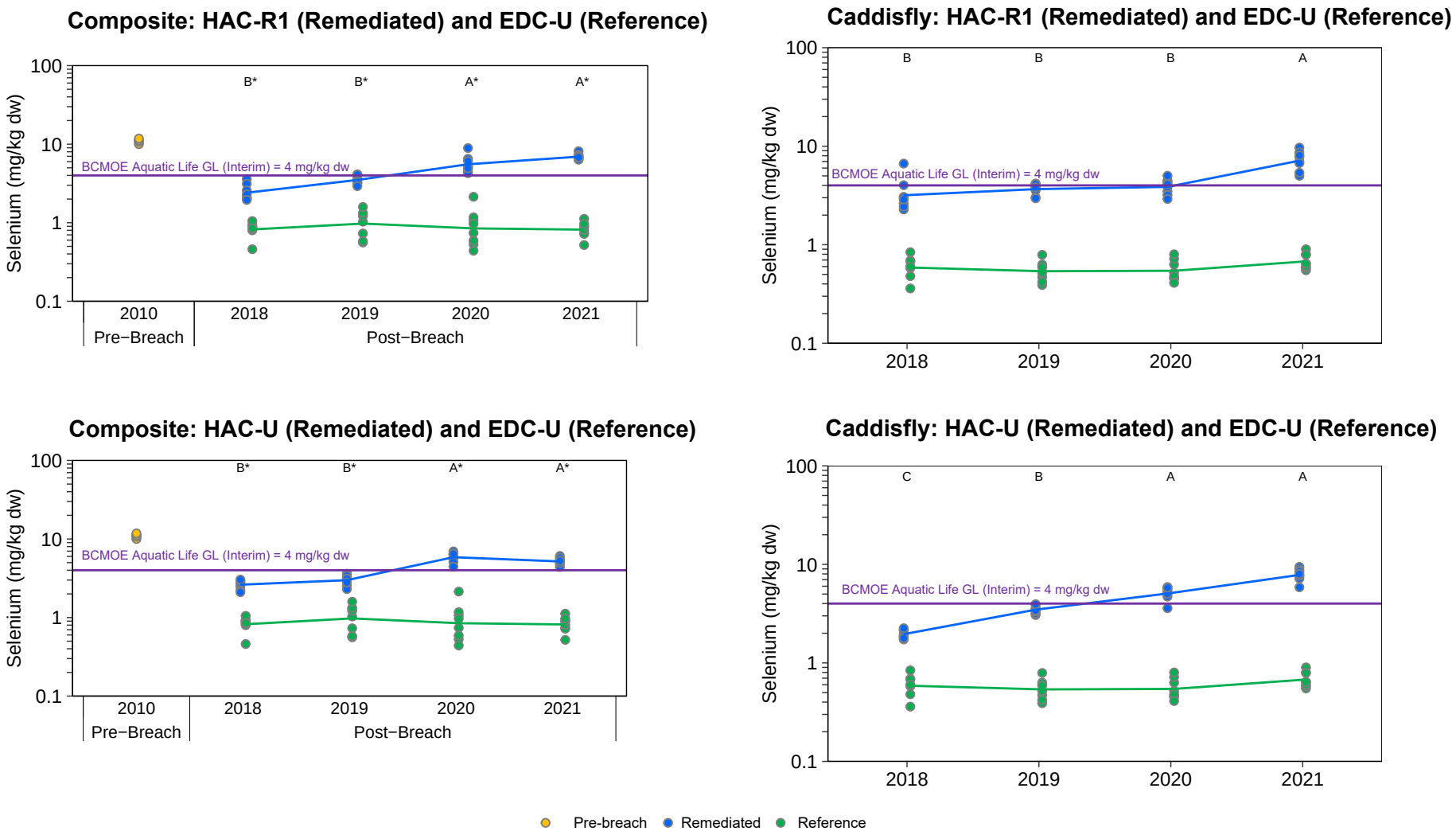
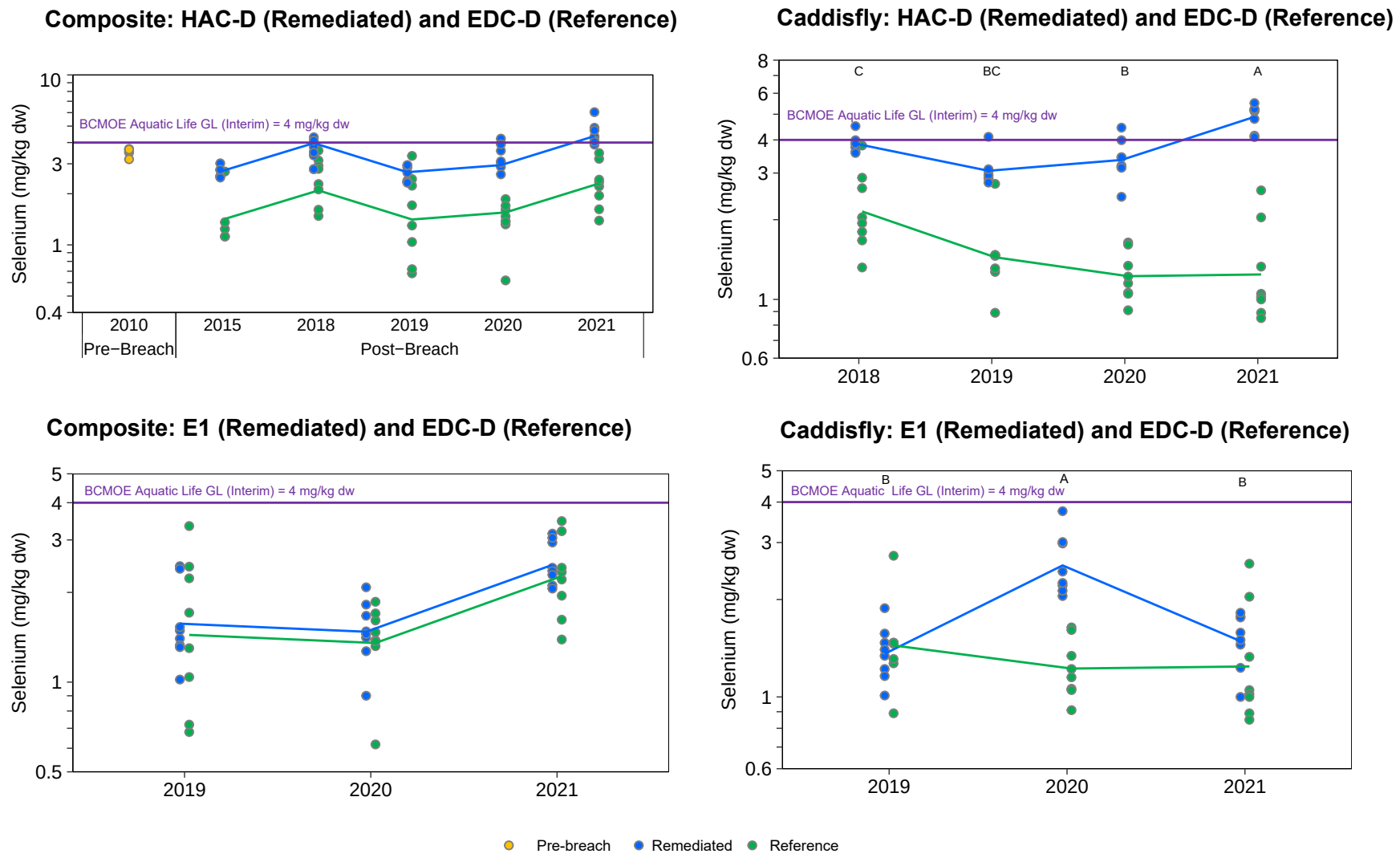


Figure 4: Concentrations of Selenium in Composite-Taxa and Caddisfly Benthic Invertebrate Tissue from Remediated (HAC-R1, HAC-U, HAC-D, E1) and Reference (EDC-U, EDC-D) Creek Areas, 2010 to 2021[a]

Notes: dw = dry weight. mg/kg = milligrams per kilogram. BCMOE = British Columbia Ministry of the Environment; GL = Guideline; dw = dry weight. Individual samples are plotted and lines join the least−squares estimated mean values for years included in the statistical analysis. Statistical analyses were conducted using a two−way ANOVA with factors Area and Year. The models were fit using Maximum Likelihood Estimation with an assumed log−normal distribution. Years that share a letter (e.g., A,B,C) have ratios of concentrations (Remediated:Reference) that do not differ significantly (p−value < 0.05) among years. Letter A was assigned to the year with the highest ratio of concentrations (Remediated:Reference). Only years with samples from both reference and exposed areas are plotted. Letters with a * designate years where the exposed site is different than pre-breach conditions, as determined using a one-way temporal ANOVA. Purple horizontal line represents British Columbia interim long-term guideline for selenium in invertebrate tissue (4 mg/kg dw; BCMOE 2014).

[a] HAC-R1 = upper Hazeltine Creek Reach 1, HAC-U = upper Hazeltine Creek Reach 2, HAC-D = lower Hazeltine Creek, EDC-U = upper Edney Creek, EDC-D = lower Edney Creek Reference, E1= lower Edney Creek Remediated.



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[a] HAC-R1 = upper Hazeltine Creek Reach 1, HAC-U = upper Hazeltine Creek Reach 2, HAC-D = lower Hazeltine Creek, EDC-U = upper Edney Creek, EDC-D = lower Edney Creek Reference, E1= lower Edney Creek Remediated.

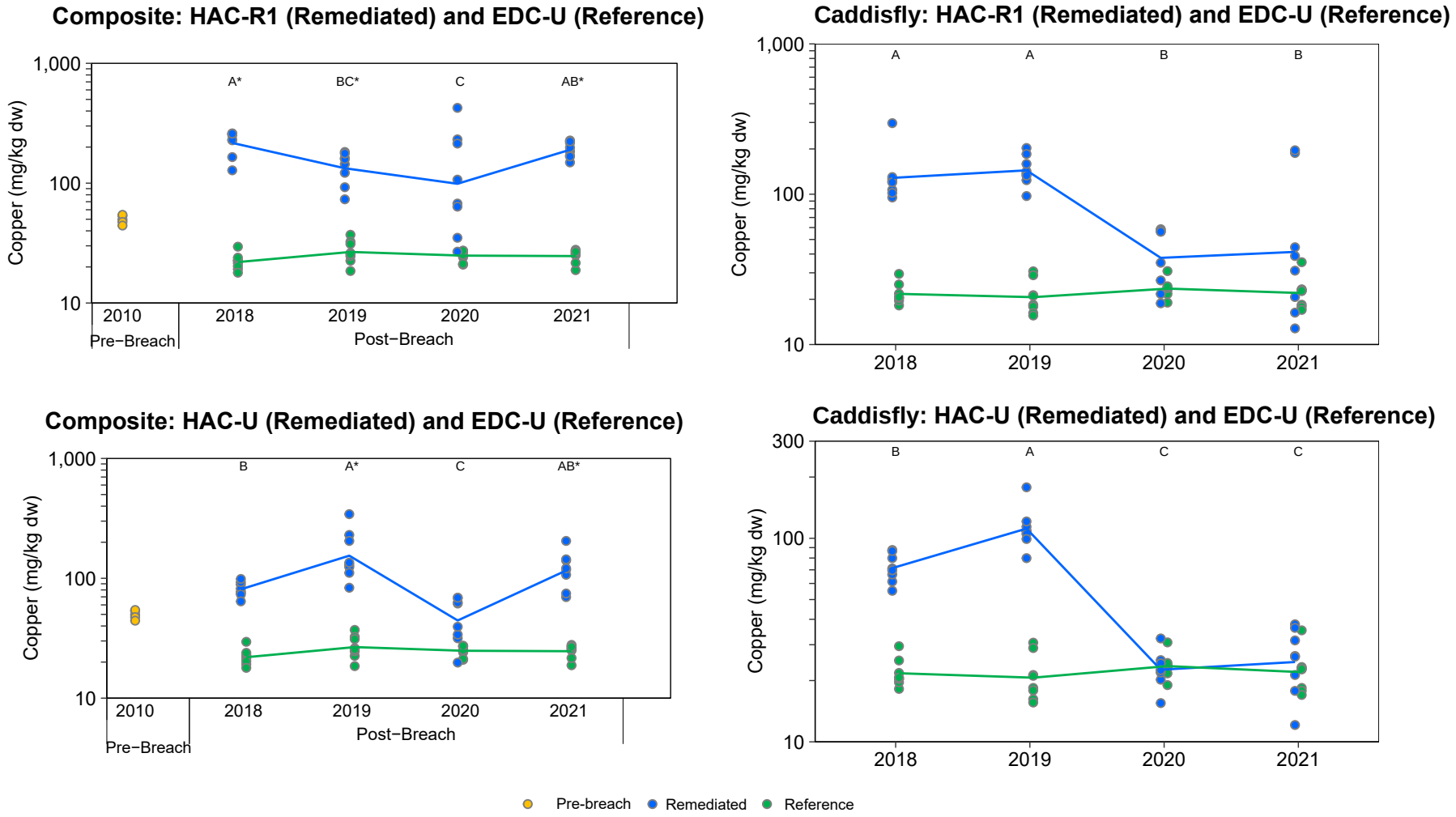


Figure 5: Concentrations of Copper in Composite-Taxa and Caddisfly Benthic Invertebrate Tissue from Remediated (HAC-R1, HAC-U, HAC-D, E1) and Reference (EDC-U, EDC-D) Creek Areas, 2010 to 2021[a]

Notes: BCMOE = British Columbia Ministry of the Environment; GL = Guideline; dw = dry weight. Individual samples are plotted and lines join the least−squares estimated mean values for years included in the statistical analysis. Statistical analyses were conducted using a two−way ANOVA with factors Area and Year. The models were fit using Maximum Likelihood Estimation with an assumed log−normal distribution. Years that share a letter (e.g., A,B,C) have ratios of concentrations (Remediated:Reference) that do not differ significantly (p−value < 0.05) among years. Letter A was assigned to the year with the highest ratio of concentrations (Remediated:Reference). Only years with samples from both reference and remediated areas are plotted. Letters with a * designate years where the remediated site is different than pre-breach conditions, as determined using a one-way temporal ANOVA.

[a] HAC-R1 = upper Hazeltine Creek Reach 1, HAC-U = upper Hazeltine Creek Reach 2, HAC-D = lower Hazeltine Creek, EDC-U = upper Edney Creek, EDC-D = lower Edney Creek Reference, E1= lower Edney Creek Remediated.

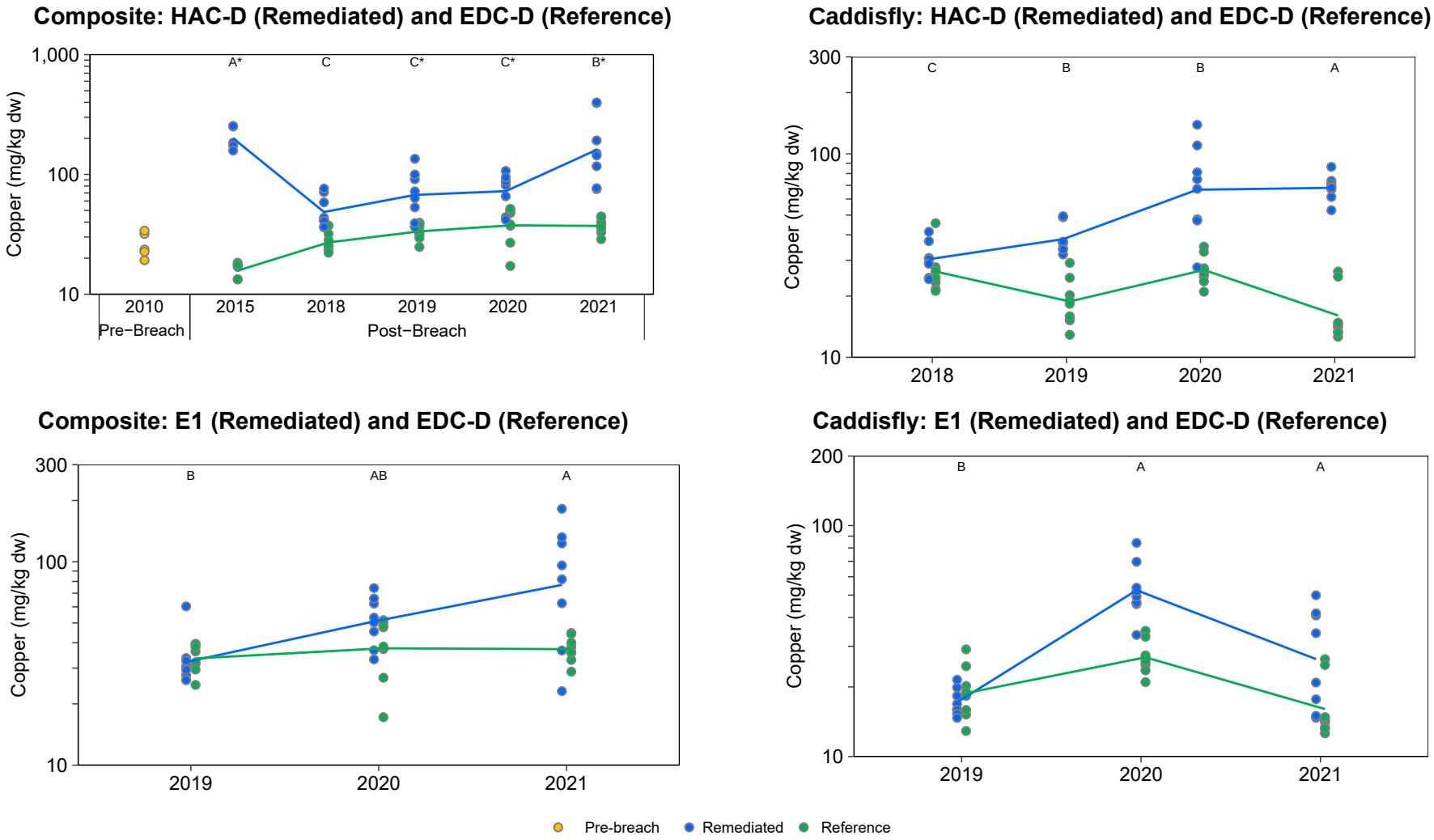


Figure 5: Concentrations of Copper in Composite-Taxa and Caddisfly Benthic Invertebrate Tissue from Remediated (HAC-R1, HAC-U, HAC-D, E1) and Reference (EDC-U, EDC-D) Creek Areas, 2010 to 2021[a]

Notes: BCMOE = British Columbia Ministry of the Environment; GL = Guideline; dw = dry weight. Individual samples are plotted and lines join the least−squares estimated mean values for years included in the statistical analysis. Statistical analyses were conducted using a two−way ANOVA with factors Area and Year. The models were fit using Maximum Likelihood Estimation with an assumed log−normal distribution. Years that share a letter (e.g., A,B,C) have ratios of concentrations (Remediated:Reference) that do not differ significantly (p−value < 0.05) among years. Letter A was assigned to the year with the highest ratio of concentrations (Remediated:Reference). Only years with samples from both reference and remediated areas are plotted. Letters with a * designate years where the remediated site is different than pre-breach conditions, as determined using a one-way temporal ANOVA.

[a] HAC-R1 = upper Hazeltine Creek Reach 1, HAC-U = upper Hazeltine Creek Reach 2, HAC-D = lower Hazeltine Creek, EDC-U = upper Edney Creek, EDC-D = lower Edney Creek Reference, E1= lower Edney Creek Remediated.

to reference, suggesting a mine influence on these tissue concentrations (Figure 4). For selenium, Bioconcentration Factors (BCFs; which are used to describe the extent to which an analyte is taken up by an organism from the surrounding environment through exposure routes other than diet; i.e., Arnot and Gobas 2006) were higher than reference for benthic invertebrate tissue (Minnow 2022a). Trophic Transfer Factors (i.e., TTF = [benthic invertebrate tissue sample]/[periphyton tissue sample]) can be used to describe the extent to which analyte concentrations increases between lower and higher trophic levels (e.g., Presser and Luoma 2010). TTFs for selenium in composite-taxa and caddisfly benthic invertebrate samples were typically stable over time (compared to reference), and selenium concentrations were similar to or lower than pre-breach results in all comparable tissues, indicating that the bioavailability and trophic transfer of selenium has not increased due to mine influence. Selenium concentrations of benthic invertebrates were above the BCWQG (BCMOE 2014; Figure 4) in both 2020 and 2021 in upper Hazeltine Creek and in 2021 only in samples from lower Hazeltine Creek, suggesting potential selenium-associated risks to aquatic life (Minnow 2022a). For copper in samples collected from Hazeltine Creek, BCFs were lower than reference and tissue concentrations and TTFs were mostly either stable or decreasing over time compared to reference, except for caddisfly tissue copper concentrations from HAC-D (HAC-R5), owing to a decrease at the reference area (Figure 5). This indicates there is no evidence of increased bioavailability or accumulation of copper in biota over time in Hazeltine Creek (Minnow 2022a). Copper concentrations in benthic invertebrate tissues from lower Edney Creek (E1) increased over time relative to reference (Figure 5) and had BCFs greater than reference, indicating increased copper at this remediated area following remediation works in summer 2020 and 2021, although TTFs did not demonstrate increased copper bioavailability (Minnow 2022a).

Increases in benthic invertebrate tissue concentrations of several secondary analytes (e.g., calcium, molybdenum, and strontium) over time were also observed, relative to reference. However, evidence was equivocal as to whether these observed increases in tissue concentrations were mine-related (due to variability among tissue types and areas); in addition there was little or no evidence of increased metal bioavailability for these analytes (based on assessment of BCFs and TTFs relative to reference and pre-breach; Minnow 2022a). Mercury in upper Hazeltine Creek was the only secondary analyte with higher concentrations relative to reference areas for both benthic invertebrate tissue types (caddisfly and composite-taxa), significantly increased TTFs (compared to reference), and tissue concentrations and TTFs that were also significantly higher than pre-breach. These findings suggest increased mercury bioaccumulation at the upper areas of Hazeltine Creek (exposed) may be mine-related, although the difference in tissue concentrations relative to reference was relatively small (Minnow 2022a).

Overall, benthic invertebrate tissue quality data showed some evidence of moderately higher bioavailability and/or trophic transfer of selenium and mercury in upper Hazeltine Creek, and selenium in lower Hazeltine Creek, and that the potential mine-influence on analyte concentrations in lower Edney Creek appears limited to increased copper. Comparison of the two benthic invertebrate tissue types (caddisfly and composite-taxa) indicated that although some variability exists between the tissues, potential changes in analyte concentrations and TTFs in caddisfly tissues would be detected if sampling were limited to composite-taxa tissue samples only (Figures 4 and 5; Minnow 2022a).

2.3 Quesnel Lake

Benthic invertebrate community data for Quesnel Lake collected prior to the TSF embankment breach are limited to a few samples collected from shallow habitats near the mouth of Hazeltine Creek in 2007 (Table 1). These data documented a mean density of approximately 31,100 organisms/m^2 and a mean taxonomic richness of 30 (Minnow 2009).

Benthic invertebrate community monitoring in 2015 following the TSF embankment breach indicated that impacts to the community in shallow habitats (lower mean organism density and taxon richness than reference) were primarily limited to near-field areas and did not extend to far-field areas (Minnow 2015a). Further monitoring in 2016 and 2017 indicated that limited recovery had occurred relative to: 1) a fine substrate reference with aquatic vegetation (2016; Minnow 2017a); and 2) two shallow sandy reference areas which more closely matching the habitat present in the near-field area in 2016 and 2017 (2017; Minnow 2018a). Benthic invertebrate community monitoring of the shallow impacted areas of Quesnel Lake was not incorporated into the MPMC CEMP (MPMC 2019).

Sediment investigations following the TSF embankment breach indicated that the majority of breach-derived material deposited to the deep habitat of Quesnel Lake (Minnow 2015a,b, 2016c). Immediately following the TSF embankment breach (2014), benthic invertebrate communities in deep exposed areas were characterized by low mean organism densities at the exposed near-field (QUL-PNF; 39.7 organisms/m^2) and far-field areas (3.4 to 22.6 organisms/m^2) relative to reference (5,840 organisms/m^2), and significantly lower mean taxon richness (0.2 to 2.6 taxa at near-field and far-field areas, 7.8 taxa at reference; Figure 6). Overall, results indicated that the biological effects were breach-related, but it was uncertain whether the effects were physical (due to smothering and/or low dissolved oxygen and low total organic carbon [TOC] content) or chemical (Minnow 2015a).

Monitoring completed between 2015 and 2021 indicated some recovery of the benthic invertebrate community in 2015 and 2016 compared to 2014 conditions, but no substantial change in community features from 2016 to 2021 at either of the deep exposed areas.

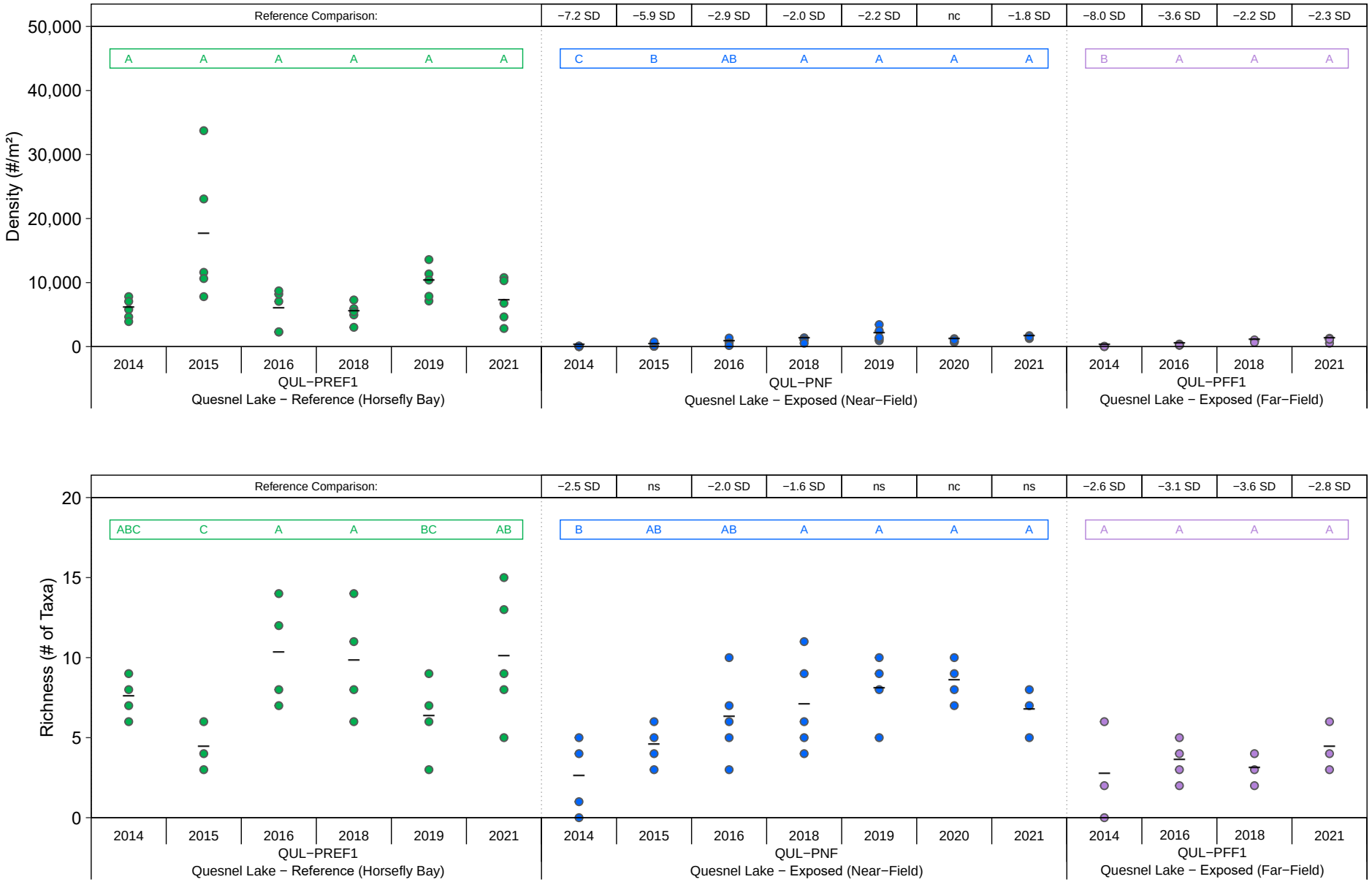


Figure 6: Benthic Invertebrate Community Endpoints in Deep Exposed (QUL-PNF, QUL-PFF1) and Reference (QUL-PREF1) Areas of Quesnel Lake, 2014 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, $\log_{10}$ −transformed or rank−transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. A number above the plot indicates significant exposed vs. reference post −hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non-significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0

Specifically, mean organism density at the near-field are in 2015 and 2016 (216 to 588 organisms/m^2), and far-field areas in 2016 (266 organisms/m^2) were higher than in 2014, but remained lower than reference and were unchanged from 2016 to 2021 at both areas (Figure 6; Minnow 2016b, 2017a). Taxon richness increased significantly at the near-field area between 2014 (mean = 2 taxa) and 2018 (mean = 7 taxa) but has remained unchanged from 2018 to 2021 (mean = 7 taxa) and has been temporally stable at the far-field area since 2014 (range = 2 to 4 taxa; Figure 6; Minnow 2022a). The benthic invertebrate community at the deep near-field area in 2021 had taxon richness that was similar to reference area but density, relative abundance and density of Oligochaeta, and density of Chironomidae that were lower than reference, while both density and richness at the deep far-field area were lower than reference (Figure 6; Minnow 2022a). The continued lower density at both the deep near-field and far-field areas compared to reference was consistent with the very low sediment TOC content at these areas (mean = 0.57 and 0.31%, respectively) in 2021. The differences in benthic invertebrate community structure compared to the reference area appear to be related to a greater proportion of fines, lower proportion of TOC, and higher metal concentrations in sediment at the mine-exposed areas. This lack of significant recovery in benthic invertebrate community since 2016 is consistent with the stability of sediment TOC content, which was well below the documented intolerance level of 1% TOC for chironomids (Suedel et al. 1993), and the stability at the near-field or increase at far-field deep areas of Quesnel Lake in copper concentrations from 2016 to 2021 (Minnow 2022a). However, sediment transplant experiments have indicated an increase in organism density and richness in sediment from the deep near-field area that was transplanted to the reference area, suggesting that sediment quality is not prohibitive of re-colonization (Minnow 2016b).

Benthic invertebrate tissue quality in Quesnel Lake was initiated in 2012 as part of the ongoing characterization of selenium incorporation into the aquatic food chain in the vicinity of the Mount Polley Mine (Minnow 2013a; Table 2). Following the TSF embankment breach, benthic invertebrate tissue quality monitoring was completed in Quesnel Lake in 2015 and 2016 (Minnow 2016a, 2017b; Table 2). DGT devices were used in shallow and deep habitats of Quesnel Lake to monitor temporal changes in labile metal concentrations in Quesnel Lake from 2015 to 2019 rather than continued benthic invertebrate tissue quality monitoring (Minnow 2016d, 2017d, 2018f, 2019a, 2020a). Benthic invertebrate tissue quality monitoring in Quesnel Lake was not included in the previous MPMC CEMP (MPMC 2019) and is also not included in this current CEMP Benthic Invertebrate Monitoring Plan.

3 STUDY DESIGN AND RATIONALE

Benthic invertebrate monitoring under the CEMP is designed to meet the combined needs of: 1) operational monitoring; 2) monitoring of the impact of the 2014 TSF embankment breach; and 3) monitoring of the response to reclamation activity following the TSF embankment breach. An overview of the proposed benthic invertebrate monitoring program is provided in Table 3, and includes benthic invertebrate community, productivity, and tissue quality. Benthic invertebrate monitoring is focused on Polley Lake, Hazeltine Creek, lower Edney Creek, Quesnel Lake, and associated reference areas (Figures 7 and 8). This CEMP Benthic Invertebrate Monitoring Plan includes revisions to the study design (i.e., updates to monitoring locations and frequency) relative to the previous study design (MPMC 2019), with revisions based on a Qualified Professional (QP) review of existing data. This section details the updated study design, outlines revisions compared to the previous study design (MPMC 2019), and provides the rationale associated with the proposed study design revisions. The frequencies for all monitoring components and areas will be reviewed following interpretation of data collected in 2025, and design modifications (e.g., changes to monitoring frequency or locations) will be made based on a QP review of the data.

3.1 Community and Productivity

3.1.1 Lakes

Benthic invertebrate community monitoring in lakes will continue to focus on Polley Lake and Quesnel Lake, with reference areas identified for each mine-influenced sampling area (i.e., Bootjack Lake for Polley Lake, unaffected areas of Quesnel Lake for impacted areas of Quesnel Lake; Figure 7, Table 3). In Polley Lake, benthic invertebrate community sampling will focus on the two basins deepest locations in Polley Lake (POL-P1 and POL-P2), which represent locations of sediment accumulation/fate, and long-term monitoring, with the deepest location in Bootjack Lake (BOL-B2) serving as reference. In Quesnel Lake, sediment investigations following the TSF embankment breach indicated that the majority of breach-derived material was deposited to deep habitat of Quesnel Lake (Minnow 2015a,b, 2016c). Therefore, benthic invertebrate community sampling in Quesnel Lake will focus on the deep areas that were previously monitored as near-field (QUL-PNF) and far-field areas (QUL-PFF1), with concurrent sampling of suitable reference areas of Quesnel Lake (QUL-PREF-1). These monitoring areas are consistent with those included in the previous study design (MPMC 2019).

Benthic invertebrate community samples will be collected using a petite ponar and sampling methods consistent with previous data collections (HKP 1996, 1997; Beak 2000; Minnow 2015a, 2016b,e, 2018a, 2019a, 2020a, 2021a, 2022a), and with technical guidance

Table 3: Mount Polley CEMP Benthic Invertebrate Monitoring Program Overview

A) Lakes

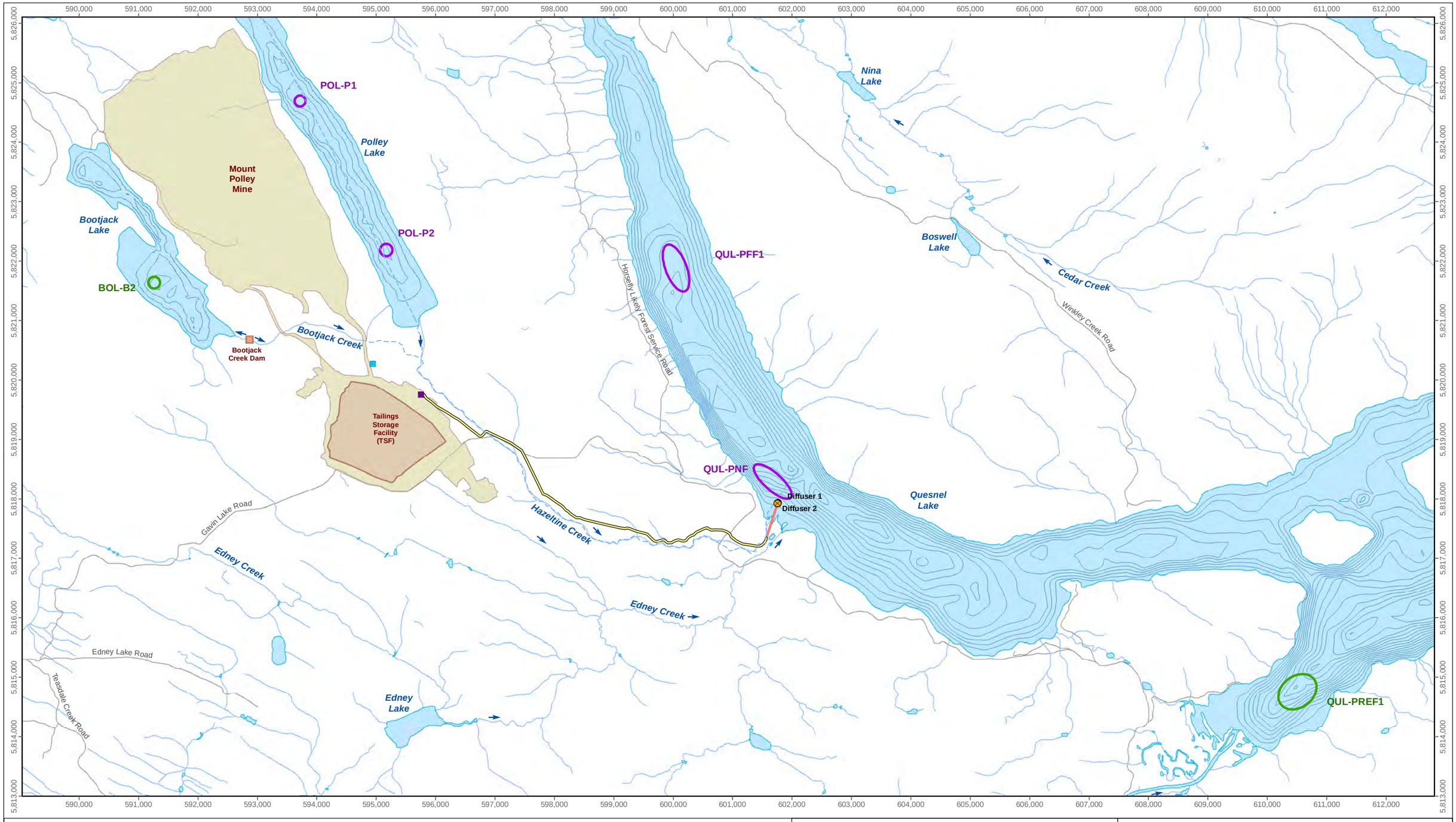
Water Body	Sampling Area	Type	Monitoring Frequency	Components[a]	Replication[b]	Rationale
Polley Lake	POL - P1 (Northwest Basin)	Exposed	Every 5 years	T	5	immediately adjacent to mine and breach-influenced
	POL - P2 (Southeast Basin)	Exposed	Every 5 years	T	5	immediately adjacent to mine and breach-influenced
Bootjack Lake	BOL - B2 (Southeast Basin)	Reference	Every 5 years	T	5	reference for Polley Lake
Quesnel Lake	QUL - PNF	Exposed	Every 5 years	T	5	breach-influenced deep habitat
	QUL - PFF1	Exposed	Every 5 years	T	5	breach-influenced deep habitat
	QUL - PREF1	Reference	Every 5 years	T	5	reference for exposed deep habitat areas of Quesnel Lake

[a] Core benthic invertebrate monitoring components: T = community taxonomy (Lowest Practical Level).
[b] Number of replicate stations within the specified sampling area.

B) Creeks

Water Body		Sampling Area	Type	Monitoring Frequency	Components[a]	Replication[b]			Rationale
						T	P	C	
Hazeltine Creek	Upper	HAC-R1 (Reach 1)	Exposed	Biennial[c,d]	T,P,C	5	5	8	adjacent to mine and breach-influenced
		HAC-U (Reach 2; HAC-R2)	Exposed	Biennial[c,d]	T,P,C	5	5	8	adjacent to mine, previously effluent- exposed, and breach-influenced
		HAC-R3 (Reach 3)	Exposed	Annual	T,P	5	5	-	adjacent to mine, previously effluent- exposed, and breach-influenced
	Lower	HAC-D (Reach 5; HAC-R5)	Exposed	Annual	T,P,C	5	5	8	adjacent to mine, previously effluent- exposed, and breach-influenced
Frypan Creek		FPC-R3 (Reach 3)	Reference	Annual	T, P	5	5	-	reference for upper Hazeltine Creek
Edney Creek	Upper	EDC-U	Reference	Biennial [c,d]	T,P,C	5	5	8	reference for upper Hazeltine Creek
	Lower	E1 (Reach 6)	Exposed	Annual	T,P,C	5	5	8	adjacent to mine and breach-influenced
		EDC-D	Reference[e]	Annual	T,P,C	5	5	8	reference for lower Hazeltine Creek [d]

[a] Core benthic invertebrate monitoring components: T = community taxonomy (Lowest Practical Level), P = productivity (wet and dry benthic biomass), and C = tissue chemistry (see Table 4 for analytes).
[b] Number of replicate stations within the specified sampling area for a given program component.
[c] Biennial indicates sampling will occur every other year for all parameters indicated with the exception of tissue chemistry, which will be monitored annually. The next bi-annual sampling event will
[d] Monitoring in upper creek areas is used to support the evaluation of the reopening of Hazeltine Creek as fish habitat. Although the proposed reduction in monitoring frequency to every 2 years is adequate for the evaluation of benthic invertebrate community and productivity recovery, this frequency may need to be more frequent (annual) to meet Habitat Remediation Working Group (HRWG) requirements for evaluation of fish habitat.
[e] Lower Edney Creek reference area will be located in an unimpacted area upstream of the breach influence (see Figure 8).



LEGEND

- Exposed Area
- Reference Area
- Diffuser (Treated Effluent Discharge, December 2015 to present)
- Effluent Discharge Pipeline (January 2018 to present)
- Discharge to Diffusers (2015 to present)
- Water Treatment Plant (WTP)
- Central Collection Sump
- Historic Watercourse

Please note: Quesnel Lake bathymetry lines are an approximate representation only and may not precisely delineate accurate depths at larger scales.

0 1 2 4 km

N W E S

Projection: North American Datum 1983 UTM Zone 10U

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Mount Polley CEMP Benthic Invertebrate Monitoring Locations, Lakes

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Project: 227202.0029

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Figure 7

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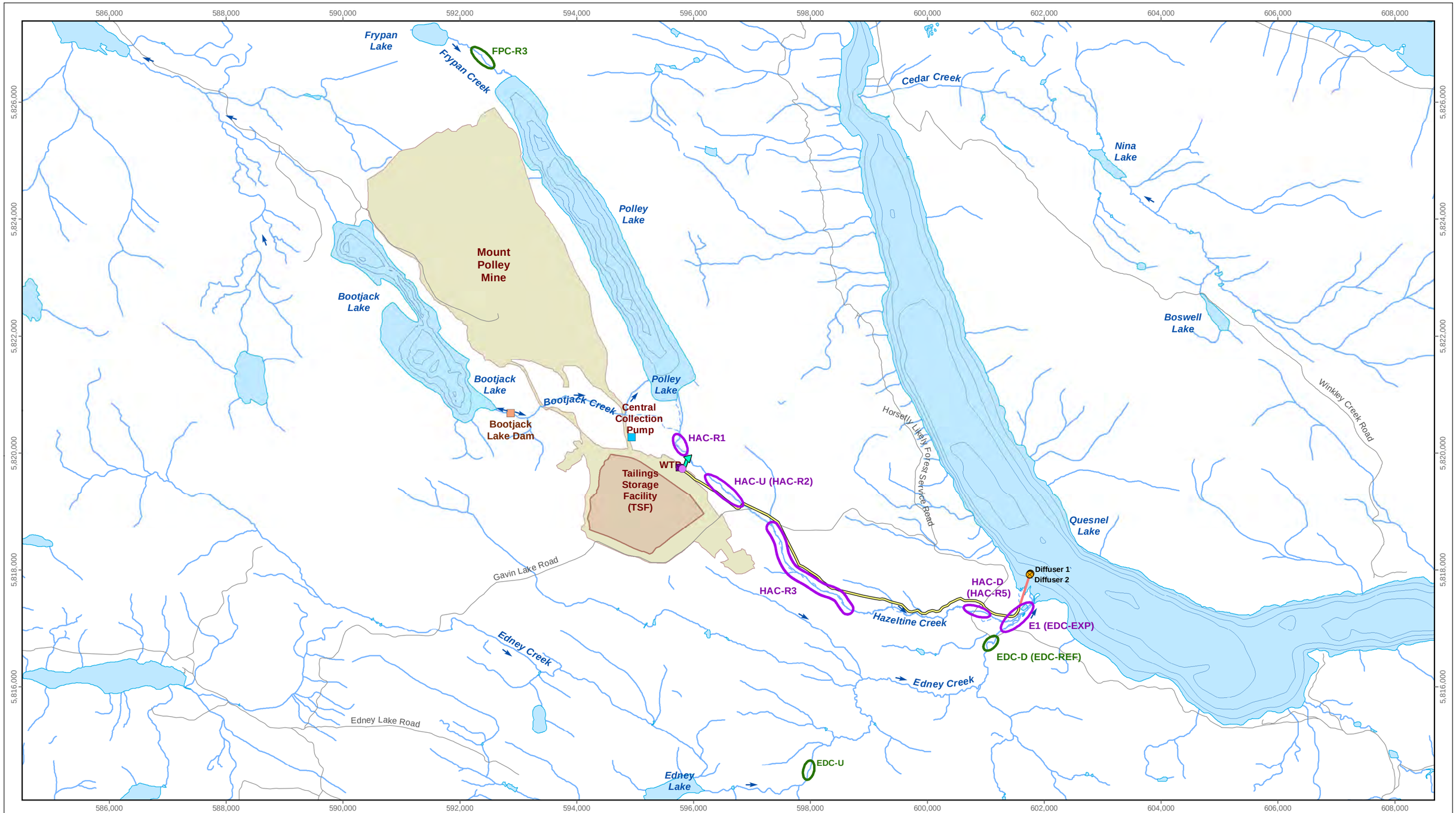

LEGEND

- Exposed Area
- Reference Area
- Diffuser (Treated Effluent Discharge, December 2015 to present)
- Effluent Mixing Tank
- Discharge to Diffusers (2015 to present)
- Discharge to Hazeltine Creek (Apr 10 2014 to Aug 14 2014 and Nov 29 2015 to Sept 30 2017)
- Effluent Discharge Pipeline (January 2018 to present)
- Historic Watercourse

0 1 2 4 km

N W E S

Projection: North American Datum 1983 UTM Zone 10U

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Mount Polley CEMP Benthic Invertebrate Monitoring Locations, Creeks

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Figure 8

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(e.g., Environment Canada 2012a; BCMOE 2013, 2016). Data interpretation will be based on a combination of: 1) statistical comparison to previous conditions; and 2) statistical comparison to reference conditions. Accordingly, five stations per area will be sampled to provide replication for the statistical contrasts (Table 3). Sampling at each station will be supported by sediment quality sampling (see CEMP Section 6.12), measurements of *in situ* water quality near the sediment-water interface (temperature, dissolved oxygen, pH, and specific conductance), water depth, Global Positioning System (GPS) coordinates, and supporting photographs at all sampling stations. The benthic invertebrate community monitoring and supporting measures detailed herein are consistent with the previous approved CEMP Benthic Invertebrate Monitoring Plan (MPMC 2019).

Benthic invertebrate community sampling will be completed in August or September, consistent with previous data collections (e.g., Minnow 2015a, 2016b,e, 2018a, 2019a, 2020a, 2021a, 2022a). The revised frequency of benthic community monitoring in deep exposed areas of Polley Lake and Quesnel Lake (and associated reference areas) will be every five years (Table 3). This represents a decrease in frequency relative to the previous study design, which was every three years (MPMC 2019). Monitoring was completed at all Polley Lake and Quesnel Lake deep areas (and reference) most recently in 2021, therefore the next monitoring event would occur in 2026 under the revised monitoring frequency. This decrease in frequency is guided by previous results, which in the deep basins of Polley Lake have shown substantial recovery since 2014 to conditions similar to reference and/or pre-breach. This has included benthic invertebrate community results in 2021 that were higher than pre-breach in terms of density, similar to pre-breach or reference in terms of taxon richness, and structure endpoints that were largely similar to pre-breach conditions. Given that the benthic invertebrate community of the deep areas of Polley Lake has largely recovered to pre-breach conditions, a monitoring frequency of every 5 years is anticipated to be sufficient to monitor the long-term stability of this community. In Quesnel Lake, some recovery of the benthic invertebrate community occurred in 2015 and 2016 compared to immediately following the breach (i.e., 2014), but no substantial change has occurred since 2016 at either of the deep exposed areas (QUL-PNF and QUL-PFF1). Specifically, organism densities at these areas have remained temporally stable and lower than reference since 2016, taxon richness has been stable since 2018 and 2014 at the deep near-field and far-field areas, respectively, and differences in community composition have continued to exist relative to reference (see Section 2.3; Minnow 2022a). The lack of significant recovery in benthic invertebrate community since 2016 is consistent with the stability of sediment TOC content at these deep areas (at concentrations that are ~50% lower than the TOC intolerance level for chironomids which are the dominant organism) and with the low rates of sediment deposition in reported in Quesnel Lake (see Section 2.3). Given the absence of a substantial

change in benthic invertebrate community at the deep exposed areas of Quesnel Lake since 2016 (i.e., in the past 6 years), it is anticipated that a monitoring frequency of every 5 years will be sufficient to track continued recovery in these areas.

Benthic invertebrate community samples will be collected, processed, analyzed, and the associated data interpreted using methodology consistent with previous assessment at Mount Polley (e.g., Minnow 2015a, 2016b,e, 2018a, 2019a, 2020a, 2021a, 2022a) and with technical guidance (e.g., BCMOE 2013, 2016). Detailed methodology is provided in Section 4, including: QA/QC, sample collection methods, sample handling and laboratory analysis, data quality assessment, and data handling and interpretation.

3.1.2 Creeks

Benthic invertebrate community and productivity monitoring will continue to focus on remediated areas of upper and lower Hazeltine Creek and lower Edney Creek, with reference areas identified for each mine-influenced sampling area (i.e., upper Edney Creek and Frypan Creek for upper Hazeltine Creek, and an unaffected area of lower Edney Creek for remediated areas of lower Edney Creek and lower Hazeltine Creek; Figure 8, Table 3). Benthic invertebrate community and productivity monitoring in Hazeltine Creek will focus on four remediated areas (Figure 8), including one area in Reach 1 (HAC-R1), Reach 2 (HAC-U [HAC-R2]), Reach 3 (HAC-R3), and Reach 5 (HAC-D [HAC-R5]), and monitoring of remediated areas in lower Edney Creek will focus on one area (E1; Figure 8). Unimpacted areas in upper Edney Creek (EDC-U) and Frypan Creek (Reach 3; FPC-R3) will serve as reference areas for the upper Hazeltine Creek monitoring areas (HAC-R1, HAC-U [HAC-R2], HAC-R3), and an unimpacted area of lower Edney Creek (EDC-D) will serve as reference for the lower Hazeltine (HAC-D [HAC-R5]) and lower Edney (E1) creek monitoring areas (Figure 8, Table 3). These sampling areas align with those proposed for periphyton monitoring in creek habitats (see CEMP Section 6.15) and are consistent with the previous study design (MPMC 2019), except for the addition of upper Hazeltine Creek area HAC-R3 (and associated reference, FPC-R3), which are monitored specifically to meet the fish and fish habitat monitoring objectives of the HRWG (see Section 1.1) and are included herein for the sake of completeness of this CEMP Benthic Invertebrate Monitoring Plan.

Benthic invertebrate community and productivity sampling will be completed at all creek monitoring areas (Figure 8, Table 3). Each benthic invertebrate community sample will be collected using a Hess or Surber sampler and will be evaluated for productivity (biomass) for the purposes of relating productivity to the assessment of fish habitat. Data interpretation will be based on a combination of: 1) statistical comparison to previous conditions; and 2) statistical comparison to reference conditions. Accordingly, five stations per area will be sampled to provide replication for the statistical contrasts. Sampling at each station will be supported by measures

of sampling depth, water velocity, *in situ* water quality measurements (temperature, dissolved oxygen, pH, and specific conductance), Global Positioning System (GPS) coordinates, notes of the presence of aquatic vegetation/bryophytes on sampled substrate and other physical observations, and supporting photographs of the sampling location and samples. Supporting single spot water quality samples will be collected from creek stations concurrent with benthic invertebrate community monitoring. The benthic invertebrate community and productivity monitoring and supporting measures detailed herein are consistent with the previous approved CEMP Benthic Invertebrate Monitoring Plan (MPMC 2019).

Benthic invertebrate community and productivity sampling will be completed in August, consistent with previous data collections (Minnow 2018a, 2019a,b, 2020a,b, 2021a,b, 2022a,b). The revised monitoring frequency at upper Hazeltine Creek areas (HAC-R1, HAC-U [HAC-R2]; and associated reference area EDC-U) will be every two years[8] (Table 3). This represents a decrease in frequency relative to the previous study design, which included annual monitoring for these upper creek areas (MPMC 2019). Benthic invertebrate community and productivity monitoring was completed most recently in 2022 in the upper creek areas; therefore the next monitoring event would occur in 2024 under the revised monitoring frequency. This decrease in monitoring frequency is guided by previous results, which have shown considerable recovery in benthic invertebrate community structure and productivity in these areas (HAC-R1 and HAC-U [HAC-R2]) since the completion of remediation efforts. This has included densities that were similar to pre-breach conditions and temporally stable from 2018 to 2020, temporal increases in taxon richness to conditions similar to pre-breach or reference, and temporal stability in productivity (dry weight biomass) since 2019 at conditions higher than reference (see Section 2.2.1; Minnow 2022a). The shift in monitoring frequency to every second year is anticipated to be sufficient to track the ongoing recovery of benthic invertebrate community composition in these areas. The revised monitoring frequency in remediated areas of lower Hazeltine Creek (HAC-D [HAC-R5]) and lower Edney Creek (E1; and associated reference area EDC-D) will be annual. This represents an increase in frequency compared to the previous study design, which included monitoring every two years in these lower creek areas (MPMC 2019). Annual monitoring will enable tracking of recovery in these habitats that were recently disturbed during the completion of remediation works in 2020 and 2021 (see Section 1.1). A reduction in monitoring frequency at these lower creek areas will be considered following interpretation of data collected in 2025, dependent on the recovery of benthic invertebrate

[8] Monitoring in upper creek areas is used to support the evaluation of the reopening of Hazeltine Creek as fish habitat. Although the proposed reduction in monitoring frequency to every 2 years is adequate for the evaluation of benthic invertebrate community and productivity recovery, this frequency may need to be more frequent to meet the HRWG requirements for evaluation of fish habitat.

community endpoints. The monitoring frequency for areas sampled specifically to meet the fish and fish habitat objectives of the HRWG (upper Hazeltine Creek [HAC-R3], Frypan Creek [FPC-R3]) will continue to be annual (Figure 8, Table 3).

Benthic invertebrate community and productivity samples will be collected, processed, analyzed, and the associated data interpreted using methodology consistent with previous assessment at Mount Polley (e.g., Minnow 2018a, 2019a,b, 2020a,b, 2021a,b, 2022a,b) and with technical guidance (e.g., BCMOE 2013, 2016). Detailed methodology is provided in Section 4, including: QA/QC, sample collection methods, sample handling and laboratory analysis, data quality assessment, and data handling and interpretation.

3.2 Tissue Quality

Benthic invertebrate tissue quality monitoring will continue to focus on remediated areas of upper and lower Hazeltine Creek and lower Edney Creek, with reference areas identified for each mine-influenced sampling area (i.e., upper Edney Creek for upper Hazeltine Creek, and an unaffected area of lower Edney Creek for remediated areas of lower Edney Creek and lower Hazeltine Creek; Figure 8, Table 3). These areas will include all those outlined above for creek benthic invertebrate community monitoring (HAC-R1, HAC-U [HAC-R2], HAC-D [HAC-R5], E1, EDC-U, and EDC-D; see Section 3.1.2) except areas that are monitored specifically to meet fish and fish habitat monitoring objectives (i.e., HAC-R3 and FPC-R3; Figure 8, Table 3). These sampling areas identified for continued benthic invertebrate tissue quality monitoring align with those proposed for both periphyton productivity (see CEMP Section 6.15) and benthic invertebrate community and productivity monitoring in creek habitats and are consistent with the previous study design (MPMC 2019). Benthic invertebrate tissue monitoring will not be completed in lake habitats, consistent with the previous study design (MPMC 2019).

Benthic invertebrate tissue quality sampling in creeks will be completed by collecting composite-taxa samples from each creek monitoring area identified above (Figure 8, Table 3). Each composite-taxa tissue quality sample will contain a mixture of taxa that is proportional to biomass at each station. Tissues will be collected for the analytical determination of moisture content, metals, and mercury (see Section 4.3.2). Data interpretation for all parameters will be based on a combination of: 1) statistical comparison to previous conditions; 2) statistical comparison to reference conditions; and 3) comparison relative to BCWQG (i.e., tissue selenium concentrations; BCMOE 2014). Accordingly, eight stations per area will be sampled to provide replication for the statistical contrasts. Sampling at each station will be supported by measures of *in situ* water quality, GPS coordinates, physical observations, supporting photographs, and a spot water quality sample collected from each area (as described in Section 3.1.2). The benthic invertebrate tissue quality monitoring and supporting measures detailed herein are consistent with

the previous approved CEMP Benthic Invertebrate Monitoring Plan (MPMC 2019) with one exception. The previous study design included concurrent collection of two types of benthic invertebrate tissue quality samples from each monitoring station: composite-taxa and single-taxon (i.e., caddisfly). Evaluation of results from these two sample types (collected from 2018 to 2021) has indicated that although some variability exists between the tissue types, potential changes in the single-taxon (i.e., caddisfly) tissues would be detected if sampling were limited to composite-taxa tissue samples only (Minnow 2022a). Therefore, the collection of composite-taxa benthic invertebrate tissue samples (which are reflective of fish diet) will be continued, while the collection of single-taxon samples will be discontinued.

Benthic invertebrate tissue quality sampling will be completed in August, consistent with previous data collections (e.g., Minnow 2016a, 2017b, 2018b, 2019a, 2020a, 2021a, 2022a). The monitoring frequency in all areas (upper and lower creek areas) will continue to be annual, consistent with the previous study design (MPMC 2019). The continuation of annual benthic invertebrate tissue quality monitoring will ensure the continued high-resolution evaluation of potential changes in tissue quality in the creek areas given the discontinuation of periphyton tissue quality monitoring (see CEMP Section 6.15).

Benthic invertebrate tissue quality samples will be collected, processed, analyzed, and the associated data interpreted using methodology consistent with previous assessment at Mount Polley (e.g., Minnow 2016a, 2017b, 2018b, 2019a, 2020a, 2021a, 2022a) and with technical guidance (e.g., BCMOE 2013, 2016). Detailed methodology is provided in Section 4, including: QA/QC, sample collection methods, sample handling and laboratory analysis, data quality assessment, and data handling and interpretation.

4 METHODOLOGY

4.1 Quality Assurance / Quality Control

All sampling will be performed by qualified field staff experienced in the implementation of benthic invertebrate community, productivity, and tissue chemistry monitoring programs. All sample collection methods, QA/QC measures, and laboratory analysis methods will be implemented in accordance with technical guidance (BCMOE 2013, 2016; BCMOECCS 2020). Specifically, QA/QC measures will include program review prior to implementation, adequate resources for all field teams including field checklists and field data sheets, the availability and maintenance of clean sampling equipment and sampling containers, and sampling in a manner that minimizes any risk of sample contamination.

Quality control (QC) samples will be collected to support the benthic invertebrate tissue quality monitoring program. To capture within-area variability, five community and productivity samples and eight replicate composite-taxa tissue quality samples will be collected from each sampling area. Field duplicate samples (i.e., splits samples of the benthic invertebrate tissue collected from one sampling station) will be collected for 10% of samples to assess field precision as part of the Data Quality Review (DQR; see Section 4.4). Duplicate water samples will be collected at a frequency of 10% to assess field precision associated with the water samples that support benthic invertebrate community, productivity, and tissue quality monitoring in creek areas. Raw field data will be transcribed from field sheets into an electronic spreadsheet. Data will then be checked by a separate individual for data entry errors as part of routine QA/QC procedures. In addition to field QA/QC, the laboratory responsible for chemical analyses will be accredited by the Canadian Association for Laboratory Accreditation (CALA) for these analyses. Specific QC sampling and associated reporting for tissue quality results will be requested of the analytical laboratory, including reagent blank results, laboratory replicate results, and laboratory accuracy results (i.e., matrix spikes, laboratory control samples, and/or certified reference materials). Laboratory Reporting Limits (LRLs) will also be evaluated in comparison to targets established by the analytical laboratory. These results will be assessed as part of the DQR (see Section 4.4).

QC samples to assess field precision (field duplicates) will not be collected for benthic community or productivity monitoring endpoints due to the high inherent natural variability of these parameters. However, composite benthic invertebrate community samples will be collected at all sampling locations to ensure that each sample is representative of the station. Taxonomic identification of benthic invertebrate community samples to the lowest practical level will be completed by a qualified laboratory certified under the Taxonomic Certification Program of

the Society for Freshwater Science (SFS; formerly the North American Benthological Society). Quality control for benthic invertebrate taxonomic analyses will be consistent with federal requirements for metal mining EEM (Environment Canada 2012a, 2014). Specific QC sampling and associated reporting will be requested from the taxonomic laboratory, including an assessment of sub-sampling error, sorting efficiency, and taxonomic quality control on at least 10% of the samples (Environment Canada 2012a, 2014). These results will be assessed as part of the DQR (see Section 4.4).

4.2 Sample Collection Methods

4.2.1 Community and Productivity

Benthic invertebrate sampling in lakes for community analysis will be collected using a stainless steel petite ponar grab sampler, consistent with previous monitoring (e.g., Minnow 2015a, 2016b,e, 2017a, 2018a, 2019a, 2019c, 2020a, 2021a; Table 1) and in accordance with provincial and federal technical guidance (i.e., BCMOE 2013; Environment Canada 2012a). Briefly, the petite ponar is a 6" x 6" (15.24 cm x 15.24 cm) grab sampler with jaws that can be held open by shear-pressure on a spring-loaded pin. The grab sampler is lowered to the substrate at which point shear-pressure is eliminated and the pin springs out. Upon upward pull at the initiation of retrieval, the jaws of the ponar close to grab surficial sediment. Care must be taken to control the rate at which the petite ponar is lowered to allow appropriate sediment penetration and to minimize sediment disturbance. The petite ponar will be carefully retrieved to surface and each grab will be placed into a plastic tote and observed for completeness and any unusual characteristics. For deep areas of Quesnel Lake, samples will be retrieved with the assistance of a commercial line hauler (Ace Line Hauler - Brutus Plus 40). Only high quality, comparable samples will be retained. If the sample is deemed acceptable, the entirety of the retrieved sample will be rinsed from the ponar into the tub to ensure the complete removal of all material The sample material will then be placed into a 250 µm mesh sieve bag and sieved free of all material less than 250 µm in diameter. At each station, a composite sample of five acceptable grabs will be collected (0.116 m^2 of bottom area in total) to ensure that each sample is representative of the station. After sieving, the retained material (sample) from the five composited grabs will then be carefully transferred to 1 or 2 Litre wide mouth plastic jars using a wash bottle while working over a plastic tub to avoid any potential loss of organisms. Any organisms that adhere to the inside of the sieve bag will be retrieved and added to the sample jar. Each jar will receive an internal and external label with the station number, area identifier, project number, date, and the initials of the field personnel. Each sample will be preserved with a 10% buffered formalin solution within six hours of collection to eliminate the potential effects of within-sample predation, which could affect

abundance estimates. Sampling will be conducted at five replicate stations in each area (see Table 3).

Supporting information collected at each lake sampling stations will include sediment quality measures (see CEMP Section 6.12), GPS coordinates, sampling depth, Secchi depth, *in situ* water quality near the sediment-water interface (temperature, dissolved oxygen, pH, and specific conductance), site and sample photographs, notes of the presence or absence of aquatic vegetation, and other physical observations (sediment texture, colour, density, etc.). In addition, a full vertical profile of *in situ* water quality measurements will be collected at a single station per area.

Sampling of benthic invertebrates in creeks for community and productivity analysis will be consistent with previous monitoring (e.g., Minnow 2009, 2016b, 2017a, 2018a,b, 2019a,b, 2020a,b, 2021a,b), and in accordance with provincial and federal technical guidance (i.e., BCMOE 2013; Environment Canada 2012a). A Hess sampler with a 0.1 m^2 diameter and upstream (incurrent) and downstream (excurrent) openings will be used if water depth allows. The incurrent opening will be covered with a mesh to prevent contamination of the sample with organisms from upstream. The excurrent opening will consist of a conical net equipped with 250 µm mesh attached to a removable collection cup that has mesh on the downstream end to allow water to exit. If creek environments are too shallow to accommodate Hess sampling, a Surber sampler (30.5 x 30.5 cm; 0.093 m^2) equipped with 250 µm mesh will be used. Each Hess/Surber sample will be collected by firmly and carefully placing the sampler on undisturbed substrate to a depth of 5 to 10 cm. All cobble and gravel within the sampler area (to a depth of approximately 10 cm) will be scrubbed and the current will be allowed to carry all dislodged organisms into the 250 µm net. The sampler net and collection cup will be rinsed, and the contents will be carefully transferred to internally and externally labelled 1 or 2 L wide mouth plastic jars. Any remaining invertebrates found clinging to the sampling equipment will be removed and placed in the sample jar. At each station, one composite sample of three sub-samples (i.e., approximately 0.3 m^2 of creek surface area if a Hess sampler is used, 0.279 m^2 if a Surber sampler is used) will be collected to ensure that each sample is representative of the station. Each sample will be preserved with a 10% buffered formalin solution as described above. Sampling will be conducted at five replicate stations in each area (see Table 3), and each station will be established at a minimum distance of approximately three bankfull widths from adjacent stations, where habitat allows. A concerted effort will be made to ensure that water velocity, water depth, and substrate characteristics are comparable among sub-samples and among respective stations to minimize natural influences on community variability.

Supporting information collected at each creek sampling station will include those parameters listed above for lakes (excluding vertical depth profiles and Secchi depth) as well as the following: water velocity, substrate size (20 randomly selected substrate pieces measured per station), the percent embeddedness of 10% of the substrate pieces measured, and general habitat characteristics assessed once for each monitoring area (channel measures, canopy cover, instream cover, periphyton coverage, and substrate characteristics) using methods adapted from the Canadian Aquatic Biomonitoring Network (CABIN) protocol (Environment Canada 2012b).

Supporting single spot water quality samples will be collected from creek stations concurrent with benthic invertebrate community monitoring. These samples will be collected by wading into a mid-channel area, moving from downstream to upstream, so as not to collect water downstream of disturbed substrates, and collecting the samples from approximately half of the total water depth. Water will be collected directly into pre-cleaned routine water quality sample bottles and preserved as required. Water samples will be kept on ice in the field, then stored in a refrigerator until shipment (in a cooler with ice) to the analytical laboratory.

4.2.2 Tissue Quality

Benthic invertebrate tissue samples will be collected using a combination of hand picking and kick-and-sweep, consistent with previous monitoring (e.g., Minnow 2011, 2013a,b, 2016a, 2017b, 2018b, 2019a, 2020a, 2021a) and with technical guidance (e.g., BCMOE 2016). Hand picking entails overturning rocks in the streambed and collecting any of benthic invertebrates observed. The kick-and-sweep method involves a field technician moving upstream and across the stream channel (in a zig-zag pattern) while holding a kick net (a net with a triangular opening and a 400 µm mesh bag) immediately downstream, and disturbing the substrate with their feet to dislodge benthic organisms into the net (a method modified from the CABIN 3-minute travelling kick-and-sweep; Environment Canada 2012b). The net will then be rinsed with water to move all debris and invertebrates to the collection cup at the bottom of the net. The collection cup will be removed and its contents (i.e., invertebrates and debris) will be placed into a plastic tote. Organisms will then be picked free of debris, and transferred into a labeled scintillation vial, without rinsing, to minimize the amount of water in each sample. One composite-taxa sample containing a mixture of taxa that is proportional to biomass at the station will be collected at each station following the methods outlined above. Sampling will be conducted at eight replicate stations in each area (see Table 3). Samples will be kept on ice in the field, then frozen before shipment (in a cooler with ice) to the analytical laboratory.

4.3 Sample Handling and Laboratory Analysis

4.3.1 Community and Productivity

Preserved benthic invertebrate community samples will be stored at room temperature until shipment to the laboratory for taxonomic identification and enumeration. Samples will be shipped with completed Chain of Custody (COC) forms immediately after the completion of the field campaign, however there are no recommended hold times for analysis.

Taxonomic identification of benthic invertebrate community samples will be completed by a qualified laboratory using standard methods that incorporate QA/QC measures (e.g., Environment Canada 2012a; 2014). Upon sample receipt, the laboratory will provide a sample receipt confirmation which will be reviewed to ensure that all samples are received and that the analytical requests are properly logged. All samples will be sieved and processed in the laboratory using the same mesh size as used in during field collections (250 µm). If the estimated number of invertebrates in a sample is greater than 600 individuals and the sample is fine and non-clumping, a subsample will be taken using a Marchant Box (Marchant 1989) as described by Environment Canada (2014). Samples (or sub-samples) will then be sorted using a gridded Petri dish under a low power stereo microscope into family/order while maintaining counts (but totals exclude Porifera, Nemata, Platyhelminthes, Ostracoda, Copepoda, Cladocera, and any terrestrial drop-ins). All samples will be processed to a minimum 300 organism count, and if 300 organisms have not been reached by the 50th cell of the Marchant Box, then the entire sample will be sorted (i.e., all 100 cells). All sorted organisms will be stored in 80% ethanol by family/order in separate labeled vials and debris will be preserved and labeled separately. Identifications of all insects to the lowest practical level (LPL; typically genus or species) and non-insects to the genus/species level (where possible, but to a minimum of family level) will be conducted by experienced, certified taxonomists using up-to-date taxonomic keys, comparisons to an externally-verified reference collection, and effort lists compiled by CABIN, SAFIT (Southwest Association of Freshwater Invertebrate Taxonomists), and PNAMP (Pacific Northwest Aquatic Monitoring Partnership). Following identification, representative specimens may be preserved and retained for inclusion in a voucher collection for Mount Polley.

Following taxonomic identification, the wet and dry biomass of total organisms in each sample from creek environments (benthic invertebrate productivity) will be determined. For wet biomass, samples will be poured through a piece of pre-weighed 212 µm Nitex mesh and dried gently between two pieces of absorbent paper. Each sample will then be weighed to the nearest 0.0001 g, and the weight of the mesh will be subtracted from the total weight to determine total sample wet weight. For dry biomass, wet samples will be then placed on a piece of pre-dried and pre-weighed glass fiber filter before being dried at 160^0F (71°C) for six hours. Following a short

period of cooling, samples will be weighed as described above, and total sample dry weight will be calculated.

Upon completion of the analyses, data will be entered into proprietary software (INSTAR1) to calculate benthic invertebrate community metrics and to generate the taxonomic report. The laboratory will provide a data report in Microsoft (MS) Excel™ and as an Adobe Acrobat Portable Document Format (PDF), including the results of the laboratory QC sample results.

4.3.2 Tissue Quality

Benthic invertebrate tissue quality samples will remain frozen until shipment (in a cooler with ice) to the analytical laboratory at the termination of the field program. Samples will be sent to the laboratory with completed COC forms leaving sufficient time to complete analyses within the recommended sample hold times (1 year for tissue quality [metals analysis]). Chemical analyses will be completed at an analytical laboratory accredited by the CALA using methods that are consistent with those specified in the British Columbia Environmental Laboratory Manual (BCMOECCS 2020). Upon sample receipt, the laboratory will provide a sample receipt confirmation when the samples are received and logged. These receipts will be reviewed to ensure that all samples are received and that the analytical requests are properly logged.

Tissue quality samples will be analysed for metals by CRC-ICP-MS (USEPA Method 6020B; USEPA 2014), mercury by CVAAS (Cold Vapor Atomic Absorption Spectrophotometry; EPA 200.2/245.7; USEPA 1994, 2005), and moisture content (Table 4). Upon completion of the analyses, the laboratory will provide a data report in MS Excel™ and as an Adobe Acrobat Portable Document Format (PDF). Reporting will include the results of the laboratory QC sample results.

4.4 Data Quality Review

Upon receipt of all analytical data, a Data Quality Review (DQR) will be performed. The DQR will confirm that all requested analyses are complete, and that acceptable LRLs have been achieved. The DQR will also include an evaluation of differences between duplicate (split) samples, as well as the QA/QC data reported by the laboratory. Completion of the DQR promptly following receipt of the benthic invertebrate monitoring data will ensure timely communication with the laboratory should any issues be identified.

For benthic invertebrate tissue quality samples, LRLs will be evaluated relative to targets established for the analytes, to “consensus” LRLs (Table 4), and to relevant British Columbia guidelines (i.e., selenium; BCMOE 2014). Comparisons between duplicate samples will be made by calculating the relative percent difference (RPD) of metal concentrations between paired duplicates. If the RPD is < 30% for concentrations that are > 5 times the LRL (for tissue

Table 4: Target Laboratory Reporting Limits (LRL) and Analytical Methods for Benthic Invertebrate Tissue Quality Analytes

Parameter	Metals in Tissue by CRC-ICPMS Micro (USEPA 2014)	Metals in Tissue by CRC-ICPMS (USEPA 2014)	Consensus LRLs[a]	British Columbia Water Quality Guidelines[b]
Units	**mg/kg wwt**	**mg/kg wwt**	**mg/kg wwt**	**mg/kg dw**
Physical Tests				
Moisture (%)	2	0.5		
Metals				
Aluminum (Al)	1.0	0.40	0.40	-
Antimony (Sb)	0.0020	0.0020	0.0020	-
Arsenic (As)	0.0060	0.0040	0.0050	-
Barium (Ba)	0.010	0.010	0.010	-
Beryllium (Be)	0.0020	0.0020	0.0020	-
Bismuth (Bi)	0.0020	0.0020	0.0200	-
Boron (B)	0.20	0.20	-	-
Cadmium (Cd)	0.0020	0.0010	0.0020	-
Calcium (Ca)	4.0	4.0	2.0	-
Cesium (Cs)	0.0010	0.0010	-	-
Chromium (Cr)	0.040	0.010	0.010	-
Cobalt (Co)	0.0040	0.0040	0.0040	-
Copper (Cu)	0.040	0.020	0.010	-
Iron (Fe)	1.0	0.60	1.0	-
Lead (Pb)	0.010	0.0040	0.0040	-
Lithium (Li)	0.10	0.10	-	-
Magnesium (Mg)	0.40	0.40	2.0	-
Manganese (Mn)	0.010	0.010	0.020	-
Mercury (Hg)[c]	0.0010	0.001	0.002	-
Molybdenum (Mo)	0.0080	0.0040	0.010	-
Nickel (Ni)	0.040	0.040	0.010	-
Phosphorus (P)	2.0	2.0	5.0	-
Potassium (K)	4.0	4.0	10	-
Rubidium (Rb)	0.010	0.010	-	-
Selenium (Se)	0.020	0.010	0.020	4.0
Silver (Ag)	0.001	0.001	0.01	-
Sodium (Na)	4.0	4.0	2.0	-
Strontium (Sr)	0.020	0.010	0.010	-
Tellurium (Te)	0.0040	0.0040	-	-
Thallium (Tl)	0.00040	0.00040	0.0010	-
Tin (Sn)	0.020	0.020	0.020	-
Titanium (Ti)	0.1	0.05	0.06	-
Uranium (U)	0.00040	0.00040	0.0010	-
Vanadium (V)	0.020	0.020	0.020	-
Zinc (Zn)	0.20	0.10	0.10	-
Zirconium (Zr)	0.040	0.040	-	-

Primary analyte.
Secondary analyte.

Notes: mg/kg = milligrams per kilogram. wwt =wet weight. To convert the wet weight LRL to dry weight LRL, multiply by 5. "-" indicates no guideline available.

[a] From Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators (BCMOE 2016).
[b] British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture (BCMOE 2018).
[c] Method for total mercury analysis will be according to USEPA (2002).

quality and water quality samples), then the duplicate sample results will be considered acceptable. Results for laboratory blanks, precision, and accuracy will be evaluated relative to Data Quality Objectives (DQO) established by the analytical laboratory that performed the analyses. Analyte concentrations in laboratory blank samples will be evaluated in relation to their respective LRLs, and the results will be used to identify potential contamination associated with equipment (e.g., cleanliness) and sample collection and handling procedures (e.g., collection, shipping).

For benthic invertebrate community samples, reanalysis for quality control endpoints (organism sorting efficiency, subsampling error, and taxonomic identification error) will be performed on 10% of samples, and results of quality control measures will be evaluated relative to pre-established DQOs. Specifically, evaluation of organism sorting efficiency will involve reprocessing previously sorted material from randomly selected samples, and then determining the number of invertebrates that were not recovered during processing of the original sample, and an efficiency of < 10% missed organisms will be considered acceptable. Evaluation of subsampling error provides a measure of analytical accuracy by comparing the numbers of benthic invertebrates recovered between at least two sub-samples, and of analytical precision by comparing sub-sample derived benthic invertebrate community numbers with the densities determined for whole benthic invertebrate community samples. An error of < 20% will be considered acceptable for subsampling. Evaluation of taxonomic identification error involves an internal quality control audit of taxonomic identification results whereby blind re-enumeration and re-identification of random samples will be performed by an analyst not involved in the original sample processing, and an error of < 5% for this endpoint will be considered acceptable.

4.5 Data Handling and Interpretation

Upon receipt of data from the analytical laboratories, all laboratory data files will be managed by the Mount Polley Mining Corporation (MPMC) Environment Department. In addition, chemical data provided by the primary analytical laboratories as an Electronic Data Deliverable (EDD) will be imported directly into the MPMC's database. Following completion of the DQR described above (see Section 4.4), all benthic invertebrate community, productivity, tissue quality, and supporting data will be managed in MS Excel™ or R (R Core Team 2022). For all replicated data (typically based on a sample size of five or eight stations per area), data will be provided to the QP for analysis and summarized by calculating mean, median, standard deviation, minimum, and maximum for each endpoint and area. Data analysis will be completed for each monitoring component (community, productivity, and tissue quality).

4.5.1 Community and Productivity

Benthic invertebrate communities will be evaluated using metrics of organism density per unit area (organisms per m²), taxonomic richness, Simpson's Diversity Index, and Simpson's Evenness Index (calculated as in Smith and Wilson 1996; Environment Canada 2012a). The densities and relative densities of the most abundant taxa will also be calculated (relative densities calculated as the abundance of each respective dominant/indicator taxon relative to the total number of organisms in the sample and expressed as a percentage). Dominant/indicator taxon groups will be defined as those groups representing more than 5% of total organism abundance within each set of areas being compared, or any taxon groups considered to be important indicators of environmental stress. These primary indices will be calculated at the LPL of taxonomy for the 250 µm fraction of all samples. Benthic invertebrate productivity in creeks will be evaluated using wet and dry total biomass converted to a standard area-based measurement (g/m^2).

Correspondence analysis (CA) multivariate ordination methods will be used to further examine benthic invertebrate community structure if differences in community structure among areas and years are not readily evident by examining the dominant/indicator taxon group results. CA is a multivariate ordination method used to reduce multivariate data into a manageable number of variables and will be applied to assist in the identification of key spatial or temporal differences in benthic invertebrate community (i.e., which areas have distinct benthic communities but also how these benthic communities differ among areas). The results of these multivariate analyses will be incorporated into the comparison of benthic invertebrate indices described below.

The benthic invertebrate community and productivity endpoints described above will be compared to previous data (including pre-breach data where possible) and to reference results through detailed interpretation that may include: graphical comparisons to reference and historical data and formal statistical contrasts of exposed versus reference results over time. The formal statistical contrasts of benthic invertebrate community and productivity at exposed versus reference areas over time will be conducted as two-way ANOVAs with Area and Year as factors and assessing the interaction between Area and Year. These contrasts will include available pre-breach and post-breach data to assess how endpoints from exposed areas compare to both reference and pre-breach conditions, and to assess temporal changes at the exposed areas. If the Area x Year interaction term is significant, all pairwise contrasts will be evaluated. If the interaction term is not significant but the Area term is significant, pairwise contrasts will be conducted between areas pooling years; if the Year term is significant, pairwise contrasts will be conducted between years pooling areas. Pairwise contrasts will be evaluated using Sidak correction to account for multiple comparisons. Prior to analysis, the assumptions of normality

and homogeneity of variances will be tested on the residuals of the two-way ANOVA model using the Shapiro-Wilk test and Levene's test based on median values, respectively using $\alpha = 0.05$. Data will be transformed as necessary to satisfy assumptions of normality and homogeneity of variance (e.g., $\log_{10}$, $\log_{10}(x+1)$ when zeros were present in the data). In instances where the residuals of the ANOVA model do not meet the assumptions of normality and homogeneity of variances, the analysis will be conducted on ranks (equivalent to a non-parametric-test). Statistically significant differences in benthic invertebrate community and productivity between areas and years will be identified using an α of 0.1.

If exposed versus reference or temporal differences in benthic invertebrate community and/or productivity results are noted, potential relationships between benthic invertebrate community metrics and physical and chemical conditions of the study areas may be explored using Spearman correlation (often referred to a Spearman Rank-Order correlation). For lake sampling areas, these physical/chemical endpoints may include results of multivariate statistical analyses used to identify key sediment quality parameters (e.g., Principal Components Analysis [PCA] axis scores; see CEMP Section 6.12). Following the derivation of correlation coefficients, a Bonferroni-type correction (i.e., p-value [0.05] divided by the total number of independent variables) will be applied to minimize the risk of declaring false positive correlations since at least 5% of derived correlations would be expected to occur by chance alone at an uncorrected p-value of 0.05. Any significant correlations found at the Bonferroni-adjusted p-value or will be further investigated using scatter plots to determine if a continuous distribution of data was realized (possible causal relationships) or if these relationships were "leveraged" by outlying points (or groups of points). Although it is recognized that a significant correlation or regression does not indicate causation (e.g., Norton et al. 2015), it is desirable to not only characterize the nature of a response (e.g., differences in benthic invertebrate community), but to also obtain evidence of cause. Correlation / regression analyses are commonly applied tools for identifying potential cause (e.g., Norton et al. 2015). Evidence of causation obtained from correlation or regression analysis will be carefully consider the strength, range, and continuity of the relationships as well as mechanistic knowledge/understanding of potential cause.

The evaluation of benthic invertebrate community and productivity results from creek areas will consider the results of routine water quality monitoring data collected by MPMC staff from these creek monitoring areas. These data will be used to support the evaluation of benthic invertebrate community monitoring results through detailed interpretation that may include graphical comparisons of primary and secondary analyte concentrations at exposed versus reference areas compared to the relevant BCWQG (BCMOECCS 2021a,b). Results of spot water quality samples collected concurrently with benthic invertebrate monitoring at each creek area will also be compared to BCWQG (BCMOECCS 2021a,b).

4.5.2 Tissue Quality

Data analysis and interpretation of benthic invertebrate tissue quality results will focus on primary and secondary analytes identified in Minnow (2020a, 2021a, 2022a; Table 4). The concentrations of primary and secondary analytes in benthic invertebrate tissue from exposed areas will be compared to previous data (including pre-breach data where possible), to reference results, and over time through detailed interpretation that may include: graphical comparisons to reference and historical data (including pre-breach data), graphical comparisons of selenium concentrations to the relevant BCWQG (BCMOE 2014), and formal statistical contrasts to evaluate if mean analyte concentrations at the exposed area have changed over time relative to the reference area.

The formal statistical contrasts of benthic invertebrate tissue quality at exposed versus reference areas over time will be conducted using a two-way ANOVA that assesses the exposed:reference ratio of results, with Area and Year as factors and assessing the interaction between Area and Year. If the Area×Year interaction term is significant ($\alpha = 0.05$), then the ratios of the concentrations from the exposed area to the reference area differ among years and pairwise contrasts will be completed among years (using $\alpha = 0.05$ to assess statistical significance). If the Area×Year interaction term is not significant ($\alpha = 0.05$), then the ratios of the concentrations from the exposed area to the reference area are consistent among years and no relative contrasts will be conducted. Temporal changes in the ratio of exposed:reference results will be quantified by calculating the difference between the value for the exposed area and the predicted value for the exposed area, assuming the same ratio (i.e., exposed:reference) from the baseline year (the first year the data were collected). Due to the potential prevalence of analyte results below the LRL for benthic invertebrate tissue quality results, the two-way ANOVA described above may be completed with a Maximum Likelihood Estimation (MLE) approach using a censored regression, assuming a lognormal distribution. Interpretation of results of these formal statistical analyses will at minimum focus on results for primary and secondary analytes with a significant Area × Time interaction in the results (i.e., the ratio of exposed:reference concentrations differed among years), and that are significantly higher at the exposed area relative to reference in the most recent monitoring year being assessed.

Concentrations of primary and secondary analytes in benthic invertebrate tissue will also be evaluated relative to concentrations in water. These ratios of concentrations will be calculated as: [tissue sample concentration]/[dissolved water concentration], and are referred to as Bioconcentration Factors (BCFs). BCFs are often used to describe the extent to which an analyte is taken up by an organism from the surrounding environment through exposure routes other than diet (i.e., Arnot and Gobas 2006), and are applicable to erosional areas where sediment is generally not present. BCFs will be calculated using tissue metal concentrations (dry weight)

and mean dissolved metal concentrations in water from each sampling area. Calculated BCFs will then be qualitatively compared among areas to identify differences in the uptake of metals by benthic invertebrate in areas impacted by effluent discharge and/or the TSF embankment breach.

An interpretive report based on the benthic invertebrate monitoring data will be prepared for integration into the Annual Environmental Report for the Mount Polley Mine that is prepared annually by MPMC and submitted to the regulators and other stakeholders by March 31st of the following year. The interpretive report will provide all data in an appendix and will include the DQR, the results of the screening against BCWQG, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots. Benthic invertebrate community and productivity monitoring data will also be incorporated into a separate interpretive report focused on the evaluation of fish and fish habitat monitoring objectives for the remediated creek areas; a report that is prepared annually and submitted to the HRWG by March 31st of the following year.

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Appendix B.1.3

Plankton Monitoring Plan

Minnow Environmental

minnow environmental inc.
A Trinity Consultants Company

Plankton Monitoring Plan

Prepared for:
Mount Polley Mining Corporation
Likely, British Columbia

Prepared by:
Minnow Environmental Inc.
Victoria, British Columbia

March 2023

Plankton
Monitoring Plan

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ACRONYMS AND ABBREVIATIONS

ANOVA – Analysis of Variance
BC – British Columbia
BCMOE – British Columbia Ministry of Environment
BCMOECCS – British Columbia Ministry of Environment Climate Change Strategy
BCWQG – British Columbia Water Quality Guidelines
CALA – Canadian Association for Laboratory Accreditation
CEMP – Comprehensive Environmental Monitoring Program
COC – Chain of Custody
CRC-ICP-MS – Collision Cell Inductively Coupled Plasma-Mass Spectrometry
CVAAS – Cold Vapor Atomic Absorption Spectrophotometry
DQO – Data Quality Objective
DQR – Data Quality Review
EDD – Electronic Data Deliverable
ERA – Ecological Risk Assessment
FOV – Field of View
GPS – Global Positioning System
HHRA – Human Health Risk Assessment
LPL – Lowest Practical Level
LRL – Laboratory Reporting Limits
MCE – Mixed Cellulose Ester
MOD – Magnitude of Difference
MPMC – Mount Polley Mining Corporation
MS – Microsoft
QA/QC – Quality Assurance/Quality Control
QC – Quality Control
RPD – Relative Percent Difference
TSF – Tailings Storage Facility
USEPA – United States Environmental Protection Agency

1 INTRODUCTION

1.1 Background

Plankton are organisms that live within the water column or surface waters of aquatic environments and are evaluated based on two groups: phytoplankton and zooplankton. Phytoplankton are photosynthetic primary producers (occurring as individual cells, filamentous arrangements, or colonial arrangements) that form the base of lake food webs, and therefore constitute a connection between nutrient availability, climate variables, and food availability for higher trophic levels (e.g., herbivorous zooplankton; Wetzel 2001). Zooplankton are the community of heterotrophic plankton which include small herbivorous rotifers and two orders of micro-crustaceans with varying feeding strategies, Copepoda and Cladocera (Sládeček 1983; Culver et al. 1985). Zooplankton are an important dietary source for fish, and therefore are an important consideration for fish habitat assessment (Hayes et al. 1996). Phytoplankton and zooplankton are both highly sensitive to changes in water chemistry and environmental variables, with communities routinely exhibiting rapid changes in response to seasonal shifts in temperature, light availability, and predator-prey interactions (Stich and Lampert 1981; Locke et al. 1994; Wetzel 2001; Moss et al. 2003). Measures of phytoplankton and zooplankton community and productivity are therefore important tools for the assessment of lake productivity. Zooplankton tissue quality monitoring provides an indication of lower trophic level exposure to aqueous analytes that are potentially influenced by the mine (metals, metalloids, and nutrients[1]) and an estimate of fish exposure to these analytes through diet. Therefore, plankton community, productivity, and tissue quality are important monitoring components that have been incorporated into the Mount Polley Mining Corporation (MPMC) Comprehensive Environmental Monitoring Program (CEMP).

The influence of the Mount Polley Mine on plankton community, productivity, and tissue quality can occur by several key mechanisms: 1) general mine influence from physical impingement, dustfall, and/or uncontained surface or groundwater flows; 2) direct discharge of mine effluent to Hazeltine Creek (April to August 2014) and Quesnel Lake (December 2015 to present)[2]; 3) the Tailings Storage Facility (TSF) embankment breach ("the breach") on August 4, 2014; and 4) remediation activities following the TSF embankment breach (via potential effects downstream

[1] Through the remainder of this section, the term "metals" will be used to include metals, metalloids, and nutrients for ease of communication.

[2] Treated effluent was discharged to Quesnel Lake via Hazeltine Creek from December 2015 to December 2017. During this period, treated effluent flowed into a settling pond in Hazeltine Creek located at the edge of Quesnel Lake prior to final discharge into Quesnel Lake via diffusers. From 2018 to present, treated effluent was conveyed to the diffusers in Quesnel Lake via a direct pipeline.

to Quesnel Lake). Potential effects associated with effluent discharge are chemical, while those associated with general mine influence, the TSF embankment breach, and subsequent remediation can be both physical and chemical.

Phytoplankton (community and chlorophyll-a) and zooplankton (community) have been monitored in waterbodies adjacent to the Mount Polley Mine since baseline investigations in 1995 and 1996 (HKP 1996, 1997). Zooplankton tissue quality monitoring was initiated in 2014 following the TSF embankment breach (Golder 2017). Results of plankton monitoring are reviewed in Section 2 and provide context for this CEMP Plankton Monitoring Plan. This study design is guided by a combination of historical findings, representative locations downstream of Mount Polley Mine operations, representative reference locations, and considerations for a statistically-based design that will facilitate the detection of spatial and/or temporal differences in plankton community, productivity, and tissue quality endpoints. Zooplankton tissue selenium results will also be evaluated relative to effects-based guidelines (e.g., British Columbia Water Quality Guidelines [BCWQG]; BCMOE 2014).

The following sections of the CEMP Plankton Monitoring Plan provide the objectives of phytoplankton (community and productivity) and zooplankton monitoring (community, productivity, and tissue quality) from 2023 to 2025, a summary of historical plankton monitoring results, an overview of the CEMP study design and associated rationale (including sampling locations, replication, frequency, and analytes), and detailed methodology for plankton community, productivity, and tissue quality monitoring (quality assurance/quality control [QA/QC], sample collection methods, sample handling and laboratory analysis, data quality review, data handling, interpretation, and reporting).

1.2 Monitoring Objectives

The objective of plankton monitoring is to evaluate the influence of Mount Polley Mine activities on phytoplankton (community and productivity) and zooplankton monitoring (community, productivity, and tissue quality) in receiving environments (Polley Lake and Quesnel Lake) in comparison to reference conditions, and to determine potential implications to aquatic life (e.g., through assessment of plankton community and productivity endpoints, and comparison of zooplankton tissue quality results to available guidelines; BCMOE 2014) and to aquatic ecosystem health by providing supporting information for the assessment of potential effects to higher trophic levels (e.g., fish and fish habitat quality; CEMP Section 6.16). Plankton monitoring also provides data to support exposure assessment as part of the Ecological Risk Assessment (ERA) and Human Health Risk Assessment (HHRA).

2 SUMMARY OF HISTORICAL FINDINGS

Plankton communities and productivity have been monitored in the vicinity of the Mount Polley Mine since 1995, and zooplankton tissue quality has been monitored since 2014. Plankton community, productivity, and tissue quality samples have been collected from Polley Lake, Bootjack Lake, and Quesnel Lake (Tables 1, 2, and 3).

Plankton sampling in the vicinity of the Mount Polley Mine has spanned three distinct time periods listed below:

1. Baseline monitoring (1995, 1996);
2. Post-breach operational monitoring (2014, 2015); and
3. Post-breach and post-discharge monitoring (2016, 2017, 2018, 2019, 2020, 2021, 2022[3]).

Plankton community and productivity monitoring in the vicinity of the Mount Polley Mine has spanned the baseline and operational time periods (time periods 1 to 3), while zooplankton tissue quality monitoring has spanned the post-breach operational time periods only (time periods 2 and 3). General findings associated with baseline and post-breach monitoring are summarized by endpoints and sampling area in the following sections.

Plankton community and productivity results collected during baseline monitoring (1995, 1996; HKP 1996, 1997) and post-breach operational monitoring (2014 to 2018; Golder 2016, 2017) are not summarized herein because these data have low comparability with 2019 to 2021 results due to changes in field sampling, changes in analytical laboratory, and due to limitations of the laboratory taxonomy methodologies that apply to these historical data. In addition, a lack of replication for plankton monitoring data in these years precludes statistical analysis and limits the interpretability of these data. Data from 1995, 1995, 2014 to 2018 are presented in graphical form in Minnow (2019a, 2020, 2021, 2022), where applicable, to provide context for results collected since 2019. Since 2019, plankton community and productivity and zooplankton tissue quality monitoring has been conducted annually in Polley Lake, Bootjack Lake, and Quesnel Lake using methods consistent with the MPMC CEMP (MPMC 2019, Minnow 2022)[4], including sample

[3] Plankton monitoring was also completed in 2022 but reporting of these results is in progress, with submission of an interpretive report that includes these results required by March 31, 2023. The 2022 plankton monitoring results are therefore excluded from the present study design.

[4] At the request of MPMC, Minnow provided recommendations regarding modifications to the plankton monitoring program outlined in the MPMC CEMP (MPMC 2018). The amended plankton monitoring program (Minnow 2019b) included measures to facilitate statistical assessment of spatial and temporal changes, and to standardize sampling methodologies across lakes (Minnow 2019b). Implementation of the amended monitoring program recommended by Minnow was initiated in 2019 following acceptance of the amended plankton monitoring program (Minnow 2019b) by

Table 1: History of Zooplankton Community and Productivity Monitoring in Waterbodies in the Vicinity of the Mount Polley Mine

Year	Locations	Report
1995	Polley Lake, Bootjack Lake	HKP 1996
1996	Polley Lake, Bootjack Lake	HKP 1997
2014	Polley Lake, Quesnel Lake	Golder 2017
2015	Polley Lake, Quesnel Lake	Golder 2017
2016	Polley Lake, Quesnel Lake	Golder 2017
2017	Polley Lake, Quesnel Lake	Golder 2017
2018	Polley Lake, Quesnel Lake	Minnow 2019a
2019	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2020
2020	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2021
2021	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2022

Table 2: History of Phytoplankton Community and Productivity Monitoring in Waterbodies in the Vicinity of the Mount Polley Mine

Year	Locations	Report
1995	Polley Lake, Bootjack Lake	HKP 1996
1996	Polley Lake, Bootjack Lake	HKP 1997
2015	Polley Lake, Quesnel Lake	Golder 2016
2016	Polley Lake, Quesnel Lake	-
2017	Polley Lake, Quesnel Lake	-
2018	Polley Lake, Quesnel Lake	Minnow 2019a
2019	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2020
2020	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2021
2021	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2022

Notes: "-" references are not displayed for data from 2016 and 2017 because these data were not contained in a specific report (to Minnow's knowledge) and these data were provided by MPMC to Minnow as a Microsoft Excel file.

Table 3: History of Zooplankton Tissue Quality Monitoring in Waterbodies in the Vicinity of the Mount Polley Mine

Year	Locations	Report
2014	Quesnel Lake	Golder 2017
2015	Polley Lake, Quesnel Lake	Golder 2017
2016	Polley Lake, Quesnel Lake	Golder 2017
2017	Polley Lake, Quesnel Lake	Golder 2017
2018	Polley Lake, Quesnel Lake	Minnow 2019a
2019	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2020
2020	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2021
2021	Polley Lake, Bootjack Lake, Quesnel Lake	Minnow 2022

replication that allows for statistical assessment. The summary of historical findings presented herein therefore focuses the results of the spatial and temporal statistical analyses of replicated plankton monitoring data that was collected annually in July since 2019 (Minnow 2020, 2021, 2022).

2.1 Polley Lake

2.1.1 Community and Productivity

The post-breach phytoplankton community of Polley Lake showed decreased density between 2019 and 2020 (and no change from 2020 to 2021). This decrease in total density driven by decreased Cyanobacteria densities and was a change that was also observed at the reference area (Bootjack Lake) in 2021 (relative to the previous two years; Figure 1; Minnow 2022). Phytoplankton densities in Polley Lake were similar to and higher than reference in 2019 and 2021, respectively, despite the observed decrease densities over this time in Polley Lake, owing to the concurrent decrease in densities at the reference area (Figure 1; Minnow 2022). The phytoplankton community in Polley Lake from 2019 to 2021 was consistently characterized by lower taxon richness, and lower and higher relative abundances of Cryptomonads and Chlorophytes, respectively, compared to reference while the exposed versus reference differences in other major taxonomic groups have been variable over time (i.e., Diatoms, Chlorophytes, and Cyanobacteria; Minnow 2022). Phytoplankton productivity (in terms of chlorophyll-a concentrations) in Polley Lake was consistently lower than reference (Bootjack Lake) from 2019 to 2021 and chlorophyll-a concentrations in both lakes have decreased year over year since 2019 (Figure 2; Minnow 2022). The successively lower chlorophyll-a concentrations in each year at both lakes may be related to local natural variability in physical and chemical factors (e.g., light exposure, water temperature, and nutrient availability) that has affected both waterbodies. The consistent difference in productivity between the two lakes (lower productivity in Polley Lake than reference) may be related to a combination of slightly lower temperatures through the photic zone and slightly lower nutrient concentrations (e.g., total nitrogen and phosphorus) in Polley Lake relative to the reference (Bootjack Lake), both of which would facilitate more phytoplankton growth (Minnow 2022). It should be noted phytoplankton productivity was evaluated solely based on chlorophyll-a concentrations in 2020 and 2021 because chlorophyll-a provides a more accurate measure of productivity than phytoplankton biomass (Minnow 2021).

British Columbia Ministry of Environment and Climate Change Strategy (BCMOECCS) in July 2019 (BCMOECCS 2019). See Minnow 2020 for details and for pre-amendment (June 2019) and amended (June to August 2019) monitoring program results. The 2019 CEMP (MPMC 2019) includes incorporation of the approved amended plankton monitoring program (Minnow 2019b), and therefore plankton monitoring has been completed in accordance with the 2019 CEMP (MPMC 2019) since its approval on February 10, 2021.

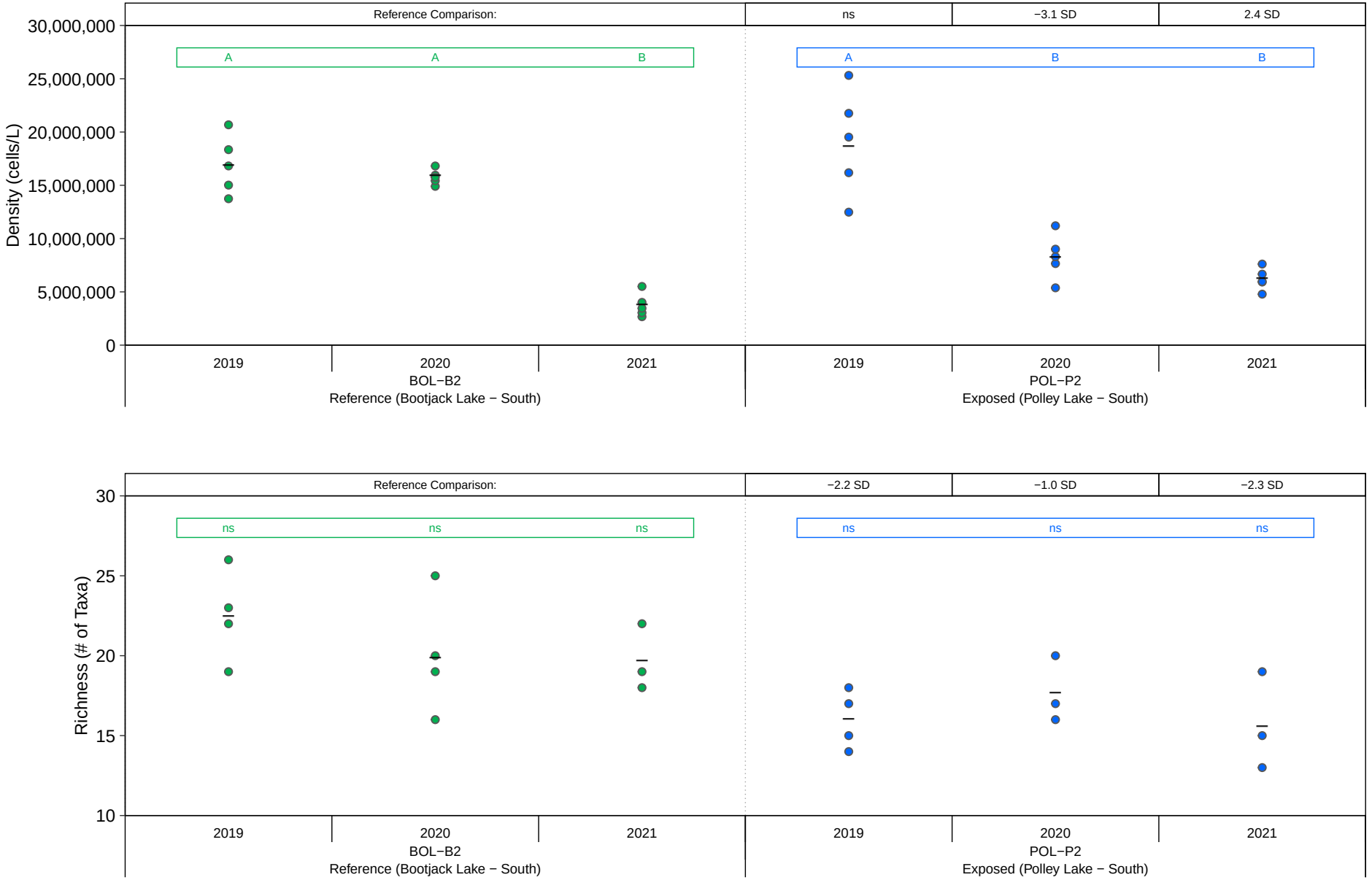

Figure 1: Phytoplankton Community Endpoints from Polley Lake (POL−P2; Exposed) and Bootjack Lake (BOL−B2; Reference), July 2019 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, $\log_{10}$−transformed or rank−transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. A number above the plot indicates significant exposed vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non−significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0. For plots of phytoplankton results prior to 2019, see Minnow 2019a, 2020a, 2021a.

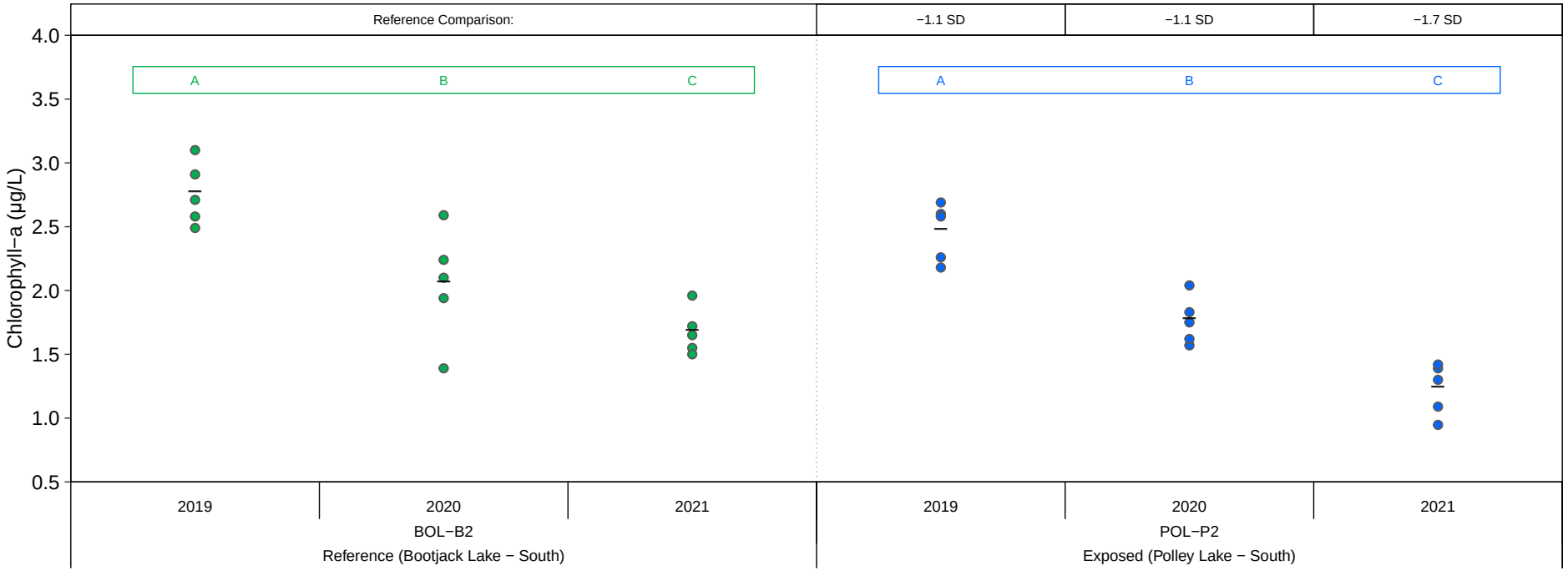

Figure 2: Phytoplankton Chlorophyll-a Concentrations from Polley Lake (POL−P2; Exposed) and Bootjack Lake (BOL−B2; Reference), July 2019 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, $\log_{10}$− transformed or rank−transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. A number above the plot indicates significant exposed vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non−significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0. For plots of phytoplankton results prior to 2019, see Minnow 2019a, 2020a, 2021a.

The zooplankton community of Polley Lake differed from the reference area from 2019 to 2021 in terms of higher density (in 2019) and lower taxon richness (in 2020; Figure 3; Minnow 2022).

Community composition from 2019 to 2021 in Polley Lake has consistently been characterized by higher relative abundances of Copepod Nauplii, Cyclopoida, and Cladocera, and lower relative abundances of Calanoida and Rotifera compared to reference. The consistent difference in zooplankton community composition between Polley and Bootjack lakes suggests that temporal changes in community composition (which were similar in both lakes over time) were likely driven by natural variability in environmental parameters (e.g., water temperature, nutrient availability, phytoplankton community; Minnow 2022). Total dry weight (dw) biomass of zooplankton in Polley Lake was either similar to or higher than reference from 2019 to 2022 (Minnow 2022).

2.1.2 Tissue Quality

The evaluation of zooplankton tissue quality results was focused on primary and secondary analytes identified in Minnow (2020, 2021, 2022).[5] Concentrations of primary analytes in zooplankton tissue from Polley Lake in 2021 were similar to reference except for copper and selenium, which were significantly greater than reference between 2019 and 2021 but demonstrated temporal stability relative to reference (i.e., the exposed – reference difference did not differ between 2019 and 2021; Figure 4; Minnow 2022). Despite the temporal stability of selenium concentrations from 2019 to 2021 in Polley Lake, relative to reference, selenium concentrations in 2021 were above the BCWQG, similar to tissue results from 2016, 2017, and 2019 which also exceeded the guideline (Figure 4). Among secondary analytes, calcium and cadmium were the only analytes with concentrations in 2021 higher than reference and that showed a temporal increase that was not observed at reference. Despite this increase, concentrations of cadmium and calcium in zooplankton tissue from Polley Lake largely remained within the range observed in previous post-breach years. The lack of temporal differences in zooplankton tissue quality from Polley Lake for most analytes was supported by trend analyses of surface water quality data (Minnow 2022).

[5] Primary analytes include arsenic, copper, iron, and selenium. Secondary analytes include barium, cadmium, calcium, cobalt, manganese, mercury, molybdenum, nickel, phosphorus, silver, sodium, strontium, tin, titanium, uranium, vanadium, and zinc.

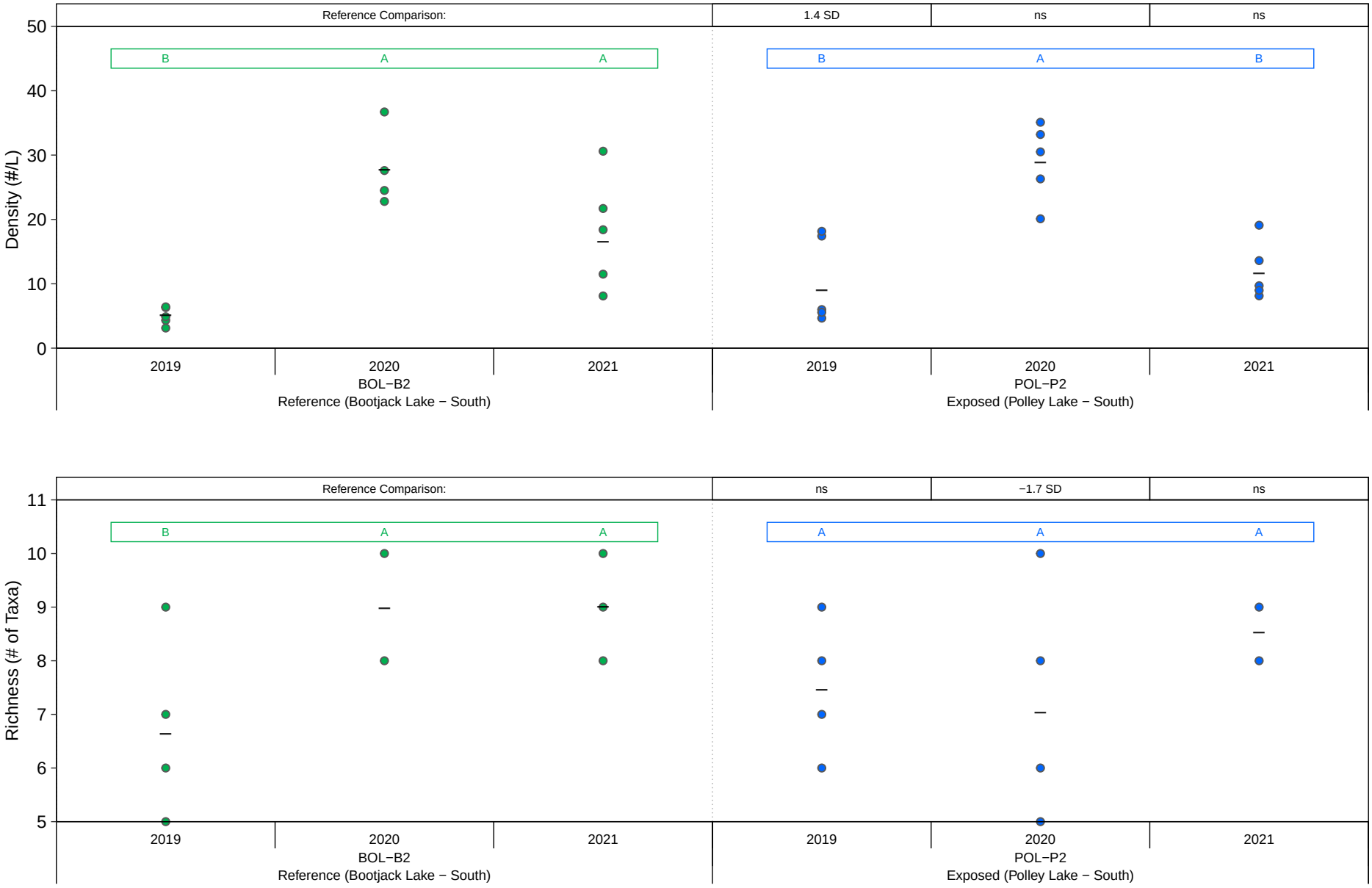

Figure 3: Zooplankton Community Endpoints from Polley Lake (POL−P2; Exposed) and Bootjack Lake (BOL−B2; Reference), July 2019 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, $\log_{10}$−transformed or rank−transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. A number above the plot indicates significant exposed vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non−significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0. For plots of phytoplankton results prior to 2019, see Minnow 2019a, 2020a, 2021a.

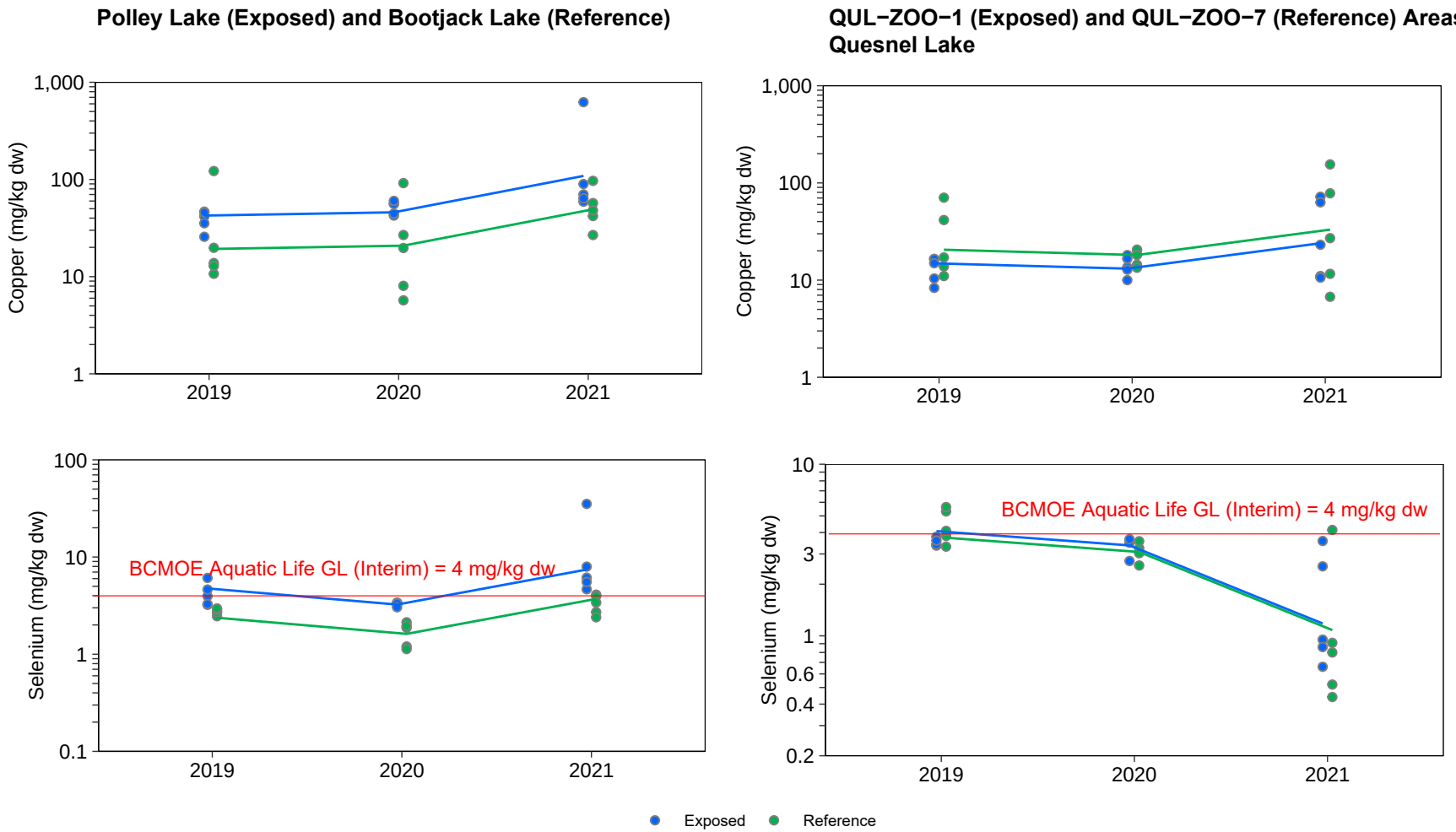

Figure 4: Concentration of Copper and Selenium in Zooplankton Tissue from Polley Lake (POL−P2; Exposed) and Bootjack Lake (BOL−B2; Reference) and from Exposed (QUL-ZOO-1) and Reference (QUL-ZOO-7) Areas of Quesnel Lake, July 2019 to 2021

Notes: Individual samples are plotted and lines join the least−squares estimated mean values for years included in the statistical analysis (i.e., not below the laboratory reporting limit). Statistical analyses were conducted using a two−way ANOVA with factors Area and Year. The models were fit using Maximum Likelihood Estimation with an assumed log−normal distribution. Years that share a letter (e.g., A,B,C) have ratios of concentrations (Exposed:Reference) that do not differ significantly (p−value < 0.05) among years. Letter A was assigned to the year with the highest ratio of concentrations (Exposed:Reference). Only years with samples from both reference and exposed areas are plotted. mg/kg dw = milligrams per kilogram dry weight. Red horizontal line represents British Columbia interim long-term guideline for selenium in invertebrate tissue (4 mg/kg dw; BCMOE 2014).

2.2 Quesnel Lake

2.2.1 Community and Productivity

The post-breach phytoplankton community of the exposed area of Quesnel Lake (QUL-ZOO-1) was characterized by density and taxon richness that were consistently similar to or greater than reference (QUL-ZOO-7) from 2019 to 2021 (Figure 5; Minnow 2022). The community composition of the exposed and reference areas from 2019 to 2021 were also similar in terms of the relative abundances and/or densities of most major algal groups (Diatoms, Cyanobacteria, Chlorophytes, and Cryptomonads), and those algal groups that did differ significantly between areas (Chrysophytes and other phytoplankton) only differed slightly (Minnow 2022). Phytoplankton productivity (as measured by chlorophyll-a) at the exposed area was consistently similar to reference from 2019 to 2021 (Figure 6). These results characterize Quesnel Lake as oligotrophic (Minnow 2022). Similar to Polley Lake, phytoplankton productivity was evaluated solely based on chlorophyll-a concentrations in 2020 and 2021 because chlorophyll-a provides a more accurate measure of productivity than phytoplankton biomass (Minnow 2021).

Zooplankton density, taxon richness, and total biomass at the exposed area of Quesnel Lake were consistently similar to the reference area from 2019 to 2021 (Figure 7; Minnow 2022). Community composition of the exposed and reference areas was also consistently similar from 2019 to 2021 in terms of the relative abundances and densities of the dominant taxa (Cladocera and Rotifera), and differences in the less dominant taxa were infrequent, indicating that the communities at the exposed and reference areas were largely similar (Minnow 2022).

2.2.2 Tissue Quality

The evaluation of zooplankton tissue quality results was focused on primary and secondary analytes identified in Minnow (2020, 2021, 2022; see Section 2.1.2). Zooplankton tissue from the exposed area of Quesnel Lake had concentrations of primary and secondary analytes (including copper and selenium; Figure 4) that were consistently similar to or lower than the reference area from 2019 to 2021 and did not change temporally relative to reference over that period (Minnow 2022). In addition, selenium concentrations in zooplankton tissue from the exposed area were consistently below the BCWQG from 2019 to 2021 (Figure 4; Minnow 2022). The lack of temporal and spatial differences in zooplankton tissue quality results since 2019 was supported by trend analyses of surface water quality data which indicated temporal stability for most analytes but slight increasing trends for total phosphorus, dissolved molybdenum, and total and dissolved selenium at exposed monitoring stations (Minnow 2022). The increasing trend for phosphorus was observed to a greater extent at the reference station indicating this change is not mine-related, while total selenium and molybdenum concentrations remain well (>10 and

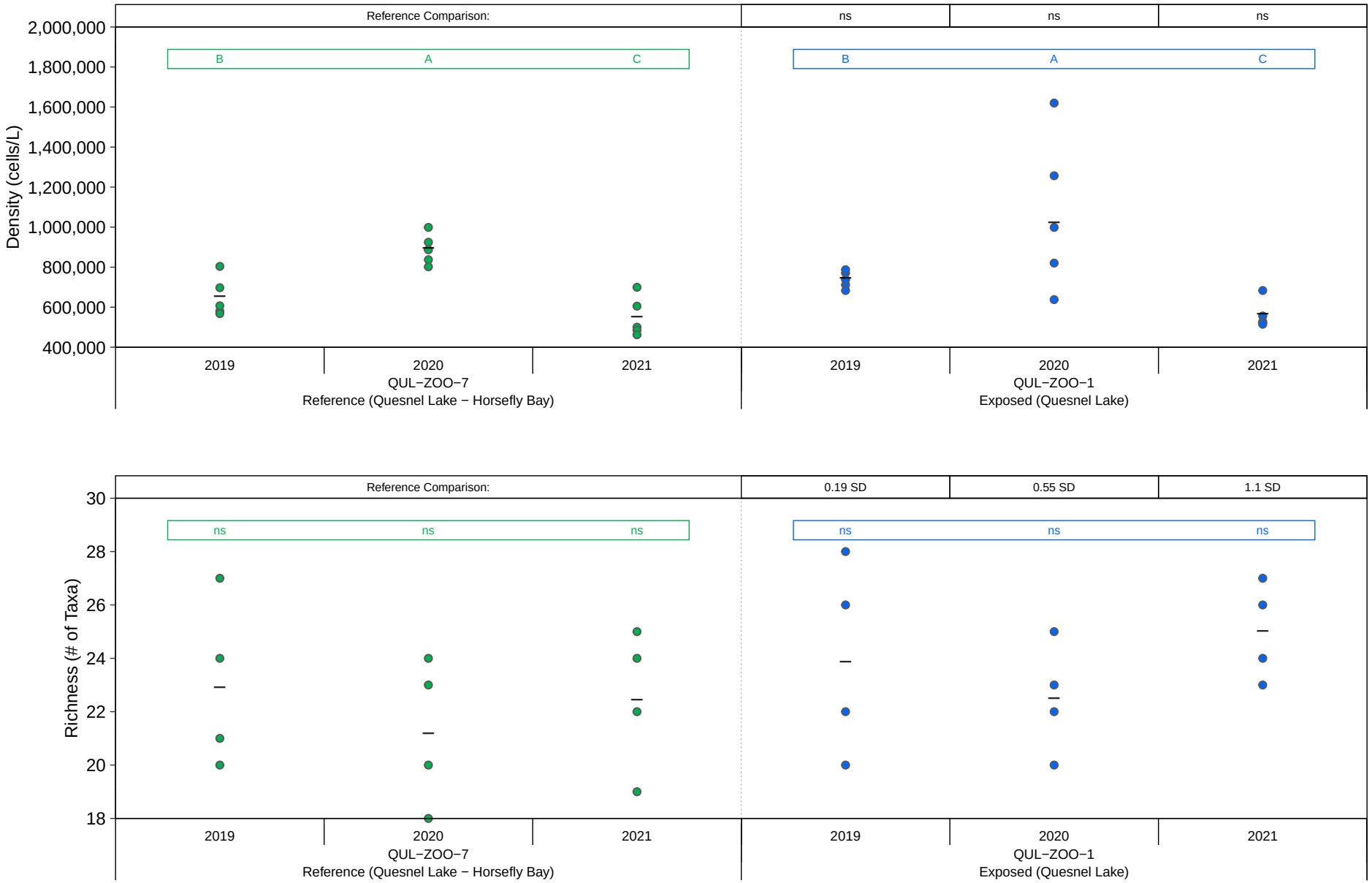

Figure 5: Phytoplankton Community Endpoints from Exposed (QUL-ZOO-1) and Reference (QUL-ZOO-7) Areas of Quesnel Lake, July 2019 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, $\log_{10}$−transformed or rank−transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. A number above the plot indicates significant exposed vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non−significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0. For plots of phytoplankton results prior to 2019, see Minnow 2019a, 2020a, 2021a.

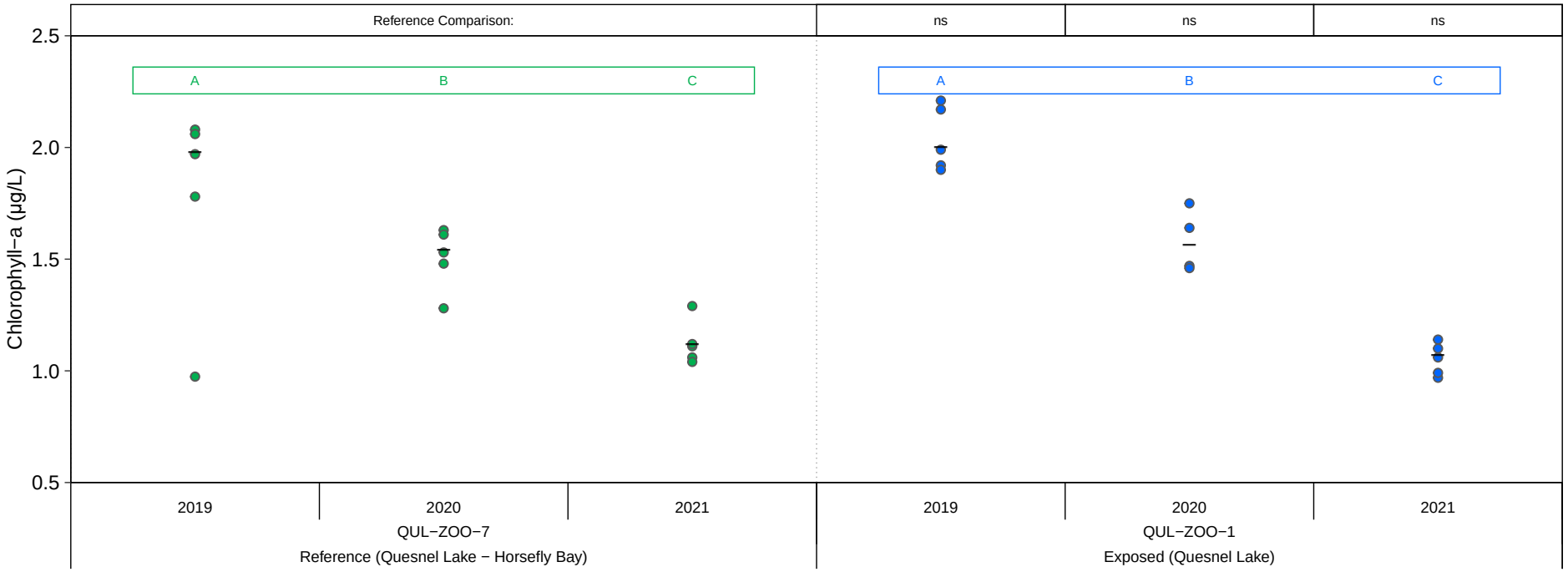

Figure 6: Phytoplankton Chlorophyll-a Concentrations from Exposed (QUL-ZOO-1) and Reference (QUL-ZOO-7) Areas of Quesnel Lake, July 2019 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, $\log_{10}$− transformed or rank−transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. A number above the plot indicates significant exposed vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non-significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0. For plots of phytoplankton results prior to 2019, see Minnow 2019a, 2020a, 2021a.

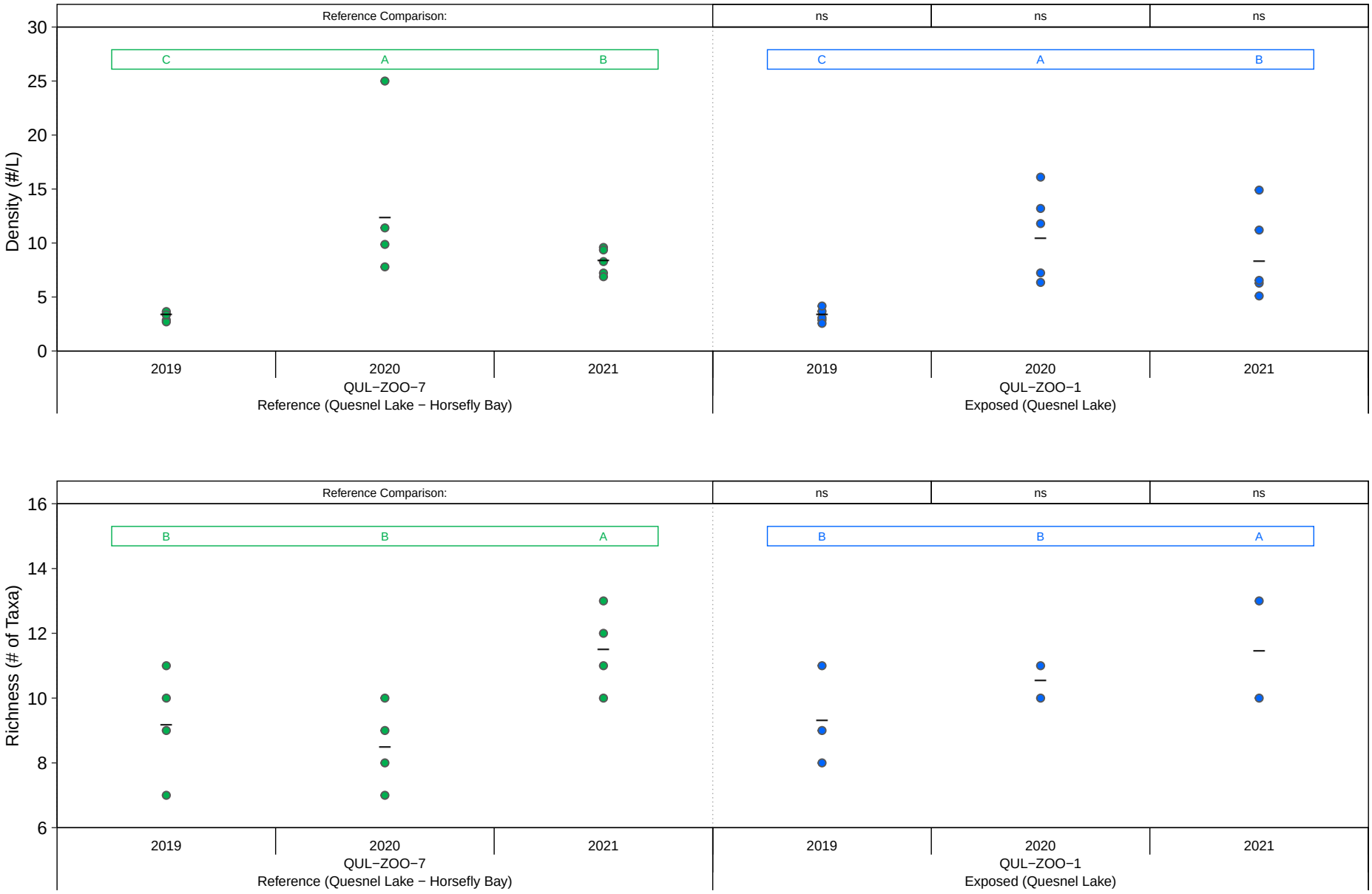

Figure 7: Zooplankton Community Endpoints from Exposed (QUL-ZOO-1) and Reference (QUL-ZOO-7) Areas of Quesnel Lake, July 2019 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, $\log_{10}$–transformed or rank−transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. A number above the plot indicates significant exposed vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non−significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0. For plots of phytoplankton results prior to 2019, see Minnow 2019a, 2020a, 2021a.

> 15,000 fold, respectively) below BCWQG (dissolved BCWQG do not exist for these analytes). Despite the identified trend in aqueous selenium concentrations, zooplankton tissue selenium concentrations were below the BC interim guideline for aquatic life at the exposed area in 2019 to 2021 (Minnow 2022). Thus, the slight increasing water quality trends (from 2015 to 2021) did not appear to have a measurable impact on concentrations of these metals in zooplankton tissues over the same period. As such, monitoring results indicate that zooplankton tissue quality in 2019 to 2021 was unimpacted by the breach and/or effluent exposure (Minnow 2022).

3 STUDY DESIGN AND RATIONALE

Plankton monitoring under the CEMP is proposed to meet the combined needs of: 1) operational monitoring; 2) monitoring of the impact of the 2014 TSF embankment breach; and 3) monitoring of the response to remediation activities following the TSF embankment breach (via potential effects downstream to Quesnel Lake). This CEMP Plankton Monitoring Plan includes revisions to the study design (i.e., updates to monitoring frequency) relative to the previous study design (MPMC 2019); revisions that are based on a Qualified Professional (QP) review of existing data. This section details the updated study design, outlines revisions compared to the previous study design (MPMC 2019), and provides the rationale associated with the proposed study design revisions.

Plankton monitoring will continue to focus on Polley Lake and Quesnel Lake, with reference areas identified for each mine-influenced sampling area (i.e., Bootjack Lake for Polley Lake, and unaffected areas of Quesnel Lake for impacted areas of Quesnel Lake; Figure 8, Table 4). In Polley Lake, plankton sampling will continue to include the southeast basin (POL-P2), with the southeast basin in Bootjack Lake (BOL-B2) serving as reference. In Quesnel Lake, plankton monitoring will continue to include one exposed area (QUL-ZOO-1) and a suitable reference area (QUL-ZOO-7; Figure 8, Table 4). These monitoring areas are consistent with those included in the previous study design (MPMC 2019).

Plankton monitoring will include an evaluation of community, productivity and tissue quality at each proposed sampling area (Table 4). This will include the evaluation of phytoplankton and zooplankton community and productivity (measured as chlorophyll-a for phytoplankton and as biomass for zooplankton), and zooplankton tissue quality (see Section 4.2 below for greater detail). Plankton monitoring will be completed in June (n =1 per area), July (n = 5 per area), and August (n=1 per area). Each sampling event will occur with a minimum of 30 days between events and plankton samples for a given lake will all be collected on the same day (e.g., all Quesnel zooplankton community and tissue samples will be collected on the same day as phytoplankton community and biomass). Data interpretation will be based on a combination of: 1) statistical comparison to previous conditions; 2) statistical comparison to reference conditions; 3) comparison of zooplankton tissue analyte concentrations relative to BCWQG (BCMOE 2014); 4) graphical comparisons for data that lack replication. Accordingly, five stations per area for the assessment of productivity and community will be sampled during the July monitoring event, as outlined above (to allow for statistical comparisons), while single samples per area will be collected during the June and August (to capture seasonal variability across the growing season). Plankton monitoring will be supported by measures of sampling depth, Secchi depth, *in situ* measurements of temperature, dissolved oxygen, pH, and specific conductance

590,000 595,000 600,000 605,000 610,000 615,000 620,000

5,825,000

5,820,000

5,815,000

Frypan Lake

Cedar Creek

Spanish Lake

Nina Lake

Polley Lake

Horsefly Lake Forest Service Road

Mount Polley Mine Perimeter

Bootjack Lake

POL-P2

BOL-B2

Boswell Lake

Winkley Creek Road

Bootjack Creek

QUL-ZOO-1

WTP

Tailings Storage Facility (TSF)

Quesnel Lake

Diffuser 1
Diffuser 2

Hazeltine Creek

Gavin Lake Road

QUL-ZOO-7

Edney Creek

Edney Lake Road

Horsefly Bay

Horsefly River

590,000 595,000 600,000 605,000 610,000 615,000 620,000

LEGEND

- Exposure Area
- Reference Area
- Diffuser (Treated Effluent Discharge, December 2015 to present)
- Water Treatment Plant (WTP)
- Central Collection Sump
- Effluent Discharge Pipeline (January 2018 to present)
- Discharge to Diffusers (2015 to present)
- Historic Watercourse

0 1 2 4 Km

Projection: North American Datum 1983 UTM Zone 10U

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N W E S

Mount Polley CEMP Plankton Monitoring Areas

Date: January 2023
Project 227202.0029

minnow environmental inc.

Figure 8

Document Path: C:\Users\CApol\Trinity Consultants, Inc\Imperial Metals - 227202.0029 - 2022 MPMC\D - GIS\CEMP Redesign\Task 5\22-29 Figure 1 Plankton and WQ Monitoring.mxd

Table 4: Mount Polley CEMP Zooplankton and Phytoplankton Quality Monitoring Program Overview

Water Body	Sampling Area	Type	Monitoring Frequency	Components [a]	Replication [b]	Rationale
Polley Lake	POL - P2 (Southeast Basin)	Exposed	Every 3 years	T,P,C	1,5,1	immediately adjacent to mine and breach-influenced
Bootjack Lake	BOL - B2 (Southeast Basin)	Reference	Every 3 years	T,P,C	1,5,1	reference for Polley Lake
Quesnel Lake	QUL - ZOO-1	Exposed	Every 3 years	T,P,C	1,5,1	adjacent to effluent discharge and breach-influenced
	QUL - ZOO-7	Reference	Every 3 years	T,P,C	1,5,1	reference for exposed deep habitat areas of Quesnel Lake

[a] Zooplankton and Phytoplankton monitoring components: T = community taxonomy (Lowest Practical Level), P = productivity (chlorophyll-a [phytoplankton] or biomass [zooplankton]), and C = tissue chemistry (see Table 5 for analytes).
[b] Number of replicate stations within the specified sampling area. Sampling collected 1,5,1 as follows late June, July, late August.

near the surface, Global Positioning System (GPS) coordinates, and supporting photographs of the sampling location and samples at each monitoring station. In addition, one full vertical profile of *in situ* water quality measurements will be collected at a single station per area. The plankton monitoring methods and supporting measures detailed herein are consistent with previous plankton monitoring at Mount Polley mine (e.g., Minnow 2019a, 2020, 2021, 2022) and with plankton monitoring requirements outlined by British Columbia Ministry of Environment and Climate Change Strategy (BCMOECCS 2021c).

Plankton community, productivity, and tissue quality sampling will be completed in June, July, and August consistent with previous data collections (Minnow 2019a, 2020, 2021, 2022) and with the previously approved study design (MPMC 2019). The revised frequency of plankton community, productivity, and tissue quality monitoring in Polley Lake and Quesnel Lake (and associated reference areas) will be every three years (Table 4). This represents a decrease in frequency relative to the previous study design, which was annual (MPMC 2019). Plankton monitoring was completed most recently in 2022, therefore the next monitoring event would occur in 2025 under the revised monitoring frequency. This decrease in monitoring frequency is guided by previous results which have shown temporal consistency since 2019 and/or similarity to reference conditions for most endpoints. Specifically, most plankton community and productivity endpoints for Polley Lake have shown consistent differences from reference since 2019, despite temporal changes within each waterbody over this period. This consistency suggests that temporal changes within each waterbody (which were similar in both lakes over time) have likely been driven by natural variability in environmental parameters (e.g., water temperature, nutrient availability; see Section 2.1.1; Minnow 2022). In Quesnel Lake, most plankton community and productivity endpoints at the exposed area have been either similar to reference (majority of endpoints) or greater than reference (e.g., phytoplankton taxon richness) since 2019 (see Section 2.2.1; Minnow 2022). Therefore, it is anticipated that a monitoring frequency of every three years will be sufficient to continue to track plankton community and productivity at these areas. Zooplankton tissue quality results have also shown temporal consistency since 2019 and/or similarity to reference conditions. Tissue concentrations of primary and secondary analytes from exposed areas (Polley Lake and exposed area of Quesnel Lake) were similar to or lower than reference from 2019 to 2021, except copper and selenium in Polley Lake zooplankton tissue which demonstrated temporal stability relative to reference over this period. Given the temporal stability or similarity to reference observed for zooplankton tissue quality endpoints over the last 3 years (i.e., since 2019), a monitoring frequency of every three years is also anticipated to be sufficient for continued monitoring of this endpoint. The frequencies for all monitoring components and areas will be reviewed following interpretation of data collected in 2025, and

design modifications (e.g., changes to monitoring frequency or locations) will be made based on a QP review of the data.

Plankton community, productivity, and tissue quality samples will be collected, processed, analyzed, and the associated data interpreted using methodology consistent with previous assessment at Mount Polley (e.g., Minnow 2019a, 2020, 2021, 2022) and with technical guidance (e.g., BCMOE 2013, 2016). Detailed methodology is provided in Section 4, including: QA/QC, sample collection methods, sample handling and laboratory analysis, data quality assessment, and data handling and interpretation.

4 METHODOLOGY

4.1 Quality Assurance / Quality Control

All sampling will be led by qualified field staff experienced in the implementation of phytoplankton and zooplankton monitoring programs. All sample collection methods, quality assurance and quality control (QA/QC) measures, and laboratory analysis methods will be implemented in accordance with technical guidance (BCMOE 2013, 2016; BCMOECCS 2020). Specifically, QA/QC measures will include program review prior to implementation, adequate resources for all field teams including field checklists and field data sheets, the availability and maintenance of clean sampling equipment and sampling containers, and sampling in a manner that minimizes any risk of sample contamination.

Quality control (QC) samples will be collected to support the plankton monitoring program. During the July monitoring program, replicate samples will be collected from each sampling area in order to capture within-area variability (samples from 5 separate stations will be collected to represent the sampling area), while single replicate samples will be collected from each area during the June and August sampling programs. Specific field QC samples will include duplicates (i.e., splits) of zooplankton tissue quality samples collected at a frequency of 10% of the total number of samples to assess field precision as part of the Data Quality Review (DQR; see Section 4.4). Duplicate water samples will be collected at a frequency of 10% to assess field precision associated with the water samples that support plankton community, productivity, and tissue quality monitoring. QC samples to assess field precision (field duplicates) will not be collected for phytoplankton productivity (chlorophyll-a) or phytoplankton or zooplankton community monitoring endpoints due to high the inherent natural variability in these parameters. Raw field data will be transcribed from field sheets into an electronic spreadsheet. Data will be checked by a separate individual for data entry errors as part of routine Quality Assurance/Quality Control (QA/QC) procedures.

In addition to field QA/QC, the laboratory responsible chemical analyses will be accredited by the Canadian Association for Laboratory Accreditation (CALA) for these analyses. Specific QC sampling and associated reporting will for phytoplankton productivity and zooplankton tissue quality endpoints will be requested of the analytical laboratory, including reagent blank results, laboratory replicate results, and laboratory accuracy results (i.e., laboratory control samples and/or certified reference materials). Laboratory Reporting Limits (LRLs) will also be evaluated in comparison to targets established by the analytical laboratory. Quality control for plankton taxonomic analyses will be requested from the taxonomic laboratory and will include an assessment of sub-sampling error for a minimum of 10% of samples to ensure that the fraction of

the total sample examined was an accurate representation of the total number of organisms. Results will be assessed as part of the data quality review (DQR; see Section 4.4).

4.2 Sample Collection Methods

4.2.1 Phytoplankton

Phytoplankton will be collected using a depth-integrated tube water sampler (length ~13 m) that is weighted at the bottom.[6] Depth-integrated samples will be collected using nearly the full length of the tube whenever station depth is greater than 12 m, or the sampling depth will be decreased to prevent collection of sediment or water from the sediment-water interface. To collect one sample, the weighted end of the plastic tubing will be lowered to the required sampling depth, the hose will be crimped, and the depth-integrated sampler will be pulled to the surface, with the hose remaining crimped the entire time. The weighted end will be placed into a clean plastic pail and the crimped end released allowing the water to flow into the clean bucket. The crimped end will be elevated above the bucket and the hose will be raised along its length towards the weighted end to ensure that all the water within the hose is transferred to the bucket. *In situ* water measurements will be immediately taken upon retrieval of water from the depth-integrated sampler.

Phytoplankton and supporting water quality samples will then be taken from the bucket by decanting into appropriate sample bottle(s) and preserved and stored as follows. Supporting water samples will be decanted into pre-cleaned routine water quality sample bottles and preserved as required. Water samples will be kept on ice in the field then stored in a refrigerator until overnight shipment (in a cooler with ice) to the analytical laboratory. Samples for phytoplankton community composition will be decanted into an opaque 250 mL plastic bottle, preserved by adding Lugol's solution using an eyedropper until the sample colour is like that of weak tea, mixed thoroughly, and stored in a cool dark environment at room temperature prior to shipment to the laboratory for analysis. Samples for phytoplankton productivity (chlorophyll-a) will be decanted into an opaque 250 mL plastic bottle and kept cool until same-day filtration. Water collected for phytoplankton chlorophyll-a measures will be vacuum-filtered using either an electronic or hand-held vacuum pump as follows. The volume of sample to be filtered (i.e., 200 mL) will be measured and decanted into the vacuum filter apparatus and filtered through a large (47 mm) 0.45 µm pore diameter Whatman mixed cellulose ester (MCE) filter paper.

[6] Phytoplankton community and productivity samples were collected by surface water grab samples prior to the amendment of the plankton monitoring program in 2019 (Minnow 2019b; BCMOECCS 2019). Using a depth-integrated sampler rather than surface grabs for phytoplankton samples was validated in 2019 when both methods were used for sample collection. Analysis of datasets from both methods of sample collection determined that the depth-integrated sampler provided greater sample recovery throughout the photic zone (the upper layer of the water column receiving light penetration) and is therefore the preferable sampling method (Minnow 2020).

After filtration is complete, the pressure will be released from the vacuum pump and clean forceps will be used to remove the filter paper from the apparatus. The filter paper will then be folded and placed into a labeled opaque centrifuge tube that will be frozen before shipment (in a cooler with ice) to the analytical laboratory. The volume of water filtered, and the number of filters used per sample, will be recorded and indicated on the Chain of Custody (COC) forms. The filter apparatus will be rinsed with a small amount of distilled water between each sample to remove any of the phytoplankton cells that may have adhered to the side of the apparatus. The volume of distilled water will not be included as part of the total volume filtered. If samples for chlorophyll-a analysis cannot be field-filtered (i.e., due to equipment malfunction), the sample will be refrigerated in the opaque 250 mL plastic bottle until overnight shipment (in a cooler with ice) to the analytical laboratory where the sample will be filtered.

Supporting information collected at each plankton monitoring station will include GPS coordinates, sampling depth, Secchi depth, and one full vertical profile of *in situ* water quality measurements collected at a single station per area.

4.2.2 Zooplankton

Zooplankton community and tissue quality samples will be collected using a 30 cm diameter, 90 cm long, zooplankton haul net with a 0.5 m diameter mouth opening and equipped with 50 µm Nitex mesh. Zooplankton community samples are generally collected by lowering the zooplankton haul net to either the lake bottom or to a pre-defined depth. Hauls for the purposes of this monitoring program will start ~2 m above the lake bottom and will therefore differ among lakes and hauls. Once the net is lowered to the desired starting depth, it is then pulled vertically through the water column, and each zooplankton sample will consist of a single vertical haul retrieved vertically to the surface at a rate of ~0.5 m/sec.[7] Upon net retrieval, material on the

[7] The CEMP approval amendment letter from BCMOECCS (dated July 15, 2019; BCMOECCS 2019) stipulated that zooplankton samples must be collected using a modified horizontal tow method; which is a condition that applies to all zooplankton sample collection. This was not the intent of the plankton program recommendations provided by Minnow (dated May 28, 2019; Minnow 2019b) which included the use of different plankton tow methods for the collection of: 1) zooplankton productivity and community samples, and 2) zooplankton tissue quality samples. Minnow maintains that zooplankton productivity and community samples should be collected using a vertical tow method only (consistent with the recommendations provided by Minnow in May 2019; Minnow 2019b). A modified horizontal tow method was not recommended for the collection of zooplankton community samples for two reasons. Firstly, zooplankton samples for community analysis have previously been collected by a single vertical tow. Changing the collection method for this sample type to a modified horizontal tow would limit comparability with previously collected data. Secondly, it is difficult to ensure that the sampling net ascends through the water column at a constant speed when conducting a horizontal tow. Since zooplankton community composition differs through the water column, variability in the amount of time that the net samples a given depth during a horizontal tow could influence the community results. Use of a vertical tow method eliminates this consideration entirely. Following consultation with MPMC regarding the above rationale and the best methodological approach to implement, Minnow collected zooplankton community and productivity samples using a vertical haul methodology between 2019 and 2021, and continue to recommend the vertical haul methodology herein. For a comparison of zooplankton community and productivity samples collected using both vertical and modified horizontal haul methodologies, see Minnow (2020).

inside of the net will be rinsed into the cod end by lifting the net in and out of the water without submerging the mouth. Sample materials will then be rinsed from the cod end of the net into a pre-labelled opaque 250 mL plastic bottle using a squeeze bottle filled with filtered water. Samples will be preserved with buffered formalin solution to a nominal concentration of 4%. Preserved samples will be stored in a dark, cool place prior to shipment to the laboratory for enumeration and taxonomic analysis.

Zooplankton tissue quality samples will be collected from Polley Lake and reference (Bootjack Lake) by completing multiple vertical plankton hauls[8] until sufficient zooplankton tissue is collected for each sample (minimum 1.5 g wet weight). The vertical zooplankton tissue hauls will be completed as described above for zooplankton community sample collection, using a vertical start depth of approximately 28 m in Polley Lake and 15 m in Bootjack Lake. Zooplankton tissue quality samples will be collected from Quesnel Lake by completing a single modified horizontal haul at each area.[9] Each modified horizontal haul will be completed by lowering the zooplankton collection net to a start depth of 31 m and then towing the net through the water column for a set time (e.g., 3 to 5 minutes) or distance (e.g., 200 m) while slowly retrieving the net vertically to the surface. Upon retrieval of each vertical or horizontal zooplankton tissue quality haul, the zooplankton net will be rinsed to concentrate the sample into the cod end, and the tissue transferred into a pre-labelled 20 mL plastic scintillation vial. Zooplankton tissue quality samples will be kept on ice in the field, then frozen before overnight shipment (in a cooler with ice) to the analytical laboratory.

Supporting measures will include those described above for phytoplankton sample collection (see Section 4.2.1).

[8] Historically, zooplankton tissue quality samples have been collected using multiple vertical hauls until a sufficient sample weight was obtained. This process was labour intensive for Quesnel Lake due to its relatively low productivity. Therefore, Minnow recommended use of a modified horizontal tow method in Quesnel Lake (instead of a vertical tow method) to decrease the time required to collect sufficient sample material and recommended the continuation of vertical haul methods in Polley Lake (Minnow 2019b). The used of modified horizontal tow methods was incorporated into CEMP approval amendment letter from BCMOECCS (dated July 15, 2019; BCMOECCS 2019), however the letter stipulates that samples must be collected using modified horizontal tow method. This condition applies to all zooplankton sample collection, although this methodology was only recommended for use in Quesnel Lake (not Polley or Bootjack Lakes) for zooplankton tissue quality sample collection for the reasons outlined above (Minnow 2019b). Minnow maintains that the use of a vertical tow method for the collection of zooplankton tissue quality samples is suitable for Polley and Bootjack lakes and implemented this methodology in 2020 to 2022 (Minnow 2021, 2022), and has recommended the same methodology herein. The haul method used for zooplankton tissue quality sample collection (vertical or horizontal) does not affect the characteristics of the resulting sample, only the time associated with sample collection.

[9] Modified horizontal tow methods were consistent with those approved by BCMOECCS (as part of the plankton program amendments in July 2019; BCMOECCS 2019).

4.3 Sample Handling and Laboratory Analysis

4.3.1 Phytoplankton

4.3.1.1 Community

Preserved phytoplankton community samples will be stored at room temperature until shipment to the laboratory for taxonomic identification and enumeration. Samples will be shipped with completed COC forms immediately after the completion of the field campaign, however there are no recommended hold times for analysis. Upon arrival, samples will be examined, and additional Lugol's preservative will be added (if required) to ensure adequate preservation. An inventory form will be created and verified with the COC to ensure that all samples are accounted for, and each sample has the appropriate number of jars as indicated on the COC.

Plankton community samples will be processed first by thoroughly mixing the samples by shaking, then dispensing sub-samples (50 to 100 mL) into Utermohl settling chambers and allowing samples to settle for 36 to 48 hours (depending on sub-sample volume). Sub-samples will then be systematically scanned using a Zeiss Axio Vert A.1 inverted phase contrast microscope at 400x magnification. All algal cells will be counted in a series of randomly located field of view (FOV) until a minimum of 300 algal units are identified and enumerated. Algal units represent single cells of all algal groups, as well as colonies or filaments of blue-green algae. Given that blue-green algal colonies/filaments may contain hundreds of cells, enumerating units (rather than individual cells) allows for a more equal representation of algal groups. The mean number of cells per unit (1 for single cells, > 1 for all other algal forms) will be estimated for all taxa and used to calculate total densities. Only "viable" cells (those that appeared to be alive at the time of collection) will be identified and enumerated. *Chrysophyte loricas* will also be counted (USEPA 2010).

Algae will be identified to genus, where possible, following the most up-to-date taxonomic references and collaborations with international and local algal taxonomic experts. Species-level identifications will only be given to identifiable taxa for which there are reliable taxonomic references available that encompass the species-level morphological diversity in North America. This approach ensures long-term consistency of data sets and is in accordance with the trend in algal taxonomic practice to be more conservative with delineation of species. Species-level identifications for some taxa may be problematic due to widespread phenotypic plasticity that can artificially inflate species richness (Wehr et al. 2015). When applicable, terms "cf." (*confertim*, possibly for species) and "sp.1" (a single undetermined species) will be employed to distinguish between different species in the same genus.

Taxa will be arranged according to their major ecological groupings and data will be reported as density (cells per liter) for each taxon, for each ecological grouping, and for the total community at each station. The laboratory will provide a data report in Microsoft (MS) Excel™ and as an Adobe Acrobat Portable Document Format (PDF), including the results of the laboratory QC sample results.

4.3.1.2 Productivity

Filtered phytoplankton productivity samples (chlorophyll-a) will remain frozen until overnight shipment (in a cooler with ice) to the analytical laboratory at the termination of the field program. Unfiltered samples will be stored in a refrigerator until overnight shipment (in a cooler with ice) to the analytical laboratory. Samples will be sent to the laboratory with completed COC forms leaving sufficient time to complete analyses within the recommended sample hold times (28 days for filtered and frozen samples, 48 hours for unfiltered and unfrozen samples). Phytoplankton productivity analyses will be completed at an analytical laboratory accredited by the Canadian Association for Laboratory Accreditation (CALA) using methods that are consistent with those specified in the British Columbia Environmental Laboratory Manual (BCMOECCS 2020). Upon sample receipt, the laboratory will provide a sample receipt confirmation which will be reviewed to ensure that all samples are received and that the analytical requests are properly logged. These receipts will be reviewed to ensure that all samples are received and that the analytical requests are properly logged.

Analysis of chlorophyll-a will follow procedures adapted from United States Environmental Protection Agency (USEPA) Method 445.0 (USEPA 1997). Briefly, chlorophyll-a will be determined by routine acetone extraction followed by fluorescence detection using a non-acidification procedure (a method that is not subject to interferences from chlorophyll-b). The target LRLs for chlorophyll-a analysis are presented in Table 5. Upon completion of the analyses, the laboratory will provide a data report in MS Excel™ and as an Adobe Acrobat Portable Document Format (PDF). Reporting will include the results of the laboratory QC sample results.

4.3.2 Zooplankton

4.3.2.1 Community and Productivity

Preserved zooplankton community samples will be stored at room temperature until shipment to the laboratory for taxonomic identification and enumeration. Sample shipment, sample receipt, and sample receipt verification will follow the procedure described above for phytoplankton (see Section 4.3.1.1).

Table 5: Target Laboratory Reporting Limits (LRL) and Analytical Methods for Zooplankton Tissue Quality Analytes and Productivity

A) Tissue Quality Parameters

Parameter	Metals in Tissue by CRC-ICPMS Micro (USEPA 2014)	Metals in Tissue by CRC-ICPMS (USEPA 2014)	Consensus LRLs[a]	British Columbia Water Quality Guidelines[b]
Units	**mg/kg wwt**	**mg/kg wwt**	**mg/kg wwt**	**mg/kg dw**
Physical Tests				
Moisture (%)	2	0.5	1.0	-
Metals				
Aluminum (Al)	1.0	0.40	0.40	-
Antimony (Sb)	0.0020	0.0020	0.0020	-
Arsenic (As)	0.0060	0.0040	0.0050	-
Barium (Ba)	0.010	0.010	0.010	-
Beryllium (Be)	0.0020	0.0020	0.0020	-
Bismuth (Bi)	0.0020	0.0020	0.0200	-
Boron (B)	0.20	0.20	-	-
Cadmium (Cd)	0.0020	0.0010	0.0020	-
Calcium (Ca)	4.0	4.0	2.0	-
Cesium (Cs)	0.0010	0.0010	-	-
Chromium (Cr)	0.040	0.010	0.010	-
Cobalt (Co)	0.0040	0.0040	0.0040	-
Copper (Cu)	0.040	0.020	0.010	-
Iron (Fe)	1.0	0.60	1.0	-
Lead (Pb)	0.010	0.0040	0.0040	-
Lithium (Li)	0.10	0.10	-	-
Magnesium (Mg)	0.40	0.40	2.0	-
Manganese (Mn)	0.010	0.010	0.020	-
Mercury (Hg)[c]	0.0010	0.001	0.002	-
Molybdenum (Mo)	0.0080	0.0040	0.010	-
Nickel (Ni)	0.040	0.040	0.010	-
Phosphorus (P)	2.0	2.0	5.0	-
Potassium (K)	4.0	4.0	10	-
Rubidium (Rb)	0.010	0.010	-	-
Selenium (Se)	0.020	0.010	0.020	4.0
Silver (Ag)	0.001	0.001	0.01	-
Sodium (Na)	4.0	4.0	2.0	-
Strontium (Sr)	0.020	0.010	0.010	-
Tellurium (Te)	0.0040	0.0040	-	-
Thallium (Tl)	0.00040	0.00040	0.0010	-
Tin (Sn)	0.020	0.020	0.020	-
Titanium (Ti)	0.1	0.05	0.06	-
Uranium (U)	0.00040	0.00040	0.0010	-
Vanadium (V)	0.020	0.020	0.020	-
Zinc (Zn)	0.20	0.10	0.10	-
Zirconium (Zr)	0.040	0.040	-	-

Primary Analyte.

Secondary Analyte.

Notes: mg/kg = milligrams per kilogram. wwt =wet weight. To convert the wet weight LRL to dry weight LRL, multiply by 5. "-" indicates no guideline available.

[a] From Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators (BCMOE 2016).

[b] British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture (BCMOE 2018).

[c] Method for total mercury analysis will be according to USEPA (1991, 2001).

B) Productivity Parameters

Parameter	Units	LRL
Chlorophyll-a	µg/L	0.02

Notes: µg/L = micrograms per litre.

Following sample receipt by the laboratory, samples will be transferred from their formalin solution into 70% ethanol and assigned a unique identification number. The zooplankton community samples will then be processed through a 45 µm screen and analyzed in two fractions as follows:

1. A “coarse” fraction comprised of cladocerans, adult copepods, and copepodids, in which a minimum count of 200 organisms will be obtained; and
2. A “fine” or “micro” fraction, in which only copepod nauplii and rotifers will be identified and enumerated. Processing of the micro fraction will be completed to either a 100-count or a minimum of three sub-samples.

The coarse fraction will be analyzed in a Bogorov tray through a stereo microscope at 10-40x magnification and the micro fraction will be analyzed using a 1-mL Sedgewick-Rafter counting chamber. Sub-sampling for all fractions will be performed using Hensen-Stempel pipettes. Generally, subsamples are 1/10 of total sample volume for the coarse fraction and 1/100 for the micro fraction. Organisms will be identified by taxonomic experts to the lowest practical level (LPL) using a compound microscope (100–400x magnification), appropriate dissection tools, and standard taxonomic references. Zooplankton will be identified to species wherever possible, although this may not be possible for immature copepods that lack differentiating features required for identification beyond order (e.g., Calanoida, Cyclopoida, or Harpacticoida). For copepods, the stage of development will be recorded (copepodite stages I-V) as will the sex for mature individuals (copepod stage VI). All identifications will be performed using taxonomic references and collaborations with external experts, where necessary. A minimum count of 200 organisms will be obtained, and identifications will be to family/genus.

Zooplankton productivity will be evaluated as biomass values derived from biovolume estimates based on cell measurements performed by the laboratory. Biomass calculations will be performed for at least the seven dominant zooplankton taxa per sampling area by measuring at least 5 to 10 specimens of each taxon and applying length/weight regression formulae (USEPA 2003). Biomass estimates will be presented as total wet-weight and dry-weight values derived from per-sample abundances. The laboratory will provide a data report in MS Excel™ and as an Adobe Acrobat Portable Document Format (PDF), including the results of the laboratory QC sample results.

4.3.2.2 Tissue Quality

Zooplankton tissue quality samples will remain frozen until overnight shipment (in a cooler with ice) to the analytical laboratory at the termination of the field program. Samples will be sent to the laboratory with completed COC forms leaving sufficient time to complete analyses within

the recommended sample hold times (1 year for tissue quality [metals analysis]). Chemical analyses will be completed at an analytical laboratory accredited by the CALA using methods that are consistent with those specified in the British Columbia Environmental Laboratory Manual (BCMOECCS 2020). Upon sample receipt, the laboratory will provide a sample receipt confirmation when the samples are received and logged. These receipts will be reviewed to ensure that all samples are received and that the analytical requests are properly logged.

Tissue quality samples will be analysed for metals by CRC-ICP-MS (USEPA Method 6020B; USEPA 2014), mercury by CVAAS (Cold Vapor Atomic Absorption Spectrophotometry; EPA 200.2/245.7; USEPA 1994, 2005), and moisture content. Tissue quality analytes are provided in Table 5, with the associated target LRLs, detection limit objectives outlined in technical guidance ("consensus" LRLs; BCMOE 2016), and available BCWQG (i.e., selenium; BCMOE 2014). Upon completion of the analyses, the laboratory will provide a data report in MS Excel™ and as an Adobe Acrobat Portable Document Format (PDF). Reporting will include the results of the laboratory QC sample results.

4.4 Data Quality Review

Upon receipt of all analytical data, a Data Quality Review (DQR) will be performed. The DQR will confirm that all requested analyses are complete, and that acceptable LRLs have been achieved. The DQR will also include an evaluation of differences between duplicate (split) samples, as well as the QA/QC data reported by the laboratory. Completion of the DQR promptly following receipt of the plankton monitoring data will ensure timely communication with the laboratory should any issues be identified.

For plankton productivity (chlorophyll-a) and zooplankton tissue quality samples, LRLs will be evaluated relative to targets established for the analytes (Table 5). The LRLs for tissue quality samples will also be evaluated relative to "consensus" LRL (Table 5), and to relevant BCWQG (i.e., selenium; BCMOE 2014). Comparisons between duplicate samples will be made by calculating the relative percent difference (RPD) of analyte concentrations between paired duplicates. If the RPD is < 30% for concentrations that are > 5 times the LRL (for chlorophyll-a, tissue quality, and water quality samples), then the duplicate sample results will be considered acceptable. Results for laboratory blanks, precision, and accuracy will be evaluated relative to Data Quality Objectives (DQO) established by the analytical laboratory that performed the analyses. Analyte concentrations in laboratory blank samples will be evaluated in relation to their respective LRLs, and the results will be used to identify potential contamination associated with equipment (e.g., cleanliness) and sample collection and handling procedures (e.g., collection, shipping).

For plankton community samples, reanalysis for subsampling error and enumeration precision will be performed on 10% of samples, and results of quality control measures will be evaluated relative to pre-established DQOs. Evaluation of subsampling error provides a measure of analytical accuracy by comparing the plankton densities determined by analysis of at least two sub-samples, and of analytical precision by comparing sub-sample derived plankton community numbers with the densities determined for whole plankton community samples. An error of < 20% will be considered acceptable for subsampling.

4.5 Data Handling and Interpretation

Upon receipt of data from the analytical laboratories, all laboratory data files will be managed by the MPMC Environment Department. In addition, chemical data provided by the primary analytical laboratories as an Electronic Data Deliverable (EDD) will be imported directly into the MPMC's database. Following completion of the DQR described above (see Section 4.4), all plankton community, productivity, and tissue quality data and supporting data will be managed in MS Excel™ or R (R Core Team 2022). For all replicated data (typically based on a sample size of five), data will be provided to the QP for analysis and summarized by calculating mean, median, standard deviation, minimum, and maximum for each endpoint and area. Data analysis will be completed for each monitoring component (community, productivity, and tissue quality).

4.5.1 Community and Productivity

Phytoplankton and zooplankton communities will be evaluated using metrics of density (cells per litre [cells/L] for phytoplankton and number per litre [#/L] for zooplankton), taxon richness, Simpson's Diversity Index, and Simpson's Evenness Index (calculated as in Smith and Wilson 1996; Environment Canada 2012a). The densities and relative densities of the most abundant taxa will also be calculated (relative densities calculated as the abundance of each respective dominant/indicator taxon relative to the total number of organisms in the sample and expressed as a percentage). Dominant/indicator taxon groups will be defined as those groups representing more than 5% of total organism abundance within each set of areas being compared, or any taxon groups considered to be important indicators of environmental stress. Phytoplankton productivity will be evaluated using chlorophyll-a results (micrograms per litre [µg/L]) and zooplankton productivity will be evaluated using biomass results.

The plankton community and productivity endpoints described above will be compared to previous data (including pre-breach data where possible[10]) and to reference results through

[10] Comparisons to available pre-breach data will be presented in graphical format only, owing to the limited comparability of these data with post-breach results and the lack of replication of these data (see Section 2 for additional details).

detailed interpretation that may include: graphical comparisons to reference and historical data and formal statistical contrasts of exposed versus reference results over time. The formal statistical contrasts of plankton community and productivity at exposed versus reference areas over time will use replicated data collected in July (starting in 2019) and will be conducted as two-way ANOVAs with Area and Year as factors and assessing the interaction between Area and Year. These contrasts will include available pre-breach and post-breach data to assess how endpoints from exposed areas compare to both reference and pre-breach conditions, and to assess temporal changes at the exposed areas. If the Area x Year interaction term is significant, all pairwise contrasts will be evaluated. If the interaction term is not significant but the Area term is significant, pairwise contrasts will be conducted between areas pooling years; if the Year term is significant, pairwise contrasts will be conducted between years pooling areas. Pairwise contrasts will be evaluated using Sidak correction to account for multiple comparisons. Prior to analysis, the assumptions of normality and homogeneity of variances will be tested on the residuals of the two-way ANOVA model using the Shapiro-Wilk test and Levene's test based on median values, respectively using $\alpha = 0.05$. Data will be transformed as necessary to satisfy assumptions of normality and homogeneity of variance (e.g., $\log_{10}$, $\log_{10}(x+1)$ when zeros were present in the data). In instances where the residuals of the ANOVA model do not meet the assumptions of normality and homogeneity of variances, the analysis will be conducted on ranks (equivalent to a non-parametric-test). Statistically significant differences in plankton community and productivity between areas and years will be identified using an α of 0.1.

4.5.2 Tissue Quality

Data analysis and interpretation of zooplankton tissue quality results will focus on primary and secondary analytes identified in Minnow (2020a, 2021a, 2022a; Table 5). The concentrations of primary and secondary analytes in zooplankton tissue from exposed areas will be compared to previous post-breach data, to reference results, and over time through detailed interpretation that may include: graphical comparisons to reference and historical data, graphical comparisons of selenium concentrations to the relevant BCWQG (BCMOE 2014), and formal statistical contrasts of replicated results (collected in July) to evaluate if mean analyte concentrations at the exposed area have changed over time relative to the reference area.

The formal statistical contrasts of zooplankton tissue quality at exposed versus reference areas over time will use replicated data collected in July (starting in 2019) and will be conducted using a two-way ANOVA that assesses the exposed:reference ratio of results, with Area and Year as factors and assessing the interaction between Area and Year. If the Area×Year interaction term is significant ($\alpha = 0.05$), then the ratios of the concentrations from the exposed area to the reference area differ among years and pairwise contrasts will be completed among years

(using $\alpha = 0.05$ to assess statistical significance). If the Area×Year interaction term is not significant ($\alpha = 0.05$), then the ratios of the concentrations from the exposed area to the reference area are consistent among years and no relative contrasts will be conducted. Temporal changes in the ratio of exposed:reference results will be quantified by calculating the difference between the value for the exposed area and the predicted value for the exposed area, assuming the same ratio (i.e., exposed:reference) from the baseline year (the first year the data were collected). Due to the potential prevalence of analyte results below the LRL for zooplankton tissue quality results, the two-way ANOVA described above may be completed with a Maximum Likelihood Estimation (MLE) approach using a censored regression, assuming a lognormal distribution. Interpretation of results of these formal statistical analyses will at minimum focus on results for primary and secondary analytes with a significant Area × Time interaction in the results (i.e., the ratio of exposed: reference concentrations differed among years), and that are significantly higher at the exposed area relative to reference in the most recent monitoring year being assessed.

The evaluation of zooplankton tissue quality results will consider the results of water quality monitoring data collected routinely by MPMC staff from Polley, Bootjack, and Quesnel Lakes. These data will be used to support the evaluation of zooplankton tissue quality monitoring results through detailed interpretation that may include: graphical comparisons of primary and secondary analyte concentrations at exposed versus reference areas compared to the relevant BCWQG (BCMOECCS 2021a,b), and formal statistical analyses of temporal trends in aqueous primary and secondary analyte concentrations at each monitoring area. Results of depth-integrated water quality samples collected concurrently with each plankton monitoring event will be also be compared to BCWQG (BCMOECCS 2021a,b).

An interpretive report based on the phytoplankton and zooplankton monitoring data will be prepared for integration into the Annual Environmental Report for the Mount Polley Mine that is prepared annually by MPMC and submitted to the regulators and other stakeholders by March 31st of the following year. The interpretive report will provide all data in an appendix and will include the DQR, the results of the screening against BCWQG and other classification schemes, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots.

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Appendix B.1.4

Periphyton Monitoring Plan

Minnow Environmental

minnow environmental inc.
A Trinity Consultants Company

Periphyton Monitoring Plan

Prepared for:
Mount Polley Mining Corporation
Likely, British Columbia

Prepared by:
Minnow Environmental Inc.
Victoria, British Columbia

March 2023

Periphyton
Monitoring Plan

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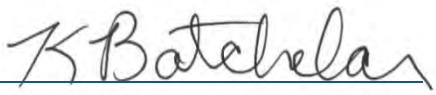

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ACRONYMS AND ABBREVIATIONS

AFDM – Ash Free Dry Mass
ANOVA – Analysis of Variance
APHA – American Public Health Association
BC – British Columbia
BCF – Bioconcentration Factors
BCMOE – British Columbia Ministry of Environment
BCMOECCS – British Columbia Ministry of Environment Climate Change Strategy
BCWQG – British Columbia Water Quality Guidelines
CALA – Canadian Association for Laboratory Accreditation
CEMP – Comprehensive Environmental Monitoring Program
COC – Chain of Custody
DFO – Fisheries and Oceans Canada
DQO – Data Quality Objective
DQR – Data Quality Review
EDD – Electronic Data Deliverable
ERA – Ecological Risk Assessment
GPS – Global Positioning System
HHRA – Human Health Risk Assessment
HRWG – Habitat Remediation Working Group
LRL – Laboratory Reporting Limits
MAD – Mean Absolute Deviation
MCE – Mixed Cellulose Ester
MDMER – Metal and Diamond Mining Effluent Regulations
MOD – Magnitude of Difference
MPMC – Mount Polley Mining Corporation
MS – Microsoft
PDF – Portable Document Format
QA/QC – Quality Assurance/Quality Control
QC – Quality Control
QP – Qualified Professional
TSF – Tailings Storage Facility
TTF – Trophic Transfer Factors
USEPA – United States Environmental Protection Agency

1 INTRODUCTION

1.1 Background

Periphyton represents an important component of aquatic food webs in creeks and consists of a complex matrix of organisms. Periphyton generally includes algae, fungi, bacteria, and protozoa attached to submerged substrate (e.g., rocks, bedrock, woody debris). These organisms are representative of the lowest trophic level in running water and take up nutrients such as nitrogen (e.g., nitrate, nitrite) and phosphorus (e.g., ortho-phosphate), as well as other substances dissolved in water (e.g., major ions, metals, and metalloids[1]) to serve physiological functions, which thereby become available to higher trophic levels through diet. Periphyton productivity and community characteristics can be influenced by factors such as physical disturbance (i.e., changes to surface water hydrology) and water quality (relating to toxicity or changes in productivity due to nutrient chemistry), and periphyton tissue quality can be influenced by water and/or sediment quality (although the latter is primarily present in suspended form in erosional streams). Therefore, periphyton monitoring is an important tool for both the assessment of creek productivity (through measures of periphyton productivity and community) and the evaluation of the trophic transfer of substances (through measures of periphyton tissue quality). These periphyton monitoring components have previously been (community and tissue quality) or continue to be (productivity) incorporated into the Mount Polley Mining Corporation (MPMC) Comprehensive Environmental Monitoring Program (CEMP).

The influence of the Mount Polley Mine on periphyton productivity, community, and tissue quality can occur (or has occurred) by several key mechanisms: 1) general mine influence from physical impingement, dustfall and/or uncontained surface or groundwater flows; 2) direct discharge of mine effluent to Hazeltine Creek (April to August 2014) and Quesnel Lake (December 2015 to present)[2]; 3) the Tailings Storage Facility (TSF) embankment breach ("the breach") on August 4, 2014; and 4) remediation activities following the TSF embankment breach. Potential effects associated with effluent discharge are chemical, while those associated with general mine influence, the TSF embankment breach, and subsequent remediation can be both physical and chemical.

[1] Through the remainder of this section, the term "metals" will be used to include metals, metalloids, and nutrients for ease of communication.

[2] Treated effluent was discharged to Quesnel Lake via Hazeltine Creek from December 2015 to December 2017. During this period, treated effluent flowed into a settling pond in Hazeltine Creek located at the edge of Quesnel Lake prior to final discharge into Quesnel Lake via diffusers. From 2018 to present, treated effluent was conveyed to the diffusers in Quesnel Lake via a direct pipeline.

The geomorphology of the entirety of Hazeltine Creek (from Polley Lake to Quesnel Lake) was substantially altered by the TSF embankment breach such that Fisheries and Oceans Canada (DFO) considered it not to be fish habitat (Golder 2015). A portion of lower Edney Creek was also impacted by the breach. Fish access to the impacted creek areas was restricted by fish fence installations from August 2014 until channel remediation works were completed. Upper Hazeltine Creek (Reach 1 [HAC-R1], Reach 2 [HAC-R2], and Reach 3 [HAC-R3]) has always been isolated from lower Hazeltine Creek (Reach 5 [HAC-R5] and Reach 6 [HAC-R6]) and Edney Creek by a canyon in Reach 4 of Hazeltine Creek (HAC-R4) which acts as a permanent barrier to upstream fish passage. Remediation of upper Hazeltine Creek was initiated in 2014 following the breach (Golder 2017a), and completed at HAC-R1, HAC-R2, and HAC-R3 in 2016, 2017 (Golder 2017b,c), and 2019 (Golder 2020), respectively. Interim remediation efforts in lower Hazeltine Creek and lower Edney Creek were initiated in 2015 with the temporary reconstruction of the two creeks as two separate watercourses. Final remediation in these lower creek areas was initiated in 2020, including the reconnection of the two watercourses, and was completed in fall 2020 except for two sections in which final works were completed in summer 2021 (Minnow 2021b). Fish access was restored to upper Hazeltine Creek in spring 2018 for Reaches 1 and 2, and in spring 2020 for Reach 3. Fish access to lower Edney Creek was restored shortly after completion of the temporary remediation works in 2015 (Golder 2017a) while lower Hazeltine Creek remained inaccessible to fish until October 2020. Fish access was also temporarily restricted to lower creek work areas during final remediation works in 2020 and 2021 (Minnow 2021b).

Periphyton community and productivity in waterbodies adjacent to the Mount Polley Mine have been monitored since baseline investigations in 1995 and 1996 (HKP 1996, 1997). Periphyton tissue quality was monitored prior to the TSF embankment breach (2010, 2012, and 2013; Minnow 2011, 2013a, 2013b). Results of previous periphyton community, productivity, and tissue quality monitoring are reviewed in Section 2 and provide context for this CEMP Periphyton Monitoring Plan. This study design is guided by a combination of available historical findings, representative locations downstream of Mount Polley Mine operations, representative reference locations, and considerations for a statistically-based design that facilitates the detection of potential spatial and/or temporal differences in periphyton productivity[3]. Periphyton productivity results (i.e., chlorophyll-a) will also be evaluated relative to provincial water guidelines for the protection of aquatic life (e.g., BCWQG; BCMOECCS 2021)

[3] The CEMP Periphyton Monitoring Plan previously included periphyton community, productivity, and tissue quality as monitoring endpoints. The current study design focuses on periphyton productivity. See Sections 2 and 3 for the historical findings and rationale related to the focus of periphyton monitoring on productivity endpoints only in the present study design.

and literature-based productivity classification values (e.g., Biggs 1996). Fish and fish habitat monitoring objectives identified and reviewed by the Habitat Remediation Working Group[4] (HRWG) for remediated creek areas are addressed in part by the CEMP Periphyton Monitoring Plan through the evaluation of fish habitat productivity (e.g., periphyton productivity).

The following sections of the CEMP Periphyton Monitoring Plan provide the objectives for periphyton monitoring from 2023 to 2025, a summary of historical periphyton monitoring results (community, productivity, and tissue quality), an overview of the CEMP study design and associated rationale (including sampling locations, replication, frequency, and analytes), and detailed methodology for periphyton monitoring (sampling methods, analytical methods, quality control methods, data interpretation, and reporting).

1.2 Monitoring Objectives

The objective of periphyton monitoring is to evaluate the influence of Mount Polley Mine activities on periphyton productivity in receiving environments (Hazeltine Creek and Edney Creek) in comparison to baseline and/or reference conditions, and to determine potential implications to aquatic life through comparison to available guidelines (i.e., chlorophyll-a; BCMOECCS 2021) and to literature-based criteria. In addition, periphyton productivity monitoring results support the evaluation of aquatic ecosystem health by providing information for the assessment of potential effects to higher trophic levels (e.g., benthic invertebrates [CEMP Section 6.13], fish, and fish habitat quality [CEMP Section 6.16]). Periphyton monitoring results also provides data that supports exposure assessment as part of the Ecological Risk Assessment (ERA) and Human Health Risk Assessment (HHRA), supports evaluation of benthic invertebrate community and productivity, and supports the evaluation of fish habitat productivity which is identified as a monitoring objective by the HRWG for remediated creek areas.

[4] The HRWG was established at the request of Fisheries and Oceans Canada (DFO; April 9, 2015), in response to regulatory requirements set out in Section 38(6) of the *Fisheries Act*. Members of the working group include: DFO, British Columbia Ministry of Environment (BCMOE), British Columbia Ministry of Forest Lands and Natural Resource Operations and Rural Development (FLNRORD), Soda Creek Indian Band, Williams Lake Indian Band, and Mount Polley Mining Company.

2 SUMMARY OF HISTORICAL FINDINGS

Periphyton communities and productivity have been monitored in the vicinity of the Mount Polley Mine since 1995, and periphyton tissue quality has been monitored since 2010. The majority of periphyton community, productivity, and tissue quality samples have been collected from Hazeltine Creek, Edney Creek and Frypan Creek (Tables 1 and 2).

Periphyton monitoring in the vicinity of the Mount Polley Mine has spanned the three distinct time periods listed below:

1. Baseline monitoring (1995, 1996);
2. Pre-breach operational monitoring (2010, 2011, 2012);
3. Post-breach and post-discharge monitoring (2017, 2018, 2019, 2020, 2021, 2022[5]).

Periphyton community and productivity monitoring in the vicinity of the Mount Polley Mine has spanned the baseline and post-breach post-discharge operational time period (time periods 1 and 3), while periphyton tissue quality monitoring has spanned operational time periods only (time periods 2 and 3). General findings associated with baseline, pre-breach, and post-breach post-discharge monitoring are summarized by endpoints and sampling area in the following sections.

2.1 Community and Productivity

The periphyton community and productivity of Hazeltine Creek and Edney Creek were characterized in baseline studies in 1995 and 1996 (HKP 1996, 1997) and during pre-breach operational monitoring in 2011 (Minnow 2012). However, limited taxonomic resolution, the use of varying degrees of qualitative taxonomic analysis, and the use of multiple taxonomic laboratories since 1995 limits the comparability of post-breach monitoring community data with these historical datasets (1995, 1996, 2011).[6] Due to these data limitations, formal statistical comparisons that included baseline and pre-breach data were limited to productivity (chlorophyll-a) results only. Periphyton chlorophyll-a results from in Hazeltine Creek during

[5] Periphyton monitoring was also completed in 2022 but reporting of these results is in progress, with submission of an interpretive report that includes these results required by March 31, 2023. The 2022 periphyton monitoring results are therefore excluded from the present study design.

[6] Periphyton taxonomy data from 1995, 1996, and 2011 were qualitative, mostly consisting of characterization of presence/absence (“predominant”, “common”, “abundant,” etc.) as opposed to discrete density values. In 1995 and 1996, proportions were reported for some dominant genera and groupings, however the degree to which those data represent quantitative data is unknown without density data. Even in 2011, when data were presented as density, many taxa were presented with “less than” values because the methodology employed by the taxonomist (Fraser Environmental Services) involved some qualitative elements.

Table 1: History of Periphyton Community and Productivity Monitoring in the Vicinity of the Mount Polley Mine

A) Community

Year	Locations	Report
1995	Hazeltine Creek, Edney Creek	HKP 1996
1996	Hazeltine Creek, Edney Creek	HKP 1997
2011	Hazeltine Creek	Minnow 2012
2017	Frypan Creek	Minnow 2018a
2019	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2020a, Minnow 2020b
2020	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2021a, Minnow 2021b
2021	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2022a, Minnow 2022b

B) Productivity

Year	Locations	Report
1995	Hazeltine Creek, Edney Creek	HKP 1996
1996	Hazeltine Creek, Edney Creek	HKP 1997
2011	Hazeltine Creek	Minnow 2012
2013	Bootjack Creek	Minnow 2013
2017	Edney Creek, Hazeltine Creek	Minnow 2018a
2018	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2019a, Minnow 2019b
2019	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2020a, Minnow 2020b
2020	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2021a, Minnow 2021b
2021	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2022a, Minnow 2022b

Table 2: History of Periphyton Tissue Chemistry Monitoring in the Vicinity of the Mount Polley Mine

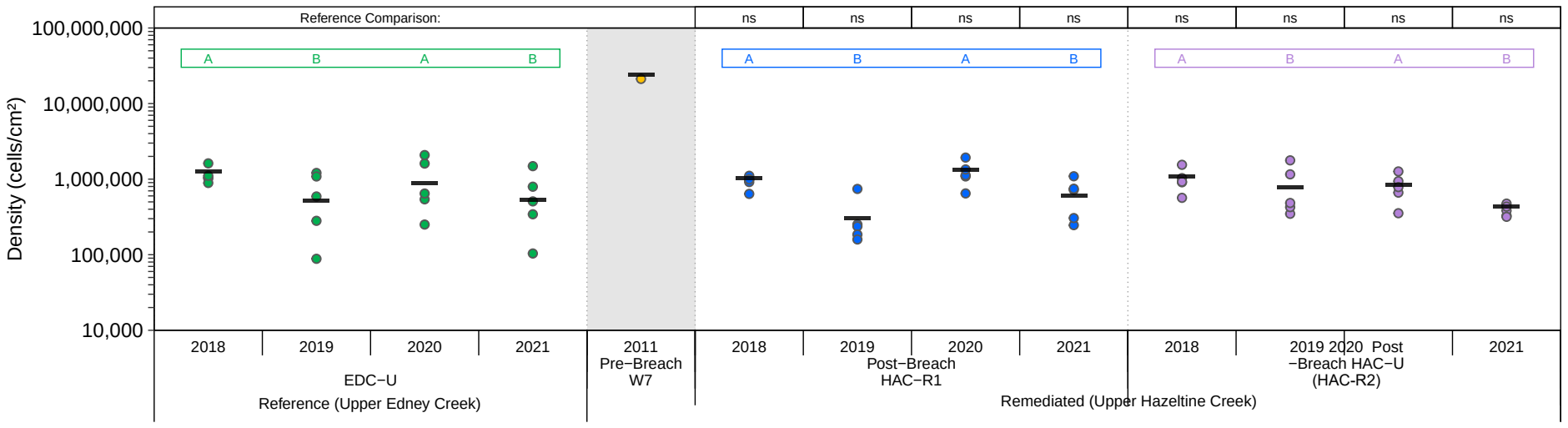
Year	Locations	Report
2010	Hazeltine Creek	Minnow 2011
2012	Hazeltine Creek, Edney Creek, North Dump Creek	Minnow 2013a
2013	Hazeltine Creek, Jacobie Creek, Morehead Creek, Trio Creek	Minnow 2013b
2017	Edney Creek, Hazeltine Creek	Minnow 2018a
2018	Edney Creek, Hazeltine Creek, Frypan Creek	Minnow 2019a
2019	Edney Creek, Hazeltine Creek	Minnow 2020a
2020	Edney Creek, Hazeltine Creek	Minnow 2021a
2021	Edney Creek, Hazeltine Creek	Minnow 2022a

baseline and pre-breach monitoring were low relative to the British Columbia Water Quality Guideline (BCWQG) of 100 mg/m^2 (BCMOECCS 2021) in both upper (9.6 to 21.4 mg/m^2) and lower (30.6 mg/m^2) Hazeltine Creek areas (HKP 1996, HKP 1997, Minnow 2012).

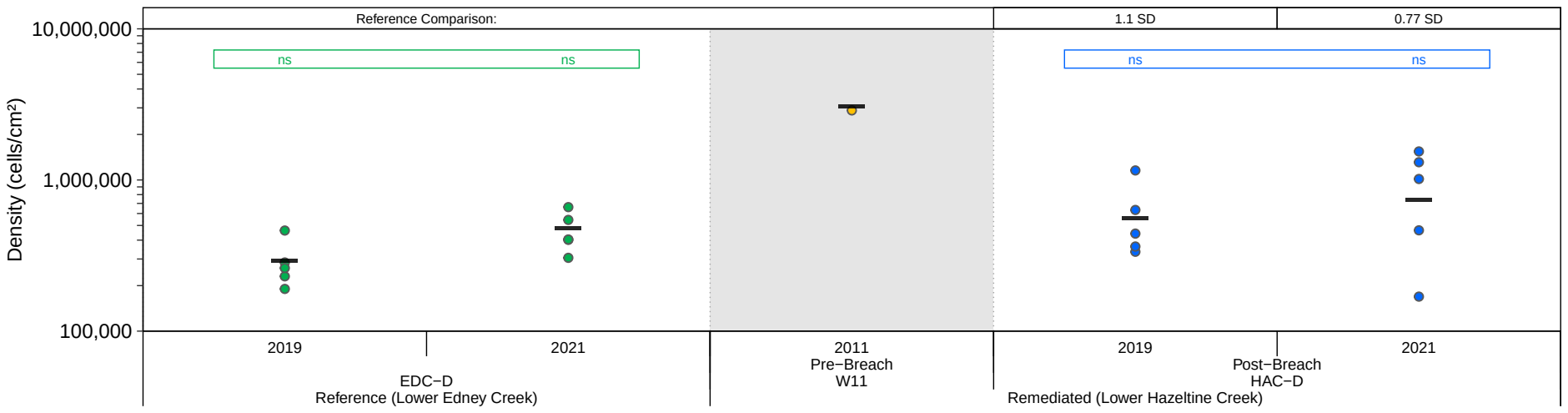
Post-breach periphyton community monitoring for upper Hazeltine Creek (HAC-R1 and HAC-U [HAC-R2]) from 2018 to 2021 characterized a community with total density consistently similar to reference (EDC-U; Figure 1) and Diatom richness consistently similar to or higher reference (EDC-U) over this time period (Minnow 2022a). Taxon richness over this period was similar to or higher than reference, except at HAC-R1 in 2021 and at HAC-U (HAC-R2) in 2018 and 2021 (Figure 2). The relative similarity of taxon richness and Diatom richness at the remediated areas relative to reference from 2018 to 2021 are indicative of good periphyton community health (Minnow 2022a). Periphyton community composition at HAC-R1, but not at HAC-U, was similar to reference in 2021. Community composition at HAC-U continued to differ from the reference area, with lower relative abundance and densities of Cyanobacteria, and higher relative abundances and densities of Diatoms (which are indicative of healthy periphyton communities) and Chlorophytes. Periphyton productivity of upper Hazeltine Creek (HAC-R1, HAC-U [HAC-R2], and HAC-R3), as assessed by mean chlorophyll-a concentrations, was below BCWQG in all years (2017 to 2021) but above the threshold indicative of moderate enrichment and pre-breach (1995) conditions from 2019 to 2021 at HAC-R1 and in 2019 and 2021 at HAC-U (HAC-R2; Figure 3; Minnow 2022a). Chlorophyll-a and Ash Free Dry Mass (AFDM) results at both upper Hazeltine Creek areas (HAC-R1, HAC-U) has been consistently similar to or significantly higher than reference (Edney Creek; EDC-U) since 2018 (Figures 3 and 4; Minnow 2022a). Periphyton productivity (chlorophyll-a and AFDM) at upper Hazeltine Creek area HAC-R3 was lower than reference (Frypan Creek; FPC-R3) since initiation of monitoring in 2020 one year following the completion of remediation works in this area in 2019 (Figures 3 and 4; Minnow 2021b, 2022b). The monitoring area HAC-R3 and its associated reference area in FPC-R3 are monitored specifically to meet the fish and fish habitat monitoring objectives of the HRWG (see Section 1.1) and are included herein for the sake of completeness of this CEMP Periphyton Monitoring Plan.

The post-breach periphyton community at the remediated areas of lower Hazeltine Creek (HAC-D [HAC-R5]) was characterized in 2019 and 2021 by total density consistently higher than reference and by consistently lower richness than the reference area (Figures 1 and 2). Lower total taxonomic richness (in 2019 and 2021; Figure 2) and Diatom richness (in 2021) compared to reference is indicative of on-going periphyton community recovery (Minnow 2022a). This was consistent with the disturbance of this area for channel remediation works just weeks prior to conducting periphyton monitoring in 2021. Community composition at HAC-D also differed from the reference area, as characterized by higher relative abundance of Diatoms and

Upper Hazeltine Creek (Remediated) and Upper Edney Creek (Reference)



Lower Hazeltine Creek (Remediated) and Lower Edney Creek (Reference)



Lower Edney Creek (Remediated and Reference)

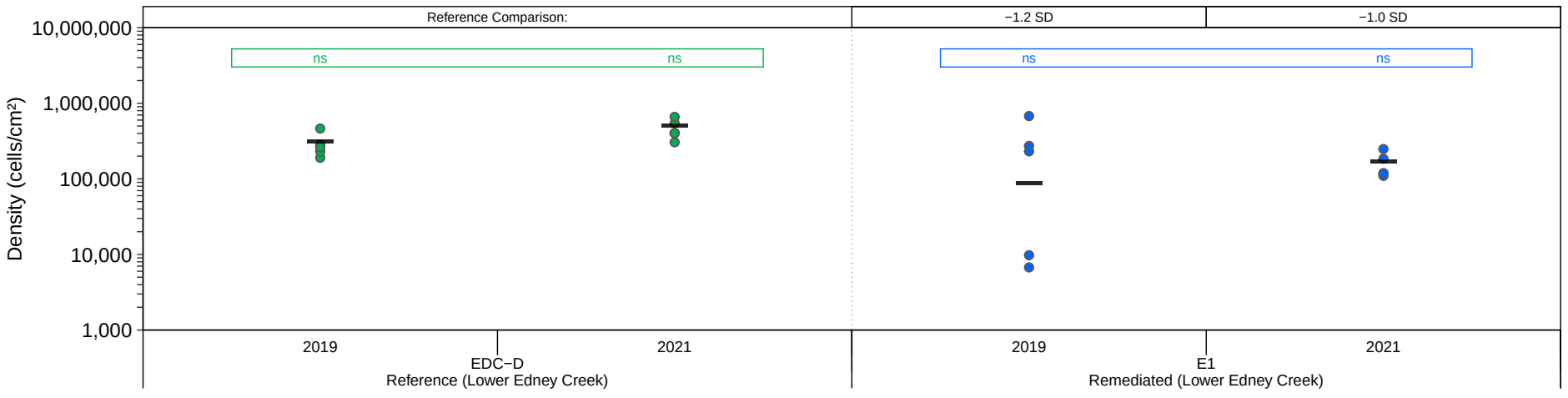


Figure 1: Periphyton Density for Remediated (HAC-R1, HAC-U, HAC-D, E1) and Reference (EDC-U, EDC-D) Creek Areas, 2011 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, $\log_{10}$−transformed or rank-transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. A number above the plot indicates significant remediated vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non −significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0. Grey shading indicates semi−quantitative data that were not included in statistical comparisons but are shown for visual comparison only.

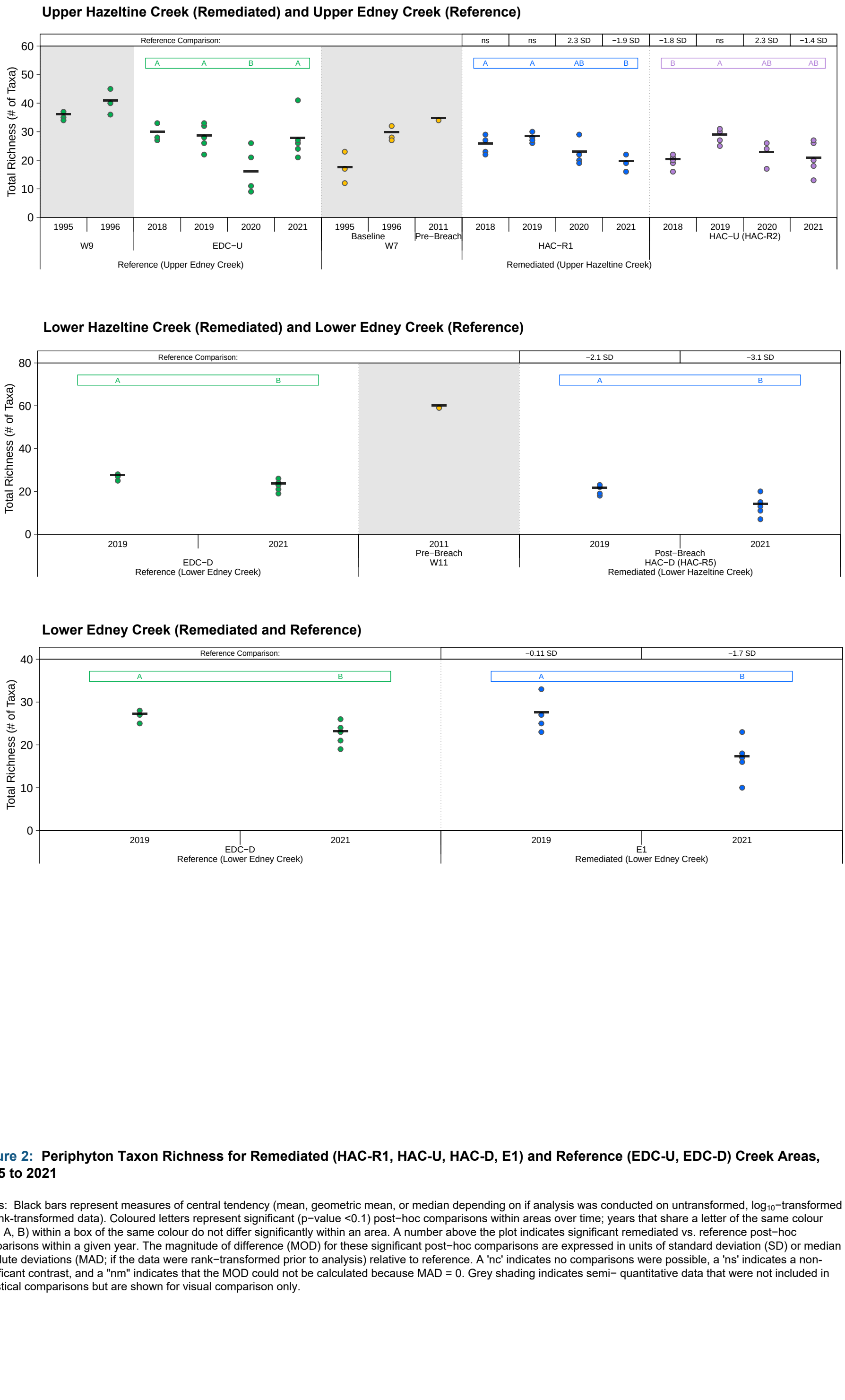


Figure 2: Periphyton Taxon Richness for Remediated (HAC-R1, HAC-U, HAC-D, E1) and Reference (EDC-U, EDC-D) Creek Areas, 1995 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, log_{10}−transformed or rank-transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. A number above the plot indicates significant remediated vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non-significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0. Grey shading indicates semi− quantitative data that were not included in statistical comparisons but are shown for visual comparison only.

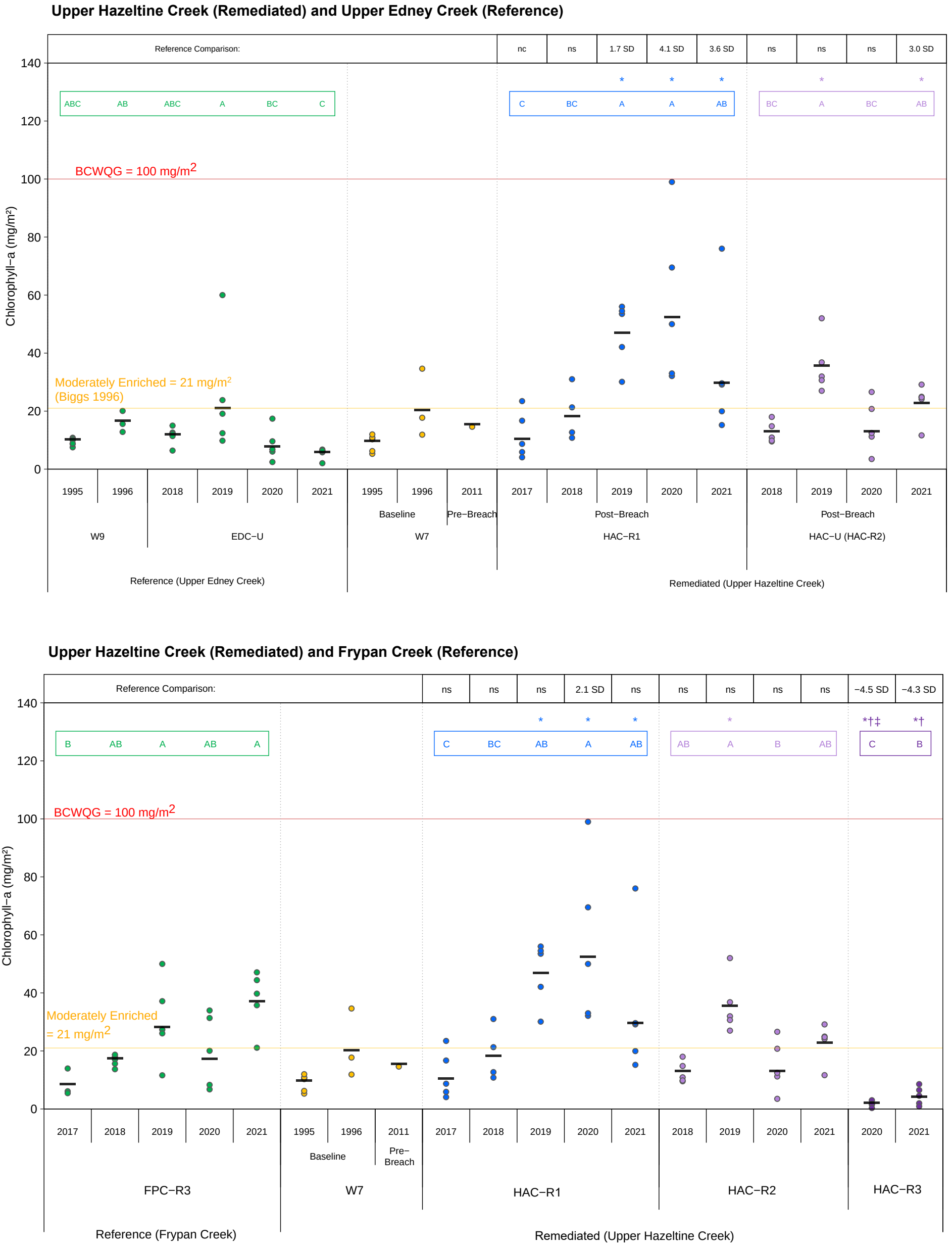


Figure 3: Periphyton Chlorophyll-a Concentrations for Remediated (HAC-R1, HAC-U, HAC-R3, HAC-D, E1) and Reference (EDC-U, FPC-R3, EDC-D) Creek Areas, 1995 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, log10−transformed or rank −transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. For statistical contrasts of Chlorophyll−a, an * indicates significant differences to W7 in 1995, a † indicates significant differences to W7 in 1996, and a ‡ indicates significant differences to W7 in 2011. A number above the plot indicates significant remediated vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non−significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0.

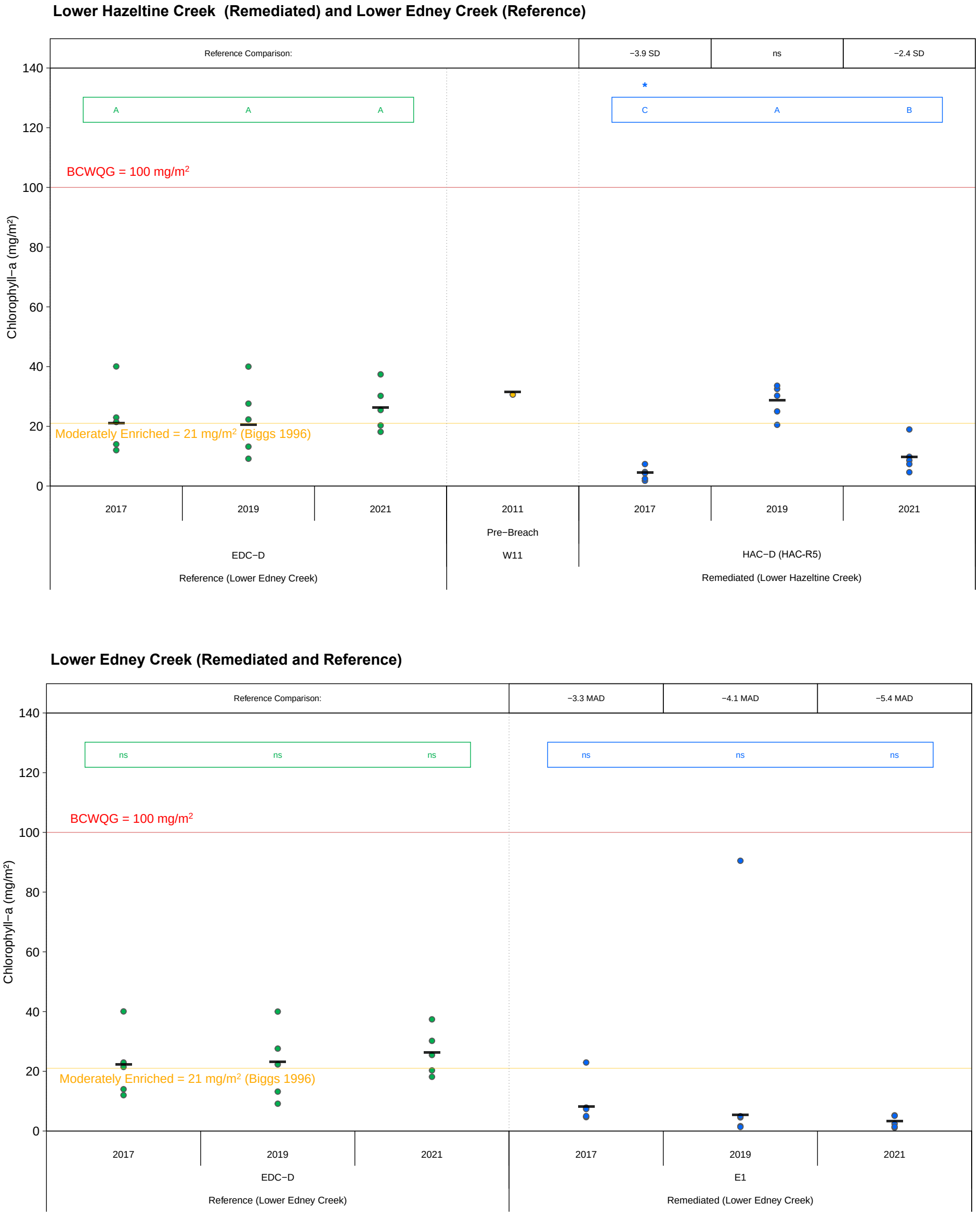
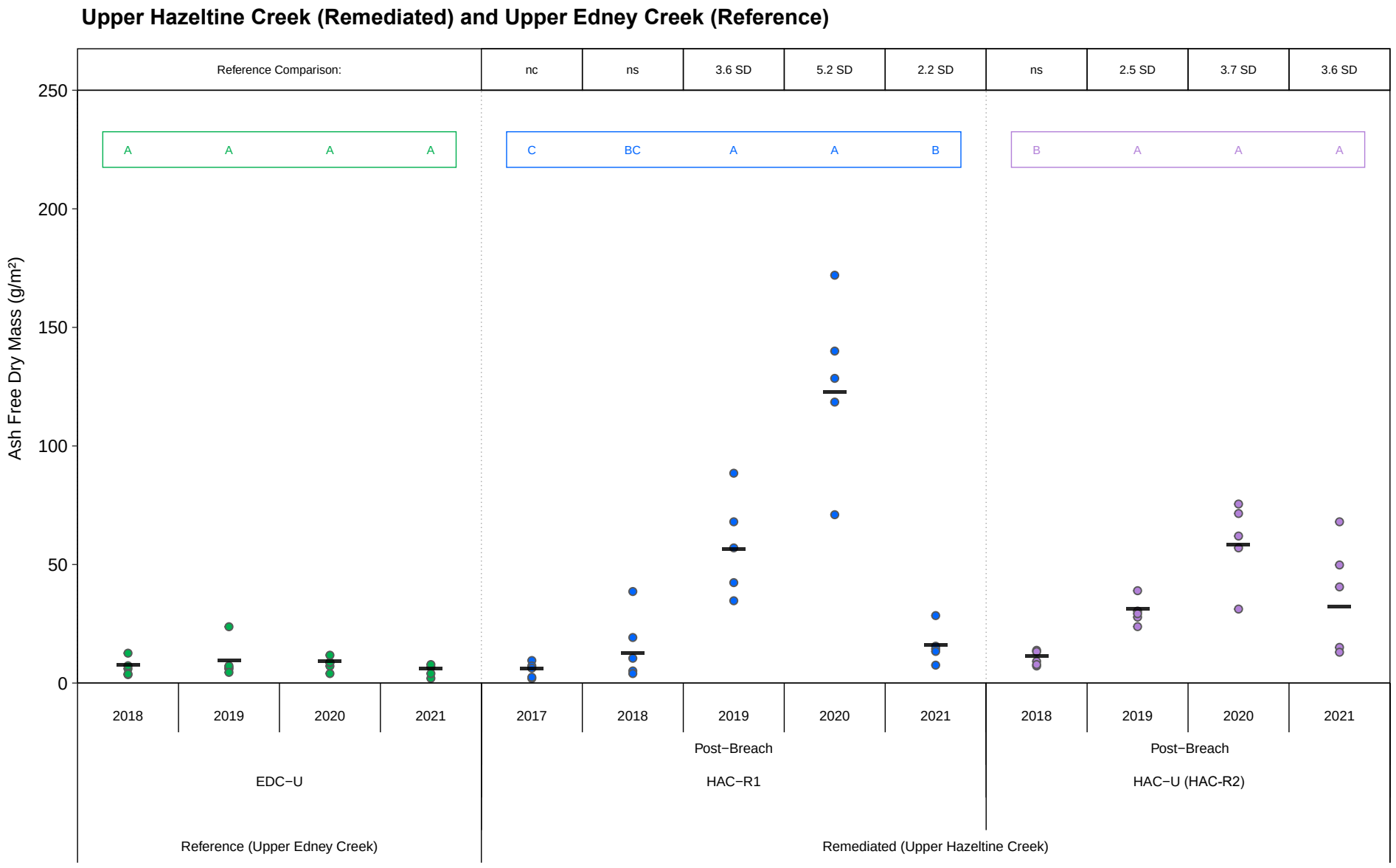


Figure 3: Periphyton Chlorophyll-a Concentrations for Remediated (HAC-R1, HAC-U, HAC-R3, HAC-D, E1) and Reference (EDC-U, FPC-R3, EDC-D) Creek Areas, 1995 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, log10−transformed or rank −transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. For statistical contrasts of Chlorophyll−a, an * indicates significant differences to W7 in 1995, a † indicates significant differences to W7 in 1996, and a ‡ indicates significant differences to W7 in 2011. A number above the plot indicates significant remediated vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non−significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0.



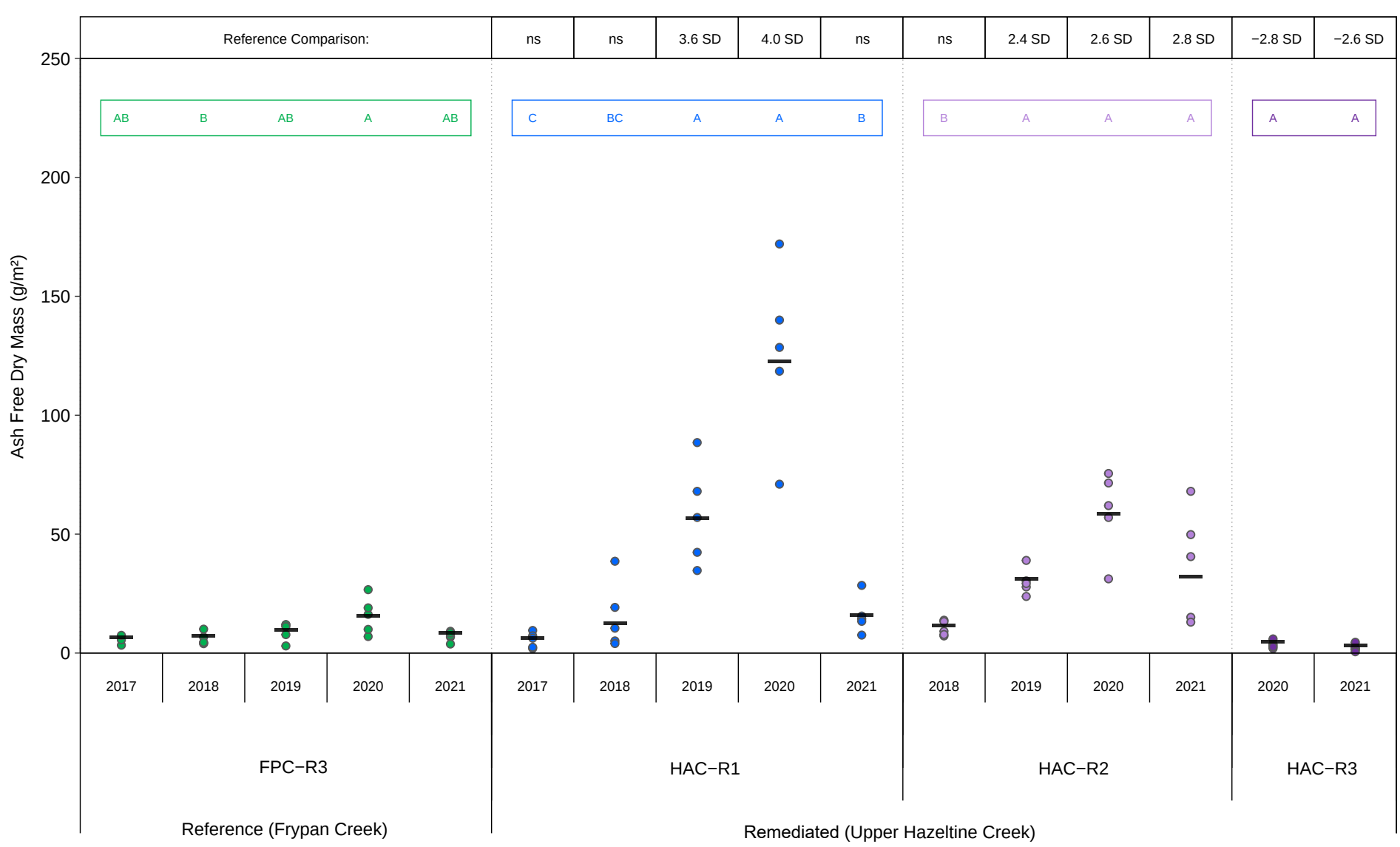
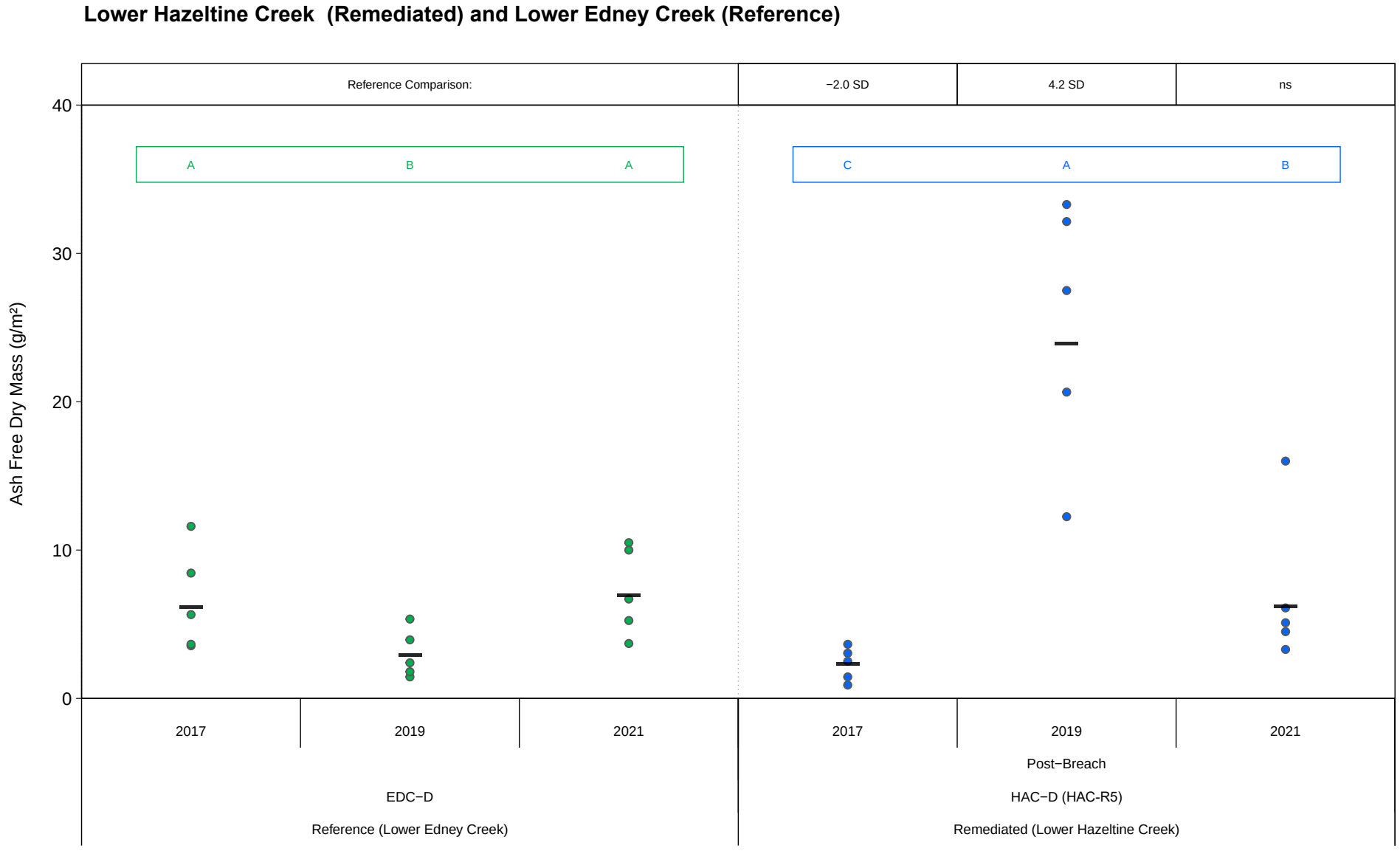


Figure 4: Periphyton Ash Free Dry Mass (AFDM) for Remediated (HAC-R1, HAC-U, HAC-R3, HAC-D, E1) and Reference (EDC-U, FPC-R3, EDC-D) Creek Areas, 2017 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, log10−transformed or rank −transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. A number above the plot indicates significant remediated vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non−significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0.



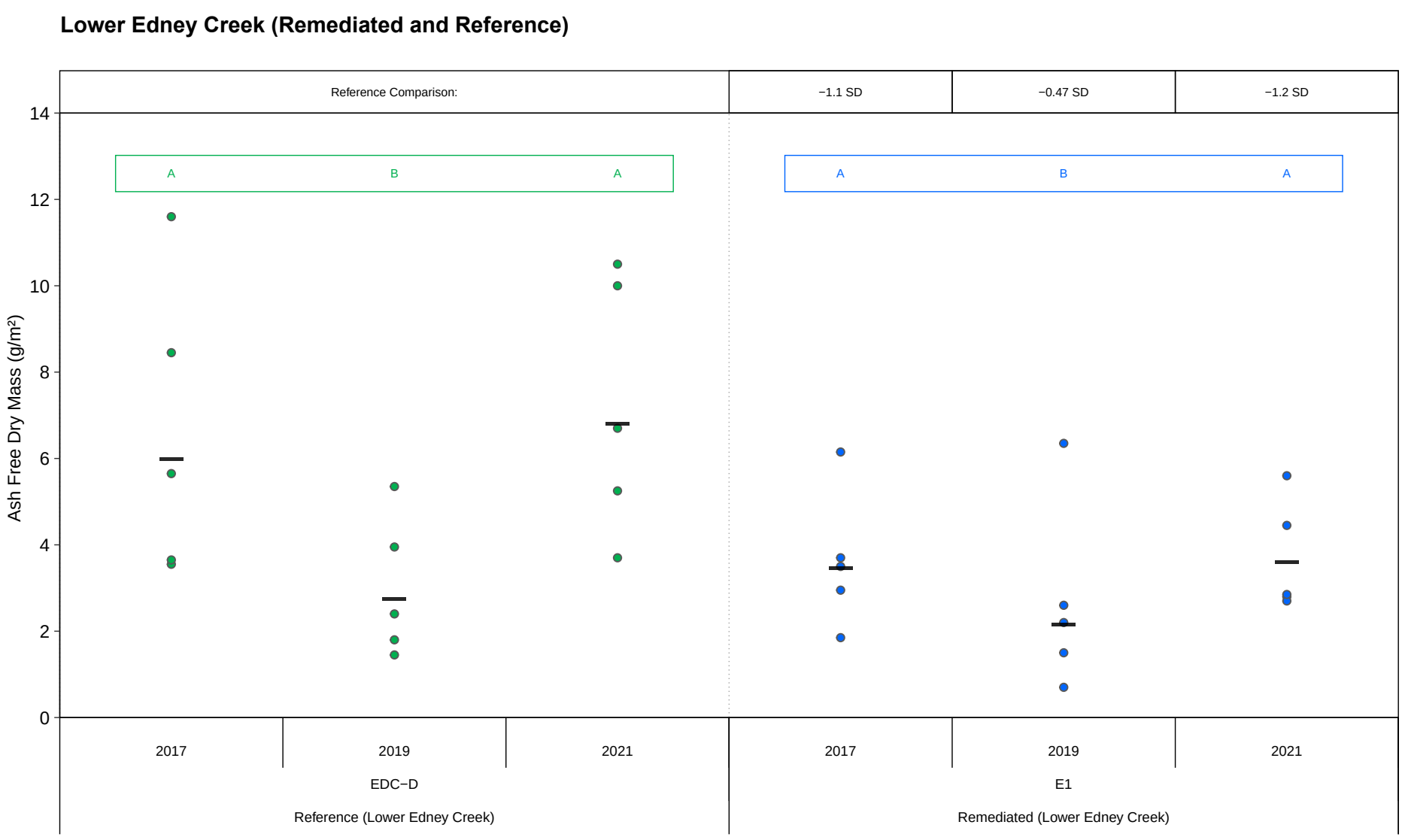


Figure 4: Periphyton Ash Free Dry Mass (AFDM) for Remediated (HAC-R1, HAC-U, HAC-R3, HAC-D, E1) and Reference (EDC-U, FPC-R3, EDC-D) Creek Areas, 2017 to 2021

Notes: Black bars represent measures of central tendency (mean, geometric mean, or median depending on if analysis was conducted on untransformed, log10−transformed or rank −transformed data). Coloured letters represent significant (p−value <0.1) post−hoc comparisons within areas over time; years that share a letter of the same colour (e.g., A, B) within a box of the same colour do not differ significantly within an area. For statistical contrasts of Chlorophyll−a, an * indicates significant differences to W7 in 1995, a † indicates significant differences to W7 in 1996, and a ‡ indicates significant differences to W7 in 2011. A number above the plot indicates significant remediated vs. reference post−hoc comparisons within a given year. The magnitude of difference (MOD) for these significant post−hoc comparisons are expressed in units of standard deviation (SD) or median absolute deviations (MAD; if the data were rank−transformed prior to analysis) relative to reference. A 'nc' indicates no comparisons were possible, a 'ns' indicates a non−significant contrast, and a "nm" indicates that the MOD could not be calculated because MAD = 0.

lower relative abundances of Cyanobacteria and Chlorophytes in 2019 and 2021 (Minnow 2022a). Periphyton productivity in lower Hazeltine Creek, as measured by chlorophyll-a concentrations, was well below BCWQG from 2017 to 2021, and below the threshold indicative of moderate enrichment over the same period except for 2018. Mean chlorophyll-a and AFDM at lower Hazeltine Creek increased significantly from 2017 to 2019, then decreased between 2019 and 2021 to values remained higher than in 2018 but were lower than and similar to reference (Figures 3 and 4). The decrease in productivity between 2019 and 2021 was consistent with the completion of channel remediation works in lower Hazeltine Creek immediately prior to sampling in 2021 (Minnow 2022a).

The post-breach periphyton community at the remediated area of lower Edney Creek (E1) was characterized by total density and taxon richness that were slightly lower than reference in all monitoring years (2019 to 2021; Figures 1 and 2). Diatom richness at the remediated area was moderately lower than reference in 2021 but similar to reference in 2019. The composition of major taxonomic groups at the remediated area was similar to reference in 2019 and 2021 (dominated by Cyanobacteria and Diatoms) and also showed similar temporal changes at the remediated area that were similar to reference. The relative similarity of most community endpoints between the remediated and reference area in 2019 and 2021 is indicative of recovery, however the continued differences in community (particularly the moderately lower Diatom richness) in 2021 compared to reference suggests that recovery is ongoing. This was consistent with the recent completion of remediation works in 2020 and 2021 (Minnow 2022a). Periphyton productivity in the remediated area of lower Edney Creek (E1), as measured by mean chlorophyll-a concentrations, was well below BCWQG, below the threshold indicating a moderately enriched creek, and lower than reference throughout 2017 to 2021 (Figure 3). AFDM was also consistently lower than reference from 2017 to 2021 and decreased significantly in 2019 compared to the other monitoring years at E1, but a similar temporal change occurred at the reference area in 2019 indicating this change was likely due to natural factors (Figure 4; Minnow 2022a).

2.2 Tissue Quality

Periphyton tissue quality has been monitored since 2010 in the vicinity of the Mount Polley Mine (primarily within Hazeltine Creek), with a focus on selenium monitoring relative to reference (Minnow 2011, 2013a,b), although additional analytes were included in analyses completed in 2010 (Minnow 2011).

The evaluation of post-breach periphyton tissue quality results was focused on primary and secondary analytes identified in Minnow (2020a, 2021a, 2022a).[7] For most primary and secondary analytes evaluated, there was no evidence of increasing concentrations in periphyton tissue from remediated areas of Hazeltine Creek or Edney Creek relative to reference areas during post-breach monitoring from 2017 to 2021. Copper and selenium were the only primary analytes in the remediated areas of Hazeltine Creek and Edney Creek with significantly higher periphyton tissue concentrations compared to reference for which the exposed-reference difference also increased significantly over time (Figures 5 and 6; Minnow 2022a). Specifically, selenium concentrations in periphyton tissues from upper Hazeltine Creek (HAC-R1 and HAC-U), but not lower Hazeltine Creek (HAC-D) or lower Edney Creek (E1), increased over time relative to reference, suggesting a mine influence on periphyton tissue concentrations (Figure 5). However, selenium concentrations in upper Hazeltine Creek were similar to or lower than pre-breach results throughout the post-breach monitoring period (Figure 5; Minnow 2022a). Copper concentrations in periphyton from 2017 to 2021, were consistently elevated in samples collected from lower Hazeltine Creek (HAC-D) and lower Edney Creek (E1), but not for the upper areas of Hazeltine Creek, relative to the reference area and pre-breach (pre-breach data for HAC-D only; Figure 6). For both selenium and copper, these elevated concentrations in exposed periphyton tissues were associated with Bioconcentration Factors (BCFs; which are used to describe the extent to which an analyte is taken up by an organism from the surrounding environment through exposure routes other than diet; Arnot and Gobas 2006), that were lower than reference for upper and lower Hazeltine Creek areas, indicating no evidence of increased bioavailability for these analytes. In lower Edney Creek, the BCFs for copper were higher than reference, coinciding with increased copper concentrations in periphyton tissue following the remediation works completed in this area in summer 2020 and 2021 (Minnow 2022a).

Mercury in periphyton tissue from lower Hazeltine Creek (HAC-D [HAC-R5]) was the only secondary analyte with concentrations that increased over time, relative to reference, and was higher than pre-breach (Minnow 2022a). Periphyton concentrations of additional secondary analytes (barium, cadmium, calcium, strontium, cobalt, molybdenum, strontium, titanium, uranium, vanadium) were higher at one or more of the remediated areas, relative to reference, in one or more years. However, concentrations of these analytes were either variable or decreased over time and evidence was equivocal as to whether these observed increases in

[7] Primary analytes include arsenic, copper, iron, and selenium. Secondary analytes include barium, cadmium, calcium, cobalt, manganese, mercury, molybdenum, nickel, phosphorus, silver, sodium, strontium, tin, titanium, uranium, vanadium, and zinc.

tissue concentrations were mine-related, and there was little or no evidence of increased metal bioavailability based on assessment of BCFs (Minnow 2022a).

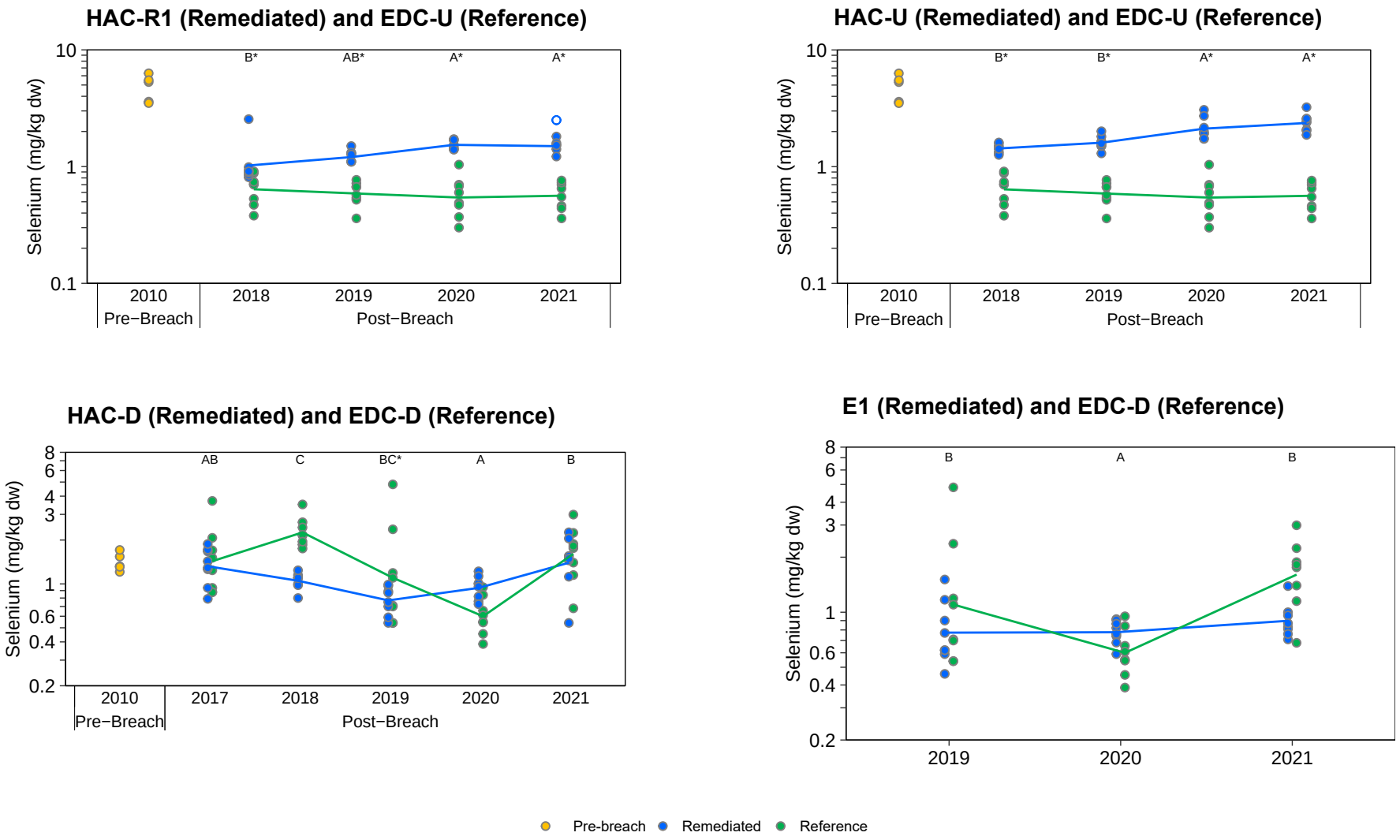


Figure 5: Periphyton Tissue Selenium Concentrations for Remediated (HAC-R1, HAC-U, HAC-D, E1) and Reference (EDC-U, EDC-D) Creek Areas, 2010 to 2021[a]

Notes: dw = dry weight. mg/kg = milligrams per kilogram. Individual samples are plotted and lines join the least−squares estimated mean values for years included in the statistical analysis. Statistical analyses were conducted using a two−way ANOVA with factors Area and Year. The models were fit using Maximum Likelihood Estimation with an assumed log−normal distribution. Years that share a letter (e.g., A,B,C) have ratios of concentrations (Remediated:Reference) that do not differ significantly (p−value < 0.05) among years. Letter A was assigned to the year with the highest ratio of concentrations (Remediated:Reference). Only years with samples from both reference and Remediated areas are plotted. Letters with a * designate years where the remediated site is different than pre-breach conditions, as determined using a one-way temporal ANOVA.

[a] HAC-R1 = upper Hazeltine Creek Reach 1, HAC-U = upper Hazeltine Creek Reach 2, HAC-D = lower Hazeltine Creek, EDC-U = upper Edney Creek, EDC-D = lower Edney Creek Reference, E1= lower Edney Creek Remediated.

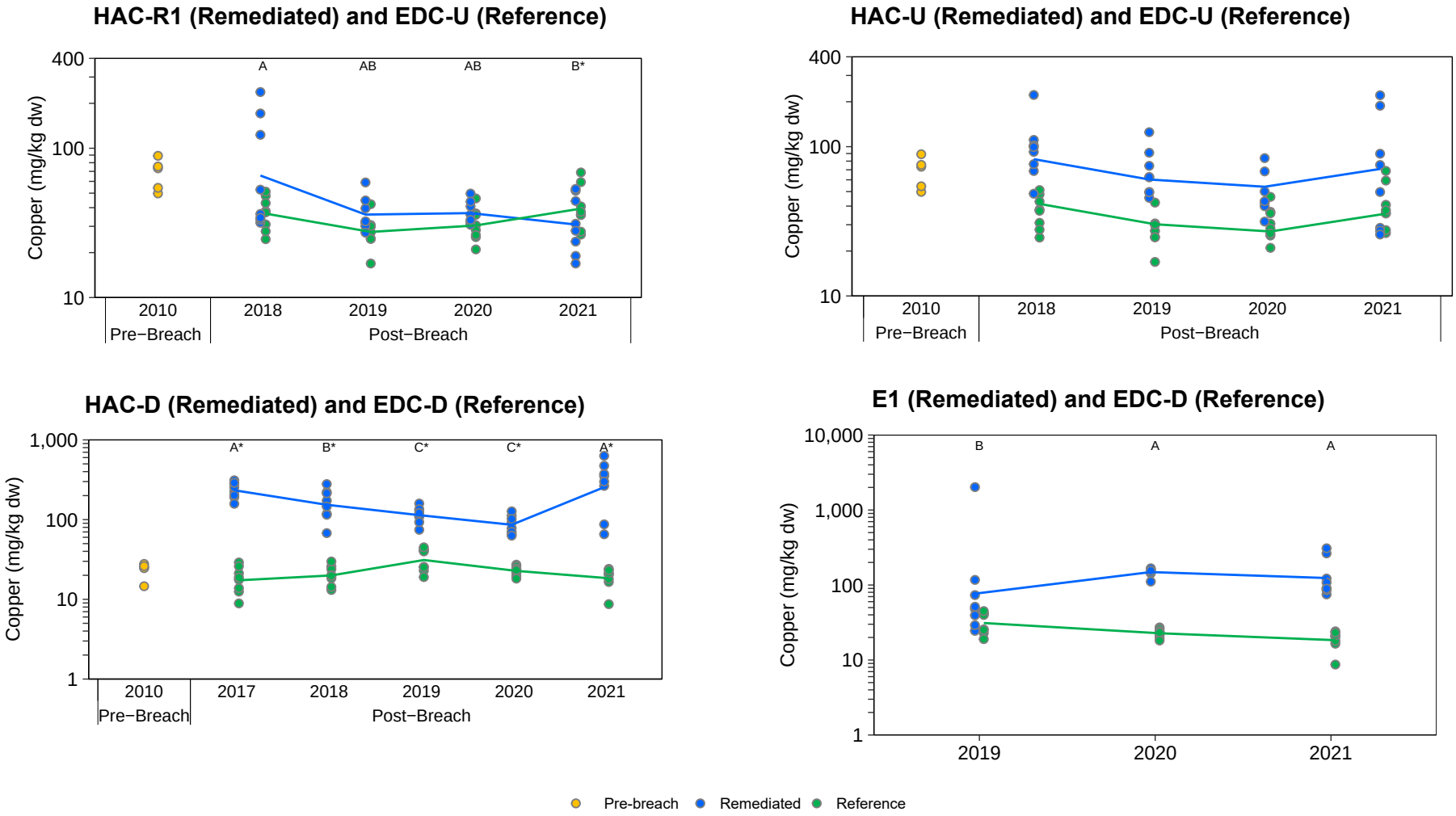


Figure 6: Periphyton Tissue Copper Concentrations for Remediated (HAC-R1, HAC-U, HAC-D, E1) and Reference (EDC-U, EDC-D) Creek Areas, 2010 to 2021[a]

Notes: dw = dry weight. mg/kg = milligrams per kilogram. Individual samples are plotted and lines join the least−squares estimated mean values for years included in the statistical analysis. Statistical analyses were conducted using a two−way ANOVA with factors Area and Year. The models were fit using Maximum Likelihood Estimation with an assumed log−normal distribution. Years that share a letter (e.g., A,B,C) have ratios of concentrations (Remediated:Reference) that do not differ significantly (p-value < 0.05) among years. Letter A was assigned to the year with the highest ratio of concentrations (Remediated:Reference). Only years with samples from both reference and remediated areas are plotted. Letters with a * designate years where the remediated site is different than pre-breach conditions, as determined using a one-way temporal ANOVA.

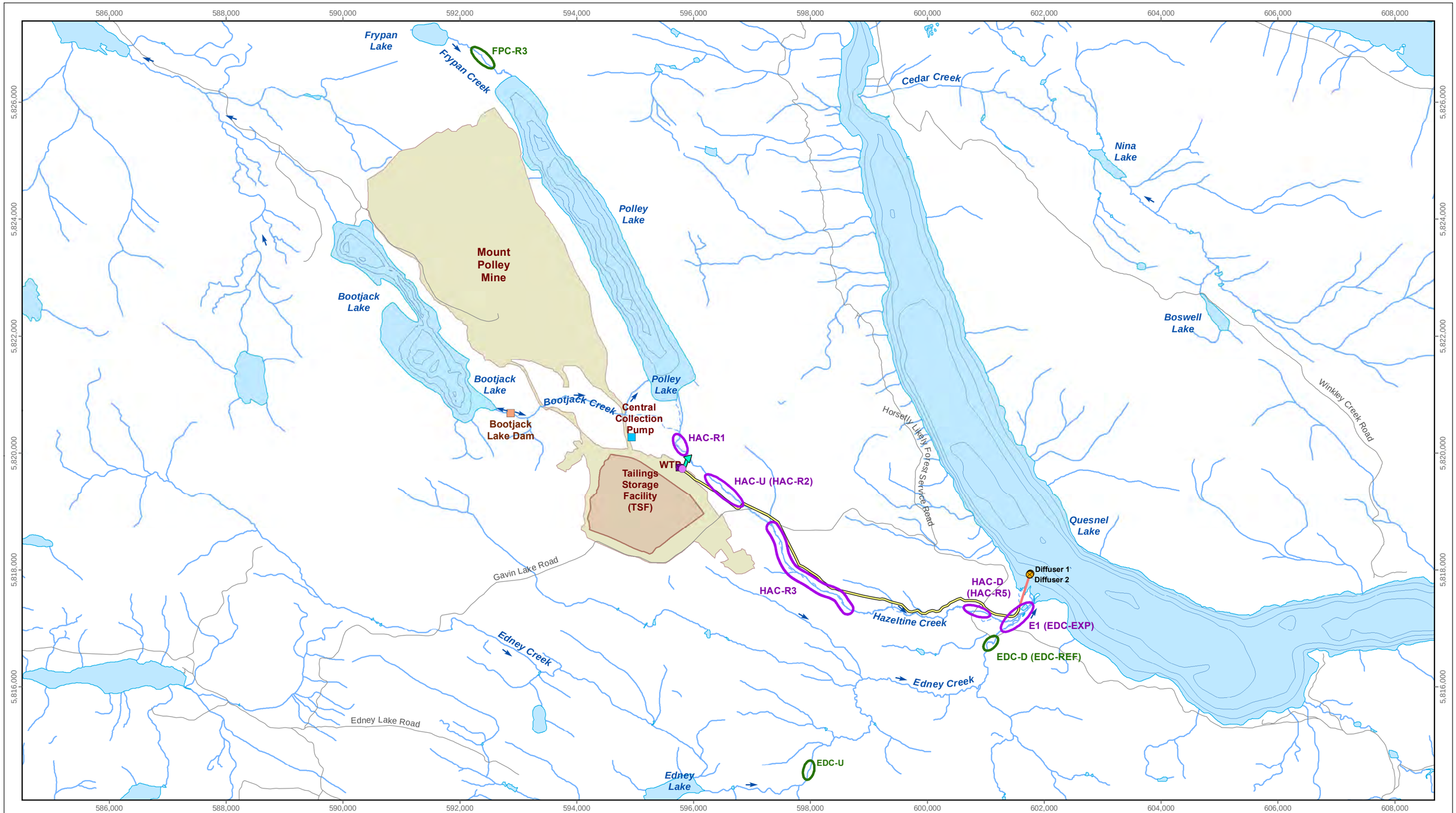
[a] HAC-R1 = upper Hazeltine Creek Reach 1, HAC-U = upper Hazeltine Creek Reach 2, HAC-D = lower Hazeltine Creek, EDC-U = upper Edney Creek, EDC-D = lower Edney Creek Reference, E1 = lower Edney Creek Remediated.

3 STUDY DESIGN AND RATIONALE

Periphyton monitoring under the CEMP is proposed to meet the combined needs of: 1) operational monitoring ; 2) monitoring of the impact of the 2014 TSF embankment breach; 3) monitoring of the response to reclamation activity following the TSF embankment breach. An overview of the periphyton monitoring program is provided in Figure 7 and Table 3. This CEMP Periphyton Monitoring Plan includes revisions to the study design (i.e., updates to monitoring locations, frequency, and endpoints) relative to the previous study design (MPMC 2019); revisions that are based on a Qualified Professional (QP) review of existing data. This section details the updated study design, outlines revisions compared to the previous study design (MPMC 2019), and provides the rationale associated with the proposed study design revisions.

Periphyton monitoring will continue to focus on remediated areas of upper and lower Hazeltine Creek and lower Edney Creek, with reference areas identified for each mine-influenced sampling area (i.e., upper Edney Creek and Frypan Creek for upper Hazeltine Creek, and an unaffected area of lower Edney Creek for remediated areas of lower Edney Creek and lower Hazeltine Creek; Figure 7, Table 3). Periphyton productivity monitoring in Hazeltine Creek will focus on four remediated areas (Figure 7), including one area in Reach 1 (HAC-R1), Reach 2 (HAC-U [HAC-R2]), Reach 3 (HAC-R3), and Reach 5 (HAC-D [HAC-R5]), and monitoring of remediated areas in lower Edney Creek will focus on one area (E1; Figure 7). Unimpacted areas in upper Edney Creek (EDC-U) and Frypan Creek (Reach 3; FPC-R3) will serve as reference areas for the upper Hazeltine Creek monitoring areas (HAC-R1, HAC-U [HAC-R2], HAC-R3), and an unimpacted area of lower Edney Creek (EDC-D) will serve as reference for the lower Hazeltine (HAC-D [HAC-R5]) and lower Edney (E1) creek monitoring areas (Figure 7, Table 3). These sampling areas align with those proposed for benthic invertebrate monitoring in creek habitats (see CEMP Section 6.13). The periphyton monitoring areas outlined above are consistent with the previous study design, except for the addition of upper Hazeltine Creek area HAC-R3 (and associated reference FPC-R3), which are monitored specifically to meet the fish and fish habitat monitoring objectives of the HRWG (see Section 1.1) and are included herein for the sake of completeness of this CEMP Periphyton Monitoring Plan.

Periphyton monitoring includes assessment of productivity (chlorophyll-a and AFDM) at all creek monitoring areas (Figure 7, Table 3). Data interpretation will be based on a combination of: 1) statistical comparison to previous conditions; 2) statistical comparison to reference conditions; 3) comparison of productivity results relative to BCWQG (BCMOECCS 2021) and literature-based classification values. Accordingly, five stations per area will be sampled to provide replication for the statistical contrasts (Table 3). Periphyton productivity monitoring will be supported by



LEGEND

- Exposed Area
- Reference Area
- Diffuser (Treated Effluent Discharge, December 2015 to present)
- Effluent Mixing Tank
- Discharge to Diffusers (2015 to present)
- Discharge to Hazeltine Creek (Apr 10 2014 to Aug 14 2014 and Nov 29 2015 to Sept 30 2017)
- Effluent Discharge Pipeline (January 2018 to present)
- Historic Watercourse

0 1 2 4 km

N W E S

Projection: North American Datum 1983 UTM Zone 10U

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Mount Polley CEMP Periphyton Monitoring Locations

Date: January 2023
Project 227202.0029

minnow environmental inc.

Figure 7

Document Path: C:\Users\CApol\Trinity Consultants, Inc\Imperial Metals - 227202.0029 - 2022 MPMC\D - GIS\CEMP Redesign\Task 6\22-29 Figure 7 benthic Creek.mxd

Table 3: Mount Polley CEMP Periphyton Monitoring Program Overview

Water Body		Sampling Area	Type	Monitoring Frequency	Components [a]	Replication [b]	Rationale
Hazeltine Creek	Upper	HAC-R1 (Reach 1)	Exposed	Biennial [c,d]	P	5	adjacent to mine and breach-influenced
		HAC-U (Reach 2; HAC-R2)	Exposed	Biennial [c,d]	P	5	adjacent to mine, previously effluent-exposed, and breach-influenced
		HAC-R3 (Reach 3)	Exposed	Annual	P	5	adjacent to mine, previously effluent-exposed, and breach-influenced
	Lower	HAC-D (Reach 5; HAC-R5)	Exposed	Annual	P	5	adjacent to mine, previously effluent-exposed, and breach-influenced
Frypan Creek		FPC-R3 (Reach 3)	Reference	Annual	P	5	reference for upper Hazeltine Creek
Edney Creek	Upper	EDC-U	Reference	Biennial [c,d]	P	5	reference for upper Hazeltine Creek
	Lower	E1 (Reach 6)	Exposed	Annual	P	5	adjacent to mine and breach-influenced
		EDC-D	Reference [e]	Annual	P	5	reference for lower Hazeltine Creek

[a] Core periphyton monitoring components: P = productivity (chlorophyll-a and ash free dry mass; see Table 4).

[b] Number of replicate stations within the specified sampling area for a given program component.

[c] Biennial indicates sampling will occur every other year. The next biennial sampling event will occur in 2024.

[d] Monitoring in upper creek areas is used to support the evaluation of the reopening of Hazeltine Creek as fish habitat. Although the proposed reduction in monitoring frequency to every 2 years is adequate for the evaluation of periphyton productivity recovery, this frequency may need to be more frequent (annual) to meet Habitat Remediation Working Group (HRWG) requirements for evaluation of fish habitat.

[e] Lower Edney Creek reference area will be located in an unimpacted area upstream of the breach influence (see Figure 7).

measures of sampling depth, water velocity, *in situ* water quality measurements (temperature, dissolved oxygen, pH, and specific conductance), Global Positioning System (GPS) coordinates, notes of the presence of aquatic vegetation/bryophytes on sampled substrate and other physical observations, and supporting photographs of the sampling location and samples, at each sampling station.

The periphyton productivity monitoring and supporting measures detailed herein are consistent with the previous approved CEMP Periphyton Monitoring Plan (MPMC 2019). However, the current study design no longer includes periphyton community or periphyton tissue quality endpoints (applicable to HAC-R1, HAC-U [HAC-R2], HAC-D, E1 and associated reference areas); monitoring components which were included in the previous study design (see Section 2). The removal of periphyton community and tissue quality endpoints from the CEMP Periphyton Monitoring Plan is based on a QP review of data collected under the previously existing study design (i.e., 2018 to 2021). Specifically, periphyton community and productivity monitoring was implemented in remediated creek areas (and associated reference areas) to evaluate the potential influence of factors such as physical disturbance (e.g., remediation efforts) and water quality on the recovery of periphyton in these areas (see Section 1.1). Periphyton monitoring since 2018 has shown that community characteristics in upper Hazeltine Creek (HAC-R1 and HAC-U [HAC-R2]) are indicative of good health relative to reference and therefore represent recovery since remediation. This result has been mirrored in periphyton productivity results for these areas that also represent recovery, with chlorophyll-a and AFDM results consistently similar to or significantly higher than reference since 2018, and mean chlorophyll-a concentrations below the applicable BCWQG in all years (see Section 2.1; Minnow 2022a). The continued evaluation of dissolved oxygen results from remediated creek areas, in combination with evaluation of chlorophyll-a concentrations relative to the BCWQG, will continue to be used to assess whether excessive periphyton productivity is occurring. The community characteristics of periphyton in lower Hazeltine Creek from 2019 to 2021 were indicative of on-going recovery; a result mirrored in periphyton productivity measures (chlorophyll-a and AFDM) that decreased over this period (i.e., represent on-going recovery), consistent with the completion of channel remediation works immediately prior to sampling in 2021 (see Section 2.1; Minnow 2022a). Given the observed similarity in periphyton community and productivity measures, it is anticipated that continued periphyton productivity monitoring (and discontinuation of periphyton community monitoring) will be sufficient to track periphyton recovery now that remediation efforts in creek areas are completed.

The proposed removal of periphyton tissue quality from the CEMP Periphyton Monitoring Plan is based on existing data which have indicated that periphyton and benthic invertebrate tissue results are highly similar, which is consistent with the literature (e.g., Presser and Luoma 2010).

Specifically, periphyton tissue quality monitoring since 2017 has shown that copper, selenium, and mercury were the only primary and secondary analytes in remediated creek areas with concentrations higher than reference, that increased significantly over time relative to reference, and were higher than pre-breach (in the case of mercury; see Section 2.2; Minnow 2022a). These analytes were also identified based benthic invertebrate tissue quality monitoring results as being higher than reference, increasing significantly over time relative to reference, and being higher than pre-breach (Minnow 2022a; see CEMP Section 6.13). In addition, evaluation of Trophic Transfer Factors (i.e., TTF = [benthic invertebrate tissue sample]/[periphyton tissue sample]), which can be used to describe the extent to which analyte concentrations increase between lower and higher trophic levels (generally ~1; Presser and Luoma 2010), has demonstrated stability or decreases in TTFs for these analytes over time, except mercury. The similarity in the tissue quality results for the two tissue types (i.e., periphyton and benthic invertebrate) and the absence of evidence of increasing trophic transfer for most analytes is supportive of continued of tissue quality monitoring in remediated creek areas through benthic invertebrate tissue, which is reflective of dietary exposure in fish, rather than periphyton tissue.

Periphyton productivity monitoring will be completed in August or September consistent with previous data collections (Minnow 2011, 2013a,b, 2018a,b,c,d, 2019a,b, 2020a,b, 2021a,b, 2022a,b). The revised monitoring frequency in upper Hazeltine Creek areas (HAC-R1, HAC-U [HAC-R2]); and associated reference area EDC-U) will be every two years[8] (Table 3). This represents a decrease in frequency relative to the previous study design, which included annual monitoring for these upper creek areas (MPMC 2019). Periphyton productivity monitoring was completed most recently in 2022 in the upper creek areas, therefore the next monitoring event would occur in 2024 under the revised monitoring frequency. This decrease in monitoring frequency is guided by previous results, which have shown that periphyton productivity (as measured by chlorophyll-a and AFDM) in upper Hazeltine Creek areas (HAC-R1, HAC-U) has been consistently similar to or significantly higher than reference since 2018, with mean chlorophyll-a concentrations below BCWQG in all years (see Section 2.1; Minnow 2022a). The revised monitoring frequency in remediated areas of lower Hazeltine Creek (HAC-D [HAC-R5]) and lower Edney Creek (E1; and associated reference area EDC-D) will be annual. This represents an increase in frequency compared to the previous study design, which included monitoring every two years in these lower creek areas (MPMC 2019). Annual monitoring will enable tracking of recovery in these habitats that were recently disturbed

[8] Monitoring in upper creek areas is used to support the evaluation of the reopening of Hazeltine Creek as fish habitat. Although the proposed reduction in monitoring frequency to every 2 years is adequate for the evaluation of periphyton productivity recovery, this frequency may need to be more frequent to meet the HRWG requirements for evaluation of fish habitat.

during the completion of remediation works in 2020 and 2021 (see Section 1.1). A reduction in monitoring frequency at these lower creek areas will be considered following interpretation of data collected in 2025, dependent on the recovery of periphyton productivity endpoints. The monitoring frequency for areas sampled specifically to meet the fish and fish habitat objectives of the HRWG (upper Hazeltine Creek [HAC-R3], Frypan Creek [FPC-R3]) will continue to be annual (Figure 7, Table 3). The frequencies for all monitoring components and areas will be reviewed following interpretation of data collected in 2025, and design modifications (e.g., changes to monitoring frequency or locations) will be made based on a QP review of the data.

Periphyton productivity samples will be collected, processed, analyzed, and the associated data interpreted using methodology consistent with previous assessment at Mount Polley (e.g., Minnow 2018a, 2019a, 2020a, 2021a, 2022a) and with technical guidance (e.g., BCMOE 2013, 2016). Detailed methodology is provided in Section 4, including: quality assurance/quality control (QA/QC), sample collection methods, sample handling and laboratory analysis, data quality assessment, and data handling and interpretation.

4 METHODOLOGY

4.1 Quality Assurance / Quality Control

All sampling will be led by qualified field staff experienced in the implementation of periphyton productivity monitoring programs. All sample collection methods, quality assurance and quality control (QA/QC) measures, and laboratory analysis methods will be implemented in accordance with technical guidance (BCMOE 2013, 2016; BCMOECCS 2020). Specifically, QA/QC measures will include program review prior to implementation, adequate resources for all field teams including field checklists and field data sheets, the availability (and maintenance) of clean sampling equipment and sampling containers, and sampling in a manner that minimizes any risk of sample contamination.

QC samples to assess field precision (field duplicates) will not be collected for periphyton productivity (chlorophyll-a and AFDM) due to high the inherent natural variability in these parameters. Raw field data will be transcribed from field sheets into an electronic spreadsheet. Data will be checked by a separate individual for data entry errors as part of routine QA/QC procedures. In addition to field QA/QC, the laboratory responsible for periphyton productivity measures will be accredited by the Canadian Association for Laboratory Accreditation (CALA) for these analyses. Specific QC sampling and associated reporting for periphyton productivity endpoints will be requested of the analytical laboratory, including reagent blank results, laboratory replicate results, and laboratory accuracy results (i.e., laboratory control samples). Laboratory Reporting Limits (LRLs) will also be evaluated in comparison to targets established by the analytical laboratory. Results will be assessed as part of the Data Quality Review (DQR; see Section 4.4).

4.2 Sample Collection Methods

Periphyton samples for productivity monitoring (chlorophyll-a analysis and AFDM) will be collected by selecting five representative submerged rocks from each monitoring station. Representative rocks from each station will be selected from locations with similar habitat (depth, velocity, and substrate characteristics), while attempting to match depth and velocity among periphyton collection stations and areas as closely as possible. Selected rocks (excluding those that are too small, highly angular, or uncharacteristic in surface texture) will be taken to shore.

For chlorophyll-a sample collection, a thin acetate template with a 2x2 cm opening in the middle will then be placed firmly on each rock, and the periphyton within this area will be scraped off using a stainless-steel razor blade or scalpel. Sample material from each of the five rocks will then be transferred from the razor blade or scalpel to a large (47 mm) 0.45 µm pore diameter

Whatman mixed cellulose ester (MCE) filter paper until a single composite sample of approximately 200 mg to 1 g wet weight is obtained per station. The filter paper will then be folded and placed into a labeled opaque centrifuge tube. The total surface area sampled at each station (5 x 4 cm^2 = 0.002 m^2, or any deviations from this surface area), will be recorded to allow calculation of chlorophyll-a on a unit area basis for comparison to the BCWQG (100 mg/m^2; BCMOECCS 2021).

The same five rocks sampled for chlorophyll-a analysis (and additional rocks if they were required) will be used to collect separate scrapings for analysis of AFDM. For AFDM sampling, methods will follow those outlined above for chlorophyll-a. However, material on the razor blade or scalpel from scraping of each rock will be rinsed into a small pre-labelled plastic jar with additional water added to cover the tissue (as necessary). Sampling will be conducted at five replicate stations in each area (see Table 3). Samples will be kept on ice in the field, then frozen before shipment (in a cooler with ice) to the analytical laboratory.

4.3 Sample Handling and Laboratory Analysis

Periphyton productivity samples (chlorophyll-a and AFDM) will remain frozen until shipment (in a cooler with ice) to the analytical laboratory at the termination of the field program. Samples will be sent to the laboratory with completed Chain of Custody (COC) forms leaving sufficient time to complete analyses within the recommended sample hold times (28 days for chlorophyll-a, 6 months for AFDM). Periphyton productivity analyses will be completed at an analytical laboratory accredited by the CALA using methods that are consistent with those specified in the British Columbia Environmental Laboratory Manual (BCMOECCS 2020). Upon sample receipt, the laboratory will provide a sample receipt confirmation which will be reviewed to ensure that all samples are received and that the analytical requests are properly logged. These receipts will be reviewed to ensure that all samples are received and that the analytical requests are properly logged.

Analysis of chlorophyll-a will follow procedures adapted from United States Environmental Protection Agency (USEPA) Method 445.0 (USEPA 1997). Briefly, chlorophyll-a will be determined by routine acetone extraction followed by fluorescence detection using a non-acidification procedure (a method that is not subject to interferences from chlorophyll-b). Determination of total AFDM will follow procedures adapted from American Public Health Association (APHA) Method 10300 C (APHA 2010). Total AFDM will be calculated as the difference between the dried sample weight and the ash weight, both of which will be determined gravimetrically. Dry weight will be determined by drying the sample at 105 °C, and the ash weight will be subsequently determined by ashing the dried sample at 500 °C. Periphyton productivity parameters (chlorophyll-a and AFDM) and their associated target LRLs

are presented in Table 4. Upon completion of the analyses, the laboratory will provide a data report in Microsoft (MS) Excel™ and as an Adobe Acrobat Portable Document Format (PDF). Reporting will include the results of the laboratory QC sample results.

Table 4: Target Laboratory Reporting Limits (LRLs) for Periphyton Productivity Endpoints

Parameter	Units	LRL
Chlorophyll-a	µg	0.02
Ash Free Dry Weight	g	0.001

Notes: µg = micrograms. g = grams.

4.4 Data Quality Review

Upon receipt of analytical data, a Data Quality Review (DQR) will be performed. The DQR will confirm that all requested analyses are complete, that acceptable LRLs have been achieved relative to established targets (Table 4) and relative to relevant British Columbia guidelines (i.e., chlorophyll-a; BCMOECCS 2021). The DQR will also include an evaluation of the QA/QC data reported by the laboratory relative to Data Quality Objectives (DQO) established by the analytical laboratory, including laboratory blanks, precision, and accuracy. Completion of the DQR promptly following receipt of the periphyton productivity monitoring data will ensure timely communication with the laboratory should any issues be identified.

4.5 Data Handling and Interpretation

Upon receipt of primary productivity data from the analytical laboratories, all laboratory data files will be managed by the Mount Polley Mining Corporation (MPMC) Environment Department. In addition, data provided by the primary analytical laboratories as an Electronic Data Deliverable (EDD) will be imported directly into the MPMC's database. Following the DQR, all periphyton data and supporting data will be managed in MS Excel™ or R (R Core Team 2022). For all replicated data (typically based on a sample size of five stations per area), data will be provided to the QP and summarized by calculating mean, median, standard deviation, minimum, and maximum for each endpoint and area.

Periphyton productivity (chlorophyll-a and AFDM) results will be converted to a standard area-based measurement (mg/m^2 and g/m^2 for chlorophyll-a and AFDM, respectively). Chlorophyll-a results will be compared to water quality guidelines for the protection of aquatic life (BCWQG = 100 mg/m^2; BCMOECCS 2021) and to literature-based criteria for moderately

enriched streams (21 mg/m^2; Biggs 1996). Periphyton productivity results will also be compared to previous data (including baseline and pre-breach data, where possible) and to reference results through detailed interpretation that may include: graphical comparisons to reference and historical data, graphical comparisons to guidelines and criteria, and formal statistical contrasts of exposed versus reference results over time.

The formal statistical contrasts of periphyton productivity at exposed versus reference areas over time will be conducted as two-way ANOVAs with Area and Year as factors and assessing the interaction between Area and Year. These contrasts will include available baseline, pre-breach, and post-breach data to assess how periphyton productivity from exposed areas compares to both reference and baseline/pre-breach conditions, and to assess temporal changes at the exposed areas. If the Area x Year interaction term is significant, all pairwise contrasts will be evaluated. If the interaction term is not significant but the Area term is significant, pairwise contrasts will be conducted between areas pooling years; if the Year term is significant, pairwise contrasts will be conducted between years pooling areas. Pairwise contrasts will be evaluated using Sidak correction to account for multiple comparisons. Prior to analysis, the assumptions of normality and homogeneity of variances will be tested on the residuals of the two-way ANOVA model using the Shapiro-Wilk test and Levene's test based on median values, respectively using $\alpha = 0.05$. Data will be transformed as necessary to satisfy assumptions of normality and homogeneity of variance ($\log_{10}$, $\log_{10}(x+1)$ when zeros were present in the data). In instances where the residuals of the ANOVA model do not meet the assumptions of normality and homogeneity of variances, the analysis will be conducted on ranks (equivalent to a non-parametric-test).

The evaluation of periphyton productivity results from will consider the results of water quality monitoring data collected routinely by MPMC staff from creek monitoring areas and spot water quality samples collected concurrently with periphyton and benthic invertebrate monitoring. These data will be used to support the evaluation of periphyton productivity monitoring results through evaluation of aqueous nutrient concentrations (e.g., total phosphorus, total nitrogen, and dissolved orthophosphate) over time and in comparison to relevant BCWQG (BCMOECCS 2021a,b).

An interpretive report based on the periphyton productivity monitoring data will be prepared for integration into the Annual Environmental Report for the Mount Polley Mine that is prepared annually by MPMC and submitted to the regulators and other stakeholders by March 31st of the following year. The interpretive report will provide all data in an appendix and will include the DQR, the results of the screening against BCWQG and other classification schemes, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear

text form supported by tables and data plots. Periphyton productivity monitoring data will also be incorporated into a separate interpretive report which focuses on the evaluation of fish and fish habitat monitoring objectives for the remediated creek areas; a report that is prepared annually and submitted to the HRWG by March 31st of the following year.

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Appendix B.1.5

Fish Monitoring Plan

Minnow Environmental

Fish Monitoring Plan

Prepared for:
Mount Polley Mining Corporation
Likely, British Columbia

Prepared by:
Minnow Environmental Inc.
Victoria, British Columbia

March 2023

Fish Monitoring Plan

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ACRONYMS AND ABBREVIATIONS

ANCOVA – Analysis of Covariance
ANOVA – Analysis of Variance
BC – British Columbia
BCMOE – British Columbia Ministry of Environment
BCMOECCS – British Columbia Ministry of Environment and Climate Change Strategy
BCWQG – British Columbia Water Quality Guidelines
CALA – Canadian Association for Laboratory Accreditation
CCME – Canadian Council of Ministers of the Environment
CEMP – Comprehensive Environmental Monitoring Program
COC – Chain of Custody
CPUE – Catch per Unit Effort
CRC-ICP-MS – Collision Cell Inductively Coupled Plasma-Mass Spectrometry
CVAAS – Cold Vapor Atomic Absorption Spectrophotometry
DFO – Fisheries and Oceans Canada
DQO – Data Quality Objective
DQR – Data Quality Review
EDD – Electronic Data Deliverable
EEM – Environmental Effects Monitoring
ERA – Ecological Risk Assessment
FLNRORD – British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development
GPS – Global Positioning System
HHRA – Human Health Risk Assessment
HRWG – Habitat Remediation Working Group
HSI – Habitat Suitability Index
LRL – Laboratory Reporting Limits
LWD – Large Woody Debris
MDMER – Metal and Diamond Mining Effluent Regulations
MOD – Magnitude of Difference
MPMC – Mount Polley Mining Corporation
MS – Microsoft
PDF – Portable Document Format
QA/QC – Quality Assurance/Quality Control
QP – Qualified Professional

RPD – Relative Percent Difference

SPIN – Summer Profundal Index Netting

TSF – Tailings Storage Facility

USEPA – United States Environmental Protection Agency

YOY – Young-of-the-Year

1 INTRODUCTION

1.1 Background

Fish are important and highly valued aquatic ecosystem components. Fish community composition, fish population characteristics (e.g., survival, growth, and reproduction), and fish tissue quality can be effective monitors of potential biological effects associated with water quality, sediment quality, and/or physical disturbance. Fish tissue quality is also an important measure of potential exposure to metals, metalloids, nutrients[1], and other substances to humans and wildlife that consume fish. Lastly, the use of fish habitat by fish is an important monitor of the physical and chemical quality of aquatic habitat. Therefore, fish community, population, habitat, and tissue quality are important monitoring components that have been incorporated into the Mount Polley Mining Corporation (MPMC) Comprehensive Environmental Monitoring Program (CEMP).

The influence of the Mount Polley Mine on fish communities, populations, habitat, and/or tissue quality can occur (or has occurred) by several key mechanisms: 1) general mine influence on creeks and lakes from physical impingement, dustfall, and/or uncontained surface or groundwater flows; 2) direct discharge of mine effluent to Hazeltine Creek (April to August 2014) and Quesnel Lake (December 2015 to present)[2]; 3) the Tailings Storage Facility (TSF) embankment breach ("the breach") on August 4, 2014; and 4) remediation activities following the TSF embankment breach. Potential effects associated with effluent discharge are chemical, while those associated with general mine influence, the TSF embankment breach, and subsequent remediation can be both physical and chemical.

The geomorphology of the entirety of Hazeltine Creek (from Polley Lake to Quesnel Lake) was substantially altered by the TSF embankment breach such that Fisheries and Oceans Canada (DFO) considered it not to be fish habitat (Golder 2015a). A portion of lower Edney Creek was also impacted by the breach. Fish access to the impacted creek areas was restricted by fish fence installations from August 2014 until channel remediation works were completed. Upper Hazeltine Creek (Reach 1 [HAC-R1], Reach 2 [HAC-R2], and Reach 3

[1] Through the remainder of this section, the term "metals" will be used to include metals, metalloids, and nutrients for ease of communication.[2] Treated effluent was discharged to Quesnel Lake via Hazeltine Creek from December 2015 to December 2017. During this period, treated effluent flowed into a settling pond in Hazeltine Creek located at the edge of Quesnel Lake prior to final discharge into Quesnel Lake via diffusers. From 2018 to present, treated effluent was conveyed to the diffusers in Quesnel Lake via a direct pipeline.

[2] Treated effluent was discharged to Quesnel Lake via Hazeltine Creek from December 2015 to December 2017. During this period, treated effluent flowed into a settling pond in Hazeltine Creek located at the edge of Quesnel Lake prior to final discharge into Quesnel Lake via diffusers. From 2018 to present, treated effluent was conveyed to the diffusers in Quesnel Lake via a direct pipeline.

[HAC-R3]) has always been isolated from lower Hazeltine Creek (Reach 5 [HAC-R5] and Reach 6 [HAC-R6]) and Edney Creek by a canyon in Reach 4 of Hazeltine Creek (HAC-R4) which acts as a permanent barrier to upstream fish passage. Remediation of upper Hazeltine Creek was initiated in 2014 following the breach (Golder 2017a), and completed at HAC-R1, HAC-R2, and HAC-R3 in 2016, 2017 (Golder 2017b,c), and 2019 (Golder 2020), respectively. Interim remediation efforts in lower Hazeltine Creek and lower Edney Creek were initiated in 2015 with the temporary reconstruction of the two creeks as two separate watercourses. Final remediation in these lower creek areas was initiated in 2020, including the reconnection of the two watercourses, and was completed in fall 2020 except for two sections in which final works were completed in summer 2021 (Minnow 2021b). Fish access was restored to upper Hazeltine Creek in spring 2018 for Reaches 1 and 2, and in spring 2020 for Reach 3. Fish access to lower Edney Creek was restored shortly after completion of the temporary remediation works in 2015 (Golder 2017a) while lower Hazeltine Creek remained inaccessible to fish until October 2020. Fish access was also temporarily restricted to lower creek work areas during final remediation works in 2020 and 2021 (Minnow 2021b).

Fish in waterbodies adjacent to the Mount Polley Mine have been monitored historically by the provincial government (Burns and Klein 1973; Lirette and Tredger 1991; Bruce and Slaney 1991) and by the Mount Polley Mine starting with baseline investigations in 1989, 1995, and 1996 (Imperial Metals 1990; HKP 1996a,b,c, 1997a). Results of fish monitoring are reviewed in Section 2 and provide context for this CEMP Fish Monitoring Plan (community, population, and tissue quality). This study design is guided by a combination of historical findings, representative locations downstream of Mount Polley Mine operations, representative reference locations, and considerations for a statistically-based design that will facilitate the detection of spatial and temporal differences. Fish tissue quality monitoring data will also be evaluated relative to guidelines for the protection of aquatic life and/or human health (e.g., the British Columbia Water Quality Guideline [BCWQG] for selenium [BCMOE 2014] and the Health Canada guideline for mercury [CFIA 2015]). In addition to monitoring required as part of the MPMC CEMP, fish population monitoring is a requirement of Environmental Effects Monitoring (EEM) under the Metal and Diamond Mining Effluent Regulations (MDMER) of the federal *Fisheries Act* if effluent concentrations exceed 1% at 250 m from the point of discharge (Government of Canada 2022). Previous monitoring has demonstrated that the Mount Polley Mine effluent discharge in Quesnel Lake does not meet this criterion (DWB 2021), indicating that fish population monitoring is no longer required under the MDMER EEM for the Mount Polley Mine effluent discharge (Minnow 2022c). Fish population monitoring under the MDMER EEM will therefore not be discussed further within the present CEMP Fish Monitoring Plan. Under the MDMER EEM, a fish tissue study for mercury is required if annual mean concentrations of total mercury in effluent are

> 0.10 µg/L, and for selenium if maximum and annual mean total selenium concentrations in effluent are > 10 µg/L and > 5 µg/L, respectively (Government of Canada 2022). Previous effluent quality data have indicated that a fish tissue selenium study, but not a fish tissue mercury study, is required for the Mount Polley Mine effluent discharge in Quesnel Lake (Minnow 2022c). Lastly, fish habitat characterization and fish usage monitoring in upper and lower Hazeltine Creek and lower Edney Creek serves to document effectiveness of the reconstructed fish habitat and to address the monitoring objectives identified and reviewed by the Habitat Remediation Working Group[3] (HRWG) for these remediated creek areas.

The following sections of the CEMP Fish Monitoring Plan provide the objectives of fish monitoring from 2023 to 2025, a summary of historical fish community, population, and tissue quality findings, an overview of the CEMP study design and associated rationale (including sampling locations, replication, frequency, and analytes), and detailed methodology for fish monitoring (quality assurance/quality control [QA/QC], sample collection methods, sample handling and laboratory analysis, data quality review [DQR], data handling, interpretation, and reporting).

1.2 Monitoring Objective

The objective of fish monitoring is to evaluate the influence of Mount Polley Mine activities on fish communities, populations, and tissue quality in receiving environments (Hazeltine Creek, Polley Lake, and Quesnel Lake) in comparison to baseline and/or reference conditions, and to determine potential implications to aquatic ecosystem health and human health (e.g., relative to available fish tissue quality guidelines [BCMOE 2014; CFIA 2015]). Fish monitoring also provides data to support exposure assessment as part of post-breach ecological risk assessment (ERA) and human health risk assessment (HHRA). Lastly, fish monitoring documents fish habitat utilization in creek and lake areas that were physically impacted by the TSF embankment breach (most notably Hazeltine Creek and the lower segment of Edney Creek), thereby addressing fish and fish habitat monitoring objectives identified and reviewed by the HRWG for the remediated creek areas. The objective of the MDMER EEM fish tissue selenium monitoring program is to evaluate fish tissue selenium concentrations in comparison to reference conditions and to determine potential implications to aquatic ecosystem health and human health (e.g., relative to available fish tissue quality guidelines [BCMOE 2014; CFIA 2015]).

[3] The HRWG was established at the request of Fisheries and Oceans Canada (DFO; April 9, 2015), in response to regulatory requirements set out in Section 38(6) of the *Fisheries Act*. Members of the working group include: DFO, British Columbia Ministry of Environment (BCMOE), British Columbia Ministry of Forest Lands and Natural Resource Operations and Rural Development (FLNRORD), Soda Creek Indian Band, Williams Lake Indian Band, and Mount Polley Mining Company.

2 SUMMARY OF HISTORICAL FINDINGS

Fish monitoring in the vicinity of the Mount Polley Mine has been undertaken since 1989, with most of the monitoring conducted in Polley Lake, Bootjack Lake, Hazeltine Creek, and Edney Creek (Table 1). Fish in Quesnel Lake have also been intensively monitored since the TSF embankment breach in August 2014 and following the initiation of effluent discharge to Quesnel Lake in December 2015. Fish monitoring in the vicinity of the Mount Polley Mine has spanned four distinct time periods:

1. Baseline monitoring (1989, 1991, 1995, 1996);
2. Pre-breach operational monitoring (1997, 1998, 1999, 2007, 2009, 2010, 2012, 2013, 2014);
3. Post-breach operational monitoring (2014, 2015); and
4. Post-breach and post-discharge operational monitoring (2016, 2017, 2018, 2019, 2020, 2021, 2022 [4]).

For Polley Lake and Hazeltine Creek, the second time period can be sub-divided into periods of: 1) prior to; 2) during; and 3) after, an uncontrolled surface runoff event from the north waste rock dump which reported to Polley Lake via North Dump Creek. This runoff started in 2006, was controlled in 2009 with the construction of the Long Ditch, and was characterized by elevated concentrations of sulphate and selenium. In addition to the construction of the Long Ditch, Mount Polley initiated selenium-specific aquatic environmental monitoring in 2009.

Fish community, population, and/or tissue quality data collected prior to the breach were summarized in an Aquatic Environmental Description Report prepared concurrent with an application for water discharge to Polley Lake in 2014 (Minnow 2014a). General findings of the historical monitoring, as well as fish monitoring data collected from 2014 to present, are provided in the following sections, by sampling area, to support the design of the CEMP Fish Monitoring Plan.

[4] Fish monitoring was also completed in 2022 but reporting of these results is in progress, with submission of an interpretive report that includes these results required by March 31, 2023. The 2022 fish monitoring results are therefore excluded from the present document.

Table 1: History of Fish Monitoring in Waterbodies in the Vicinity of the Mount Polley Mine

A) Lakes

Year	Locations	Endpoints[a]	Report
1989	Bootjack, Morehead	C, P, T[b]	Imperial Metals 1990
1995	Polley, Bootjack	C, P, T	HKP 1996a
1996	Polley, Bootjack	C[c]	HKP 1997a
1999	Polley, Bootjack	C, P, T	Beak 2000
2009	Polley, Bootjack, Trio, Frypan, Quesnel (near Hazeltine Creek)	C, P, T	Minnow 2011
2010	Polley, Quesnel (near Hazeltine Creek and North Arm)	C, P, T	Minnow 2011
2012	Polley, Bootjack, Trio, Frypan, Quesnel (near Hazeltine Creek, North Arm)	C, P, T[d]	Minnow 2013a
2014	Polley, Bootjack, Quesnel (multiple locations)	C, P[e], T	Lirette 2015; Golder 2016
2015	Polley[f], Bootjack, Quesnel (multiple locations), Trio	C, P, T	Golder 2016; Zirnhelt 2016; Zirnhelt and Dolighan 2015
2016	Polley, Quesnel (multiple locations)	C, P, T	Minnow 2016, 2017a,b; Lirette 2017
2017	Polley, Bootjack, Quesnel (multiple locations)	C, P, T	Minnow 2018a
2018	Polley, Bootjack, Quesnel (multiple locations)	C, P, T	Minnow 2019a
2019	Polley, Bootjack, Quesnel (multiple locations)	C, P, T	Minnow 2020a
2020	Polley, Bootjack, Quesnel (multiple locations)	C, P, T	Minnow 2021a
2021	Polley, Bootjack, Quesnel (multiple locations)	C, P, T	Minnow 2022a

[a] C = Community, P = Population, and T = Tissue.
[b] Rainbow trout in Bootjack Lake only.
[c] Recreational angling use survey only.
[d] Selenium concentrations only.
[e] Population estimates only taken at Polley Lake (Lirette 2015).
[f] Rainbow trout collected from Frypan Creek and pooled with samples from Polley Lake.

B) Creeks and Rivers

Year	Locations	Endpoints[a]	Report
1989	Upper Hazeltine, Lower Hazeltine, Upper Edney, Lower Edney, Bootjack, Morehead, Lower Morehead, 4K, 6K	C	Imperial Metals 1990
1990	Hazeltine, Bootjack	C, P	Bruce and Slaney 1991
1995	Upper Edney (multiple tributaries)	C, P	HKP 1996b,c
1996	Upper Edney (multiple tributaries)	C, P	HKP 1997a
1997	Upper Edney (multiple tributaries)	C, P	HKP 1997b
1998	Upper Edney (multiple tributaries)	C, P	Beak 1999
2007	Upper Hazeltine, Lower Hazeltine, Upper Edney (NE trib), Reference (Upper Edney [SW trib], Upper Cedar, Lower Whiffle)	C, P	Cariboo Envirotech 2008; Minnow 2009
2009	Upper Hazeltine	C, P, T[b]	Minnow 2011
2010	Upper Hazeltine	T[b]	Minnow 2011
2012	Upper Hazeltine	C, P, T[b]	Minnow 2013a
2013	Upper Hazeltine	T[b]	Minnow 2013b
	Bootjack	C, P	Minnow 2014b
2014	Upper Hazeltine, Horsefly, Quesnel, Soda, Edney	C, T[b]	DWB 2014; Golder 2016
2015	Frypan[c], Edney, Quesnel	C, P, T	DWB 2015; Golder 2016
2016	Edney	C, P	Minnow 2018b
2017	Edney, Quesnel	C, P, T	Minnow 2018a,b
2018	Upper Hazeltine, Frypan	C, P, T	Minnow 2019a,b
2019	Upper Hazeltine, Edney, Frypan, Quesnel	C, P, T[d]	Minnow 2020a,b
2020	Upper Hazeltine, Frypan, Quesnel	C, P, T[d]	Minnow 2021a,b
2021	Upper and Lower Hazeltine, Edney, Quesnel	C, P, T[d]	Minnow 2022a,b

Notes: SW = southwest, NE = northeast, trib = tributary.
[a] C = Community, P = Population, and T = Tissue.
[b] Selenium concentrations only.
[c] Rainbow trout collected from Frypan Creek and pooled with samples from Polley Lake.
[d] Tissue only collected at Quesnel River (rainbow trout)

2.1 Polley Lake

2.1.1 Community / Population

Baseline monitoring in Polley Lake and reference lakes (Bootjack, Trio, Morehead, and Frypan lakes) was conducted in 1989, 1995, and 1996 and documented the presence of rainbow trout, longnose sucker, and redside shiner. Peamouth chub and largescale sucker have also been reported in Bootjack Lake. The fish species composition of Polley and Bootjack lakes has remained the same through operational monitoring and following the TSF embankment breach. Catchability of rainbow trout and longnose sucker in Polley Lake and Bootjack Lake by gill netting remained reasonably consistent from baseline to the most recent gill netting effort in 2016 (HKP 1996a, Minnow 2013a, Lirette 2015, 2017). More recent monitoring of fish catchability in Polley Lake and Bootjack Lake (2016 to 2021) has been conducted by hoop netting, which was adopted as a preferred method as captures are non-lethal (Table 2). The results of these hoop netting efforts are detailed below.

After the TSF embankment breach (August 2014), a barrier was installed at the outlet of Polley Lake preventing Polley Lake fish from accessing Hazeltine Creek; creek habitat which previously supported the majority of fish recruitment to Polley Lake. There was a noticeable decline in rainbow trout recruitment post-breach which was evident in the smaller relative sizes of the age 1 and 2 cohorts in 2016, and the age 1 to 3 cohorts in 2018 (Figure 1 ; Minnow 2017a). The barrier preventing fish from entering Reaches 1 and 2 (HAC-R1, HAC-R2) of Hazeltine Creek from Polley Lake was removed in the early spring of 2018, and the barrier to Reach 3 (HAC-R3) was removed in early spring 2020 (see Section 1.1).

Fish community and population health assessments undertaken in Polley Lake from 2019 to 2021 have documented the influence of the temporary loss of habitat in Hazeltine Creek (from August 2014 to April 2018), and the ongoing recovery of the fish population since access to Hazeltine Creek was restored. Rainbow trout catch per unit effort (CPUE) recorded for spring fishing efforts (which specifically target spawning fish) decreased from 2019 to 2021 and was substantially lower in all three years compared to 2016, which was consistent with loss of recruitment and natural mortality of older fish since the breach (Table 2; Minnow 2022b). However, CPUE reported during fall fishing efforts (when fishing is randomized in Polley Lake) was higher from 2019 to 2021 than in 2016 and 2018, and highest in 2021. In addition, more smaller rainbow trout were caught from 2019 to 2021 than in 2016 and 2018 during fall fishing and many of these individuals likely represented young-of-the-year (YOY) to age-2. This result indicated successful recruitment of rainbow trout to Polley Lake and overwintering survival. In 2021, the length frequency distribution for rainbow trout indicated a relatively diverse range of size classes (including YOY to age -4 or -5), further suggesting successful rainbow trout survival

Table 2: Catch-Per-Unit-Effort (CPUE) Results for Hoopnetting Collections in Polley Lake for A) Spring and B) Fall, 2016 to 2021

A) Spring

Year	Data Source	Effort (days)	Rainbow Trout		Longnose Sucker		Redside Shiner	
			Catch	CPUE[a]	Catch	CPUE[a]	Catch	CPUE[a]
2016	Minnow (2017a)	33.5	1,737	51.9	2,422	72.4	1,179	35.3
2017	Minnow (2018a)	0.870	8	9.22	247	284	0	0
2018	Minnow (2019a)	5.37	22	4.10	227	42.3	155	28.9
2019	Minnow (2020a)	3.71	35	9.45	37	10.0	29	7.83
2020	Minnow (2021a)	8.98	72	8.02	901	100.4	15	1.67
2021	Minnow (2022a)	23.1	87	3.76	892	38.6	103	4.46

B) Fall

Year	Data Source	Effort (days)	Rainbow Trout		Longnose Sucker		Redside Shiner	
			Catch	CPUE[a]	Catch	CPUE[a]	Catch	CPUE[a]
2016	Minnow (2017a)	108	497	4.58	3,288	30.3	8,288	76.3
2018	Minnow (2018a)	22.2	63.0	2.84	627	28.2	267	12.0
2019	Minnow (2019a)	33.0	329	10.0	623	18.9	787	23.9
2020	Minnow (2020a)	32.0	291	9.1	429	13.5	2,497	78.3
2021	Minnow (2021a)	32.4	383	11.8	451	13.9	923	28.5
2022	Minnow (2022a)	32.0	213	6.7	198	6.2	463	14.5

Notes: The tables above only display effort and catch details for hoopnetting at Polley Lake. For seining details, see Minnow 2018a. For gill netting details, see HKP (1996a), Minnow (2013a), and Lirette (2015, 2017).
[a] CPUE units are # fish / trap / day.

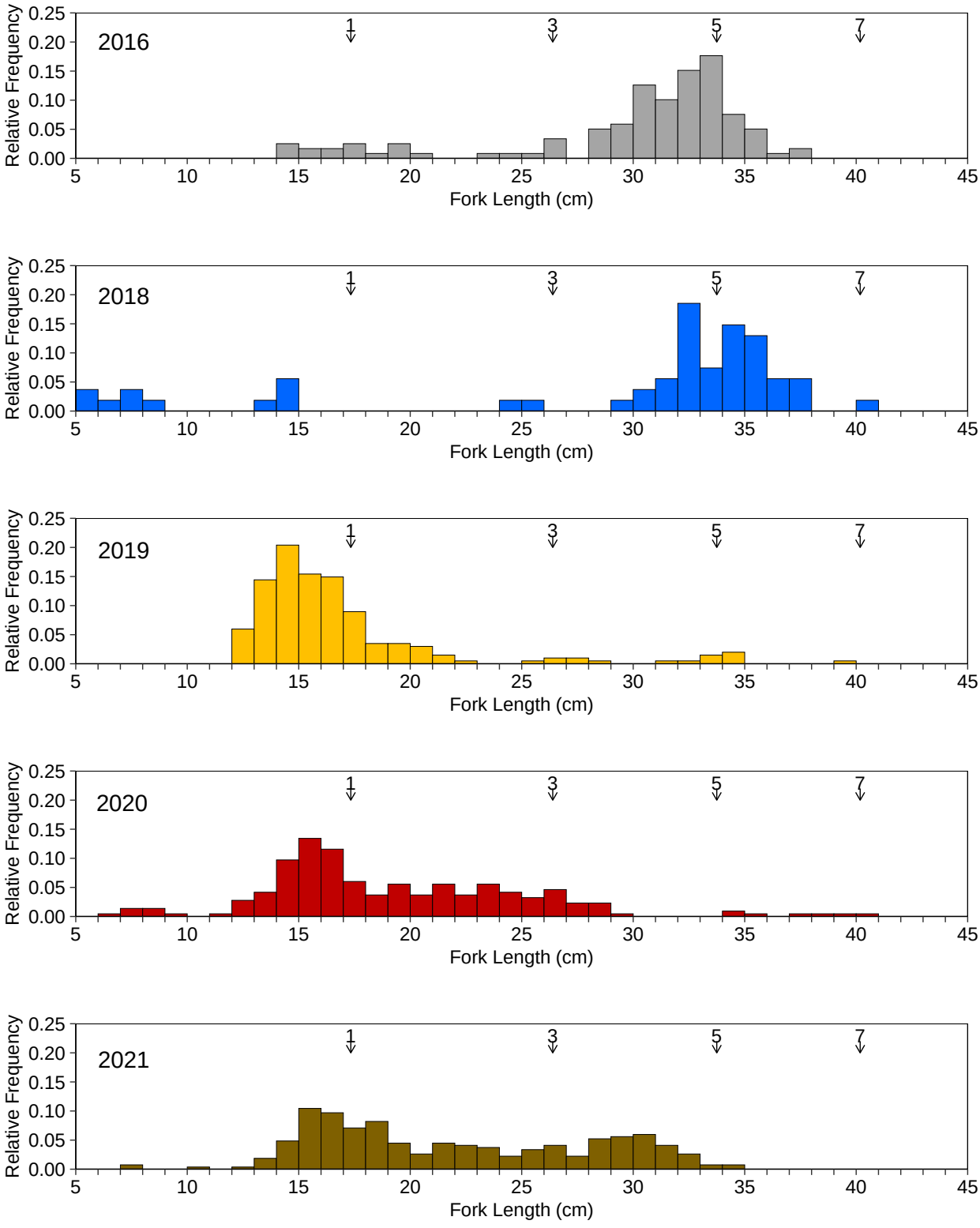


Figure 1: Histograms of Rainbow Trout Fork Length Frequency from Hoopnetting in Polley Lake, 2016 to 2021

Notes: Numbers and arrows along the tops of figures represent predicted fork lengths at various ages from a linear model: $\log_{10(\text{Fork Length})} = 1.0564 + \log_{10(\text{Age}+1)} \times 0.6063$, with $R^2 = 0.79$. The linear model uses fish collected in Spring and Fall.

and recruitment from 2018 to 2021 (Figure 1). More age-4 rainbow trout were captured in 2021 compared to 2020 and 2019; and the majority of these fish (which are from the 2018 cohort) are anticipated to spawn for the first time in 2022 (Minnow 2022b). The CPUE for longnose sucker has varied without evidence of a consistent directional trend over time but was lower in spring 2021 than most previous years (Table 2). More smaller longnose sucker were caught in 2020 and 2021 compared to 2016, and individuals were captured across a broad size range in 2019, suggesting ongoing recruitment success (Figure 2; Minnow 2022b).

2.1.2 Tissue Quality

Tissue quality of Polley Lake (and Bootjack Lake) fish was evaluated in 1989, 1995, 1996, and 1999[5], providing baseline metal concentrations in muscle and liver tissue of rainbow trout and longnose sucker (Imperial Metals 1990; HKP 1996a, 1997a; Beak 2000). Fish tissue quality monitoring was subsequently undertaken in 2009 in response to the uncontrolled surface runoff event from a north waste rock dump which reported to Polley Lake via North Dump Creek (Minnow 2011). Results of the post-runoff but pre-breach monitoring (2009 to 2012) indicated that selenium concentrations in muscle tissue of rainbow trout and longnose sucker were near or above the BCWQG for protection of aquatic life (BCMOE 2014), respectively, and were below the BCWQG in ovary tissue[6] (Figure 3). Ovary tissue is the best tissue for evaluating the potential adverse effects of selenium to fish (which are considered the most selenium sensitive organisms; Presser and Luoma 2009; Janz et al. 2010; DeForest et al. 2012; Janz 2012). Selenium concentrations were well below the effect threshold of 20 mg/kg dw developed by DeForest et al. (2012).

The evaluation of post-breach fish tissue quality results was focused on primary and secondary analytes identified in Minnow (2020a, 2021a, 2022a).[7] Post-breach fish tissue quality monitoring in Polley Lake (and reference) since 2015 indicated that mercury and selenium concentrations in muscle tissue of rainbow trout and longnose sucker were below guidelines for the protection of human health (i.e., that fish are usable for moderate human consumption) although one rainbow trout from Polley Lake 2021 marginally exceeded the guideline for mercury (Figures 3 and 4; Minnow 2022a). Mean selenium concentrations in muscle tissue from rainbow trout and longnose

[5] Although the 1999 collections occurred after mine start-up, the results of the collections were verified against previous data and, based on similar results, were used to augment the baseline database to a sample size of ten fish.

[6] Adult rainbow trout were collected either from Polley Lake or from upper Hazeltine Creek. The latter were adult fish from Polley Lake that had moved into Hazeltine Creek to spawn and are considered indistinct from Polley Lake fish for tissue quality monitoring purposes.

[7] Primary analytes include arsenic, copper, iron, and selenium. Secondary analytes include barium, cadmium, calcium, cobalt, manganese, mercury, molybdenum, nickel, phosphorus, silver, sodium, strontium, tin, titanium, uranium, vanadium, and zinc.

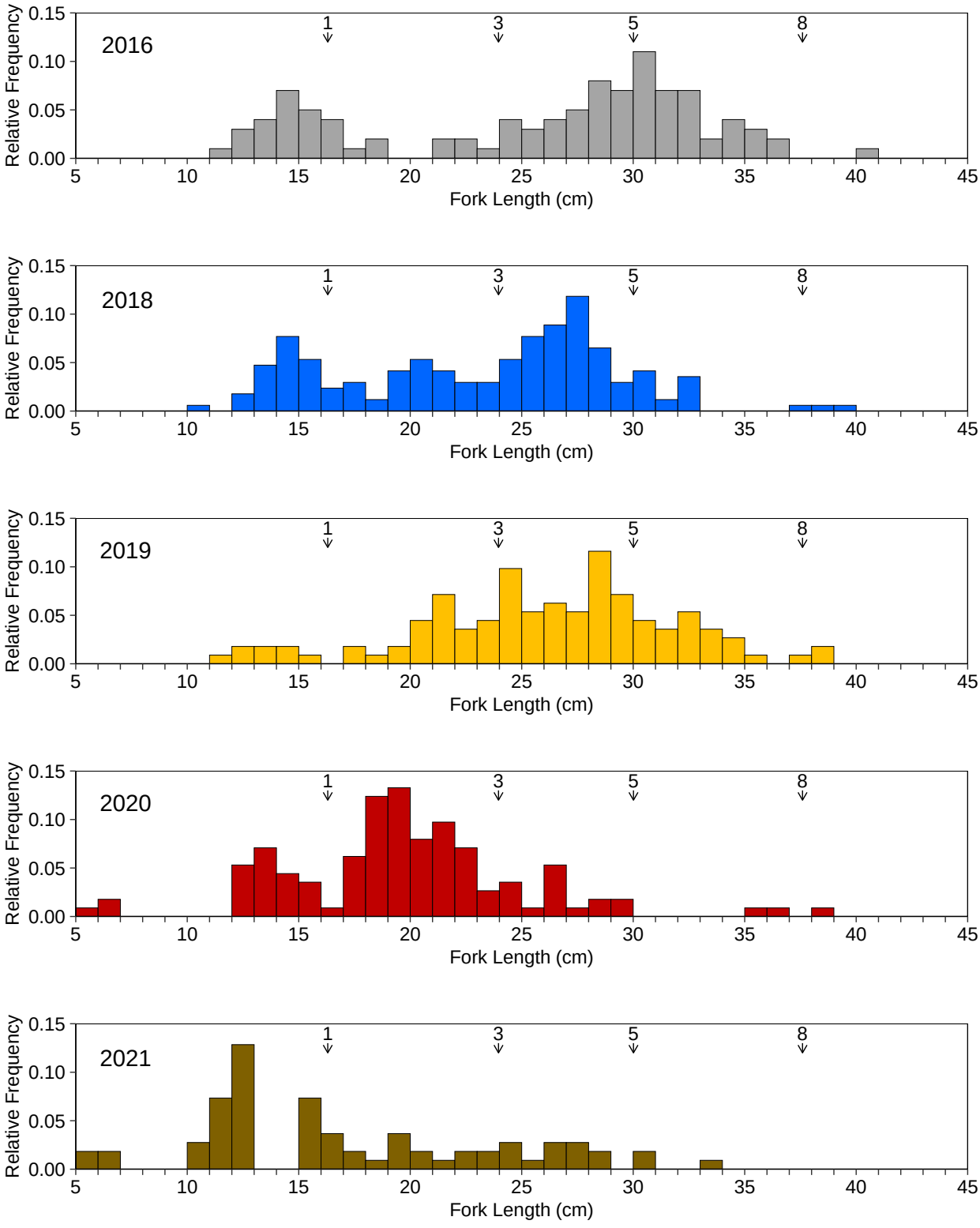


Figure 2: Histograms of Longnose Sucker Fork Length Frequency from Hoopnetting in Polley Lake, 2016 to 2021

Notes: Numbers and arrows along the tops of figures represent predicted fork lengths at various ages from a linear model: $\log_{10(\text{Fork Length})} = 1.0450 + \log_{10(\text{Age}+1)} \times 0.5555$, with $R^2 = 0.88$. The linear model uses fish collected in Spring and Fall.

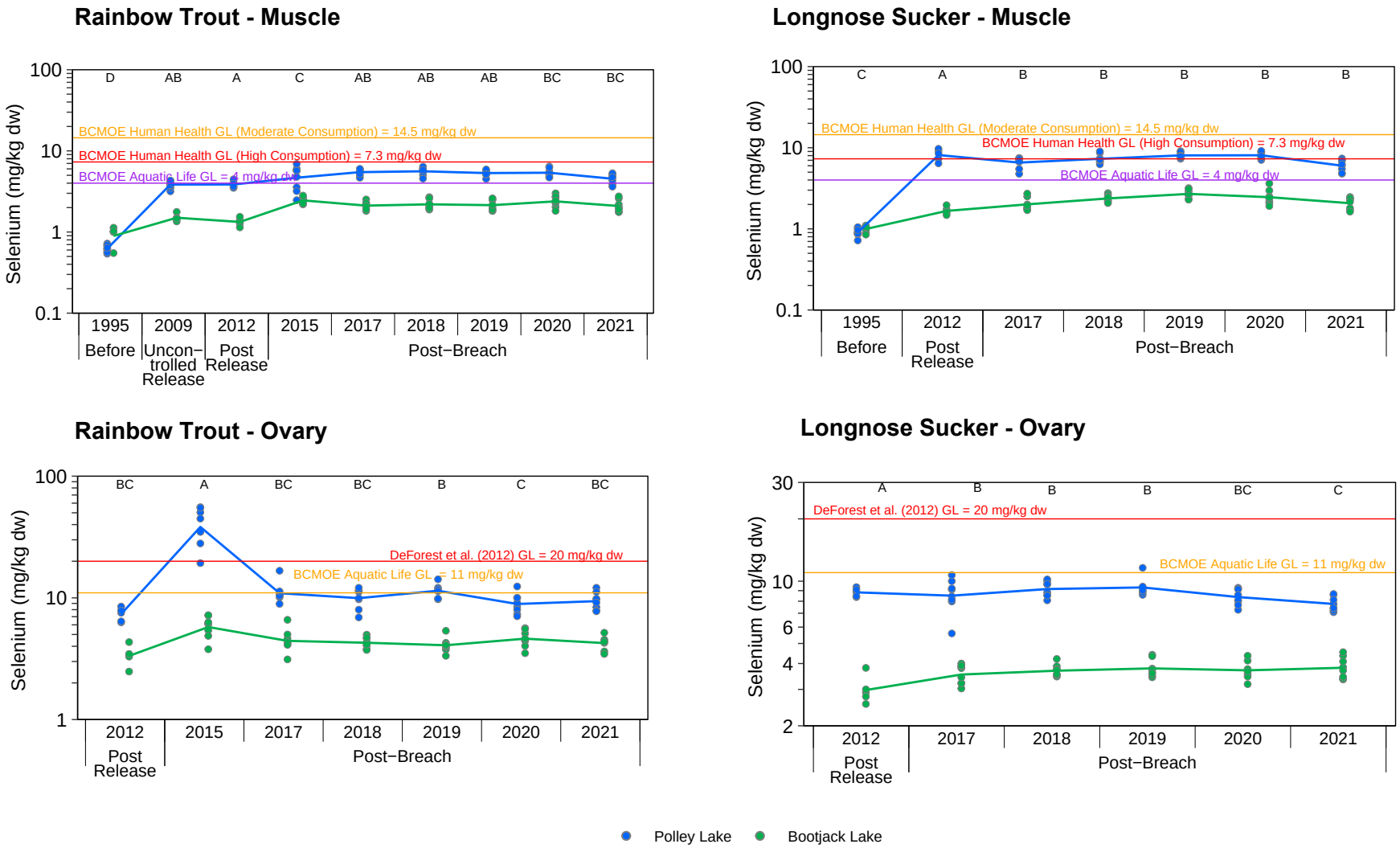


Figure 3: Concentrations of Selenium in Fish Tissue from Polley Lake (Exposed) and Bootjack Lake (Reference), 1995 to 2021

Notes: BCMOE = British Columbia Ministry of the Environment, GL = Guideline, dw = dry weight, ww = wet weight;Individual samples are plotted and lines join the least−squares estimated mean values for years included in the statistical analysis (i.e., not below laboratory reporting limit. Statistical analyses were conducted using a two−way ANOVA with factors Area and Year. The models were fit using Maximum Likelihood Estimation with an assumed log−normal distribution. Years that share a letter (e.g., A,B,C) have ratios of concentrations (Polley Lake:Bootjack Lake) that do not differ significantly (p-value < 0.05) among years. Letter A was assigned to the year with the highest ratio of concentrations (Polley Lake:Bootjack Lake). Only years with samples from both reference and exposed areas are plotted.

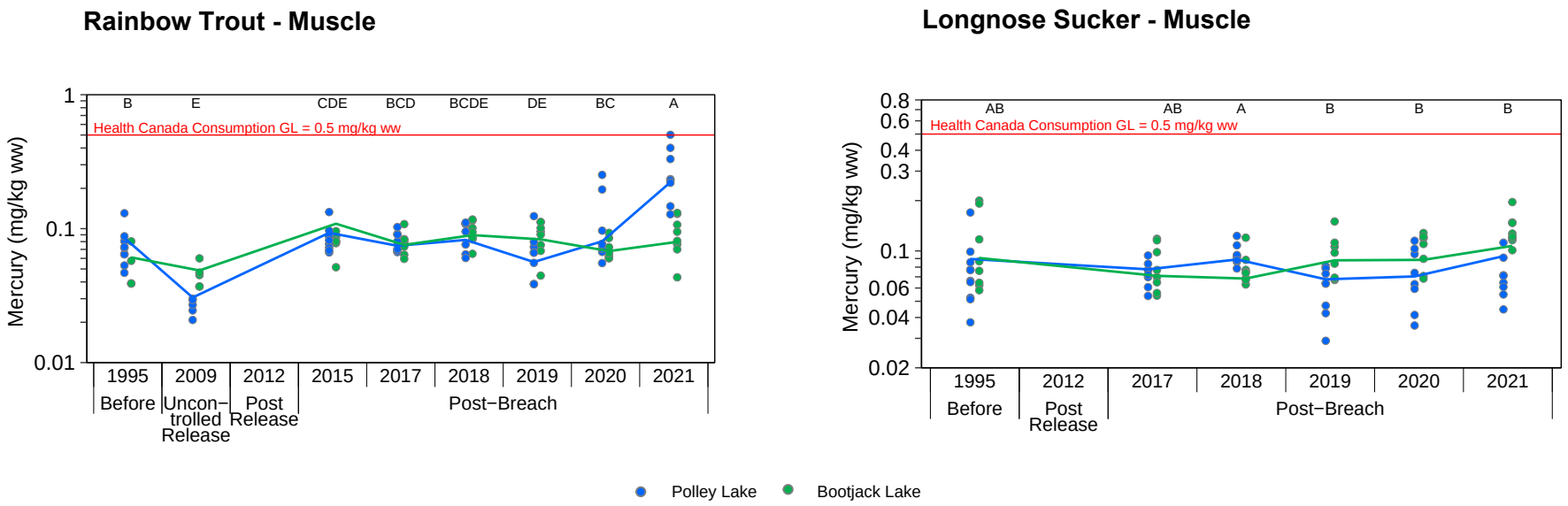


Figure 4: Concentrations of Mercury in Fish Tissue from Polley Lake (Exposed) and Bootjack Lake (Reference), 1995 to 2021

Notes: BCMOE = British Columbia Ministry of the Environment, GL = Guideline, dw = dry weight; ww = wet weight. Individual samples are plotted and lines join the least−squares estimated mean values for years included in the statistical analysis (i.e., not below the laboratory reporting limit). Statistical analyses were conducted using a two−way ANOVA with factors Area and Year. The models were fit using Maximum Likelihood Estimation with an assumed log −normal distribution. Years that share a letter (e.g., A,B,C) have ratios of concentrations (Polley Lake:Bootjack Lake) that do not differ significantly (p-value < 0.05) among years. Letter A was assigned to the year with the highest ratio of concentrations (Polley Lake:Bootjack Lake). Only years with samples from both reference and exposed areas are plotted.

sucker was higher than the guideline for aquatic life from 2015 to 2021 (Figure 3). Mean selenium concentrations in ovary tissue of rainbow trout (but not longnose sucker) also excceded the BCWQG for the protection of aquatic life in 2015[8], 2017, and 2019, and in each monitoring year since 2015 in individual samples (i.e., ≤ 50% of results; Figure 3; Minnow 2022a), but have remained below the effect threshold of 20 mg/kg dw (DeForest et al. 2012) in all years except 2015 (Figure 3). Overall, selenium concentrations in Polley Lake fish tissue have remained elevated relative to reference conditions since the uncontrolled runoff from 2006 to 2009 but the difference compared to reference has remained stable over the post breach period (Figure 3; Minnow 2022a). Mercury was significantly elevated in all Polley Lake rainbow trout tissue types in 2021 compared to reference, which may signal a mine-related effect, although there is no evidence that mercury is increasing over time, and mercury concentrations in zooplankton tissue were not similarly elevated (Figure 4; Minnow 2022a). Evidence of breach influence was not detected for the majority of other primary and secondary analytes assessed in fish tissue from Polley Lake, and the analytes that were elevated relative to reference varied among years (Minnow 2022a). The primary analyte arsenic and secondary analytes calcium, cobalt, manganese, molybdenum, phosphorus, strontium, tin, vanadium, and zinc were elevated relative to reference in at least one year from 2019 to 2021, and in one tissue type in one or both species (rainbow trout and longnose sucker), but results were inconsistent, indicating that the weight of evidence does not support a pattern of increasing analyte concentrations over time due to mine-exposure (Minnow 2022a).

2.2 Hazeltine Creek

2.2.1 Community / Population

The fish community of Upper Hazeltine Creek since baseline has been dominated by juvenile rainbow trout during every sampling effort since (Table 3). The fish community documented in lower Hazeltine Creek and lower Edney Creek (both of which flow into Quesnel Lake) since baseline has included bridgelip sucker, burbot, chinook salmon, coho salmon, kokanee, largescale sucker, longnose dace, longnose sucker, mountain whitefish, northern pikeminnow, peamouth chub, rainbow trout, redside shiner, and sockeye salmon (Table 3).

Prior to the TSF embankment breach, the majority of rainbow trout collected in upper Hazeltine Creek and Edney Creek have been YOY (79%; SNC-Lavalin 2015). In baseline, the density of rearing rainbow trout in upper Hazeltine Creek was 710 fish/100 m^2 and in lower Hazeltine Creek was 325 fish/100 m^2 (Imperial Metals 1990). By comparison, density in Bootjack Creek

[8] Data are considered suspect and are likely influenced by laboratory error or contamination (Golder 2016; Minnow 2017b).

Table 3: Summary of Fish Collected in Hazeltine Creek, Edney Creek, and Associated Reference Areas, 1989 to 2021

Area		Year	Report	Fishing Method	Bridgelip Sucker	Burbot	Chinook Salmon	Coho Salmon	Kokanee	Largescale Sucker	Longnose Dace	Longnose Sucker	Mountain Whitefish	Northern Pikeminnow	Peamouth Chub	Rainbow Trout	Redside Shiner	Sockeye Salmon	Salmon fry[d]	Juvenile Sucker sp.
Frypan Creek		2015	Minnow 2017b	electrofishing[a]	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-
		2016	Minnow 2017a	electrofishing, fry trap	-	-	-	-	-	-	-	-	-	-	-	52	-	-	-	-
		2017	Minnow 2018d	electrofishing	-	-	-	-	-	-	-	-	-	-	-	59	-	-	-	-
		2018	Minnow 2019b	electrofishing, fry trap	-	-	-	-	-	-	-	1	-	-	-	194	-	-	-	-
		2019	Minnow 2019b	electrofishing	-	-	-	-	-	-	-	-	-	-	-	68	-	-	-	-
		2020	Minnow 2020b	electrofishing	-	-	-	-	-	-	-	-	-	-	-	29		-	-	-
		2021	Minnow 2021b	electrofishing	-	-	-	-	-	-	-	-	-	-	-	68	1	-	-	-
Hazeltine Creek	Upper Hazeltine Creek (Remediated)	1989	Imperial Metals 1990	minnow trap, electrofishing	-	-	-	-	-	-	-	-	-	-	-	48	-	-	-	-
		1990	Bruce and Slaney 1991	electrofishing	-	-	-	-	-	-	-	-	-	-	-	616	-	-	-	-
		2007	Minnow 2009	electrofishing	-	-	-	-	-	-	-	-	-	-	-	198	-	-	-	-
		2012	Minnow 2013a	electrofishing	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-
		2013	Minnow 2013b	electrofishing	-	-	-	-	-	-	-	-	-	-	-	40	-	-	-	-
		2014[b]	Golder 2016	unknown	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-
		2018	Minnow 2019b	electrofishing	-	-	-	-	-	-	-	183	-	-	-	970	2	-	-	-
		2019	Minnow 2020b	electrofishing	-	-	-	-	-	-	-	43	-	-	-	322	-	-	-	-
		2020	Minnow 2021b	electrofishing	-	-	-	-	-	-	-	13	-	-	-	285	-	-	-	-
		2021	Minnow 2022b	electrofishing	-	-	-	-	-	-	-	42	-	-	-	37	11	-	-	-
	Lower Hazeltine Creek (Remediated)	1989	Imperial Metals 1990	minnow trap, electrofishing	-	-	-	-	-	-	-	-	2	-	-	142	-	8	-	-
		2007	Minnow 2009, Cariboo Envirotech 2008	electrofishing	6	158	38	9	-	9	24	-	-	-	18	96	6	-	-	-
		2021	Minnow 2022b	minnow trap	-	12	1	13	-	1	114	51	1	3	-	10	-	-	-	-
Edney Creek	Upper Edney Creek[c]	1989	Imperial Metals 1990	minnow trap, electrofishing	-	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-
		1995	HKP 1996b	electrofishing	-	-	-	-	-	-	-	-	-	-	-	295	-	-	-	-
		1996	HKP 1997a	electrofishing	-	-	-	-	-	-	-	-	-	-	-	435	-	-	-	-
		1997	HKP 1997b	minnow trap, electrofishing	-	-	-	-	-	-	-	1	-	-	-	200	-	-	-	-
		1998	Beak 1999	electrofishing	-	-	-	-	-	-	-	-	-	-	-	156	-	-	-	-
		2007	Minnow 2009, Cariboo Envirotech 2008	electrofishing	-	-	-	-	-	-	-	-	-	-	-	155	-	-	-	-
	Lower Edney Creek	1989	Imperial Metals 1990	minnow trap, electrofishing	-	12	16	-	-	-	-	7	3	-	-	24	-	869	-	-
		1995	HKP 1996b	electrofishing	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-
		1996	HKP 1996b, 1997a	electrofishing	-	-	-	-	-	-	-	-	-	-	-	158	-	-	-	-
		1997	HKP 1996b, 1997b	electrofishing	-	-	-	-	-	-	-	-	-	-	-	111	-	-	-	-
		1998	Beak 1999	electrofishing	-	-	-	-	-	-	-	-	-	-	-	111	-	-	-	-
		2007	Cariboo Envirotech 2008	unknown	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	-
		2014	DWB 2014	electrofishing	-	-	-	-	-	-	-	-	-	-	-	52	-	-	-	-
		2015	DWB 2015	electrofishing	-	16	-	-	-	-	11	27	-	18	-	125	4	-	39	-
	Lower Edney Creek (Remediated)	2016	Minnow 2018a	minnow trap, electrofishing, hoop net	-	17	6	11	-	4	58	2	8	9	-	245	33	-	-	10
		2017	Minnow 2018a	minnow trap	-	2	-	181	-	-	35	19	-	32	4	66	56	-	-	17
		2019	Minnow 2020a	minnow trap, hoop net	-	12	1	18	-	-	11	5	1	2	-	26	-	-	-	-
		2021	Minnow 2022b	minnow trap	-	5	6	25	-	16	-	13	-	4	1	17	8	-	-	-
	Lower Edney Creek (Reference)	2016	Minnow 2018a	minnow trap, electrofishing	-	4	3	21	-	-	12	-	1	1	-	93	1	-	-	-
		2017	Minnow 2018a	minnow trap	-	-	1	96	3	-	6	-	-	-	-	76	-	-	-	-
		2019	Minnow 2020a	minnow trap, hoop net	-	2	-	14	-	-	1	-	-	-	-	37	-	-	-	-
		2021	Minnow 2022b	minnow trap	-	-	-	37	-	-	-	-	-	-	-	47	-	-	-	-
Other	Horsefly River	2014[b]	Golder 2016	unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	30	-	-
	Lower Whiffle Creek	2007	Minnow 2009	unknown	-	27	-	-	-	-	-	-	-	-	-	118	-	-	-	-
	Soda Creek	2014[b]	Golder 2016	electrofishing	-	-	-	-	-	-	-	-	-	-	-	-	-	30	-	-

Note: "-" indicates species not captured.

[a] Electrofishing was conducted with the goal of obtaining 8 rainbow trout for tissue sampling purposes.

[b] Catch numbers are amount of fish retained for tissue analysis, more fish may have been collected.

[c] Upper Edney Creek includes all stations on Upper Edney as well as two tributaries of Edney Creek

[d] Fry could not be identified to species level but suspected to include Coho, Chinook, and Sockeye

was 1,500 fish/100 m^2 (Imperial Metals 1990). Sampling in 1991 documented rainbow trout YOY density of 287 to 444 fish/100 m^2 in Hazeltine Creek compared to Bootjack Creek which had a density of 465 fish/100 m^2 (Bruce and Slaney 1991). In 2007, upper Hazeltine Creek had a higher density of rainbow trout (400 to 700 fish/100 m^2) compared to the reference area, upper Edney Creek in the same year (200 to 640 fish/100 m^2; Minnow 2009). Rainbow trout densities in Edney Creek varied considerably over time, with baseline densities of 169 fish/100 m^2 in 1996 and 17 fish/100 m^2 in 1997 (Minnow 2014b).

Post-breach fish community and population monitoring in upper and lower Hazeltine Creek and lower Edney Creek has been completed specifically to document the effectiveness of the reconstructed fish habitat, as identified by a monitoring objective by the HRWG. This monitoring is detailed below for the upper and lower creek areas.

Post-breach monitoring in upper Hazeltine has been completed since the reopening of this remediated area as fish habitat in spring 2018 (see Section 1.1; Minnow 2019b, 2020b, 2021b, 2022b). Monitoring in upper Hazeltine Creek has shown that rainbow trout YOY densities in 2021 were 2 fish/100 m^2 in HAC-R1, 4 fish/100 m^2 in HAC-R2, and 12 fish/100 m^2 in HAC-R3 which corresponded (Minnow 2022b). These rainbow trout densities in 2021 were substantially lower than previous monitoring years (2018 to 2020) and historical pre-breach data (Beak 1999, Minnow 2014, 2017, 2018c; 2019b, 2020b, 2021b, 2022b). Approximately 2,450 YOY rainbow trout were produced in upper Hazeltine Creek in 2021 and were available for recruitment to Polley Lake; this is substantially lower than the estimated number of recruits in 2020 (~22,100), 2019 (~13,500) and 2018 (~49,300) and was based on a larger sampling area than in 2018 and 2019 (27,492 m^2 compared to 9,730 m^2; Minnow 2019b, 2020b, 2021b, 2022b). The estimate is also substantially lower than the estimated recruitment in upper Hazeltine Creek pre-mining in 1991 (54,500; Bruce and Slaney 1991), and only 3.3% of the combined production of Hazeltine and Bootjack creeks in 1991 (72,900; Bruce and Slaney 1991) based on a larger sampling area than the historic surveys (27,492 m^2 compared 15,000 m^2). However, the reduction was likely due to ongoing mortalities of older adults from Polley Lake with little replacement from the 2014 to 2017 cohorts when Hazeltine Creek was inaccessible to fish (Minnow 2022b). Collectively, although very few fish were present to use the available habitat in 2021, the weight-of-evidence indicates that the remediated fish habitat in upper Hazeltine Creek is performing as designed and expected, and it is anticipated that fish from the 2018 cohort (i.e., those which reared in the first year of creek accessibility since channel remediation) may spawn in 2022 (Minnow 2022b). There are no chemical constraints or food availability constraints with sufficient productivity in upper Hazeltine Creek to continue supporting rainbow trout. Fish habitat conditions are expected to continue to improve as the remediated habitat within upper Hazeltine Creek matures (Minnow 2022b).

Post-breach monitoring in lower Edney and Hazeltine creeks has been completed since 2016 and 2021, respectively (the year following remediation works in each area, see Section 1.1; Minnow 2018a, 2020a, 2022b). This post-breach monitoring has shown that all fish species historically documented in Edney Creek (Imperial Metals 1990, Minnow 2009) have been captured in the remediated section of lower Edney Creek between 2016 and 2021 except juvenile sockeye salmon (Table 3; Minnow 2018a, 2020a, 2022b). However, adult sockeye salmon were observed in lower creek areas during spawning surveys in 2019 and 2021 (Minnow 2020a, 2022b). More fish species were caught in remediated lower areas than in the upstream lower creek reference area in all monitoring years which is likely due to the proximity of remediated areas to Quesnel Lake. In 2021, this could also possibly be related to low-flow fish barriers documented in late summer and fall although the presence of coho salmon and rainbow trout in the upstream reference area suggests suitable passage between the remediated and unimpacted areas of lower Edney Creek during higher flow periods. Fish usage and spawning surveys in 2021 continued to provide evidence of salmonid spawning and rearing in remediated lower creek areas that was initially documented in 2016 and 2017 (Minnow 2018a). In addition to the repeat presence of YOY and juvenile coho salmon and rainbow trout, spawning surveys have documented sockeye salmon either actively spawning or as spawned out carcasses in 2019 and 2021, and coho salmon live and dead adults in 2021 (Minnow 2020a, 2022b). Based on fish usage and spawning survey data collected from 2016 to 2021, it appears that remediation objectives for these lower creek areas are being met and that the habitat is performing as designed and expected since remediation, particularly for they key target species, coho salmon, rainbow trout, and sockeye salmon (Minnow 2022b). There were no chemical constraints to fish usage and food availability is likely adequate to support fish species although the lower creek remediated areas are still recovering from recent remediation in 2020 and 2021 (Minnow 2021b, 2022b). Fish habitat conditions are expected to continue to improve as the remediated habitats in these lower creek areas mature (Minnow 2022b).

2.3 Quesnel Lake

2.3.1 Community / Population

The fish community of Quesnel Lake has been well characterized and includes a total of 21 species (Table 4). Prior to the TSF embankment breach, fish monitoring in Quesnel Lake was limited to collections for tissue quality analysis (2009, 2010, 2012, and 2014; Minnow 2011, 2013a; Golder 2016). These collections resulted in the capture of burbot, lake trout, largescale sucker, longnose sucker, mountain whitefish, peamouth chub, and rainbow trout (Table 5). Fish collections, primarily for tissue quality, have been undertaken annually since the TSF embankment breach in 2014, with community composition similar to that documented previously

Table 4: Fish Species Documented in Quesnel Lake

Common Name	Latin Name
Bridgelip Sucker	*Catostomus columbianus*
Bull Trout	*Salvelinus confluentus*
Burbot	*Lota lota*
Chinook Salmon	*Oncorhynchus tshawytscha*
Coho Salmon	*Oncorhynchus kisutch*
Kokanee	*Oncorhynchus nerka*
Lake Chub	*Couesius plumbeus*
Lake Trout	*Salvelinus namaycush*
Lake Whitefish	*Coregonus clupeaformis*
Largescale Sucker	*Catostomus macrocheilus*
Leopard Dace	*Rhinichthys falcatus*
Longnose Dace	*Rhinichthys cataractae*
Longnose Sucker	*Catostomus catostomus*
Mountain Whitefish	*Prosopium williamsoni*
Northern Pikeminnow	*Ptychocheilus oregonensis*
Peamouth Chub	*Mylocheilus caurinus*
Pygmy Whitefish	*Prosopium coulteri*
Rainbow Trout	*Oncorhynchus mykiss*
Redside Shiner	*Richardsonius balteatus*
Slimy Sculpin	*Cottus cognatus*
Sockeye Salmon	*Oncorhynchus nerka*

Notes: This table represents all documented species in Quesnel Lake, including those from external sources. See Table 5 for species captured during monitoring for Mount Polley Mine.

Table 5: Summary of Fish Collected in Quesnel Lake, 2009 to 2021

Area		Year	Report	Fishing Method	Bridgelip Sucker	Bull Trout	Burbot	Chinook Salmon	Coho Salmon	Kokanee	Lake Trout	Largescale Sucker	Longnose Dace	Longnose Sucker	Mountain Whitefish	Northern Pikeminnow	Peamouth Chub	Rainbow Trout	Redside Shiner	Sockeye Salmon	Juvenile Sucker sp.
Quesnel Lake (Exposed)	Near Hazeltine Creek	2009	Minnow 2011	gill net, angling	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-
		2010	Minnow 2011	gill net, angling	-	-	-	-	-	-	-	-	-	5[b]	-	-	-	5	-	-	-
		2012	Minnow 2013a	gill net	-	-	1	-	-	-	7	28	-	9	15	-	41	13	-	-	-
		2014[a]	Golder 2016	unknown	-	-	12	-	-	-	51	-	1	1	4	36	1	-	2	-	-
		2015	Zirnhelt and Dolighan 2015, Zirnhelt 2016	gill net, trap net	-	-	4	-	-	-	10	72	-	-	-	53	18	-	18	-	-
		2016	Minnow 2017b	hoop net	-	-	16	2	-	-	-	65	20	-	21	123	444	18	33	-	-
		2017	Minnow 2018a	gill net, minnow trap	-	1	3	-	-	2	-	-	-	-	-	27	-	2	-	1	2
		2018	Minnow 2019a	hoop net, minnow trap	-	0	5	0	0	3	0	27	0	10	0	10	11	1	4	1	4
		2019	Minnow 2020a	hoop net	-	-	17	-	-	30	-	103	4	-	-	16	13	3	-	-	-
			Minnow 2019c	hoop net, minnow trap	2	4	18	1	-	1	-	233	-	18	35	235	656	6	57	-	-
		2020	Minnow 2021a	hoop net	-	-	23	-	-	10	-	33	-	5	2	45	78	-	-	-	-
		2021	Minnow 2022a	hoop net	-	-	14	-	-	15	-	67	-	115	1	24	112	14	-	-	-
	Near Likely[a]	2014	Golder 2016	unknown	-	-	1	-	-	10	-	-	-	-	1	7	12	1	-	-	-
		2015	Golder 2016	unknown	-	-	-	-	-	8	-	-	-	-	-	-	-	8	-	-	-
	Near Cedar Point Park	2018	Minnow 2019a	gill net	-	-	-	-	-	-	11	-	-	-	1	-	-	-	-	16	-
		2019	Minnow 2020a	gill net	-	9	-	-	-	68	11	1	-	-	6	-	-	-	-	2	-
		2020	Minnow 2021a	gill net	-	1	-	-	-	-	9	-	-	1	5	-	1	-	-	-	-
		2021	Minnow 2022a	gill net, angling	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	1	-
	Near Poquette Creek	2018	Minnow 2019a	seine	-	-	-	-	-	28	-	-	-	-	2	-	-	4	-	7	-
	Middle[a,c]	2014	Golder 2016	unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-
		2015	Golder 2016	unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	-
	West Arm[a]	2014	Golder 2016	unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	-
		2015	Golder 2016	unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	-

Note: "-" indicates species not captured.

[a] Catch numbers are amount of fish retained for tissue analysis, more fish may have been collected, Golder 2016 Summary Report.

[b] Sample presented as longnose sucker but could possibly be largescale sucker.

[c] Potentially exposed.

Table 5: Summary of Fish Collected in Quesnel Lake, 2009 to 2021

Area		Year	Report	Fishing Method	Bridgelip Sucker	Bull Trout	Burbot	Chinook Salmon	Coho Salmon	Kokanee	Lake Trout	Largescale Sucker	Longnose Dace	Longnose Sucker	Mountain Whitefish	Northern Pikeminnow	Peamouth Chub	Rainbow Trout	Redside Shiner	Sockeye Salmon	Juvenile Sucker sp.
Quesnel Lake (Reference)	North Arm	2010	Minnow 2011	gill net, angling	-	-	-	-	-	-	-	-	-	5[b]	-	-	-	5	-	-	-
		2012	Minnow 2013a	gill net	-	-	-	-	-	-	-	3	-	-	6	-	-	7	-	-	-
		2014[a]	Golder 2016	unknown	-	-	-	-	-	10	-	-	-	-	-	31	2	-	-	13	-
		2015	Zirnhelt and Dolighan 2015, Zirnhelt 2016, Golder 2016	gill net, trap net	-	-	7	-	-	-	10	39	-	-	-	12	8	-	70	10[a]	-
		2016	Minnow 2017b	hoop net	-	-	14	-	-	-	-	23	-	2	2	53	5	-	130	-	-
		2017	Minnow 2018a	gill net	-	2	-	-	-	1	-	-	-	-	5	-	-	-	-	2	-
		2018	Minnow 2019a	tangle net, hoop net	-	-	-	-	-	70	-	-	-	-	-	7	-	-	-	-	-
	Near Grain Creek	2018	Minnow 2019a	gill net, hoop net, minnow trap	-	2	15	0	0	159	0	18	0	2	30	12	11	4	3	65	0
			Minnow 2019c	hoop net, seine net, gill net, minnow trap	1	4	23	1	1	-	3	94	-	-	71	157	100	3	226	7	-
		2019	Minnow 2020a	hoop net	-	-	18	-	-	62	-	31	-	-	23	9	148	4	-	12	-
		2020	Minnow 2021a	hoop net	-	-	5	-	-	3	-	41	-	20	2	59	90	-	-	-	-
		2021	Minnow 2022a	hoop net	-	2	13	-	-	35	-	32	-	12	21	8	18	2	-	1	-
	East Arm[a]	2014	Golder 2016	unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
		2015	Golder 2016	unknown	-	-	7	-	-	-	10	-	-	-	-	-	-	-	-	10	-
		2018	Minnow 2019a	gill net	-	2	-	-	-	6	8	1	-	-	7	-	-	6	-	18	-
		2019	Minnow 2020a	gill net	-	-	-	-	-	6	14	1	-	-	-	-	-	-	-	-	-
		2020	Minnow 2021a	gill net	-	-	7	-	-	-	15	-	-	-	1	-	-	-	-	-	-
		2021	Minnow 2022a	gill net	-	-	-	-	-	-	16	-	-	-	2	-	-	-	-	1	-
	Near Horsefly	2014[a]	Golder 2016	unknown	-	-	1	-	-	-	-	-	2	-	-	10	6	-	-	-	-
	Peninsula Bay	2016	Minnow 2017b	hoop net	-	2	25	-	1	-	-	100	7	4	63	67	24	1	189	-	-
		2017	Minnow 2018a	gill net	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-
		2018	Minnow 2019c	hoop net, gill net	1	-	10	-	1	-	-	89	-	8	4	124	43	2	117	-	-

Note: "-" indicates species not captured.

[a] Catch numbers are amount of fish retained for tissue analysis, more fish may have been collected, Golder 2016 Summary Report.

[b] Sample presented as longnose sucker but could possibly be largescale sucker.

[c] Potentially exposed.

(Table 5). Additional collections for federal MDMER Environmental Effects Monitoring (EEM) were undertaken in 2016 (Minnow 2016) and 2019 (Minnow 2019c).

The Mount Polley EEM included a population study of northern pikeminnow and largescale sucker (with a supporting evaluation of peamouth chub) in Phase 1 (Minnow 2016), and of redside shiner, peamouth chub, northern pikeminnow, and largescale sucker in Phase 2 (Minnow 2019c). The objective of this monitoring was to determine if exposure to Mount Polley mine effluent (discharged to Quesnel Lake starting in December 2015) effects the survival, growth, or reproduction of sentinel fish populations as compared to reference populations. Some differences in fish population endpoints (i.e., survival, energy storage, and energy use) were observed for the evaluated sentinel species in Phase 1 and 2 captured from effluent-exposed versus reference areas (Minnow 2016, 2019c). However, there was no concordance between the results of comparisons of effluent-exposed populations to the two reference area populations (i.e., the metrics for effluent-exposed populations were often intermediate between the two references) nor among the species evaluated. Overall, that effluent discharges from the mine were not affecting fish populations or fish health in the effluent-exposed relative to the reference areas (Minnow 2016, 2019c).

Catchability of fish during tissue quality sampling has indicated that catchability of lake trout at both exposed and reference areas of Quesnel Lake in 2021, while catchability of peamouth chub and northern pikeminnow were higher in 2021 at the exposed area relative to reference, which contrasted the findings from 2020 when higher CPUE for these species were documented in the reference area (Minnow 2022a).

2.3.2 Tissue Quality

Tissue quality of Quesnel Lake fish was evaluated following the TSF embankment breach in 2014. This monitoring has included 12 fish species and variously included whole body, muscle tissue, liver tissue, kidney tissue, and ovary tissue samples (Golder 2016; Minnow 2017b, 2018b). Concentrations of mercury and selenium in tissues of fish collected in Quesnel Lake from 2015 to 2017 (burbot, kokanee, lake trout, largescale sucker, northern pikeminnow, peamouth chub, redside shiner) were lower than guidelines for the protection of human health in all cases except for mercury in large burbot and lake trout (Table 6; Minnow 2017b, 2018b). Large burbot and large lake trout (greater than approximately 66 cm in length [fork length and total length, respectively]) had mercury concentrations at levels where consumption limitation should be considered in accordance with provincial and federal guidance (e.g., BCMOE 2014; CFIA 2015). Smaller burbot and lake trout, as well as all other species can be safely consumed at consumption levels typical of the general population. There was no evidence that the Mount Polley Mine had an influence on mercury concentrations in burbot or lake trout. Rather, these

Table 6: Comparison of Muscle and Whole Body Samples Collected in Quesnel Lake to Consumption Guidelines for Protection of Human Health or Guidelines for the Protection of Aquatic Life, 2015 to 2021

Sample Collection Timing	Area	Species	Tissue	Sample Size	Mercury		Selenium				
					Health Canada Human Health (0.5 mg/kg ww)		BCMOE Human Health (Moderate = 14.5 mg/kg dw) (High = 7.3 mg/kg dw)			BCMOE Guideline (4 mg/kg dw)	
					Mean	Frequency > guideline	Mean	Frequency > moderate	Frequency > high	Mean	Frequency > guideline
Fall 2015 Golder (2016), Minnow (2017b)	near Hazeltine Creek	Burbot	Muscle	4	0.353	0%	2.79	0%	0%	2.79	0%
		Lake Trout	Muscle	10	0.218	10%	1.86	0%	0%	1.86	0%
		Largescale Sucker	Muscle	8	0.118	0%	3.13	0%	0%	3.13	13%
		Northern Pikeminnow	Muscle	7	0.244	0%	2.02	0%	0%	2.02	0%
		Peamouth Chub	Whole Body	8	-	-	-	-	-	3.08	13%
		Redside Shiner	Whole Body	8	-	-	-	-	-	2.72	0%
	near Likely	Kokanee	Muscle	8	0.0921	0%	2.43	0%	0%	2.43	0%
	East Arm (Reference)	Burbot	Muscle	7	0.256	14%	2.41	0%	0%	2.41	0%
		Lake Trout	Muscle	10	0.262	10%	1.59	0%	0%	1.59	0%
	Near Grain Creek (North Arm, Reference)	Largescale Sucker	Muscle	8	0.109	0%	1.59	0%	0%	1.59	0%
		Peamouth Chub	Whole Body	8	-	-	-	-	-	2.19	0%
		Redside Shiner	Whole Body	8	-	-	-	-	-	1.98	0%
	Quesnel River	Rainbow Trout	Muscle	8	0.0646	0%	2.17	0%	0%	2.17	0%
Spring 2016 (Minnow 2017b)	near Hazeltine Creek	Largescale Sucker	Muscle	8	0.112	0%	2.76	0%	0%	2.76	0%
		Northern Pikeminnow	Whole Body	8	-	-	-	-	-	3.08	0%
		Peamouth Chub	Muscle	8	0.242	0%	2.75	0%	0%	2.75	0%
	Near Grain Creek (North Arm, Reference)	Largescale Sucker	Muscle	8	0.105	0%	1.59	0%	0%	1.59	0%
		Northern Pikeminnow	Whole Body	8	-	-	-	-	-	2.12	0%
		Peamouth Chub	Muscle	8	0.150	0%	1.61	0%	0%	1.61	0%
Fall 2017 (Minnow 2018b)	near Hazeltine Creek	Northern Pikeminnow	Whole Body	8	-	-	-	-	-	2.32	0%
	Quesnel River	Rainbow Trout	Muscle	8	0.0928	0%	3.23	0%	13%	3.23	13%
Fall 2018 (Minnow 2019a)	near Hazeltine Creek	Lake Trout	Muscle	8	0.313	0%	2.18	0%	0%	2.18	0%
		Northern Pikeminnow	Whole Body	8	-	-	-	-	-	2.37	0%
		Peamouth Chub	Muscle	8	0.123	0%	3.03	0%	0%	3.03	13%
	near Grain Creek (Reference)	Northern Pikeminnow	Whole Body	8	-	-	-	-	-	1.72	0%
		Peamouth Chub	Muscle	8	0.139	0%	2.08	0%	0%	2.08	0%
	East Arm (Reference)	Lake Trout	Muscle	8	0.443	13%	2.21	0%	0%	2.21	0%
	North Arm (Reference)	Kokanee	Muscle	8	0.0944	0%	1.97	0%	0%	1.97	0%
	near Likely	Kokanee	Muscle	8	0.0873	0%	2.11	0%	0%	2.11	0%
	Quesnel River	Rainbow Trout	Muscle	8	0.0497	0%	2.36	0%	0%	2.36	0%
Fall 2019 (Minnow 2020a)	near Hazeltine Creek	Lake Trout	Muscle	9	0.305	11%	1.76	0%	0%	1.76	0%
		Northern Pikeminnow	Whole Body	8	-	-	-	-	-	3.36	38%
		Peamouth Chub	Muscle	8	0.137	0%	2.90	0%	0%	2.90	0%
	near Grain Creek (Reference)	Northern Pikeminnow	Whole Body	8	-	-	-	-	-	1.60	0%
		Peamouth Chub	Muscle	8	0.139	0%	2.08	0%	0%	2.08	0%
	East Arm (Reference)	Lake Trout	Muscle	8	0.481	50%	1.87	0%	0%	1.87	0%
	Quesnel River	Rainbow Trout	Muscle	8	0.0395	0%	2.35	0%	0%	2.35	0%
Fall 2020 (Minnow 2021a)	near Hazeltine Creek	Northern Pikeminnow	Whole Body	8	-	-	-	-	-	3.12	25%
		Peamouth Chub	Muscle	8	0.144	0%	3.26	0%	0%	3.26	0%
	Near Grain Creek (North Arm, Reference)	Northern Pikeminnow	Whole Body	8	-	-	-	-	-	1.82	0%
		Peamouth Chub	Muscle	8	0.124	0%	1.72	0%	0%	1.72	0%
	near Cedar Point	Lake Trout	Muscle	8	0.319	13%	1.96	0%	0%	1.96	0%
	East Arm (Reference)	Lake Trout	Muscle	8	0.625	63%	1.87	0%	0%	1.87	0%
	Quesnel River	Rainbow Trout	Muscle	8	0.0545	0%	1.96	0%	0%	1.96	0%
Fall 2021 (Minnow 2022a)	near Hazeltine Creek	Northern Pikeminnow	Whole Body	8	-	-	-	-	-	2.95	0%
		Peamouth Chub	Muscle	8	0.182	0%	3.94	0%	0%	3.94	38%
	Near Grain Creek (North Arm, Reference)	Northern Pikeminnow	Whole Body	8	-	-	-	-	-	1.81	0%
		Peamouth Chub	Muscle	8	0.146	0%	1.76	0%	0%	1.76	0%
	near Cedar Point	Lake Trout	Muscle	8	0.243	0%	1.77	0%	0%	1.77	0%
	East Arm (Reference)	Lake Trout	Muscle	8	0.632	63%	2.07	0%	0%	2.07	0%
	Quesnel River	Rainbow Trout	Muscle	8	0.0544	0%	2.48	0%	0%	2.48	0%

Indicates mean mercury concentration greater than Health Canada's Human Health concentration for muscle tissue in fish (0.5 mg/kg ww; CFIA 2015).

Value exceeds Se Guideline for Human Health, general population, high consumption (7.3 mg/kg dw; BCMOE 2014).

Indicates mean selenium concentration greater than the BCMOE Human Health guideline for moderate fish consumption (14.5 mg/kg dw; BCMOE 2014).

Indicates mean selenium concentration greater than the BCMOE guideline for muscle tissue or whole body in fish (4 mg/kg dw; BCMOE 2014).

Notes: ww = wet weight; dw = dry weight. "-" indicates no applicable.

species are piscivores (eat other fish) and are expected to have naturally higher concentrations of mercury (which is known to biomagnify). Concentrations of selenium in all fish species and tissues collected in Quesnel Lake from 2015 to 2017 were below BCWQGs for the protection of aquatic life.

The evaluation of fish tissue quality results collected as part of the CEMP (i.e., 2018 to 2021) was focused on primary and secondary analytes identified in Minnow (2020a, 2021a, 2022a; see Section 2.1.2). Fish tissue quality monitoring from 2018 to 2021 evaluated up four tissues (muscle, liver, kidney, and ovary) from four species (lake trout, northern pikeminnow, peamouth chub, and rainbow trout) in Quesnel Lake[9]. This monitoring has reported mean mercury and selenium concentrations in fish muscle tissue from 2018 to 2021 were below guidelines for the protection of human health (i.e., that fish are usable for moderate human consumption) except mercury in lake trout from the reference area and in a single lake trout from the exposed area each year in 2019 and 2020 (Figures 5 and 6, Table 6; Minnow 2022a). Concentrations of selenium in fish muscle and ovary tissue were also generally below the guideline for aquatic life, except for occasional exceedances for peamouth chub (muscle) and northern pikeminnow (whole body) samples from the exposed area. Ovary selenium concentrations in each species have been well below the threshold for reproductive effects since 2015 with a single exception in 2018 (for peamouth chub at the exposed area; Figure 5; Minnow 2022a). Concentrations of all primary and secondary analytes except cobalt and silver showed elevated concentrations consistent with a pattern of mine-exposure (i.e., higher in exposed fish tissues compared to reference) in at least one year between 2019 and 2021, in at least one tissue type from at least one species. Despite this, there is either no evidence of increasing concentrations of these analytes over time in exposed tissues, the results are not consistent among fish tissues, and/or the results are not supported by zooplankton tissue quality results, indicating that the weight of evidence does not support a pattern of increasing analyte concentrations over time due to mine-exposure (Minnow 2022a).

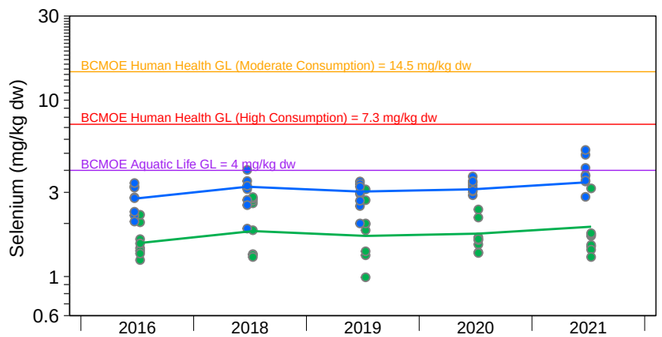
2.4 Quesnel River

2.4.1 Community / Population

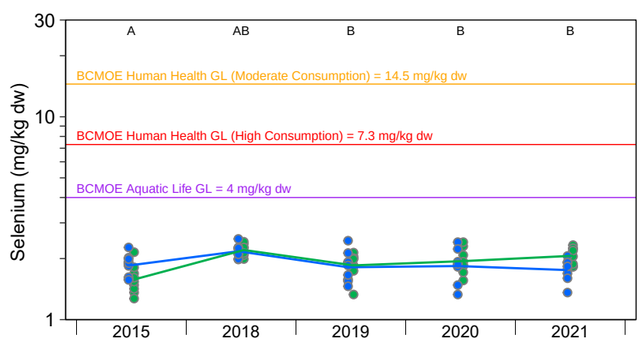
Fish were sampled in the Quesnel River in 2014, 2015, and annually from 2017 to 2021, targeting rainbow trout, primarily by angling. Other species were captured, including bull trout, burbot, mountain whitefish, and peamouth chub (Table 7). Rainbow trout that were collected in the Quesnel River from 2015 to 2021 were of relatively similar age (mean: 2.8 to 5.8 years) and size

[9] A fifth species (kokanee) was monitored in 2018 only, therefore is not included in this summary of historical findings (Minnow 2019a).

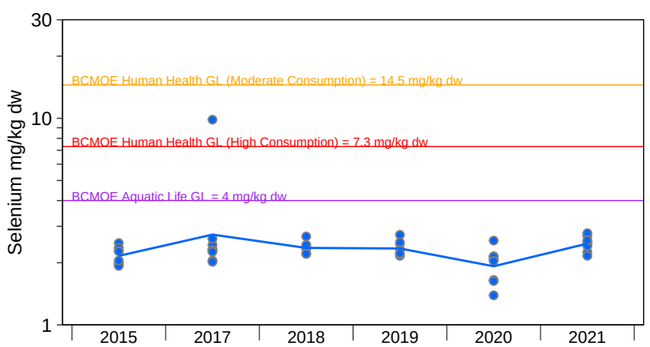
Quesnel Lake
Peamouth Chub - Muscle



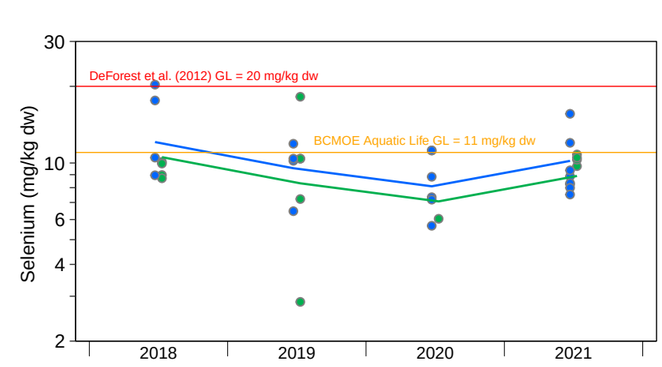
Quesnel Lake
Lake Trout - Muscle



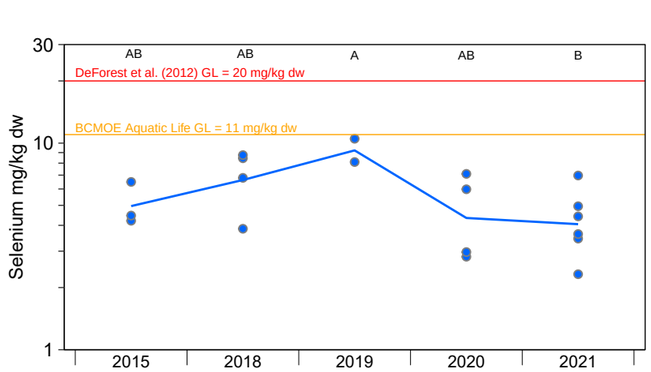
Quesnel River
Rainbow Trout - Muscle



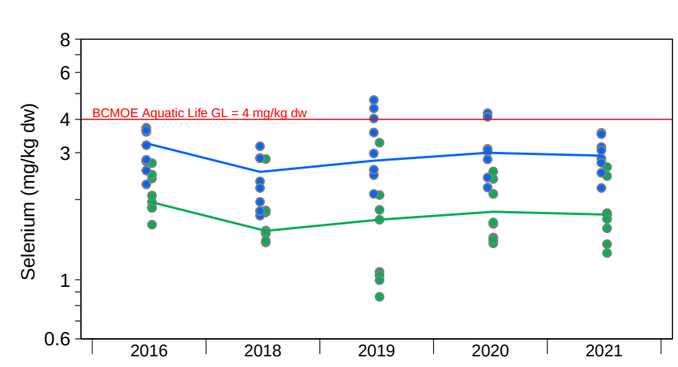
Quesnel Lake
Peamouth Chub - Ovary



Quesnel Lake
Lake Trout - Ovary



Quesnel Lake
Northern Pikeminnow - Whole Body



Exposed Reference

Figure 5: Concentrations of Selenium in Fish Tissue from Quesnel Lake and Quesnel River, 2015 to 2021[a]

Notes: BCMOE = British Columbia Ministry of the Environment; GL = Guideline; dw = dry weight; ww = wet weight. Individual samples are plotted and lines join the least−squares estimated mean values for years included in the statistical analysis (i.e., not below the laboratory reporting limit). Statistical analyses were conducted using a two−way ANOVA with factors Area and Year. The models were fit using Maximum Likelihood Estimation with an assumed log−normal distribution. Years that share a letter (e.g., A,B,C) have ratios of concentrations (Exposed:Reference) that do not differ significantly (p−value < 0.05) among years. Letter A was assigned to the year with the highest ratio of concentrations (Exposed:Reference). Only years with samples from both reference and exposed areas are plotted.

[a] For lake trout collection, reference area is the East Arm of Quesnel Lake and exposed area is near Cedar Point Park. For peamouth chub and northern pikeminnow, reference area is neat Grain Creek and exposed area is near Hazeltine Creek. Rainbow trout tissue was collected in Quesnel River.

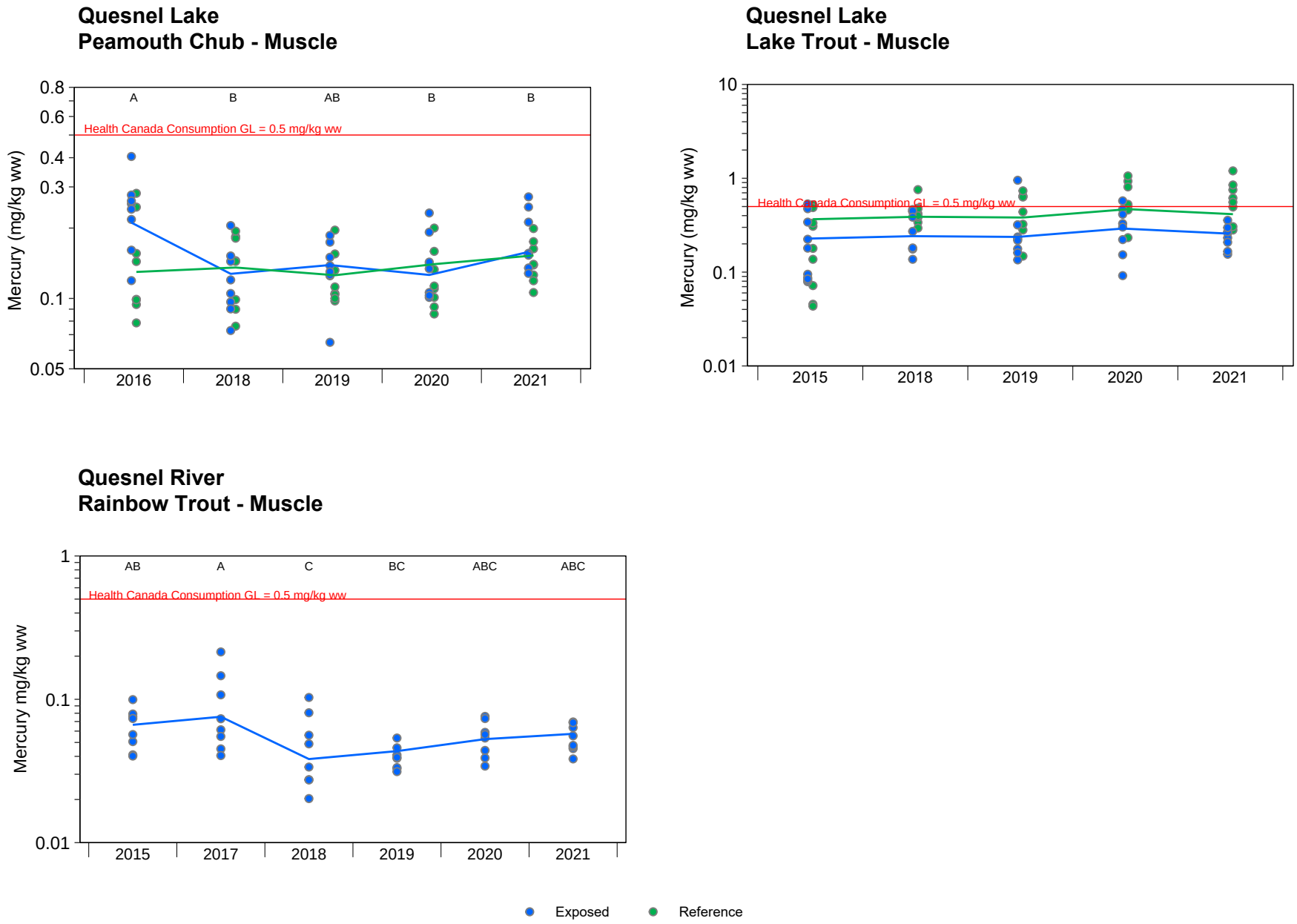


Figure 6: Concentrations of Mercury in Fish Tissue from Quesnel Lake and Quesnel River, 2015 to 2021[a]

Notes: BCMOE = British Columbia Ministry of the Environment, GL = Guideline; dw = dry weight, ww = wet weight. Individual samples are plotted and lines join the least−squares estimated mean values for years included in the statistical analysis (i.e., not below the laboratory reporting limit). Statistical analyses were conducted using a two−way ANOVA with factors Area and Year. The models were fit using Maximum Likelihood Estimation with an assumed log−normal distribution. Years that share a letter (e.g., A,B,C) have ratios of concentrations (Exposed:Reference) that do not differ significantly (p−value < 0.05) among years. Letter A was assigned to the year with the highest ratio of concentrations (Exposed:Reference). Only years with samples from both reference and exposed areas are plotted.

[a] For lake trout collection, reference area is the East Arm of Quesnel Lake and exposed area is near Cedar Point Park. For peamouth chub and northern pikeminnow, reference area is neat Grain Creek and exposed area is near Hazeltine Creek. Rainbow trout tissue was collected in Quesnel River.

Table 7: Summary of Fish Collected in Quesnel River, 2014 to 2021

Year	Report	Fishing Method	Bull Trout	Burbot	Mountain Whitefish	Peamouth Chub	Rainbow Trout
2014	Golder (2016)	unknown	-	-	-	3	12
2015	Zirnhelt and Dolighan (2015)	angling	-	-	-	-	8
2017	Minnow (2018b)	angling	-	1	2	-	8
2018	Minnow (2019a)	angling	-	-	-	-	8
2019	Minnow (2020a)	angling	1	-	-	-	9
2020	Minnow (2021a)	angling	1	-	-	-	9
2021	Minnow (2022a)	angling	-	-	11	-	10

Note: "-" indicates species not captured.

(mean fork length: 28.8 to 32.5 cm) among years (Minnow 2022a). The CPUE for rainbow trout in 2021 at the Quesnel River sampling area was higher than in the previous two years (2019 and 2020; Minnow 2022a).

2.4.2 Tissue Quality

Rainbow trout tissue quality monitoring in the Quesnel River from 2015 to 2021 indicated that mean muscle concentrations of mercury and selenium were below the guidelines for the protection of human health throughout this period (Figures 5 and 6, Table 6), demonstrating that these fish are usable for moderate human consumption (Minnow 2022a). Selenium concentrations in rainbow trout muscle were below the BCWQG for the protection of aquatic life from 2015 to 2021 except one sample in 2017 (Figure 5), and in ovary tissue were below the BCWQG over this period except for one sample each year in 2018, 2019, and 2021 (Minnow 2022a).

Temporal comparisons from 2015 to 2021 increased concentrations of arsenic, phosphorus, selenium, and sodium in various tissues in more or more years since 2015. However, temporal inconsistencies (i.e., for arsenic and selenium), inconsistencies among tissue types (i.e., for phosphorous and selenium), and lack of corroboration in tissues from other fish species in Quesnel Lake, suggest that the observed differences may be reflective of natural variability of these analytes within the area. Therefore, no corroborated (reasonably unequivocal) temporal changes have been identified for rainbow trout (muscle, liver, and kidney tissue) collected from the Quesnel River between 2015 and 2021 (Minnow 2022a).

3 STUDY DESIGN AND RATIONALE

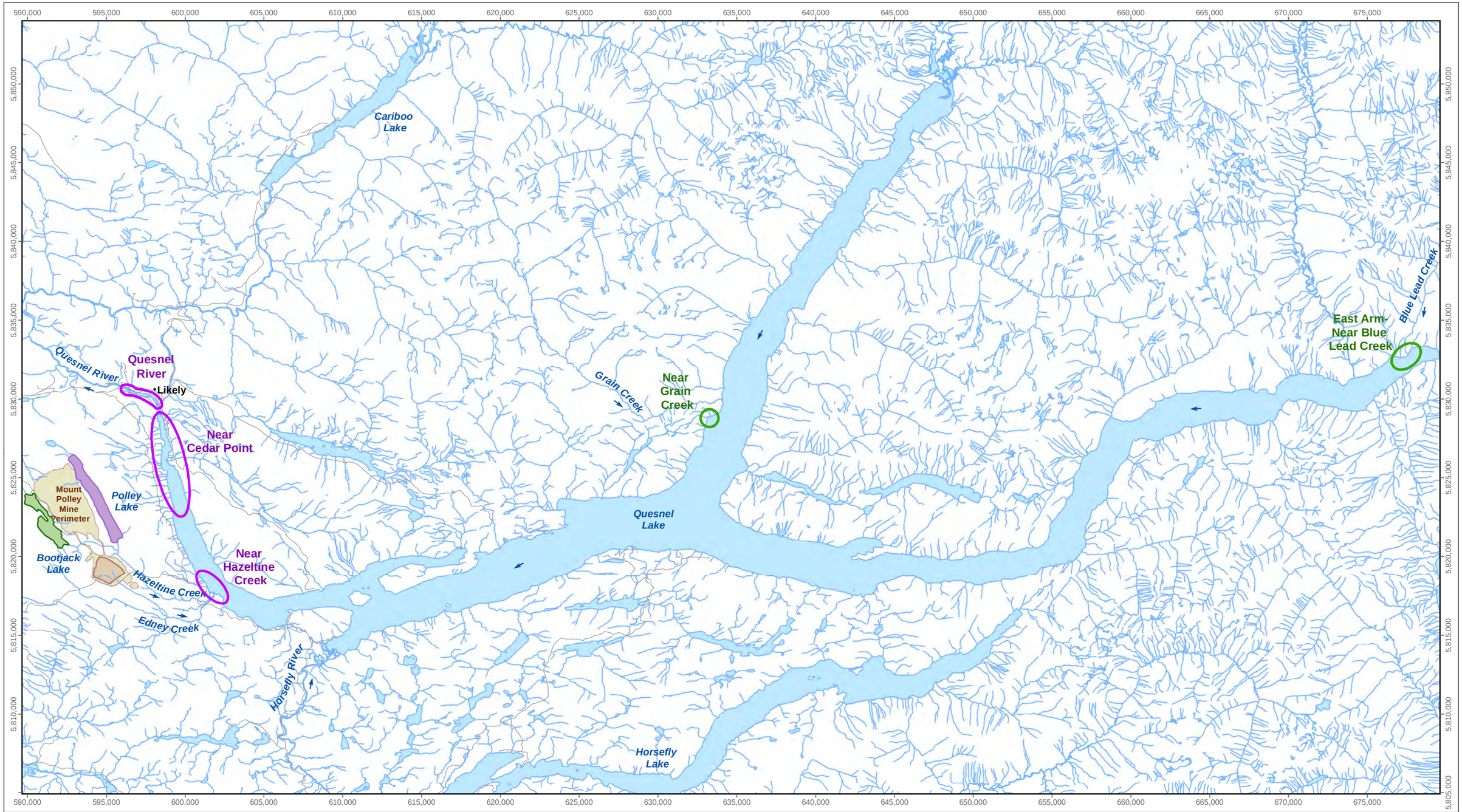
Fish monitoring under the CEMP is designed to meet the combined needs of: 1) operational monitoring (including the discharge of treated effluent to Quesnel Lake); 2) monitoring of the impact of the TSF embankment breach; and 3) monitoring of the response to remediation following the TSF embankment breach. As previously indicated, fish monitoring includes fish tissue quality monitoring, sentinel fish population monitoring, fish habitat characterization and fish usage monitoring, and fish community monitoring. An overview of the proposed fish monitoring program is provided in Figures 7 and 8 and Table 8. This CEMP Fish Monitoring Plan includes revisions to the study design (i.e., updates to monitoring frequency) relative to the previous study design (MPMC 2019); revisions that are based on a Qualified Professional (QP) review of existing data. This section details the updated study design, outlines revisions compared to the previous study design (MPMC 2019), and provides the rationale associated with the proposed study design revisions. The frequencies for all monitoring components and areas will be reviewed following interpretation of data collected in 2025, and design modifications (e.g., changes to monitoring frequency or locations) will be made based on a QP review of the data.

3.1 Tissue Quality

Fish tissue quality monitoring will continue to focus on Polley Lake and Quesnel Lake, with un-impacted reference areas identified for each mine-influenced sampling area (i.e., Bootjack Lake for Polley Lake, unaffected areas of Quesnel Lake for exposed areas of Quesnel Lake; Figure 7, Table 8). These monitoring areas are consistent with those included in the previous study design (MPMC 2019).

In Polley Lake, fish tissue quality monitoring is undertaken to monitor the combined influence of general mine proximity, uncontrolled surface runoff from the north dump (2006 to 2009), and influence of the TSF embankment breach. Monitoring in Polley Lake (and reference) will continue to focus on the collection of female rainbow trout and longnose sucker in the spring so that ripe ovaries can be collected to evaluate selenium in these tissues. The full complement of tissues collected will continue to include muscle, liver, kidney, and ovary (Table 8). This sampling approach for Polley Lake and reference (species, tissues, and sampling timing) is consistent with the previous study design (MPMC 2019).

Fish tissue quality monitoring in Quesnel Lake and Quesnel River, is used to evaluate the combined influence of the TSF embankment breach and the discharge of Mount Polley mine effluent (December 2015 to present). Data collected for this fish tissue monitoring in Quesnel Lake will serve satisfy the MDMER EEM requirement for fish tissue selenium study



LEGEND

Fish Sampling Area
- Exposed
- Reference

Fish Sampling Area
- Exposed Area
- Reference Area

- Tailings Storage Facility
- Active Mine Operation

0 3.75 7.5 15 km

N W E S

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Mount Polley CEMP Fish Monitoring Areas, Lakes and Quesnel River

Date: January 2023
Project 227202.0029

minnow environmental inc.

Figure 7

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LEGEND

- Fish Fence (August 2021)
- Fish Fence (July to October 2020)
- Fish Fence (April 2015 - April 2018)
- Fish Fence (April 2018 - July 2020)
- Reach Break
- Fish Usage and Habitat Sampling Area
- Historic Watercourse

0 0.75 1.5 3 km

N W E S

Projection: North American Datum 1983 UTM Zone 10U

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Mount Polley CEMP Fish Monitoring Areas, Creeks

Date January 2023
Project 227202.0029

minnow environmental inc.

Figure 8

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Table 8: Mount Polley CEMP Fish Monitoring Plan Overview

A) Fish Tissue Quality Monitoring[a]

Water Body	Type	Fish Species	Tissues[b,c]	Replication	Frequency	Rationale
Polley Lake	Exposed	RB, LSU	M,L,K,O	8	every 3 years	immediately adjacent to mine and breach-influenced
Bootjack Lake	Reference	RB, LSU	M,L,K,O	8	every 3 years	reference for Polley Lake[d]
Quesnel Lake	Exposed	RB, LT, NSC, PCC	M,L,K,O	8	every 3 years	adjacent to effluent discharge and breach-influenced
	Reference	RB, LT, NSC, PCC	M,L,K,O	8	every 3 years	reference for Quesnel Lake exposed
Quesnel River	Far-Field Exposed	RB	M,L,K,O	8	annual	far-field exposed area near Quesnel Lake outlet

Notes: RB = rainbow trout, LSU = longnose sucker, LT = lake trout, NSC = northern pikeminnow, PCC = peamouth chub.

[a] All fish tissues will be evaluated for the following analytes: percent moisture, metals by ICP-MS scan, and total mercury (Table 9).

[b] Fish tissues: M = muscle (except for small-bodied fish [e.g., juvenile NSC], which will be submitted whole), L = liver, K = kidney, O = ovary (as available/developed; note that females will only be specifically targeted in Polley and Bootjack lakes).

[c] Except for small bodied fish (juvenile NSC) which will be submitted as wholebody samples for analyses.

[d] Bootjack Lake is retained as the reference for Polley Lake due to the fact that it has not been notably affected by the mine, there is a long-term dataset available for it, and its watershed includes similar geology to Polley Lake. The latter is not true for other potential reference areas.

B) Fish Population Monitoring

Water Body	Type	Fish Species	Endpoints[a]	Replication	Frequency	Rationale
Polley Lake	Exposed	RB	L,W,C	100 adults, 100 juveniles	annual (fall)	immediately adjacent to mine and breach-influenced

Note: RB = rainbow trout.

[a] L = length-frequency distribution (indicative of recruitment and survival), W = weight, C = condition (indicative of overall health / energy storage).

C) Fish Habitat Characterization and Usage Monitoring

Water Body	Type	Fish Species	Measures	Frequency	Rationale
Upper Hazeltine Creek (HAC-R1, HAC-R2, HAC-R3)	Exposed	RB, LSU	Fish habitat characterization[b], fish occupancy and meristics[c]	annual	immediately adjacent to mine and breach-impacted
Frypan Creek (FPC-R3)	Reference	RB, LSU		annual	reference for Upper Hazeltine Creek
Lower Hazeltine Creek (HAC-R5)	Exposed	all/ any[a]		every 2 years	breach-impacted
Lower Edney Creek (EDC-EXP)	Exposed	all/ any[a]		every 2 years	breach impacted
Lower Edney Creek (EDC-REF)	Reference [d]	all/ any[a]		every 2 years	upstream unimpacted area; reference for lower Hazeltine Creek and impacted area of lower Edney Creek

Notes: RB = rainbow trout, LSU = longnose sucker.

[a] A total of 20 fish species have been documented in Quesnel Lake (SNC-Lavalin 2015) and would have access to Lower Hazeltine and Lower Edney creeks.

[b] Fish habitat characterization using methodology outlined in Section 4.2.4

[c] Fish occupancy as determined by observation (including spawning, and general presence) and by fishing with record of catch/effort and meristic measures (length and weight).

[d] Lower Edney Creek reference area will be located in an unimpacted area upstream of the breach influence (see Figure 8).

D) Fish Community Monitoring

Water Body	Collection Methods [a,b,c]	Endpoint	Frequency	Rationale
Polley Lake	HN, SN	CPUE[e]	every 3 years (spring) / annual (fall)	to support fish tissue quality (every 3 years) and population monitoring (annual)
Bootjack Lake	HN, SN	CPUE [e]	every 3 years	to support fish tissue quality monitoring
Upper Hazeltine Creek (HAC-R1, HAC-R2, HAC-R3)	EF[d]	CPUE [e]	annual	to support fish population and habitat usage monitoring
Frypan Creek (FPC-R3)	EF[d]	CPUE [e]	annual	to support fish population and habitat usage monitoring
Lower Hazeltine Creek (HAC-R5)	MT, SN	CPUE [e]	every 2 years	to support fish habitat usage monitoring
Lower Edney Creek (EDC-EXP and EDC-REF)	MT, SN	CPUE [e]	every 2 years	to support fish habitat usage monitoring
Quesnel Lake	HN, MT, SN, GN	CPUE [e]	every 3 years	to support fish tissue quality monitoring
Quesnel River	AG	CPUE [e]	annual	to support fish tissue quality monitoring

Note: Qualitative fish community data will be collected to support all fish tissue, fish population, and fish habitat usage collections.

[a] In order of preference for non-lethal fish collection methods whenever possible (e.g., hoop netting, minnow trapping, electrofishing).

[b] HN = hoop netting, MT = minnow trapping, SN = seining, EF = electrofishing, GN = gill netting, AG = angling.

[c] Prohibited in waters over twenty degrees Celsius.

[d] Subject to electrofishing prohibition during spawning and incubation periods and in waters below five degrees Celsius.

[e] CPUE = catch-per-unit-effort. For HN and MT, CPUE will be expressed as catch per trap hour/day; for SN, CPUE will be expressed as catch per unit area; for EF, CPUE will be expressed as catch per unit electroshocking time and per unit area; for GN, CPUE will be expressed as catch per unit net surface area-time; and for AG, CPUE will be expressed as catch per unit of angling effort.

associated with the Mount Polley Mine effluent discharge in Quesnel Lake (Minnow 2022c). In Quesnel Lake (exposed and reference; Figure 7), fish tissue quality monitoring will continue to focus on the sentinel species identified in the previous study design (rainbow trout, lake trout, northern pikeminnow, and peamouth chub; MPMC 2019). These sentinel species were selected based on their trophic position, their status as sportfish or non-sportfish, their typical home range sizes, and the availability of historical tissue quality data. Rainbow trout (to be collected in the Quesnel River near the lake outlet; see below, Figure 7) and lake trout were selected as the sentinel sportfish species to monitor potential changes in tissue quality over time relative to human consumption of sportfish. Northern pikeminnow and peamouth chub were selected as sentinel species with small home ranges to monitor potential changes in fish tissue quality associated with the TSF embankment breach and effluent discharge from the perspective of aquatic ecosystem health. Fish species with small home ranges are better monitors of the potential effects of defined point sources (since they are more continuously exposed) than fish with larger home ranges (e.g., Environment Canada 2012). Fish collections in Quesnel Lake and Quesnel River will occur in late summer consistent with previous collections. The full complement of tissues collected larger bodied fish (i.e., lake trout, rainbow trout, and peamouth chub) will continue to include muscle, liver, kidney, and ovary (Table 8). Ovary will only be sampled when available (i.e., when fully developed in mature females); additional fish will not be targeted and sacrificed to achieve the target sample size for ovary tissues. The small bodied fish (i.e., juvenile northern pikeminnow) will be submitted as headless carcasses (as the heads will be submitted for otolith extraction and age determination). This sampling approach (species, tissues, and sampling timing) for Quesnel Lake and Quesnel River is consistent with the previous study design (MPMC 2019).

Tissues will be collected for the analytical determination of moisture content, metals, and mercury (see Section 4.3). Supporting data will include CPUE, length, weight, and age (see below). Data interpretation will be based on a combination of: 1) statistical comparison to previous conditions; 2) statistical comparison to reference conditions (except for Quesnel River for which a reference does not exist); and 3) concentrations relative to fish tissue quality guidelines for the protection of aquatic life and human health (BCMOE 2014; CFIA 2015). A sample size of eight fish per species per area will provide replication for the statistical contrasts. Fish community and population data will be collected to support all fish tissue quality monitoring in Quesnel Lake and Polley Lake (as discussed in greater detail below). All collections will be supported by capture records for all species and documentation of effort that will be used to calculate catch-per-unit-effort (CPUE). All fish selected for tissue quality will be subject to measurement of length, weight (total and fork), and the collection of structures for age determination. Detailed methodology for fish collection, measurement, tissue sample collection, tissue sample

processing, sample handling and laboratory analysis, QA/QC, DQR, data handling, interpretation, and reporting is provided in Section 4. The fish tissue quality monitoring (monitoring locations and endpoints) and supporting measures detailed herein are consistent with the previous approved CEMP Fish Monitoring Plan (MPMC 2019).

The revised frequency of fish tissue quality monitoring in Polley Lake and Quesnel Lake (and associated reference areas) will be every three years (Table 8). This represents a decrease in frequency relative to the previous study design, which was annual (MPMC 2019). Monitoring was completed in Polley Lake most recently in 2022, therefore the next monitoring event will occur in 2025 for Polley Lake (and reference) under the revised monitoring frequency (Table 8). This decrease in frequency is guided by previous results that have not shown a pattern of increasing analyte concentrations since the breach (2014) despite pre-existing elevation of several analytes relative to reference in various tissue types in one or both species evaluated (rainbow trout and longnose sucker). Mean selenium and mercury concentrations in fish from Polley Lake have been below guidelines for the protection of human health since 2015, indicating that fish are useable for human consumption. Selenium concentrations in muscle tissue and occasionally ovary tissues of fish from Polley Lake have exceeded guidelines for the protection of aquatic life, but neither selenium nor mercury have increased over the post-breach period, relative to reference (see Section 2.1.2; Minnow 2022a). This stability, or lack of increasing analyte concentrations, over time is supportive of a decrease in monitoring frequency. It is anticipated that a sampling frequency of every three years will be sufficient to continue to track potential temporal changes in fish tissue quality in Polley Lake, and continued monitoring will provide information regarding human health through consumption of rainbow trout.

Fish tissue quality monitoring in Quesnel Lake will serve to meet monitoring requirements under both this CEMP Fish Monitoring Plan and the MDMER EEM. A monitoring frequency of every three years is required under the MDMER EEM which was implemented most recently in 2021 (Minnow 2022c). Therefore, the next fish tissue quality monitoring event in Quesnel Lake will occur in 2024, and every three years thereafter (unless aqueous selenium concentrations in effluent drop below the criteria for a fish tissue study, see Section 1.1), to fulfill the requirement for fish tissue selenium study associated with the Mount Polley Mine effluent discharge in Quesnel Lake (Government of Canada 2022; Minnow 2022c). This represents a decrease in frequency relative to the previous study design, which was annual (MPMC 2019). This decrease in monitoring frequency is guided by previous results showing that, for the majority of analytes assessed (primary and secondary analytes), there is either no evidence of increasing concentrations over time in exposed fish tissues or the results are not consistent among tissue types, indicating that the weight of evidence does not support a pattern of increasing analyte concentrations over time due to mine-exposure (see Section 2.3.2; Minnow 2022a). In addition,

mean selenium and mercury concentrations in Quesnel Lake fish have been below guidelines for the protection of human health since 2015 (except for reference fish occasionally), indicating that fish are useable for human consumption. Selenium concentrations in muscle and ovary tissues of fish from Quesnel Lake have occasionally exceeded guidelines for the protection of aquatic life, but selenium has not increased temporally (see Section 2.1.2; Minnow 2022a). Overall, these results indicate a temporal stability (or lack of evidence of increase) for analyte concentrations that is supportive of a decrease in monitoring frequency to every three years, aligning with the MDMER EEM fish tissue selenium monitoring requirement.

The frequency of fish tissue quality monitoring in Quesnel River will continue to be annual, with the next monitoring event to occur in 2023. This monitoring frequency is consistent with the previous study design (MPMC 2019) and will allow for the continued evaluation of potential human exposure through consumption of sport fish (i.e., Quesnel River rainbow trout; Minnow 2022a).

3.2 Sentinel Populations

Fish population monitoring will continue to focus on Polley Lake to track the population structure of rainbow trout (Figure 7, Table 8). Specifically, with the inaccessibility of Hazeltine Creek (the major spawning and juvenile rearing location for Polley Lake Fish) between August 2014 and spring 2018, recruitment of Polley Lake rainbow trout was substantially diminished for four years. The purpose of the fish population monitoring in Polley Lake will be to continue to document changes in population structure over time (i.e., recovery of age-class balance) following the restoration of upper Hazeltine Creek as accessible fish habitat in spring 2018. Polley Lake fish population monitoring will be conducted by hoop netting in the spring as part of fish tissue quality monitoring (see Section 3.1) and in the fall specifically for the purpose of monitoring fish populations when catch results are not influenced by fish aggregation for spawning. All fish captured by hoop netting will be identified and counted and a minimum of 30 juvenile and 30 adult rainbow trout captured in the spring and 100 juvenile and 100 adult rainbow trout captured in the fall will measured (total length, fork length, and weight) to provide data that can be used in statistical contrasts to characterize size-frequency distributions indicative of recruitment and survival. The fish population monitoring approach detailed herein is consistent with the previous approved CEMP Fish Monitoring Plan (MPMC 2019).[10]

[10] Fish population monitoring in Polley Lake will continue to focus on the measurement of rainbow trout, consistent with the previous study design (MPMC 2019). Physical measures for longnose sucker and redside shiner were collected (in addition to rainbow trout) in 2018 to 2021 (Minnow 2019a, 2020a, 2021a, 2022a). The collection of physical measures from longnose sucker and redside shiner will be discontinued so that methodology is consistent with the previous study design (MPMC 2019; i.e., physical measures collected for rainbow trout only).

Fish population monitoring in Polley Lake in the fall will continue at an annual frequency, consistent with the previous study design (MPMC 2019), to document recovery of the Polley Lake rainbow trout population until the population structure has returned to pre-breach conditions (e.g., until individuals from the 2018 cohort have reached the end of their life expectancy in ~2024 to 2026). The revised frequency of fish population monitoring in Polley Lake in the spring will be every three years. This aligns with the revised monitoring frequency for spring fish tissue quality monitoring in Polley Lake (and reference; see Section 3.1) which is completed concurrent with spring fish population monitoring. This represents a decrease in frequency relative to the previous study design, which was annual (MPMC 2019). Spring fish tissue and population monitoring was completed most recently in 2022, therefore the next monitoring event would occur in 2025 under the revised monitoring frequency. Although some fish population data are collected in the spring to support fish tissue quality monitoring, fish population data collected during fall monitoring are the focus of data interpretation because these data are collected using a randomized design (see Section 4.2.1) and are not influenced by fish aggregation for spawning that occurs in the spring. As such, the reduction in monitoring frequency to every three years for spring fish population monitoring will have limited effect on the evaluation of fish population data from Polley Lake, which has previously included both annual spring and fall monitoring data in the interpretation.

As outlined in Section 1.1, fish population monitoring is no longer required under the MDMER EEM for the Mount Polley Mine effluent discharge in Quesnel Lake (Minnow 2022c). Detailed methodology for fish collection in Polley Lake, measurement, QA/QC, data handling, interpretation, and reporting is provided in Section 4.

3.3 Habitat Characterization and Usage

Fish habitat characterization and fish usage monitoring will continue to focus on upper and lower Hazeltine Creek and lower Edney Creek (and associated reference areas detailed below) to document the effectiveness of the reconstructed fish habitat, with the specific purpose of addressing the monitoring objectives identified and reviewed by the HRWG for these remediated creek areas (Figure 8, Table 8). The fish habitat and usage monitoring will be consistent with previous monitoring in these remediated areas (Minnow 2018a, 2019b, 2020a,b, 2021b, 2022b) and for upper Hazeltine Creek will also be consistent with the study designs previously submitted to the HRWG (Minnow 2018d, 2020c).

Fish habitat characterization will monitor key characteristics of remediated Hazeltine Creek and Edney Creek habitat to document recovery. In upper Hazeltine Creek (Reaches 1 to 3), this will include spot measures of habitat recorded at the locations where fish are observed during spring and summer visual surveys. The habitat details recorded will include measures of *in situ* water

quality measures, depth, flow, substrate, and wetted channel widths, consistent with previous monitoring (Minnow 2019b, 2020b, 2021b, 2022b). Fish habitat characterization methods completed in lower Hazeltine and lower Edney creeks (and an associated reference area; unimpacted area of lower Edney Creek) will be consistent with those previously applied to these areas (Minnow 2018a, 2020a, 2022b) which are adapted from Johnston and Slaney (1996) and described in detail in Section 4.2.4. Fish habitat will be characterized in spring, summer, and fall in relation to the needs of fish that could potentially use the habitat and will include documentation of in-stream barriers and cover, spawning and overwintering habitat, riparian features, channel hydrology, bank condition, and water quality parameters.

Fish usage monitoring will document the use of these remediated creek habitats by all fish species and life stages by a combination of visual observation and fish collections. Visual observations will include the enumeration and documentation of spawning and rearing fish in spring and summer months in both upper and lower creek areas (May to August) and fall months (August to November) in lower creek areas that are accessible to spawning salmonids. For upper Hazeltine Creek (and reference area; Frypan Creek), fish collections will be completed in the summer (August) by closed-station electrofishing to provide an estimate of the density of rearing rainbow trout. Fish capture data will be utilized to document the production of rainbow trout and any temporal changes by comparing to historical estimates (e.g., Minnow 2009). Fish collections in lower Hazeltine Creek and lower Edney Creek (and an unimpacted reference area of lower Edney Creek), will be completed using minnow trapping in the spring (May) once fish have begun to aggregate for spawning, in the summer (August), and in the fall (September / October, including when fish are spawning). All captured fish captured by either technique (minnow trapping or electrofishing) will be identified and enumerated, and fishing efforts will be documented for CPUE calculations. Captured individuals (all rainbow trout from upper Hazeltine Creek, and up to 100 individuals of each collected species from each area of lower creek areas) will be temporarily retained for length and weight measurements. Fish physical measures data will be used to calculate summary statistics of length, weight, condition, and size-frequency distributions that will also be compared to historical results (e.g., Minnow 2009).

Fish habitat characterization and fish usage monitoring will continue at an annual frequency in upper Hazeltine Creek and will continue at frequency of every two years in lower Hazeltine Creek and lower Edney Creek. These monitoring frequencies are consistent with the previous study design (MPMC 2019). Fish habitat and usage monitoring in both the upper and lower creek areas was completed most recently in 2022, so will be completed next in 2023 and 2024 for the upper and lower areas, respectively. Adjustments to these monitoring frequencies or monitoring approaches would require review and acceptance by the HRWG prior to implementation since this monitoring is completed to satisfy the HRWG monitoring requirements. Detailed methodology

for fish collection, fish measurement, QA/QC, data quality review, data handling, interpretation, and reporting is provided in Section 4.

3.4 Community

Fish community monitoring is a supporting measure to be determined in association with all fish collections (i.e., fish tissue quality monitoring, fish population monitoring, and fish habitat usage monitoring). Fish community monitoring effort will only be as required to collect the fish needed for these other purposes. Thus, the locations, timing, and frequency of fish community monitoring will be as outlined above (Sections 3.1 to 3.3, inclusive). In association with each fishing effort, all captured fish will be identified and counted. Details of each fishing effort (GPS coordinates, gear type and dimensions, and actual fishing time) will be recorded to provide the most quantitative record of fish community results possible. Specifically, the effort details will be collected to support the expression of CPUE on the basis of time (catch per time), area (catch per area), or the combination of gear-dimension and time (e.g., catch per 100 m net-hour). Interpretation of CPUE data will be based on a combination of: 1) comparison to previous conditions; 2) comparison to reference conditions; and 3) comparison of species proportions temporally and spatially (e.g., has the relative abundance rainbow trout versus longnose sucker changed over time and/or relative to the reference lake). Detailed methodology for fish collection, QA/QC, data quality review, data handling, data interpretation, and reporting is provided in Section 4.

4 METHODOLOGY

4.1 Quality Assurance / Quality Control

All sampling will be performed by qualified field staff experienced in the implementation of fish and fish habitat monitoring programs. All sample collection, quality assurance and quality control, and laboratory analysis methods will be implemented in accordance with technical guidance (BCMOE 2013, 2016; BCMOECCS 2020). Specific QA/QC measures will include program review prior implementation, adequate resources for all field teams including field checklists and field data sheets, the availability and maintenance of clean sampling equipment and sampling containers, and sampling in a manner that minimizes any risk of sample contamination (i.e., for tissue quality samples).

Quality control (QC) samples will be collected to support the fish monitoring program. For the tissue quality component of the fish monitoring program, eight replicate tissue chemistry samples will be collected from each sampling area to capture within-area variability. Fish tissue samples will include muscle, liver, kidney, and ovary tissues (or whole-body analysis for smaller fish). Specific field QC samples will include field duplicates (i.e., split samples collected from the same fish tissue) collected at a frequency of 10% of the total number of samples to assess field precision as part of the Data Quality Review (DQR; see Section 4.4). The collection of field duplicate tissue samples will be evenly distributed among species and tissue types, to the extent possible. Raw field data will be transcribed from field sheets into an electronic spreadsheet and data collected using digital data collection devices will be exported from a geodatabase to electronic spreadsheets. Data will then be checked by a separate individual for entry errors as part of routine QA/QC procedures. In addition to field QA/QC, the laboratory responsible for chemical analyses will be accredited by the Canadian Association for Laboratory Accreditation (CALA) for these analyses. Specific QC sampling and associated reporting for tissue quality results will be requested of the analytical laboratory, including reagent blank results, laboratory replicate results, and laboratory accuracy results (i.e., matrix spikes, laboratory control samples, and/or certified reference materials). Laboratory Reporting Limits (LRLs) will also be evaluated in comparison to targets established by the analytical laboratory. These results will be assessed as part of the DQR (see Section 4.4).

4.2 Sample Collection Methods

4.2.1 Collection

All fish monitoring will be undertaken under fish collection permits from the British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD)

and all fish monitoring in waters frequented by salmon (e.g., Quesnel Lake and Quesnel River) will also be undertaken under fish collection permits from DFO. All conditions associated with the fish collection permits will be strictly adhered to (including the general prohibition of fishing in waters with temperatures > 20°C).

Fish collections will be completed in accordance with applicable provincial and federal technical guidance (BCMOE 2013, BCMOE 2016, Environment Canada 2012). A variety of techniques will be applied to collection of fish required for the monitoring of fish tissue quality, fish populations, and habitat usage. To the extent possible, preference will be for non-destructive fish collection methods (e.g., hoop nets, minnow traps, backpack electrofishing) to minimize the potential impact of monitoring activities on fish populations and/or communities. The following fish collection techniques will be used to support the CEMP fish monitoring plan, with details of each method included below:

- hoop netting;
- gill netting;
- minnow trapping;
- seining; and
- backpack electrofishing.

Hoop netting will be applied to the collection of large-bodied fish in lakes as the preferred collection method since it is a non-lethal method. Hoop nets ranging in size from 0.6 m diameter, 2 cm stretched mesh to 0.75 m diameter, 3.8 cm stretched mesh with four to eight hoops and leads of approximately 30.5 m in length will be set as appropriate to target the fish required for tissue quality monitoring and fish population monitoring. For fish population monitoring, nets will be set overnight at randomized locations in Polley Lake (determined a priori) for a total of five nights (to standardize level of effort), consistent with previous methods (Minnow 2019a, 2020a, 2021a, 2022a).

Gill nets will be used as required to support hoop netting for fish tissue collection in lakes, as required, with application minimized and short deployment duration. Net size and deployment configuration will be as required to capture target fish most effectively and will follow technical guidance (i.e., BCMOE 2016). Specifically, lake trout will be targeted in Quesnel Lake using a Profundal Index Netting methodology similar to the Summer Profundal Index Netting (SPIN) method (e.g., Jessup and Millar 2011).

Minnow traps (galvanized mesh – 42 cm length, 0.6 cm mesh, 2.5 cm diameter opening) will be set in lakes and creeks to capture small-bodied fish and juveniles. Minnow traps will be baited

and will be tied off on shore or set on the substrate and marked with a float. Minnow traps set in creeks will be set so that the openings will be oriented upstream and downstream.

Seining may also be completed in lakes and creeks to augment catches by other techniques. A 15 m long seine with a 0.3 mm mesh size will be used. The seine net will be pulled through shallow habitats by wading through the sampling area; in deeper areas, a boat may be used to pull one end of the seine (BCMOE 2013). Care will be taken to ensure that the lead line remains in contact with the substrate and the float-line remains at the surface to prevent fish from escaping. The contents of the seine will be brought to shore, and depending on number of fish caught, may be emptied into a water-filled tote and the seine will be inspected to confirm that all fish are removed.

Open-station and/or closed-station backpack electrofishing will be completed in creeks. All electrofishing will be completed by an experienced and certified electrofishing team, consisting of a backpack electrofisher operator and one or more netters using electrofisher settings appropriate for the target species (i.e., frequencies and pulse width) and starting with lowest possible power output (voltage and duty cycle). Open stations will be fished by single electrofishing pass in an upstream direction. During open-station electrofishing, the operator will create a series of smooth, zig-zagging sweeps with the anode. Fish will follow the anode; therefore, the operator will move the anode towards the netter, who will net the stunned fish. Closed stations will be created using 3/8” mesh stop nets and care will be taken to ensure that the enclosed habitat is suitable for the potential presence of target fish. The dimensions (length and wetted and bankfull widths) and water depth (average of three measures) of each open and closed station will be measured at equally-spaced transects using a measuring tape and meter stick, respectively. During each closed station electrofishing effort, the electrofisher operator and netter will employ a multiple pass removal method at each station whereby one upstream pass (or “sweep”) of the enclosed reach is repeated three or more times to yield a fish removal pattern (i.e., diminishing catches) that can be used to determine fish density using removal method equations. Fish captured during each open electrofishing pass or closed station sweep will be placed in separate buckets of aerated water.

Fish will be captured from the Quesnel River by angling (targeting rainbow trout for fish tissue quality monitoring). Angling will be conducted using barbless, single hook lures, and/or flies. The general location of each effort will be recorded using a handheld GPS accompanied by notes on the hooks/lures/flies used, effort duration, and habitat.

Upon fishing gear retrieval, all captured fish will be identified and counted for each fishing effort. For experimental gill nets, fish counts will be recorded for each gill net panel. For electrofishing catches, fish counts will be recorded for each separate bucket or “sweep.” Target species will be

retained for measurement or measured immediately and released (depending on the objective of the monitoring component) while non-target species will be released immediately at the location of capture. Individuals of the target fish species will be measured as outlined in Sections 4.2.2 and 4.2.3, according to the requirements of the particular monitoring component of the CEMP Fish Monitoring Plan.

For each of the fish collection methods detailed above, the location of each fishing effort will be recorded using a handheld GPS accompanied by notes on the set configuration (including depth for hoop nets, gill nets, and minnow traps), and the time of deployment and retrieval. For seine netting notes will include habitat features and the area and maximum depth sampled. For electrofishing, recorded notes will include the start and end times of fishing efforts, active electrofishing seconds, the total sampling area, and habitat descriptions including observations of stream morphology and substrate characteristics, riparian vegetation and relative stream shading, as well as any potential confounding influences or other observations deemed relevant to interpretation of the fish survey data. Passive fishing gear (i.e., hoop nets and minnow traps) will be deployed for a maximum of three nights between checks, although daily checks will be most common. Gill nets will be deployed for short durations during daylight hours only (in accordance with fish collection permit conditions). All fishing effort data will be recorded on field sheets or digital data collection devices. *In situ* water quality measurements (i.e., temperature, pH, dissolved oxygen, conductivity, and specific conductance) will also be recorded to support fishing efforts.

4.2.2 Physical Measures Data

Physical measures will be collected from target species as follows. Physical measurements from fish that will not be retained for lethal sampling will be recorded prior to releasing the fish at their point of capture. Fish retained for lethal sampling will be anesthetized using a clove oil solution or will be euthanized with a decisive blow to the head and spinal severance.

Fish will be subjected to measurement of fork length, total length, and body weight (BCMOE 2013). Fork and total length of large-bodied fish will be measured to the nearest millimeter using a measuring board and fork and total length of small-bodied fish will be measured to the nearest 0.1 mm using digital calipers. Fresh body weight will be measured using an analytical balance or a set of Pesola™ spring scales (depending on fish weight). The Pesola™ scales are demarcated at intervals of 1 to 2% of the total scale range, providing an accuracy of plus or minus (±) 0.3% of the fish mass. The Pesola™ spring scale for individual weight measurement will be selected so that the fish weight is near the top of the scale's range to ensure that measurements achieve a resolution near 1%.

Age structures will be retained for all fish collected for tissue quality monitoring using available guidance for the best age structure for each species (e.g., Environment Canada 2012). Otoliths will be removed and used as the primary aging structure for all fish species except for sucker. Pectoral fin rays will be removed and used as the primary aging structure for sucker. Scales will also be collected for use as backup structures for age determination. Aging structures will be wrapped in waxed paper, and placed in labelled coin envelopes, which will then be frozen prior to submission to a qualified fish aging laboratory.

4.2.3 Tissue Quality

For large-bodied fish targeted for tissue quality monitoring, tissue quality samples will be collected after physical measures are collected and will include muscle, liver, kidney, and ovary (the latter as available). For small-bodied fish targeted for tissue quality monitoring (i.e., juvenile northern pikeminnow), whole body samples will be analyzed for tissue chemistry. Tissue samples (muscle, liver, kidney, and/or ovary) will be removed, weighed to the nearest 0.001 g (±1% precision) using an analytical balance, placed in labelled Whirl-Pak™ bags, and kept cool on ice in the field. All tissue samples will be collected using clean implements (cutting boards, filet knives, and tweezers; BCMOE 2016). Livers and kidneys will be collected whole, whereas approximately 10 to 50 g of boneless, skinless muscle will be collected, and a similar sized ovary sub-sample will be collected when available (or will be collected whole if smaller than this). Eight replicate samples will be targeted for each tissue type for each fish species from each sampling area (see Table 8). Samples will be kept on ice in the field, then frozen before shipment (in a cooler with ice) to the analytical laboratory.

4.2.4 Habitat Characterization and Usage

Fish habitat characterization methods will be consistent with those previously for monitoring in remediated areas of Hazeltine and Edney creeks (Minnow 2018a, 2019b, 2020a,b, 2021b, 2022b), and for upper Hazeltine Creek will be also be consistent with the study designs previously submitted to the HRWG (Minnow 2018d, 2020c). These methods are described briefly below.

In upper Hazeltine Creek, spot habitat measurements will be collected from different habitat types where fish are observed during the visual fish usage surveys that will be completed in spring (May) and summer (August). The target sample size for habitat measurements will be 15 sets of measurements in HAC-R1 and HAC-R2 and 21 sets of measurements in HAC-R3. Habitat variables to be collected with each set of measures will include *in situ* water quality measures (temperature, specific conductance, pH, and dissolved oxygen) water velocity (measured at bottom, 60%, and top of the water column), GPS coordinates, water depth, wetted

stream width, and a visual estimates of substrate composition (RIC 2001). These fish habitat measures will be recorded on field data sheets or using a digital data collection device and will be summarized and compared to relative to general habitat preferences tabulated for the spawning and rearing of rainbow trout.

In lower Hazeltine Creek and lower Edney Creek, habitat characterization methods will include those adapted from Johnston and Slaney (1996). Habitat characterization methods will be a composite of two standard methods: 1) Reconnaissance Fish Habitat Inventory (RIC 2001); and 2) Level 1 Field Fish Habitat Assessment ("Habitat Unit Assessment"; Johnston and Slaney 1996).

The first method, Reconnaissance Fish Habitat Inventory using methods adapted from RIC (2001) will be completed in spring (May), summer (August), and fall (October) at replicate stations (eight stations per remediated area, three stations per reference area). Habitat measures collected at each station will include measures of channel dimensions, water velocity, *in situ* water quality (for the parameters listed above), representative photographs, and GPS coordinates. Specifically, channel dimensions (bankfull width, wetted width, wetted depth, and bankfull-wetted depth) and water velocity (at 60% depth) at each station will be measured at a minimum of five points along one wetted channel cross-sectional width. Additional habitat characteristics to be assessed at each station will include description of channel bed features (substrate type, relative proportion of each substrate type, etc.), channel and bank gradient, substrate size, bank stability, riparian vegetation, and in-stream cover. Substrate size will be assessed (100 randomly selected rocks per station) for the purpose of monitoring temporal changes in substrate size distribution. During each seasonal survey, any unique or significant physical or biological features (e.g., tributaries, groundwater seeps, partial or seasonal fish barriers to fish migration) will be documented, including a brief description of the feature, together with its GPS coordinates.

The second habitat assessment approach using Level 1 Field Fish Habitat Assessment methods ("Habitat Unit Assessment"; Johnston and Slaney 1996) will be undertaken in August. At least seven consecutive habitat units (i.e., pool, glide, or riffle) will be identified towards the center of each monitoring area and the dimensions of each habitat unit (i.e., pool, riffle, or glide) will be recorded. Specifically, the length, mean width (wetted and bankfull; mean of at least 3 measures), and mean depth (wetted and bankfull; mean of at least 5 measures) will be determined for each habitat unit. For pools, the maximum and residual (maximum minus crest depth) wetted depth will also be measured, as well as pool type. Additional habitat characteristics assessed at each habitat unit will include included channel gradient, substrate type, riparian vegetation (vegetation types, growth stage, and canopy cover), in-stream cover,

access to off-channel habitat, the number of pieces of large woody debris (LWD) present, and indicators of disturbance.

Fish habitat usage monitoring in upper and lower creek areas will document the use of these rehabilitated creek habitats by all fish species and life stages, including the specific documentation of spawning and rearing in spring, summer, and fall months (May to October). Fish habitat usage will be determined by a combination of visual observation and fish collection techniques as outlined in Section 3.3. These fish collection techniques (minnow trapping and backpack electrofishing) will be completed as described in Section 4.2.1. All captured fish will be identified and enumerated and the captured fish (all rainbow trout and up to 100 individuals of each collected species from each area of lower creek areas) will be temporarily retained for the non-lethal collection of physical measures as outlined in Section 4.2.2. Fishing efforts will be documented for CPUE or density calculations and any observations of specific behaviours (e.g., spawning) will be noted.

4.3 Sample Handling and Laboratory Analysis

Fish tissue quality and fish aging samples will remain frozen until shipment (in a cooler with ice) to the analytical laboratory at the termination of the field program. Samples will be sent to the laboratory with completed COC forms leaving sufficient time to complete analyses within the recommended sample hold times (1 year for tissue quality [metals analysis], no recommended hold time for aging structures). Upon sample receipt, the laboratory will provide a sample receipt confirmation when the samples are received and logged. These receipts will be reviewed to ensure that all samples are received and that the analytical requests are properly logged.

Chemical analyses will be completed at an analytical laboratory accredited by the CALA using methods that are consistent with those specified in the British Columbia Environmental Laboratory Manual (BCMOECCS 2020). Tissue quality samples will be analysed for metals by CRC-ICP-MS (USEPA Method 6020B; USEPA 2014), mercury by CVAAS (Cold Vapor Atomic Absorption Spectrophotometry; EPA 200.2/245.7; USEPA 1994, 2005), and moisture content (Table 9). Tissue quality analytes are provided in Table 9, with the associated target LRLs, detection limit objectives outlined in technical guidance (“consensus” LRLs; BCMOE 2016), and applicable guidelines (BCMOE 2014; CFIA 2015). Upon completion of the analyses, the laboratory will provide a data report in Microsoft (MS) Excel™ and as an Adobe Acrobat Portable Document Format (PDF). Reporting will include the results of the laboratory QC sample results.

Aging structures will be shipped to a qualified fish ageing laboratory where samples will be thawed, otoliths extracted from heads if required, and the otoliths and fin rays will be sectioned, mounted on a glass slide using a mounting medium, and then read under a compound microscope using transmitted light. For each structure, age and edge condition will be recorded along with a

Table 9: Analytes and Laboratory Reporting Limits (LRLs) for Mount Polley CEMP Fish Tissue Quality Monitoring

Analyte	Metals in Tissue by CRC-ICPMS Micro (USEPA 2014)	Metals in Tissue by CRC-ICPMS (USEPA 2014)	Consensus LRLs[a]	Tissue Quality Guidelines
	mg/kg wwt	mg/kg wwt	mg/kg wwt	
Physical Tests				
Moisture (%)	2	0.50	1.0	-
Metals				
Aluminum (Al)	1.0	0.40	0.40	-
Antimony (Sb)	0.0020	0.0020	0.0020	-
Arsenic (As)	0.0060	0.0040	0.0050	-
Barium (Ba)	0.010	0.010	0.010	-
Beryllium (Be)	0.0020	0.0020	0.0020	-
Bismuth (Bi)	0.0020	0.0020	0.0200	-
Boron (B)	0.20	0.20	-	-
Cadmium (Cd)	0.0020	0.0010	0.0020	-
Calcium (Ca)	4.0	4.0	2.0	-
Cesium (Cs)	0.0010	0.0010	-	-
Chromium (Cr)	0.040	0.010	0.010	-
Cobalt (Co)	0.0040	0.0040	0.0040	-
Copper (Cu)	0.040	0.020	0.010	-
Iron (Fe)	1.0	0.60	1.0	-
Lead (Pb)	0.010	0.0040	0.0040	-
Lithium (Li)	0.10	0.10	-	-
Magnesium (Mg)	0.40	0.40	2.0	-
Manganese (Mn)	0.010	0.010	0.020	-
Mercury (Hg)[b]	0.0010	0.001	0.002	0.5mg/kg wwt[b]
Molybdenum (Mo)	0.0080	0.0040	0.010	-
Nickel (Ni)	0.040	0.040	0.010	-
Phosphorus (P)	2.0	2.0	5.0	-
Potassium (K)	4.0	4.0	10	-
Rubidium (Rb)	0.010	0.010	-	-
Selenium (Se)	0.020	0.010	0.020	11.0 mg/kg dw[c]
Silver (Ag)	0.001	0.001	0.01	-
Sodium (Na)	4.0	4.0	2.0	-
Strontium (Sr)	0.020	0.010	0.010	-
Tellurium (Te)	0.0040	0.0040	-	-
Thallium (Tl)	0.00040	0.00040	0.0010	-
Tin (Sn)	0.020	0.020	0.020	-
Titanium (Ti)	0.1	0.05	0.06	-
Uranium (U)	0.00040	0.00040	0.0010	-
Vanadium (V)	0.020	0.020	0.020	-
Zinc (Zn)	0.20	0.10	0.10	-
Zirconium (Zr)	0.040	0.040	-	-

Primary Analyte.

Secondary Analyte.

Notes: mg/kg = milligrams per kilogram. wwt =wet weight. To convert the wet weight LRL to dry weight LRL, multiply by 5. "-" indicates no guideline available.

[a] From Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators (BCMOE 2016).

[b] Health Canada guideline for mercury (CFIA 2015).

[c] British Columbia Water Quality Guideline for aquatic life for selenium in fish ovary tissue (BCMOE 2014). Additional guidelines for the protection of aquatic life of 4 mg/kg dw in fish muscle/ whole fish and for the protection of human health at moderate consumption levels (14.5 mg/kg dw for general population) will also be applied.

confidence rating for the age determination. Scales collected as backup structures will only be used as required. Methods for determining fish age will be fully consistent with the technical guidance (Environment Canada 2012). The laboratory will provide a data report in MS Excel™ and as an Adobe Acrobat PDF, including the results of the laboratory QC sample results.

4.4 Data Quality Review

Upon receipt of fish tissue quality data from the analytical laboratory, a Data Quality Review (DQR) will be performed. The DQR will confirm that all requested analyses are complete, and that acceptable LRLs are achieved. The LRLs will be evaluated relative to targets established for the analytes, to "consensus" LRLs (Table 9), and to relative to available fish tissue quality guidelines (BCMOE 2014; CFIA 2015). The DQR will also include an evaluation of differences between duplicate (i.e., split) samples, as well as the QA/QC data reported by the laboratory. Completion of the DQR promptly following receipt of the tissue quality data will ensure timely communication with the laboratory should any issues be identified.

Comparisons between duplicate samples will be made by calculating the relative percent difference (RPD) of metal concentrations between paired duplicates. If the RPD is <30% for concentrations that are > 5 times the LRL, then the duplicate sample results will be considered acceptable. Analyte concentrations in laboratory blank samples will be evaluated in relation to their respective LRLs, and the results will be used to identify potential contamination associated with equipment (e.g., cleanliness) and sample collection and handling procedures (e.g., collection, shipping).

4.5 Data Handling, Interpretation, and Reporting

Upon receipt of data from the analytical laboratories, all laboratory data files will be managed by the Mount Polley Mining Corporation (MPMC) Environment Department. In addition, chemical data provided by the primary analytical laboratories as an Electronic Data Deliverable (EDD) will be imported directly into the MPMC's database. Following completion of the DQR described above (see Section 4.4), all fish community and population, tissue quality, habitat, and supporting data will be managed in MS Excel™ or R (R Core Team 2022). For all replicated data (based on a sample size of at least eight per area or tissue type), data will be provided to the QP for analysis and summarized by calculating mean, median, standard deviation, minimum, and maximum for each endpoint and area. Data analysis will be completed for each monitoring component (community and population, tissue quality, and habitat).

4.5.1 Community and Population

Catch-per-unit-effort (CPUE) and summary statistics for fish physical measurements will be calculated using the field collected data. CPUE will be calculated for each fish species by fishing method and sampling area. For hoop netting and minnow trapping, CPUE will be expressed as number of fish per day. For seining, CPUE will be calculated as the number of fish per square meter. CPUE for gill netting and angling will be calculated as the number of fish captured per square meter-hour and the number of fish per angler day, respectively. CPUE will be calculated as the number of fish per 100 electrofishing seconds for open-station electrofishing efforts. For closed-station electrofishing efforts, fish density will be calculated by removal depletion formulas using the removal function within the Fisheries Stock Assessment package in R (Ogle et al. 2021), and the Carle Strub method (Carle and Strub 1978) will be used to estimate population size and density. Fish density at individual sites will then be standardized to the number of fish per 100 m^2 using the total capture area. Estimates of fish population size for each reach in Hazeltine Creek where closed-station electrofishing is completed will be generated by multiplying the reach specific mean fish density (fish/m^2) by the total area of the reach. CPUE and calculated fish densities and population sizes will be competed to previously reported data for data interpretation, where possible.

Although community and population data is collected during every phase or component of the fish monitoring program, the sample size will be defined by the study objectives and may be insufficient to address corollary questions. For example, the sample size required for tissue quality analyses (n = 8) is not large enough to support formal contrasts of population endpoints. To this end, evaluation of fish community data in these instances (e.g., associated with tissue quality monitoring objectives) will rely on qualitative comparisons. Data collected for the assessment of fish community and population in Polley Lake, Hazeltine Creek, and Edney Creek will include a level of replication that enables formal statistical comparisons of fish health endpoints (see Sections 3.2 and 3.3). These comparisons will include evaluation of body size (fork length and body weight), energy storage (as condition [weight-at-length], and length-frequency distributions.

Statistical comparisons of length and weight among areas will be conducted using an ANOVA when the assumptions of normality and homogeneity of variances are met (Shapiro-Wilks' test and Levene's test, respectively; $\alpha = 0.05$). Data will be $\log_{10}$-transformed as necessary to meet the assumptions. The Kruskal-Wallis test will be used when the assumptions cannot be met. Post-hoc pairwise comparisons between areas will be conducted using least-squares means with Sidak correction for multiple contrasts at $\alpha = 0.1$ for ANOVA models, and uncorrected Dunn's Test

for Kruskal-Wallis. No adjustment for multiple comparisons will be made for Dunn's test due to the lower power of non-parametric tests.

Statistical comparisons of condition and weight-at-age (where age data are available) will be compared among areas and/or years using a two-way analysis of covariance (ANCOVA) with Area and Year as factors, and log_{10}-transformed body weight as the response and log_{10}-transformed age or fork length as a covariate. Significant interactions between the Area, Year, and the covariate (i.e., the assumption of homogeneity of regression slopes between areas and years) in the ANCOVA will be assessed using $\alpha = 0.1$. When an interaction term is significant, the coefficients of determination (R^2) of the interaction model and parallel slope model will be compared to assess whether the slopes are practically significant. If the R^2 is greater than 0.8 and within 0.02 between the two models then the conclusion will be that the interaction model and parallel slope models are practically the same (Environment Canada 2012) and the ANCOVA proceeded will the parallel slope model. Influential points will be assessed using Cook's distance when a significant interaction is detected. If the interaction is driven by influential points, these will be removed from the analysis (Environment Canada 2012). When the interaction cannot be removed by comparison of R^2 values or removal of influential points, then the conclusion will be that the difference in the response variable between areas is dependent on the covariate values. When the interaction term is not significant, the interaction term will be removed from the model and the parallel slope ANCOVA model will be fit. When the covariate is not a significant predictor of the response variable in the parallel slope ANCOVA model then the analysis will proceed as an ANOVA or Kruskal-Wallis test.

Length frequency distributions of data will be plotted using histograms and Cumulative Relative Frequency Distribution (CRFD) among areas and years. The CRFD is a plot of the proportion of fish on the y-axis and length on the x-axis that shows the proportion of fish with a length less than a given value on the x-axis. Statistical comparisons of length frequency distribution between years will be conducted using the two-sample Kolmogorov-Smirnov (K-S) test. The two-sample K-S test compares the maximum difference in the CRFDs between areas and evaluates whether this maximum difference varies significantly among years ($p < 0.1$).

Summary statistics, including mean, median, minimum, maximum, standard deviation, and sample size, will be calculated for fish age, fork length, total length, and body weight by area, species, and year. Statistical comparisons for fish health endpoints among areas and years will be conducted at $\alpha = 0.1$.

4.5.2 Tissue Quality

Data analysis and interpretation of fish tissue quality results will focus on primary and secondary analytes identified in Minnow (2020a, 2021a, 2022a; Table 9). The concentrations of primary and

secondary analytes in fish tissue from exposed areas will be compared to previous data (including pre-breach data where possible), to reference results, and over time through detailed interpretation that may include: graphical comparisons to reference and historical data (including pre-breach data), graphical comparisons of selenium and mercury concentrations to the relevant guidelines and thresholds (see below), and formal statistical contrasts to evaluate if mean analyte concentrations at the exposed area have changed over time relative to the reference area.

The formal statistical contrasts of fish age, length, weight, and fish tissue metal concentrations at exposed versus reference areas over time will be conducted using a two-way ANOVA that assesses the exposed:reference ratio of results, with Area and Year as factors and assessing the interaction between Area and Year. If the Area×Year interaction term is significant ($\alpha = 0.05$), then the ratios of the concentrations from the exposed area to the reference area differ among years and pairwise contrasts will be completed among years (using $\alpha = 0.05$ to assess statistical significance). If the Area×Year interaction term is not significant ($\alpha = 0.05$), then the ratios of the concentrations from the exposed area to the reference area are consistent among years and no relative contrasts will be conducted. Temporal changes in the ratio of exposed:reference results will be quantified by calculating the difference between the value for the exposed area and the predicted value for the exposed area, assuming the same ratio (i.e., exposed:reference) from the baseline year (the first year the data were collected). Due to the potential prevalence of analyte results below the LRL for fish tissue quality results, the two-way ANOVA described above may be completed with a Maximum Likelihood Estimation (MLE) approach using a censored regression, assuming a lognormal distribution for metals data. Interpretation of results of these formal statistical analyses will at minimum focus on results for primary and secondary analytes with a significant Area × Time interaction in the results (i.e., the ratio of exposed:reference concentrations differed among years), and that are significantly higher at the exposed area relative to reference in the most recent monitoring year being assessed.

When reference area data were not collected concurrently with the exposed area over time (i.e., for fish tissue data collected from the Quesnel River), statistical comparisons of concentrations of metals in fish tissues over time will be conducted using a one-way ANOVA with Year as the factor. The analyses of tissue metal concentration data will be completed using a censored regression one-way ANOVA fit with MLE and assuming a lognormal distribution, as described above.

Mercury concentrations will be analyzed using units of mg/kg ww, in keeping with the reporting units for mercury guidelines. Mercury analyses will be completed using ANCOVA

with log_{10}(fork length) as a covariate when the covariate was a significant predictor of mercury concentration, since mercury is known to bioaccumulate (i.e., larger fish have higher tissue concentrations; Kidd and Batchelar 2012). If fork-length is not a significant covariate ($\alpha = 0.05$) in the ANCOVA, the analysis will proceed using the ANOVA methods described above, consistent with the other analytes.

Fish tissue quality data will also be evaluated in comparison to tissue quality guidelines for human health and/or for aquatic ecosystem health (available for mercury and selenium). Tissue quality guidelines will include the Canadian Food Inspection Agency/Health Canada mercury guideline for the protection of human health (0.5 milligrams per kilogram wet weight [mg/kg ww]; CFIA 2015) and the British Columbia (BC) selenium guidelines (BCMOE 2014). Selenium guidelines for BC include guidelines for the protection of human health, which are based on fish consumption levels (7.3 milligrams per kilogram dry weight [mg/kg dw] for subsistence consumers, 14.5 mg/kg dw for the general population, and 75 mg/kg dw for the recommended two servings of fish per week). Selenium guidelines for BC also include guidelines for the protection of aquatic life, which are 4 mg/kg dw in muscle tissue and whole-body samples, and 11 mg/kg dw in egg/ovary tissues. Selenium concentrations in fish ovaries will also be compared to the threshold for reproductive effects in eggs and ovaries (20 mg/kg dw; DeForest et al. 2012).

4.5.3 Habitat

Results of the fish habitat characterizations for upper Hazeltine, lower Hazeltine, and lower Edney creeks will be summarized, along with fish usage results, according to season (spring, summer, and fall) and year. Fish habitat characterization measures will be summarized by season, reach, and area (rehabilitated and reference), with summary statistics (mean and standard deviation) calculated for all numerical parameters. These summarized variables will then be compared to general habitat preferences for relevant fish species. Additionally, recorded habitat measures will also be compared to “optimal” ranges of habitat parameters indicated in Habitat Suitability Index (HSI) models (i.e., suitability index value = 1) or in the literature (where available) for those fish species identified in rehabilitation design criteria and objectives. Specifically, mean results for habitat measures collected in each season at each reach will be compared to the tabulated optimal “habitat suitability criteria” ranges and identified as either meeting or not meeting these criteria. The proportions of habitat measures meeting the habitat suitability criteria in the remediated and reference areas, respectively, will also be compared for the lower creek areas.

Habitat unit assessment measures collected for the lower creek areas will be summarized by habitat unit type within each reach, with mean values calculated for all numerical parameters. Measures will be used to calculate endpoints such as bankfull width to depth ratio, channel complexity, % pool, pool frequency, and LWD pieces per bankfull channel width. These endpoints

and other observational measures (presence of off-channel habitat) will then be evaluated relative to diagnostics of salmonid habitat condition modified from Johnston and Slaney (1996), and rated as poor, fair, or good.

An interpretive report based on the fish tissue quality monitoring data and Quesnel Lake and Quesnel River community and fish population data will be prepared for integration into the Annual Environmental Report for the Mount Polley Mine. This report is prepared annually by MPMC and submitted to the regulators and other stakeholders by March 31st of the following year. The interpretive report will provide all data in an appendix and will include the DQR, the results of the screening against BCWQG, and the results of temporal and spatial comparisons. All data interpretation will be summarized in clear text form supported by tables and data plots. A separate interpretive report based on the fish community and population monitoring data for Hazeltine Creek, Edney Creek, and Polley Lake (i.e., those areas monitored to serve the objectives of the HRWG) will be prepared for submission to the HRWG by March 31st of the following year. This report prepared for the HRWG will provide data, analysis, and interpretation similar to those described above for the MPMC Annual Environmental Report above.

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Appendix B.2

Wildlife, Soil, Soil Invertebrate and Vegetation Monitoring

Golder Associates

TECHNICAL MEMORANDUM

DATE 9 August 2018 **Reference No.** 1894924-025-TM-Rev1-23182

TO Stephen Monninger
Mount Polley Mining Corporation

CC Colleen Hughes

FROM Blair McDonald and Barbara Wernick **EMAIL Blair_McDonald@golder.com; Barbara_Wernick@golder.com**

STUDY DESIGN CONCEPT: TERRESTRIAL COMPONENT FOR THE MOUNT POLLEY MINE COMPREHENSIVE ENVIRONMENTAL MONITORING PLAN – MOUNT POLLEY MINE

1.0 INTRODUCTION

1.1 Purpose of the Study Design Concept

Mount Polley Mining Corporation (MPMC) is preparing a Comprehensive Environmental Monitoring Plan (CEMP) to integrate the environmental monitoring components from a variety of regulatory processes applicable to the Mount Polley Mine into a single document. An Ecological Risk Assessment (the ERA; Golder 2017) was prepared that integrated the available chemical and biological information to provide an overall conclusion about the magnitude and extent of ecological risks associated with the deposit of tailings. The ERA was accepted by the Ministry of Environment & Climate Change Strategy (ENV) on 31 January 2018, contingent on the implementation of additional monitoring in relation to specific areas of uncertainty identified in the ERA. There were several points of uncertainty in the terrestrial ERA with respect to plants, soil invertebrates and wildlife and these are outlined in Table 53 of the ERA. The purpose of this memorandum is to outline the monitoring concept proposed to MPMC to address those terrestrial ERA uncertainties in the CEMP. Contingent on acceptance by ENV, a detailed study design document and specific work instructions will be prepared by Golder as the basis for executing of the CEMP process.

1.2 Scope and Approach of the Risk Assessment

The ERA evaluated the site conditions as they existed in the first few years after the failure of the glacial lacustrine layer beneath the Perimeter Embankment of the Tailings Storage Facility. The terrestrial ERA included the “floodplain” area where the forest and native soils were removed by the debris flow, and the “halo” area where the forest floor was relatively undisturbed but buried to varying depths by scoured material and tailings. Tailings can limit the successful re-establishment of ecological communities because of a variety of chemical and/or physical limitations in the soil (Hossner and Hons 1992). The ERA used a “triad” style approach to evaluate the relative influence of physical issues versus chemical issues for a given receptor group using three different types of information:

- What is the magnitude of the exposure associated with tailings?
- What is the magnitude of effects associated with tailings under controlled experimental conditions?
- What is the magnitude of effects associated with tailings under field conditions?

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Copper was identified as the primary contaminant of concern. The ERA also found that the bioavailability of copper in tailings at the site was low. A low bioavailability does not mean that bioaccumulation was zero as copper has bioaccumulated in different parts of the ecosystem at concentrations that are greater than reference areas. However, the overall conclusion, based on a weight-of-evidence integration of the available information collected over several years, was that risks associated with copper were low, and that the effects associated with nutrient deficiencies and soil structural limitations were likely to be a larger influence on the long-term management goal of reintroducing a biologically diverse, functional and self-sustaining ecosystem. As with any complex risk assessment, there was uncertainty associated with the risk conclusions which were described in the risk assessment.

1.3 Summary of Main Areas of Uncertainty

The study design concept focuses on reducing the main sources of uncertainty described in Table 53 of the ERA. In brief, the main sources of uncertainty in the terrestrial ERA were:

1) Field-based monitoring of the diversity or abundance of plants, soil invertebrates or other parts of the soil ecosystem is valuable in an ecological risk assessment but was not practical in the current application because of the expected variability related to natural successional changes.

2) The ability to quantify the relative influence of copper versus the physical limitations of the soil is important from a theoretical perspective. This would typically be evaluated using controlled experiments. However, further experiment-based studies are not warranted unless there is evidence (from field monitoring) that natural succession is not progressing. It is reasonable to continue refining the site-specific understanding of copper bioaccumulation in plants and soil invertebrates in lieu of further experimental studies while the long-term field monitoring is executed.

3) Risks to wildlife are assessed with a single technique (a food chain model). Conservative assumptions were used in the model. Hazard quotients were less than 1 for eleven of the 15 receptor species evaluated in the model. Further refinement of the wildlife food chain model was requested with respect to the four receptor species that had a hazard quotient greater than 1.

Each of these main sources of uncertainty are addressed in further detail in Section 3.

2.0 BASIS OF DESIGN

Golder understands that MPMC is structuring the CEMP to be a stand-alone document that does not require reviewers to have a detailed understanding of the ERA. A summary of the available data and how those data were evaluated in the ERA (Golder 2017) is provided in this section as context for the specific recommendations in Section 4.

2.1 Plants

Information relevant to plants that was evaluated in the ERA included:

- Concentrations of metals in tailings were lower than numerical standards for the protection of soil invertebrates and plants, except for copper (and marginally, vanadium).
  - For copper, the numerical standard is 150 mg/kg. The 95% upper confidence limit of the mean (UCLM) concentration in untreated tailings was 737 mg/kg. Treatment (scarification, intermixing or transplanting soils) resulted in 95% UCLMs ranging from 197 to 538 mg/kg.
  - For vanadium, the numerical standard is 200 mg/kg. The 95% UCLM vanadium concentration in untreated tailings and the three treatment types were less than the numerical standard. Vanadium was retained as a contaminant of potential concern because the 90th percentile concentration in untreated tailings was marginally greater than the standard (213 mg/kg versus 200 mg/kg).
- A 42-d lodgepole pine (*Pinus contorta*) and bluebunch wheatgrass (*Pseudorogneria spicata*) germination and growth toxicity test was conducted on two representative samples of tailings (Section 3.3.3 of the ERA). Seedling emergence or survival was not impacted, but greater than 20% reductions in growth were observed for both species compared to the performance of a negative control consisting of clean silica sand of a similar grain size. All plants demonstrated some degree of growth over the 42-day exposure, despite copper concentrations ranging from approximately 800 to 1100 mg/kg.
- Multiple lines of evidence in the ERA demonstrated that copper had low bioavailability. The lines of evidence included geochemical modeling and three different chemical surrogate measurements in tailings samples (water soluble fraction; humidity cell and leach tests; physiological-based extraction tests – see Section 3.2.2 of the ERA). The toxicity testing (see above) also included a side-by-side trial where an equivalent concentration of copper was added to clean silica sand (in the form of copper sulphate). The bioavailability of copper from tailings was much lower than copper added to the tailings.
- There were physical effects of tailings on plant growth. The toxicity testing (see above) found that tailings tended to form hard crusts and germination was highest in the surface cracks. The measured bulk densities of tailings, till and lacustrine deposits at the site were greater than values from the literature that correspond to reductions in plant growth. Nutrient levels in the tailings were also limited and in a range that could limit plant growth (see Section 3.2.3.2 of the ERA).
- Plants appeared to bioaccumulate copper, but bioaccumulation factors were less than 1 and the bioaccumulation was concentration-dependent. There were no obvious differences in copper bioaccumulation during the 42-d toxicity testing (see above) between tailings and copper added to soils. There was no consistent pattern where copper concentrations in field-collected plant samples were greater in the impacted areas than in background and/or baseline samples (see Section 3.3.2.2 of the ERA). Copper concentrations were within the range of concentration considered to be adequate for plant growth (see Section 3.3.2.4 of the ERA) despite being collected over a wide range of soil concentrations. Overall, these lines of evidence demonstrate that many plants can control the uptake of copper.

2.2 Soil Invertebrates

The ERA involved fewer lines of evidence for soil invertebrates because: a) the findings of low copper bioavailability from plants would be expected to be consistent for soil invertebrates, and b) the physical alterations to the soil and habitat would be expected to have a more significant effect on soil invertebrates. Further discussion about the overall ecological succession expected at the site is provided below in Section 3.1. Additional information specific to soil invertebrates that was considered in the ERA included:

- There were relatively few soil invertebrates collected in 2015 and 2016. Composite samples were collected for beetles/ants (n = 15), spiders (n = 4), and worms/slugs (n = 8). Between two and four tissue samples of each soil invertebrate type were collected from background areas and the data used in a control chart (i.e., the average ± 2 standard deviations [SD]). There was a high degree of variability between individual samples in a given tissue composite type, but the average concentration of copper in beetle/ant composite samples was higher than the average (+ 2SD) upper limit of the control chart.
- The limited number of worm/slug samples had an average copper concentration that was within the range of copper tissue concentrations from laboratory studies that had the potential for reduced survival, growth or reproduction of soil invertebrates. There was not sufficient data to determine the relationship between soil concentrations and the tissue concentration of specific types of soil invertebrates, and many of the papers that evaluated the critical body residue of copper in soil invertebrates acknowledge that there are many factors that can limit site-specific bioavailability. The available data were thus not definitive that a risk to soil invertebrates is present but did provide a qualitative indicator that monitoring was appropriate.

2.3 Wildlife

Risks to wildlife were evaluated using a food chain model. In brief:

- A total of 15 surrogate species were selected from different feeding guilds (e.g., herbivores, carnivores; Table 1). Species-specific variables such as body weight, ingestion rates, and dietary preferences were adopted from federal risk assessment guidance or other reputable sources.
- Realistic worst-case exposure concentrations were determined for soil, water and the various dietary items, typically based on the 95% upper confidence limit of the mean. Site-specific bioaccumulation models were developed and used to predict tissue concentrations from soil concentrations. Bioaccumulation factors for small mammal tissue concentrations (needed to evaluate risk to carnivores) were taken from the literature.
- Relative bioavailability was used to calculate the dose for the wildlife receptors. Relative bioavailability of copper in water was assumed to be 100%. Relative bioavailability of copper in soil was based on site-specific physiologically-based extraction test (PBET) data. Relative bioavailability of copper in dietary items was assumed to be 40% based on information from the literature.
- The total amount of copper ingested per day was compared to conservative toxicity reference values. The food chain model was run separately for different areas and different soil rehabilitation approaches (i.e., transplanted, scarified or intermixed). A risk estimate for each surrogate species was calculated for the entire study area using area weighting. Risks were also calculated for background areas for context.

- Hazard quotients (HQ) were less than 1 for all receptors exposed to vanadium, and most receptors exposed to copper. HQs were greater than 1 for robin, common nighthawk, olive-sided flycatcher and masked shrew. The aggregate HQs (i.e., the area-weighted HQ for the site as a whole) for those four receptors ranged from 1.7 to 2.8. The maximum observed HQ for an individual subarea was 5.1 for masked shrew in the Polley Flats area.
- A hazard quotient greater than 1 does not mean that there are risks to wildlife. The food chain model used many conservative assumptions which were identified in the terrestrial ERA. HQs were also greater than 1 for olive-sided flycatcher and masked shrew exposed to background copper concentrations.

Table 1: Wildlife receptors evaluated with the food chain model

Receptor Group	Feeding Guild	Surrogate Species
Birds	Herbivore	Dark-eyed junco
	Insectivore	Robin; olive-sided flycatcher; common nighthawk
	Omnivore	Raven
	Carnivore	Northern pygmy owl
	Piscivore	Osprey, great blue heron
Mammals	Herbivore	Meadow vole; mule deer
	Insectivore	Masked shrew
	Omnivore	Deer mouse
	Carnivore	Ermine, fisher
	Piscivore	River otter

3.0 FURTHER CONSIDERATION OF UNCERTAINTY

3.1 Uncertainty Related to Ecological Succession

A “triad” style approach (exposure, experimental effects, field effects) is common in weight-of-evidence because the three different types of information are complementary. A well-designed field study provides a meaningful evaluation of risks because it provides direct information about what is being protected under realistic conditions. However, field studies are not always able to determine the cause of effects (if any are observed) and can be confounded by many different variables. Many of those variables (e.g., weather) are unrelated to the management question being evaluated.

A “triad” approach was used in the terrestrial ERA but it was not possible to assess every terrestrial receptor with a field study. In areas of the site that were subjected to extensive scouring, there was a near-complete loss of natural soils and their related ecological communities (i.e., soil microbes, fungi, invertebrates and plants). Quantitative assessment to establish the magnitude of that physical impact was unnecessary. Field measurement of the structure of the plant or soil invertebrate community was not possible because recolonization and ecological succession had only just started. Nevertheless, field studies are expected to be an important aspect of long-term monitoring because they will help to determine if the soil ecosystem is recovering as expected over time.

3.1.1 Summary of Expected Ecological Succession

An example of ecological succession in a hypothetical plant community is provided in Figure 1. Succession progresses through several distinct phases:

- Early succession is dominated by opportunistic species that have high growth or reproductive output, or some specialized ability to occupy a niche that other species cannot. An example would be an invasive, weedy species with a high output of wind-carried seeds. Species that can grow in nutrient-poor soil because they can convert nitrogen to a useable form (“nitrogen fixation”) would also have an advantage. Mites are an example of a primary colonizer from the soil invertebrate community because they have a high dispersal capacity, can tolerate low nutrient levels, and reproduce quickly (Hagvar et al. 2009).
- Middle succession involves increasing competition for resources (i.e., the limited nutrients that are introduced by the decay of leaf litter from the early stages). An example of the middle stages of succession would be the proliferation of alder which have a similar capacity for nitrogen fixation as grasses, but also the ability to outcompete grasses for moisture and light through root and shoot growth. Examples of invertebrates at this stage include ground-dwelling beetles or ants.
- Late succession continues competition in an increasingly diverse number of niches. At a late succession stage, the humic layer has regenerated through the decay and processing of organic material, and there is an ongoing cycle of nutrients in soils from the activity of microbes, fungi and soil invertebrates. Earthworms and other invertebrates that process organic material would be common. The overall ecological function (e.g., production of biomass, respiration, diversity) in the ecosystem has reached its maximum capacity, and the ecosystem has settled into a dynamic equilibrium.

Golder has identified several examples of natural ecological succession from the literature in Table 2, including recolonization of a landscape after a landslide or retreat of a glacier, or reclamation from non-metal mining such as quarrying.

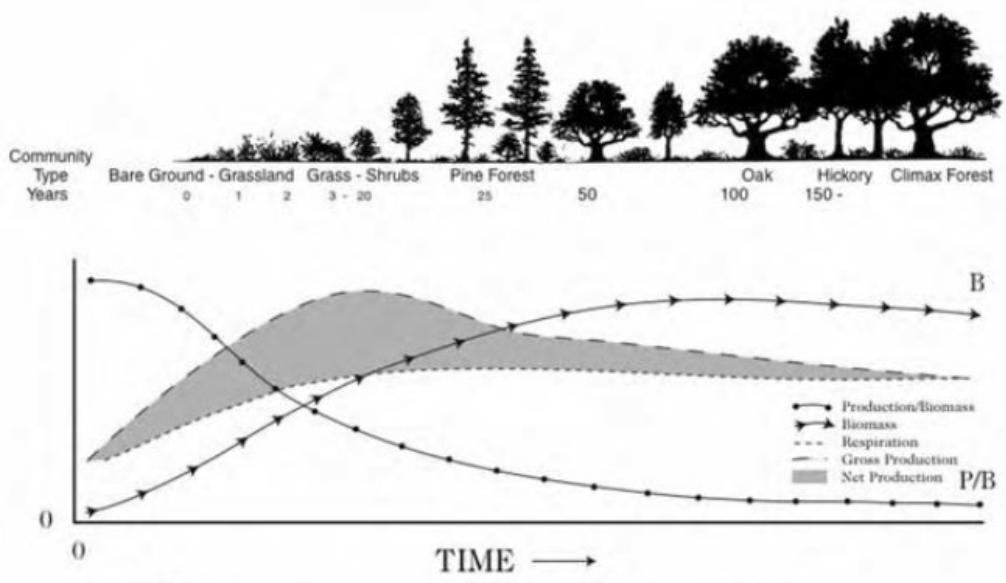


Figure 1: General schematic of vegetative succession over time (from Schneider 2008)

Table 2: Examples of Ecological Succession

Authors	Site Context	Observations
Russell and La Roi (1986)	34-hectare spoil heap of overburden generated from coal mining activities in Rocky Mountain foothills, Alberta.	Vegetative cover limited by coarseness of material and low nutrient levels. Total plant cover is less than 10% despite relatively long length of time since formation of the spoil heap (34 years). Perennial grass and forbs are the dominant species.
Frouz et al. (2008)	Chronosequence of 27 sites on four different coal mine spoil heaps (100+ km^2) in Europe. Total length of time since disturbance was 40 years.	Plant and soil invertebrate communities were assessed. Statistical analysis found that succession was driven by the formation of the humic layer. Sites tended to switch from “no humus” to “humus forming” at roughly 15 years, and from “humus forming” to “humus present” at roughly 25 years.
Miles and Swanson (1986)	Chronosequence of 25 landslides in Oregon. Total length of time since disturbance was 30 years.	Total vegetation cover ranged from 51% (in the primary scar) to 78% (in the primary deposition area). Cover consisted of trees (approximately 50% of the total), shrubs (25% of total) and herbs (25% of total), suggesting that succession had progressed to a mature state.

Authors	Site Context	Observations
Smith et al (1986)	Chronosequence of 49 landslides in Haida Gwaii. Total length of time since disturbance was 150 years. Logged and non-logged areas included for comparison.	Humic layer reformed relatively quickly but had decreased nutrient levels until Year 30. There was a relatively thick cover of red alder (an early colonizing tree species) within 20 years, but the total vegetative cover in the slide areas did not reach the undisturbed areas for 50 years. (For context, a logged area returned to a total cover like the undisturbed area within 20 years).
Gobbi et al. (2006).	Chronosequence of soil invertebrates colonizing a receding terminal glacier moraine. Total length of time was 150 years.	Species richness increased from 2 to 26 genera. Spiders and beetles were the primary colonizers, while ants and centipedes are only present in the older sites. The pattern of succession was consistent with the available information about the habitat preference and life history strategies of each species.

Note: A chronosequence is an ecological study that investigates a set of similar sites that share similar attributes and a similar disturbance but have different ages in order to understand the time-dependent aspects of succession.

3.1.2 Influence of Natural Succession on the Design of the CEMP

Although MPMC has conducted a variety of actions over the last two years to facilitate natural ecological succession, the plant and soil invertebrate community in the area impacted by tailing deposition is likely still in the early, opportunistic stages of recolonization. Further information about the following activities conducted to date can be found in the Conceptual Remediation Plan (Golder 2018):

- Soil manipulation (e.g., scarification to create a “rough and loose” soil material with better physical structure)
- Blending and placement of native topsoils to improve moisture retention and nutrient levels, and to reintroduce native microbes, fungi, seeds and soil invertebrates
- Mounding and placement of coarse woody debris to create preferential microsites where plant recolonization can be accelerated
- Placement of wood chip mulch to increase organic carbon and nutrient levels as the mulch decays
- Riparian planting of native shrubs and conifers
- Seeding of upland areas with a mix of native grasses

The net effect of the original impact and the subsequent rehabilitation effort is that a high degree of variability between areas is still expected because the treated and untreated areas are still in the first few years of succession. The total length of time to reach a mature, dynamic equilibrium is unknown, but likely on the order of 20 to 30 years based on the examples from Table 2. The rehabilitation activities described above would be expected to accelerate and enhance that process. A field study to measure the difference between "control" and "impact" that could separate the relative influence of copper versus physical limitations would be challenging in this early phase. Specifically:

- Comparison to reference is not expected to be practical in the near-term (i.e., one can reasonably conclude that there will be substantive changes between the impacted areas and areas that have not covered with tailings). No suitable reference areas (i.e., an area that has been logged and all vegetation and humic material removed) are currently known.
- Comparison between individual years may not add significant value because differences in weather (e.g., rainfall, snowpack, temperature) would also introduce significant year-to-year variability.

Instead, monitoring of the plant and soil invertebrate community should focus on establishing a long-term trend analysis rather than to support a multitude of pair-wise comparisons that would have limited value for making site management decisions. This would involve:

- **Selecting representative, permanent monitoring plots.** The number of plots will depend on the number of different habitat units to be monitored. These units could be based on copper concentrations, remedial areas, the types of rehabilitation already applied, or other attributes that will influence succession (e.g., slope, moisture content, distance from undisturbed edge).
- **Monitoring each plot in a consistent manner to support analysis of trends over time.** No consensus exists at this time about which specific metrics are needed to monitor progress towards a biologically diverse, functional and self-sustaining ecosystem. Input from other subject matter experts (e.g., mine reclamation specialists) is likely required given that the timelines for monitoring will extend into the mine closure process.
- **Sufficient sampling effort to make informed management decisions.** A defensible trend analysis needs to consider statistical power. Statistical power is influenced by the minimum measurable change and the variability amongst replicates of a given habitat unit. Even if a formal power analysis is not needed, the study design needs a common understanding about how the trend analysis would be used to make future decisions. For example, trend analysis may benefit more from measuring 5 metrics at 50 plots for three years followed by a 5-year hiatus than measuring 10 metrics at 20 plots every year. The 750 measurements in the first option may be more meaningful than the 1,600 measurements in the second option because option 1 provides more spatial coverage and measures inter-year variability.

3.2 Uncertainty about the Relative Influence of Copper on Soil Invertebrates and Plants

The ERA concluded that risks from copper were low, and therefore, further focused investigations to determine the relative influence of copper on soil invertebrates and plants versus physical variables (such as through toxicity testing or greenhouse experiments) were not warranted until there was information from the field monitoring that succession was not progressing towards the long-term management goal of reintroducing a biologically diverse, functional and self-sustaining ecosystem (Table 53 of the ERA). A trend analysis will not provide a definitive check on progress towards this management goal for several years. In the meantime, continued refinement of the site-specific relationships between copper concentrations in soil and copper concentrations in various soil invertebrate and plant tissues is recommended because:

- The presence of sufficient plants or invertebrates for sampling across the range of copper concentrations in soil provides important qualitative evidence (pending confirmation from the trend analysis) that copper is not exerting a significant effect on the survival of soil invertebrates or plants. If areas with the upper range of copper concentrations in soil lack soil invertebrates, or show visual evidence of copper toxicity to plants, it would be a trigger for the more focused investigation (or, could lead directly to supplemental remediation as part of the overall adaptive management strategy).
- Refining the soil-to-tissue relationships provides direct evidence about copper bioavailability and bioaccumulation. This helps to clarify potential differences in copper bioaccumulation between different species or taxonomic groups, and the site-specific relationships can be compared to similar relationships from the scientific literature or other copper-contaminated sites to provide further support to the ERA conclusion that copper bioavailability is relatively low.
- The site-specific bioaccumulation relationships are also used as part of the wildlife food chain model. Some of the existing relationships are based on limited data sets, which have added uncertainty to the results of the food chain model. A more robust relationship between soil and tissue concentrations increases the overall sophistication and future application of the food chain model as part of the CEMP.

3.2.1 Uncertainty in Risk Estimates for Wildlife Species

The food chain model used appropriately conservative assumptions and model parameters consistent with common practices for a screening-level risk assessment.

In terms of risk management decisions, some qualified professionals default to a prescriptive interpretation that any HQ than 1 represents a potential risk that requires further assessment or remediation. Realistically, marginal HQs (e.g., less than 2 or 3) are unlikely to present an unacceptable risk but there is no consensus on a specific threshold between acceptable or unacceptable risk beyond the prescriptive guidance about HQ = 1. The existing HQs are not considered to represent an unacceptable risk but are sufficiently higher than 1 to warrant further refinement of the model to reduce uncertainty. The uncertainty in the HQs generated from the food chain model is the product of the uncertainty in each of the variables used. Not all variables need to be refined. The variables that would benefit most from refinement are:

- Improving the quality of data with respect to tissue concentrations in invertebrates. This can be accomplished by expanding on the bioaccumulation sampling as described in Section 3.2. The food chain model has also conservatively assumed that flying insects have the same tissue concentrations as soil-dwelling insects, which is a data gap that should be addressed by further sampling.

- Refining the toxicity reference values (i.e., the denominator in the HQ). The current toxicity reference value was taken from the ECO-SSL guidance (USEPA 2018) and is based on a conservative “no-observed adverse effect level” from the available literature. This toxicity reference value may be substantially lower than a true “acceptable” concentration that corresponds to low (i.e., not statistically significant) effects on growth or reproduction. A common area for refinement in a wildlife risk assessment is to update the toxicity reference value to reflect an effects-based threshold in lieu of a highly conservative screening threshold.
- Reviewers of the ERA identified the use of relative bioavailability as an uncertainty in the food chain model but did not reach a consensus about whether this issue was significant in terms of the final risk conclusion. There are unresolved differences in professional opinion on this topic which would ideally be addressed as part of the food chain model refinement. Golder notes that ENV has previously accepted the approach used in the current ERA at other sites and believes that further dialogue on this point prior to initiating additional investigation is warranted.

Refinement (or resolution) on these three topics is expected to reduce the overall uncertainty in the food chain model. Golder understands that the refined model would be run for the same subareas and HQs presented for both individual subareas and for the aggregate of the entire study area. Golder also understand that ENV desires that bats (*Myotis* sp.) be added as an additional receptor.

4.0 CONCEPTUAL STUDY DESIGN

4.1 General Approach

A proposed approach to address the remaining areas of uncertainty in the terrestrial ERA is provided in Figure 2. In brief, the following activities are proposed for the remainder of 2018 and the first quarter of 2019:

- Conduct a reconnaissance-level assessment and conduct limited pilot-scale investigation for candidate metrics for inclusion in the long-term trend analysis monitoring of ecological succession.
- Engage stakeholders and subject matter experts in a workshop to review the findings from the reconnaissance-level assessment and to obtain consensus about how a “biologically diverse, functional and self-sustaining ecosystem” will be measured.
- Conduct a one-time supplemental sampling program to refine the current information regarding copper bioaccumulation and relative bioavailability. Refine the toxicity reference values and use all three outputs from the one-time supplemental sampling program to update the food chain model.
- Develop the preliminary design for the trend monitoring in terms of specific metrics, sampling effort, frequency and interpretative approaches and submit for regulatory approval.

At the completion of these four activities, the CEMP will be updated to incorporate the specific design for long-term monitoring of the ecological succession expected to occur over time. The long-term monitoring will need triggers for when ecological succession will be deemed to be insufficient (even if such triggers are narrative). Additional rehabilitation or additional investigation regarding the cause of the insufficient progress would occur if those triggers are exceeded.

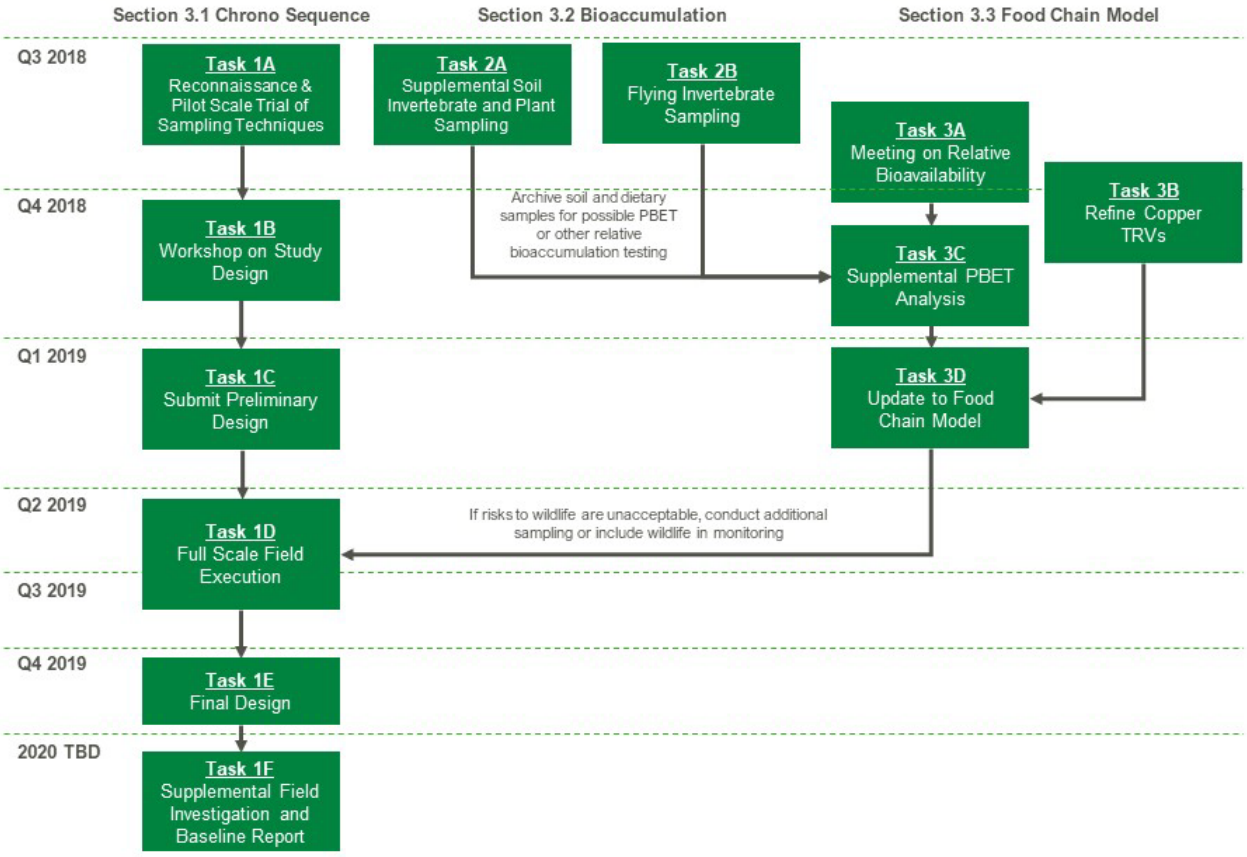


Figure 2: Proposed Approach for the Terrestrial CEMP Component

4.2 Additional Information

4.2.1 Task 1A – Reconnaissance and Pilot-Scale Sampling

There is value in conducting a reconnaissance-level sampling program in the summer of 2018 to provide at least a narrative description (supported by field measurement) of the current state of ecological succession. The reconnaissance-level sampling will focus on:

- Determining the diversity and percent cover of plants in three plots in each of the seven major terrestrial units (Halo; Untreated – Polley Flats; Untreated – Upper Hazeltine; Untreated – Lower Hazeltine; Transplanted; Intermixed; Scarified) for a total of 21 plots.
- Making detailed observations about plant succession in selected locations where additional rehabilitation was conducted (e.g., placement of large woody debris, mounding, placement of mulch).
- Conduct an overall site inspection to identify if there are areas that were subject to additional rehabilitation where no ecological succession appears to be occurring.

- Conducting a standardized bird survey at five locations (for spatial coverage) to document which species are using the available habitat. (Birds are selected for the survey because of the potential that listed species would use the habitat). Habitat monitoring for other wildlife species is not included in the scope of this reconnaissance-level sampling.

Data from the reconnaissance sampling will help to inform the design of the long-term trend analysis. Golder will also use the opportunity to conduct a pilot-scale trial of sampling techniques that could be used to measure other aspects of ecological succession. For example, the future trend analysis (see tasks below) may involve a metric related to soil invertebrate diversity, density or function. The literature describes a wide array of possible sampling techniques (e.g., a soil core to measure the diversity and abundance of mites; a bait-trap to measure the biomass of ants; a pit-fall trap to measure the diversity of ground-dwelling beetles). Golder is using malaise traps, pit-fall traps and Berlese funnels as part of the tissue sampling, any one of which could add value to the design of the long-term monitoring.

4.2.2 Task 1B – Workshop on Design of Trend Analysis

Golder expects that reviewers and stakeholders would comment extensively on the design of the trend analysis, and a variety of technical opinions are expected. There is a wide diversity of possible technical approaches, compounded by an absence of risk assessment guidance on how ecological succession should be monitored.

Golder expects that it will be necessary to draw on regulatory guidance from other relevant Ministries (e.g., Mines, Forestry) where landscape level changes in plant communities are more commonly assessed. For example, BCMOFR/BCMOE (2010) provides guidance on how to assess terrestrial ecosystems, but guidance on measuring successional state is limited to a semi-quantitative assessment that tracks the proportion of early colonizers (‘seral’ species) to later colonizers (‘climax’ species). No specific thresholds for the different states are described and therefore, the site could conceivably remain in a “pioneer” state for 60 or more years. This type of narrative assessment, although described in regulatory guidance, would not add value for site management decisions. Conversely, there are examples of how plant succession is being monitored for mine closure purposes in a quantitative manner (e.g., Highland Valley Copper focuses on plant diversity and functional contribution as a surrogate for the broader ecological succession; Smyth et al. 2016) but no specific thresholds are described beyond “continued progress”.

Golder proposes a one-day workshop where a focused overview of the findings from the reconnaissance-level sampling and tissue sampling can be presented, followed by discussion of relevant examples of risk-based mine closure and monitoring elsewhere in British Columbia. Potential examples where publicly-available information is likely available include the Britannia Mine, the Sullivan Mine, and Highland Valley Copper. It is important to establish at least a preliminary consensus with the regulators about the intended application of this part of the CEMP before effort is expended on the design and costing of specific methods. This workshop is intended to be similar to the Problem Formulation Workshop that helped to build consensus on how the ERA was ultimately executed.

4.2.3 Task 1C – Preliminary Design of Trend Analysis

Golder will develop a preliminary design for the long-term trend analysis based on the reconnaissance sampling, further consideration of relevant examples at other BC mine sites, and input from the reviewers.

4.2.4 Task 1D – Full Scale Field Execution

Golder proposes that the preliminary sampling design would be implemented in the spring and summer of 2019. The scope of this program is currently unknown, pending the outcome of the preliminary design.

4.2.5 Task 1E – Refinement to Design

Conceptually, Golder envisions that the preliminary design might specify a larger number of potential metrics which would be reduced to a final subset based on the data collected in 2019. The intent of the refinement step is to provide a formal check that the preliminary design has been fully optimized in terms of effectiveness and efficiency. A key aspect of optimization is that it is not necessary to continually monitor all aspects of the ecosystem as a conservative, precautionary approach. Instead, the goal is that the CEMP component provides a science-based framework for adaptive management. Adaptive management focuses on monitoring a smaller number of metrics (but monitoring them well) so that there is a clear baseline with pre-defined triggers for when one-time supplemental investigations might become necessary.

4.2.6 Task 1F – Baseline Report

Conceptually, the terrestrial monitoring component will focus on monitoring succession at pre-defined intervals rather than annually. The ERA and its supporting appendices contain information about conditions up to approximately D+3 (disturbance + 3 years). The reconnaissance sampling is effectively an interim snapshot about D+4, and the full field execution would provide the formal baseline that reflects conditions at D+6 (and possibly D+7, if year-to-year variability is included in the study design). Subsequent cycles of the terrestrial monitoring program would then document the ongoing ecological succession at defined intervals post-baseline (e.g., baseline + 2 years, B+5, B+10, B+20).

4.2.7 Task 2A – Soil Invertebrate and Plant Sampling

This task is a standalone activity intended to reduce the uncertainty in the existing site-specific bioaccumulation models (Figure 3) for soil invertebrates and plants. Both models could be improved by obtaining additional co-located soil and tissue samples so that the relationships are not based on composite samples (e.g., separate ‘surface insects’ into ‘ants’, ‘spiders’ and ‘beetles’; separate ‘grass’ into the main species that have been seeded on the site). Conceptually, Golder would target different specific taxa or species emphasizing areas that have not yet been sampled (i.e., the three reclamation treatments). These areas tended to have copper concentrations in the middle of the range bounded by the background and untreated areas. All data (i.e., data from Golder 2017 and data collected in August 2018) will be used to refine the existing bioaccumulation relationships (see Figure 3, below). Note that the total number of tissue samples submitted for analysis will be dependent on the trap effectiveness. A decision on whether the supplemental data are sufficient will be made in light of the uncertainty in the regression equation.

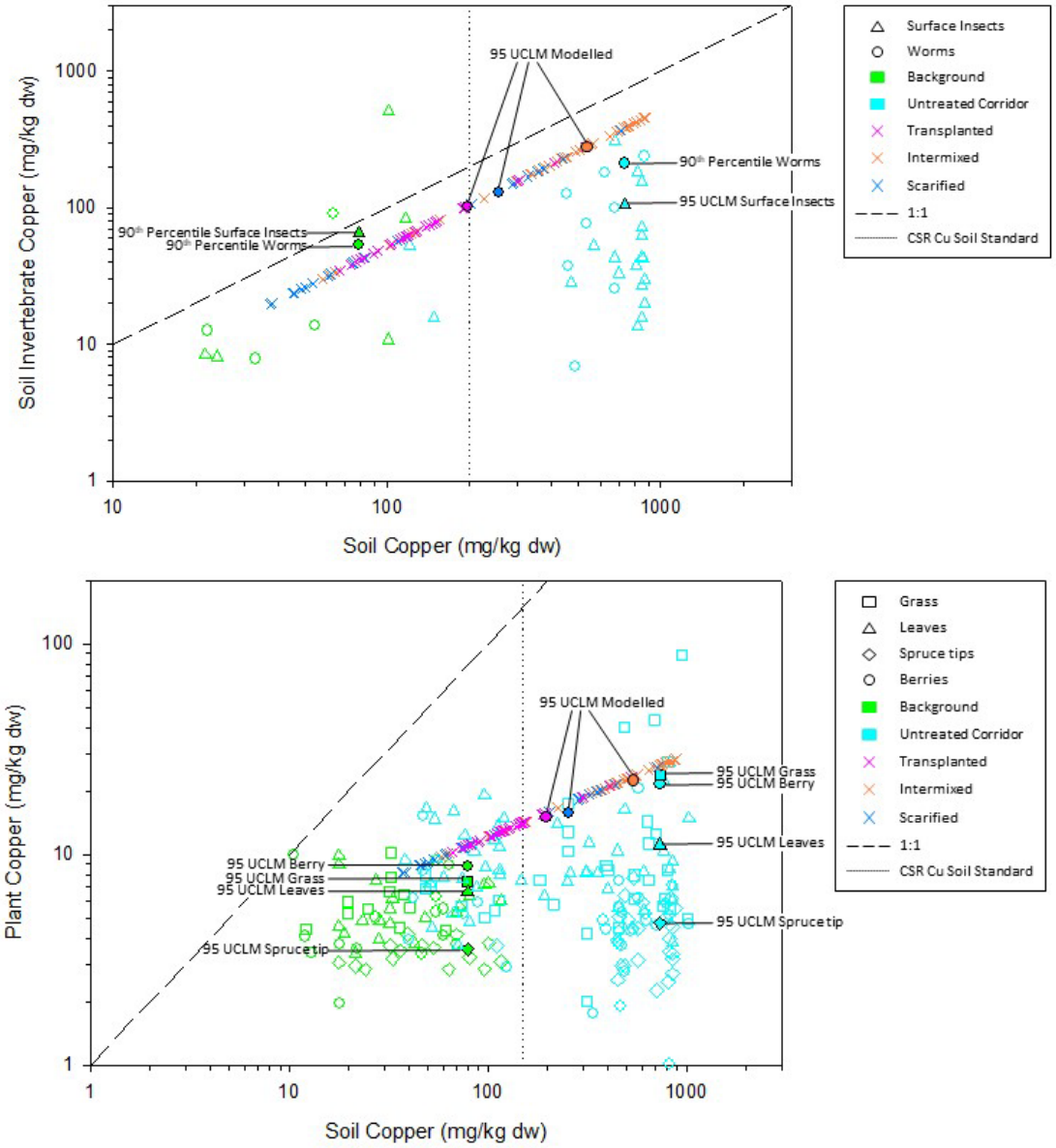


Figure 3: Existing bioaccumulation models for soil invertebrates and plants (from Golder 2017, Appendix F)

4.2.8 Task 2B – Flying Insect Sampling

This task is a standalone activity to address a data gap in the food chain model. Golder will collect flying insects (e.g., moths, flies, flying ants, grasshoppers) using malaise traps with lights. These taxonomic groups reflect the likely dietary items for insectivorous birds and bats. Hand collection with butterfly nets will also be employed. Ideally, sufficient biomass will be collected from a single location to allow for submission of taxa-specific composites (not a composite of all flying insects). Tissue concentrations are not expected to be directly related to local soil concentrations because flying insects are mobile, and therefore, the goal would be to focus on sampling from five broad zones (e.g., Polley Flats, Upper Hazeltine, Lower Hazeltine, Halo, and Background. The goal is to obtain at least seven tissue samples per taxonomic group per area (to allow for the calculation of a 95% upper confidence limit of the mean). The total number of tissue samples submitted for analysis will be dependent on the trap effectiveness.

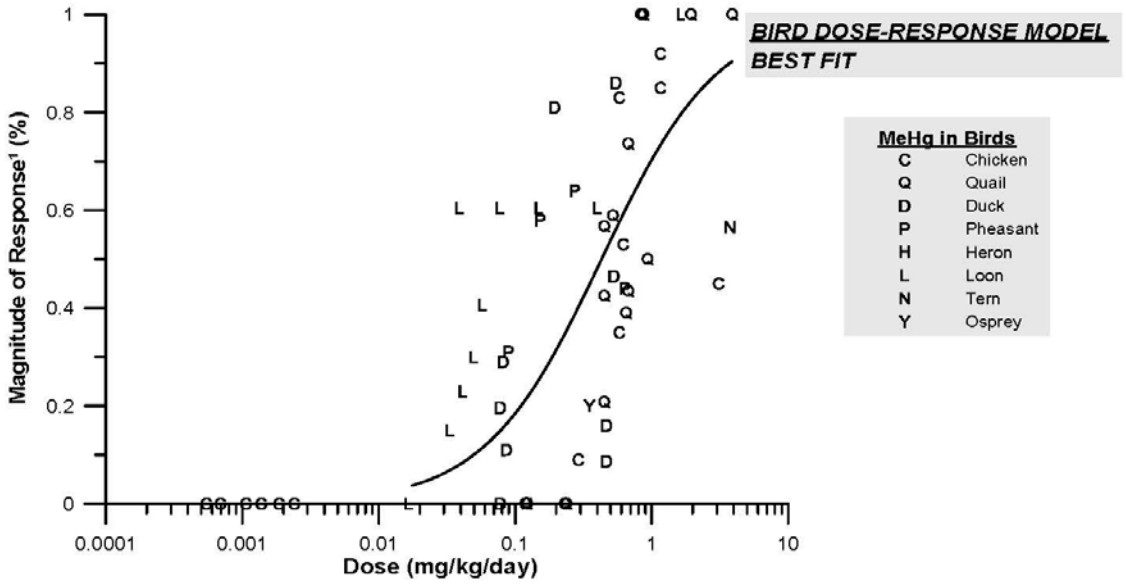
4.2.9 Task 3A – Meeting on Relative Bioavailability

There was conflicting feedback from technical reviewers about how the food chain model incorporated the relative bioavailability of copper in water, food and dietary items once ingested by different ecological receptors. Golder assumed that copper in water would have a 100% bioavailability relative to the form of copper added to the food used in the original mammalian or avian toxicity test. Site-specific PBET data was used as a surrogate for the relative bioavailability of soil, and information from the literature was used to provide a conservative estimate of the relative bioavailability of copper once incorporated into biological tissues. Similar approaches have been approved by ENV at other sites, including the risk-based management of elevated copper in soils at the Britannia Mine. Relative bioavailability for soil and dietary items has also been evaluated in the risk assessment literature with specific consideration of the potential for differences in gastrointestinal bioavailability between mammals and birds (e.g., Sample et al., 2014; Kaufman et al., 2007).

Golder recommends holding a focused meeting on this specific technical topic with the subject matter experts and ENV. Eliminating relative bioavailability from the food chain model would be demonstrably over-conservative and inconsistent with the scientific principles that influence how an ingested dose is ultimately absorbed by birds and mammals. If the consensus from that meeting is that further quantitative assessment is needed to support the existing approach, it would be completed this fall in Task 3C. Golder proposes to collect archive tissue and soil samples in the summer sampling program (Task 2A) as a precaution (subject to the availability of sufficient tissue mass).

4.2.10 Task 3B – Refinement of Copper TRV

Golder will update the existing toxicity reference values for copper to use a multi-study concentration profile in lieu of the existing point-estimate based TRVs adopted from ECO-SSL. A similar approach has been proposed in the amphibian monitoring component of the CEMP. The development and application of ECx-based toxicity reference values in wildlife food chain model is well-established in the scientific literature (e.g., Allard et al. 2010) and has been adopted by provincial and federal risk assessment guidance manuals (e.g., Environment Canada 2010) as an accepted practice to refine screening-level ERAs.



[1] *The magnitude of response y-axis scale extends from 0 to 1 (e.g., 0.5 corresponds to a 50% effect size such as reduction in reproductive output relative to control).*

Figure 4: Example of a multi-study concentration response profile (from Environment Canada 2010, courtesy of Azimuth Consulting Group)

4.2.11 Task 3C – Supplemental Bioavailability Analysis

Golder believes that there is sufficient technical support and past precedents for the current use of relative bioavailability in the wildlife food chain model. However, if necessary based on Task 3A, Golder would conduct additional analysis on archived soil, plant and invertebrate tissue samples to provide further information about how bioavailability can be incorporated into the food chain model. Conceptually, relative bioavailability is about establishing a common modifying factor to interpret the total copper concentrations that are established by the chemical analytical laboratory. A focused assessment that involves the same bioavailability analysis on water, soil, food and representative “spiked-food” samples made to duplicate the original approach used in the key toxicology studies from the literature would create a common basis for relative bioavailability in the food chain model.

4.2.12 Task 3D – Update to Food Chain Model

This task is a standalone activity to update the food chain model with the information obtained in Tasks 2A, 2B, 3B, and 3C. Depending on the quantity of information from 2A and 2B, it may be possible to add additional refinement in terms of dietary preferences to more closely reflect how different receptors would be expected to use the site. A bat will also be added as an additional surrogate receptor per ENV’s request. The deliverable for this task would be an update to the existing food chain model report (Appendix F of the ERA).

5.0 SUMMARY

This memorandum describes a proposed approach for the terrestrial component of the CEMP. Not all tiers are recommended for immediate implementation, and there are significant technical and regulatory issues that would need to be resolved as part of the design and execution. Golder recommends that the current CEMP focus on executing the proposed tasks up to the end of Q1 2019. This includes progressing the proposed chrono sequence approach for the long-term CEMP up to the point of submitting a preliminary design for formal ENV approval. The proposed tasks also include activities to reduce the uncertainty in risk estimates to soil invertebrates and wildlife that addresses the content of Table 53 of the ERA.

6.0 CLOSURE

The reader is referred to the Study Limitations, which follows the text and forms an integral part of this technical memorandum.

Please do not hesitate to contact the undersigned if there are questions regarding this memorandum.

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Attachment: Study Limitations

https://golderassociates.sharepoint.com/sites/10023g/documents_1894924/2. issued/025-tm-23182-terrestrialconcept/rev1/1894924-025-tm-rev1-23182-terrestrialdesignconcept_09aug_18.docx

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STUDY LIMITATIONS

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Appendix B.2.1

Updated Scope for Terrestrial Wildlife Monitoring Plan in the Hazeltine Creek Corridor

DWB Consulting Services Ltd.

October 27, 2021
Project: 21274-004 LB

Mount Polley Mining Corporation
PO Box 12
Likely, BC V0L 1N0
Via email: mathieu.o'leary@mountpolley.com

Attention: **Mathieu O'Leary, Technical Services Superintendent**
Gabriel Holmes, Environmental Technician

Dear Matt, Gabe:

Reference: **Updated Scope for the Terrestrial Wildlife Monitoring Plan for the Hazeltine Creek Corridor**

1.0 INTRODUCTION

Mount Polley Mining Corporation (MPMC), a subsidiary of Imperial Metals, operates the Mount Polley Mine ("Mount Polley" or "the mine") where a copper-gold porphyry deposit has been developed since 1997. The mine is located approximately 10 km south from Likely, BC, and 60 km northeast from Williams Lake, BC, on the unceded traditional territory of the Northern Secwepemc (Shuswap), and near two Indigenous communities: the T'exelc (Williams Lake), and Xatśūll (Soda Creek) First Nations. The total lease area of the mine is approximately 19,000 ha.

An unexpected Tailings Storage Facility (TSF) permitter embankment breach (the breach) occurred in 2014, resulting in 25 million m^3 of tailings, interstitial water, and construction material spilling into Polley Lake, Hazeltine Creek and Quesnel Lake. The mine temporarily ceased operations in response to the spill and initiated an ecological risk assessment with follow-up remediation and research programs. Initial remediation activities focused on removing the spilled tailings, stabilizing and revegetating spill-impacted environments, and restoring the Hazeltine Creek channel and riparian areas for fish.

Mount Polley returned to operations in 2015 and was granted approval to discharge effluent under ENV Permit 11678 (discharge permit) to Quesnel Lake through a diffuser pipeline. One of the conditions of the permit was the development of a Comprehensive Environmental Management Plan (CEMP) to evaluate and mitigate the effects of mining-related activities on the physical, chemical, and biological characteristics of the impacted areas (ENV 2020).

The most recent revision of the CEMP (October 2019) included provisions for wildlife monitoring in Section 6.17 and objectives that included documenting mammals and birds on the mine site and adjacent areas for the purposes of land use planning and monitoring (MPMC 2019). Pursuant to these conditions, MPMC developed the Mammal Monitoring Plan (DWB 2020), which utilized remote cameras to observe and monitor mammals. In addition, MPMC continued vegetation and avian point count surveys as outlined in the pre-existing Terrestrial Wildlife Monitoring study (Golder 2019a). Feedback provided by the

Government-to-Government Technical Working Group (TWG) and LGL Limited (LGL) on behalf of the T'exelc and Xatśūll First Nations determined that the existing monitoring plans were lacking quantitative data and relied too heavily on assumptions drawn from other research (ENV 2021; LGL 2021).

ENV approved the most recent revision of the CEMP in February, 2021, with a set of conditions, including the development of a more quantitative wildlife study program (Condition 18):

> *18) MPMC must submit a plan for a quantitative wildlife study design by October 30, 2021 to determine wildlife recovery by area and reclamation type, which includes associated outcomes from the previous years as an attachment. The submitted study design and results should incorporate the following comments from the Government to Government Technical Working Group (G2G TWG) on the 2019 "Detailed Study Design for Terrestrial Wildlife Monitoring", the "Update to Wildlife Food Chain Model for Mount Polley Mine", and the "Amphibian Hazard Assessment"…*

The CEMP Approval Letter and LGL's feedback letter can be found in Attachment C. The existing wildlife monitoring plans, which TWG and LGL provided feedback on, can be found in Attachment D.

This updated wildlife monitoring study seeks to develop a quantitative monitoring methodology which specifically addresses the TWG comments in Condition 18 (ENV 2021), and feedback provided by LGL on the 2020 Mammal Monitoring Plan (LGL 2021). The plan will fulfill the objectives of the CEMP, as required by Discharge Permit 11678. Refer to Section 1.4 for the overall objectives of the updated wildlife monitoring program.

1.1 REGULATORY REQUIREMENTS

Two primary regulatory permits apply to Mount Polley in relation to wildlife. Permit 11678 (ENV 2020), issued by BC ENV under the Environmental Management Act (EMA), requires the development and periodic revision of a CEMP, which stipulates the implementation of a wildlife study. Section 3.2.1 of Permit 11678 specifies that the CEMP "evaluate the effects of mining-related activities on the physical, chemical, and biological characteristics of Hazeltine Creek, Edney Creek, Bootjack Lake, Morehead Creek, Polley Lake, Quesnel Lake, Quesnel River, and associated riparian and upland areas."

The conditionally approved CEMP provides direction in terms of project objectives relating to wildlife (MPMC 2019). The objectives are "to evaluate the environmental impacts of the august 2014 TSF embankment breach, to inform the rehabilitation plan, as well as to evaluate the effects of mitigation measures that are implemented as part of the rehabilitation strategy;" and "to inform reclamation and closure (Mines Act Permit M-200)."

Interrelated with the objectives of the CEMP are requirements for wildlife protection and reclamation under Permit M-200, issued by the BC Ministry of Energy, Mines, and Low Carbon Innovation (EMLI) under the Mines Act (EMLI 2020). Section 12 of Permit M-200 requires the development of a Wildlife Management Plan, which was completed in March 2021, and incorporates monitoring as one of its components (MPMC 2021). In Section 5.4 of the Wildlife Management Plan, the stated objectives of wildlife monitoring are to "determine the success of remediation works completed at Polley Flats and the Hazeltine creek Corridor, as well as the success of any future remediation that is implemented to achieve long term reclamation and closure objectives."

End land use objectives are outlined in the Reclamation and Closure Plan (MPMC 2017), as required by Permit M-200, which states that "The main objective of the reclamation program is to return all areas that have been disturbed by mining operations (except pit walls) to equivalent or greater land capability than existed prior to mining, on an average property basis." And specifies that "prior to mine development the main land uses in the Mine Site area were commercial forestry and wildlife habitat." It is important to note that, prior to reclamation and closure, the permitted mine area as defined by permit M-200 is not considered wildlife habitat and is outside the scope of this study.

Another requirement of Permit M-200, under section 14. (a), is the development of a Reclamation Research Program, which was completed in March 2021 (MPMC 2021b). Ecosystem restoration, soil management, and plant community re-establishment are identified as avenues for the redevelopment of wildlife habitat, pursuant to end land use objectives. This wildlife study, while not required by the Reclamation Research Program, will contribute to a body of work that informs future reclamation activities by assessing the effectiveness of restoration in the Hazeltine Creek corridor, on the end land use objective of wildlife habitat. Overall, the regulatory requirements relating to Mount Polley's impact on terrestrial wildlife are complex and require a quantitative assessment of the physical, chemical, and biological impact of the breach, and other mine related activities, on wildlife.

Some terrestrial wildlife monitoring has already been completed, largely associated with the Post-Event Environmental Impact Assessment Report (PEEIAR) and its update (MPMC 2015, 2016). This study is designed to fill gaps that exist in wildlife monitoring, as identified by ENV in the CEMP Conditional Approval Letter, as well as those identified by the TWG and LDL in their reviews of the prior wildlife monitoring plans. It is appropriate to focus monitoring on the Hazeltine Creek corridor, which includes Polley Flats, Hazeltine Creek, and Edney Creek, as well as their riparian areas. Monitoring the Hazeltine Creek corridor will simultaneously fulfill multiple regulatory objectives, such as assessing the impact from mine-related activities, informing restoration efforts, and contributing to a body of reclamation research.

1.2 STAKEHOLDER AND FIRST NATIONS FEEDBACK

LGL, acting as representatives of T'exelc and Xatśūll, found the Mammal Monitoring Plan plan to be limited in its ability to provide sufficient information for land use planning and environmental monitoring (LGL 2021). LGL recommended providing information on small mammal species and developing a statistically robust dataset that could be used to determine population metrics, such as relative abundance or species-habitat relationships. LGL also recommended using more cameras and moving them less frequently, to establish time-series data to assess mammal occurrence, distribution, and occupancy.

The TWG identified deficiencies with the Terrestrial Wildlife Monitoring Plan and the Food Chain Model and stated they would like to see assessments of species abundance by subarea and the establishment of reference areas that represent end land use objectives. The TWG also expressed interest in analysis of songbird communities and periodic monitoring of soil invertebrates, to create a dataset that is more robust to seasonal variations and migratory pressures on birds. The TWG also identified uncertainties in the food chain model, which was developed by Golder (2019b), to assess the potential for trophic transfer of trace metals in wildlife species.

1.3 SCOPE AND LIMITATIONS

There are extensive requirements for wildlife monitoring at Mount Polley, stemming from different institutions with separate and often overlapping objectives. It is not practical or desirable for this wildlife study to fulfill all regulatory objectives and, therefore, limiting the scope of this study is essential. The scope of the study is made based on Condition 18 of the CEMP approval letter, and feedback from TWG on the pre-existing Terrestrial Wildlife Monitoring Plan (Golder 2019a) and from LGL on the Mammal Monitoring Plan (DWB 2020).

This study is designed to fulfill CEMP requirements for wildlife monitoring and meet Condition 18 of the February 2021 CEMP Approval Letter. The study will produce a quantitative dataset that can be used for land use planning and to monitor the effectiveness of reclamation initiatives providing wildlife habitat in the Hazeltine Creek corridor. A longer-term study was determined to be necessary to assess environmental change over time and to overcome variability that is inherent in wildlife monitoring programs. The study is planned for 10 years and incorporates adaptive management principals to address the potential for site changes over time (see Section 5.0).

Monitoring will focus on terrestrial environments in the Hazeltine Creek corridor, which includes riparian and upland areas associated with Polley Flats, Hazeltine Creek, and lower Edney Creek. Monitoring in the Hazeltine Creek corridor will simultaneously fulfill multiple management objectives for reclamation by evaluating the success of revegetation, surface treatment, and riparian restoration.

Assessment and validation of the food chain model, as summarized in Golder (2019b), will be completed under a separate project scope to determine the risk of bioaccumulation. This study was designed on the premise that the food chain model is accurate in its initial interpretation that the risk of bioaccumulation of heavy metals in the Hazeltine Creek corridor is low (Golder 2019b).

Specific indicators are targeted for wildlife monitoring, including birds, small and large mammals, and terrestrial invertebrates (see Section 2.0). Monitoring of aquatic environments and vegetation communities fall under separate monitoring programs and are considered outside the scope of this study.

1.4 PROGRAM OBJECTIVE

The objective is to complete a quantifiable study that will provide the following evidence at the end of the monitoring program:

1. Ecological succession is actively occurring in the Hazeltine Creek corridor in response to reclamation initiatives.
2. Wildlife is utilizing the available habitat on the reclaimed sites.
3. The habitat on the reclaimed sites is capable of supporting important wildlife life-history functions, such as breeding, foraging, and establishing territories.

Direct measures of wildlife status and trends will be used to assess the dynamics of wildlife and relevant fauna that were chosen as performance indicators for this study.

2.0 PERFORMANCE INDICATORS

The reclaimed areas of the Hazeline Creek corridor are primarily representative of an early successional ecosystem characterized by recent establishment of soil and vegetation. A reclaimed area on the northeast side of Hazeltine Creek at the confluence with Quesnel Lake (referred to as the 'Halo Zone') is considered the farthest along the successional gradient based on the presence of standing trees, soil substrate, and mature shrubs that remained after the tailings breach in 2014. Quantifying changes in early successional ecosystems can be challenging due to the high degree of variability in the environment and the duration of time it can take for soil, vegetation, and fauna to mature and develop, relative to the timespan of monitoring (Walker and del Moral 2011).

To achieve the objective of the program (Section 1.3), while balancing time and effort constraints, monitoring will be focused on indicators that will provide direct or indirect evidence that ecological succession is developing along a trajectory that will support native wildlife. Indirect evidence, such as inferring relationships between habitat characteristics and wildlife presence, can inform reclamation progress/success, and ecosystem recovery (Mac Nally 1997, Hanson et al. 2009, O'Brien and Dawson 2016), and is often favoured due to ease of monitoring. However, indirect evidence often relies on the assumption that wildlife presence is correlated with the capacity for the chosen habitat to support crucial life-history requirements, which may not be accurate in disturbed ecosystems. For example, migratory birds may choose habitat based on selection pressures and availability of site characteristics that meet basic breeding requirements (e.g., vegetation type and size; Chalfoun and Schmidt 2012); however, recently revegetated sites with poorly developed terrestrial substrate may be insufficient for supporting invertebrate communities that birds would rely on to feed nestlings (O'Brien and Dawson 2016).

Indirect evidence that relies solely on wildlife-habitat associations can also be difficult to interpret since wildlife populations can be influenced by other unmeasured factors such as climate and weather patterns (Mawdsley et al. 2009), natural inter-annual population changes (Rowe and Terry 2014, O'Brien and Dawson 2016), and predator-prey dynamics (Stenseth et al. 1997). To address this concern, performance indicators that provide evidence of ecological productivity have been included in the study to supplement species observations, so that stronger inferences can be made at the end of the monitoring program (see Section 6.0). Food resources was chosen as the primary measure of habitat productivity for this study, since nutrition is a limiting factor for survival and population growth for many wildlife species observed in this program (Hobbs and Swift 1985; O'Brien and Dawson 2008, Parker et al. 2009, Nielsen et al. 2010, O'Brien and Dawson 2016). Habitat on disturbed sites with poor productivity can have the unintended consequence of negatively impacting wildlife populations if left unaddressed (Heinrichs et al. 2015).

Table 1 summarizes the selected performance indicators that will be the focus in this program, and which will help determine whether wildlife habitat targets have been achieved (see Section 6.0).

TABLE 1. PERFORMANCE INDICATORS

INDICATOR	OBJECTIVE	RATIONALE
Reference Sites	Natural Variability and Comparison with Reclamation Sites	• Establishing reference sites will allow for a distinction between natural variability in performance indicators and variability in indicators caused by reclamation site characteristics. • Will inform monitoring targets at a spatio-temporal level that is locally meaningful for the reclaimed sites being assessed.
Breeding Birds	Indicator of Habitat Availability	• Different groups of birds have specific habitat requirements to support their various life history functions (breeding, foraging, territory), which make them informative indicators of habitat availability (Mac Nally 1997, Hanson et al. 2009, O'Brien and Dawson 2016). • Relatively efficient to survey. • Can be combined with other survey results (i.e., vegetation and terrestrial invertebrates) to provide stronger evidence that the habitat is capable of supporting breeding populations. Different assemblages of bird species (hereafter referred to as communities) can also signal when ecological succession is progressing to a more mature state (Block 1987, Schieck and Song 2006, Hawkes 2021).
Small Mammals	Indicator of Habitat Availability and Productivity	• Respond quickly to disturbed environments and have relatively short generation times (Pearce and Venier 2005). • Utilize coarse woody debris (CWD), which is one of the reclamation tactics used to improve wildlife habitat availability in the impacted areas of the Hazeltine Creek corridor. • Provide an important food source for many other wildlife groups, including raptors, furbearers, and large carnivores (Pearce and Venier 2005).
Terrestrial Invertebrates	Indicator of Habitat Availability and Productivity	• Provide an important food source for other wildlife, especially for many early-successional bird species that rely on ground-dwelling arthropods to support nestling growth. • Act as an indicator of terrestrial substrate development in early-successional ecosystems (Hernández et al. 2014, Gervan et al. 2021).
Large Mammals	Indicator of Habitat Availability	• Indicate whether the reclaimed features, such as reconstructed stream channel, CWD, and vegetation are

INDICATOR	OBJECTIVE	RATIONALE
		attractive for the purposes of breeding, foraging, travel, and/or shelter. • Can be combined with other survey results (i.e., vegetation and small mammals) on the reclaimed sites to provide stronger evidence that reclamation initiatives are supporting large mammal populations and facilitating predator-prey dynamics.

Habitat Availability – The existence of site characteristics, such as terrestrial substrate (soil and amendments), vegetation, CWD, and watercourses, that attract wildlife and meet at least one or more of their life-history requirements, such as shelter.

Habitat Productivity – The ability of a site to provide sufficient food resources to support wildlife survival and population growth. Used as a proxy for habitat quality.

3.0 SPECIES AT RISK

Wildlife that are provincially and/or federally identified as a species at risk, or a species of concern, will be documented during each reporting period. Recommendations will be provided in accordance with all appropriate provincial and federal guidance documents to ensure any habitat-specific requirements of at-risk species that are present are accounted for throughout the program.

4.0 METHODOLOGY

The updated methods for the monitoring program were developed using the *Mount Polley Mine – Detailed Study Design for Terrestrial Wildlife Monitoring* as a foundation (Golder, 2019a), which already has two years of monitoring data that can be incorporated into the long-term program. The existing study design also has a 5-year monitoring program that assesses vegetation to quantify ecological succession; this portion of the program is anticipated to continue for 3 more years without any additional changes. Therefore, vegetation has not been included in this version of the updated wildlife program except to assess the suitability of reference sites and characterize point count stations for breeding birds.

Table 2 discusses the key tactics that will be used to monitor performance indicators.

TABLE 2. MONITORING METHODOLOGY

INDICATOR	METHODS
Reference Sites	• Reference sites will be established in 2022 for comparison to the reclaimed sites. A minimum of 6 sites will be established and will correspond with areas that are: ▪ Examples of mid-successional habitat (e.g., forestry blocks harvested in the last 10 – 30 years). ▪ Mature forest sites representative of the habitat along Hazeltine Creek prior to the breach (100 – 200 years). • Vegetation Resource Inventory (VRI) data and Biogeoclimatic Ecosystem Classification (BEC) information will be used to identify reference sites.

INDICATOR	METHODS
	Sites will be field-verified in the spring of 2022. Ease of access will also be an important consideration to ensure survey efficiency. • Habitat along the upstream reach of Edney Creek (Watershed Code: 160-585700-03800) and unnamed creek (Watershed Code: 160-585700-03800-27000) have been identified as potential areas for reference sites. See Attachment B for a map of potential areas.
Reclaimed Sites	• Reclaimed sites have already been established and currently correspond with the impacted areas along Hazeltine Creek that were delineated according to reach location, site characteristics, and treatment types (Golder, 2019a): ▪ Lower Hazeltine – Near Quesnel Lake: mounded with CWD and recontoured with topsoil. ▪ Lower Hazeltine – Halo Zone: characterized by trees and vegetation that survived the breach. ▪ Lower Hazeltine – CWD: recontoured with topsoil and CWD, ripped and mounded with CWD, application of wood chip mulch. ▪ Upper Hazeltine: Mounded and recontoured with topsoil and CWD. ▪ Polley Flats: ripped and mounded with CWD, covered in soil
Breeding Birds	• Breeding Bird Surveys will continue to be conducted according to the methods established by Golder (2019a). A total of 15 plots currently exists on the reclaimed sites; however, an additional 15 plots will be established in 2022 across a minimum of 5 reference sites for comparison. • Vegetation characteristics, such as shrub and tree species composition, percent ground cover, and percent canopy cover, will continue to be documented for each survey plot. • Population metrics will be reported after each survey period, including: ▪ Species Abundance ▪ Species Richness ▪ Shannon's Diversity Index ▪ Simpson's Diversity Index ▪ Conservation Value analysis ▪ Indicator Species Analysis • Multivariate analyses that explore differences in songbird community assemblages between reference and reclaimed sites over time will be reported in Years 5 and 10. Songbird communities will be categorized according to early-successional species, mid-successional species, and mature forest species. The songbird communities will be assessed to see if changes in community structure can be observed in the reclaimed sites over time following similar methods to Hawkes (2021).
Small Mammals	• Small mammal surveys will be conducted to determine relative abundance and species richness. Methods may include live trapping and/or the use of remote cameras to achieve these outcomes.

INDICATOR	METHODS
	• If live trapping methods are used, surveys will be consistent with the standards provided by the BC Resources Information Standards Committee (RIC 1998a). • If remote camera methods are used, the sampling design will be field-fit to ensure the data is interpretable and applicable to at least one of the benchmarks outlined in Section 6.0.
Terrestrial Invertebrates	• Pitfall trap surveys will be conducted in Year 5 and Year 10 to determine the relative abundance and species richness of terrestrial invertebrates (primarily arthropods). Years 5 and 10 were chosen to provide time for ground cover and soil amendments to mature on the reclaimed sites. • Pitfall trap surveys will be conducted to the standards provided by RIC (1998b) and will include the installation of safeguards to prevent small mammals and amphibians from falling into traps.
Large Mammals	• A presence/not detected wildlife survey targeting larger mammals was established on the reclaimed sites in 2021 using remote cameras (DWB 2020). A continuation of the survey may be recommended for 2022, depending on the results of the 2021 survey. • The survey was not developed with the intention of calculating population metrics. However, relative abundance and species richness will be determined if sample sizes are sufficient.

All surveys will include the daily collection of weather variables, such as precipitation, wind speed, and ambient air temperature. Based on the 10-year timeline of the program (see Section 5.0), methods may need to be updated and tailored to reflect changes in site conditions, or additional site improvements and modifications. Any changes made to the methodology should aim to reduce bias and variation, as well as maximize consistency between Years 1 – 5 and Year 10. This will ensure that the results of the monitoring program are still interpretable and applicable to at least one of the benchmarks for each performance indicator (see Section 6.0).

Although the plan will incorporate sample sizes that will allow for statistical comparisons among different indicator groups, and to compare performance indicators through time, limitations during data analyses may occur as a result of low detection or capture rates (mammals, invertebrates) and/or high margins of errors. Any limitations that are encountered will be discussed when reporting and interpreting the results.

5.0 TIMELINE

Monitoring will occur over a 10-year period. Although this timeframe is short relative to the period of time it can take for ecological succession to progress (Hawkes and Gerwing 2019), 10 years has been identified as the minimum requirement for detecting trends in wildlife populations with respect to natural variation and reclaimed habitats (Gibbs et al. 1998, Hawkes 2011). The first two years of data have already been collected. An initial timeline to complete the surveys is proposed in Table 3.

TABLE 3. MONITORING TIMELINE

MONITORING YEAR	TIME PERIOD	CURRENT STATUS	SURVEYS AND SAMPLING REGIMES
1	Spring 2020	**Complete**	• Avian Point Count
2	Spring 2021	**Complete**	• Avian Point Count • Large Mammals – presence/not detected survey
3	Spring 2022	TBC	• Select and Establish Reference Sites • Avian Point Count • Large Mammals – presence/not detected survey • Small Mammals
4	Spring / Fall 2023	TBC	• Avian Point Count • Small Mammals
5	Spring / Summer 2024	TBC	• Avian Point Count • Terrestrial Invertebrates • Small Mammals
6	2025	-	No surveys planned (break year)
7	Spring 2026	TBC	• Avian Point Count • Small Mammals
8	2027	-	No surveys planned (break year)
9	2028	-	No surveys planned (break year)
10	2029	TBC	• Avian Point Count • Large Mammals – presence/not detected survey • Small Mammals • Terrestrial Invertebrates

TBC – To be Completed

Minor changes to the schedule may occur as long as the overall project objectives are met (see Section 6.0). The 10-year timeline also provides an opportunity for adaptive management if the survey results suggest that additional work on the reclaimed sites is recommended, or if additional surveys are required.

6.0 BENCHMARKS

Identifying quantifiable benchmarks is important for interpreting the results of the surveys and for confirming when the objectives of the program have been achieved (Section 1.3). However, standardized endpoints for tracking ecological succession, and the long-term response of wildlife utilizing disturbed environments, does not presently exist. The rate of ecological succession is also site-specific and can be difficult to compare to other sites (Walker et al. 2010; Hawkes and Gerwing 2019). Therefore, benchmarks have been selected based on the premise that any quantifiable trend that demonstrates by year 10 that ecological succession is actively occurring on the reclaimed sites, and that wildlife are using the sites while increasing in abundance and/or richness, will be considered sufficient evidence that the program objective has been achieved.

The reclaimed sites are not anticipated to be closely comparable to mature forest sites, or even mid-successional habitats, by Year 10 since the reference sites will still be significantly farther along in terms of ecological maturity when compared to the primary successional stage of most reclaimed sites. Therefore, interpretations in the reporting should be cautious when making direct comparisons between the reclaimed sites and reference sites and should also consider inherent differences in detectability between the two areas (Thompson et al. 1998, as cited in Gibbs et al. 1999; Block et al. 2001). Rather, comparisons between the reclaimed and reference sites will be considered successful in Year 10 if there is a quantifiable trend demonstrating that wildlife habitat on the reclaimed sites are closer in similarity to the reference sites compared to at the start of the program (Hawkes and Gerwing 2019, Hawkes 2021).

Table 4 summarizes the benchmarks of the program for each performance indicator in association with relevant research that influenced the choices in benchmarks.

TABLE 4. MONITORING BENCHMARKS

INDICATOR	BENCHMARKS
Breeding Birds *Relevant Literature:* *EDI 2017* *Hanson et al. 2009* *Hawkes and Gerwing 2019* *Hawkes et al. 2021* *Schieck and Song 2006*	The relative abundance **and/or** species richness **and/or** species diversity on the reclaimed sites: ▪ Is similar to the reference sites, particularly the reference sites that are examples of mid-successional habitat, **and/or** ▪ Is higher on the reclaimed sites where improvements to facilitate vegetation growth have been applied for a longer duration of time, indicating that these reclaimed sites will have a higher likelihood of success, **and/or** ▪ Is higher in Year 10 when compared to previous years, indicating that habitat availability for breeding bird populations have improved, particularly for early- to mid-successional communities. Alternatively, bird communities on the reclaimed sites may demonstrate at least one of the following trends: ▪ A transition from an early-successional community to a mid-successional community ▪ A transition from a mid-successional community to a mature-successional community ▪ An increase in community similarity to the reference sites.
Small Mammals *Relevant Literature:* *Hawkes and Gerwing 2019* *Pearce and Venier 2005* *Rowe and Terry 2014*	The relative abundance **and/or** species richness on the reclaimed sites: ▪ Is similar to the results of the reference sites, particularly the reference sites that are examples of mid-successional habitat, **and/or** ▪ Is higher on the reclaimed sites where amendments and improvements have been applied for a longer duration of time, indicating that these reclaimed sites will have a higher likelihood of success, **and/or** ▪ Is higher in Year 10 when compared to previous years, indicating that small mammal populations have improved.

INDICATOR	BENCHMARKS
Terrestrial Invertebrates *Relevant Literature:* *Borges et al. 2021* *Gervan et al. 2021* *Hernández et al. 2014* *Majer et al. 2007*	The relative abundance **and/or** taxa richness on the Reclaimed Sites: ▪ Is similar to the results of the Reference sites, particularly the reference sites that are examples of mid-successional habitat, **and/or** ▪ Is higher on the reclaimed sites where amendments and improvements have been applied for a longer duration of time, indicating that these reclaimed sites will have a higher likelihood of success, **and/or** ▪ Is higher in Year 10 when compared to previous years, indicating that colonization of terrestrial invertebrates has improved.
Large Mammals *Relevant Literature:* *Rovero et al. 2013*	Large mammals are being detected on the reclaimed sites and are using the reclaimed features for foraging, hunting, travel, and shelter.

If you have any questions, please contact the undersigned at your earliest convenience.

Respectfully submitted,

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Attachment A – Literature Review
Attachment B – Map of Potential Areas for Establishing Reference Sites
Attachment C – CEMP Condition of Approval Letter and Feedback from LGL
Attachment D – Existing Terrestrial Wildlife Monitoring Plans

Attachment A
Literature Review

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Attachment B

Map of Potential Areas for Establishing Reference Sites

Potential Areas for Establishing Reference Sites

Scale:1:10,000
Map Datum: NAD 1983 UTM Zone 10N
Date: October 27, 2021
IMC_21274-004_WildlifeStudyDesign.mxd

N

0 250 500 1,000
Meters

DWB Consulting Services Ltd.

Potential Reference Site Area

Polley Lake

Quesnel Lake

Hazeltine Creek
WSC: 160-585700

Unnamed Creek
WSC: 160-585700-03800-27000

Edney Creek
WSC: 160-585700-03800

Edney Lake

Moorhouse Lake

Source: Esri, Maxar, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Attachment C

CEMP Conditional Approval Letter and LGL Feedback, on behalf of T'exelc and Xatśūll First Nations

February 10, 2021 Authorization Number: 11678

VIA EMAIL: don.parsons@imperialmetals.com

Mount Polley Mining Corporation
Suite 200 – 580 Hornby St.
Vancouver BC V6C 3B6

Dear Mr. Parsons:

Re: Approval of the Comprehensive Environmental Monitoring Plan, dated October 31, 2019

Mount Polley Mining Corporation (MPMC) holds the *Environmental Management Act* Permit 11678 for the Mount Polley Mine. Section 3.2 requires an updated Comprehensive Environmental Monitoring Plan (CEMP) be submitted to the Director for approval by March 31, 2020 and every three years thereafter.

An updated CEMP was received by ENV on October 31, 2019.

By way of this letter, the CEMP, dated October 31, 2019 is approved under Permit 11678 and thus becomes a requirement under this permit. Approval of the October 31, 2019 CEMP is subject to the following requirements:

1) The following documents are hereby approved as part of the October 31, 2019 CEMP:
   a) Supplemental soil and terrestrial tissue sampling and evaluation of bioaccumulation relationships for the terrestrial food chain model. Submitted to MPMC. Ref. No. 1894924-064-TMRev0- 23136. Golder Associates Ltd., March 13, 2019.
   b) Update to Wildlife Food Chain Model – Mount Polley Mine. Submitted to MPMC. Ref. No. 1894924-069-R-Rev0-23196. Golder Associates Ltd., March 26, 2019.
   c) Amphibian hazard assessment (Comprehensive Environmental Monitoring Plan). Submitted to MPMC. Ref no. 1894924-062-R-Rev0-23151. Golder Associates Ltd., March 18, 2019.

2) The conditions in this approval letter are monitoring requirements as part of the CEMP and thus this approval letter must be followed and attached to the hereby approved October 31, 2019 CEMP when provided to staff or external parties.

3) In addition to the objectives listed in the CEMP, monitoring objectives for the CEMP include meeting the requirements outlined in the Engineer's Order.

4) Mount Polley's fish & fish habitat program must be finalized in consultation with the Habitat Remediation Working Group (HRWG). The monitoring plan must achieve the general objectives of:
   a) Monitoring the recovery and health of rainbow trout populations in Polley Lake, Hazeltine Creek and any other locations potentially affected by the tailings breach, as well as salmon smolt health in Hazeltine Creek;
   b) Monitoring the recovery and utilization of remediated instream habitat throughout Hazeltine Creek by rainbow trout and salmon;
   c) Monitoring the success and utilization of instream habitat created as a part of subsequent habitat offsetting designed to achieve the requirements of the Engineers Order.

   Mount Polley must report out in their annual report on how the concerns, comments and recommendations from the Habitat Remediation Working Group were considered in the study designs.

5) Sampling at Quesnel Lake operational surface water monitoring stations (stations identified in Table 6.6 of the August 15, 2018 CEMP) must occur while the discharge to Quesnel Lake is occurring, for those sites where water quality monitoring happens less frequently than monthly (i.e., four times per year or semi-annually). In the event of an unexpected shutdown of the water treatment plant, MPMC must extend reasonable efforts to re-sample within the timeframe of the quarterly or other specified time period sampling upon restart of effluent discharge to Quesnel Lake.

6) For this condition, samples include both water chemistry samples and depth profile samples. Samples from HAD-3 must be collected on the same day as samples are collected at any Quesnel Lake sample location (i.e., QUL-58, -57, or -59) for comparisons to be made between water quality in the lake and in the discharge. QUL-57, QUL-58, and QUL-59 must all be sampled within a one-week period. Sampling at QUL-57 and QUL-59 must include consistent sample depths with QUL-58, except, if the plume or the thermocline is at or below the water depth at the site. Then a bottom sample must replace the sample below the plume (under a below) or the thermocline (under b below).. The profiling depths at each Quesnel Lake sample location must be matched to the water chemistry sample depths to allow comparisons over time and between sites. The sample depths shall be the following:
   a) If plume is detected samples must be collected mid plume, 5 m above plume and 5 m below plume. If the plume is found to be at the lake bottom no below plume sample is required and a bottom sample will represent the below plume sample ; and
   b) If plume is not detected samples must be collected from surface, 1 m above thermocline and 1 m below thermocline (or mid-depth if no thermocline exists), and from bottom.

7) Frequency of sediment sampling as per Appendix B1 is to be followed.

8) DGT sampling may be discontinued for shallow and deep areas of Quesnel Lake and shallow areas of Polley and Bootjack Lakes. DGT sampling must be conducted in deep areas of Polley and Bootjack Lakes for one additional year to confirm decreasing trends for copper above the bottom sediment. Rationale shall be provided to ENV to explain the installation of the DGTs at 1 m above the bottom sediment at deep sites vs. 0.5 m above the bottom sediment at shallow sites.

9) Regarding the update of Condition 11) of the approval letter of November 09, 2018 in the approval letter of March 14, 2019, the Director approves discontinuation of the Hyalella azteca toxicity testing using sediment of shallow habitat from Polley Lake. However, the 14-day sediment toxicity test on H. azteca must be conducted every three years (i.e., next in 2022) using sediment of shallow habitat from Polley Lake unless MPMC can clearly show that copper concentrations in all Polley Lake shallow sediment samples are below the 95th percentile of the copper concentrations in the Bootjack Lake reference area shallow sediment samples. H. azteca toxicity testing using sediment from shallow areas of Quesnel Lake must be continued as stated in the March 14, 2019 approval letter. “No effect to H. azteca” in that letter shall mean “no unacceptable response” relative to the reference area, as defined on page 37 of “Mount Polley Comprehensive Environmental Monitoring Program 2019 – Sediment and Aquatic Life” (Minnow 2020; Appendix K to MPMC’s 2019 Annual Environmental Report for the Mount Polley Mine).

10) In the submission of the next update of the CEMP (in 2023), MPMC must submit details on the monitoring that is or was conducted to determine which lake would be the best reference lake for Polley Lake. In addition, results of this monitoring and rationale for the selection of the reference lake based on these results must be provided in the next CEMP iteration.

11) Parameters measured at QUL-57 and QUL-59 must include the same parameters and field measurements as listed in Table 6.4 of the CEMP for QUL-58.

12) Any updated CEMP documents in the future must include all sample sites in a Site Matrix.

13) QUL-120a must continue to be used as a reference site and sampling must be conducted at a minimum four times per year at evenly spaced time series plus or minus one month. In addition, for future CEMP versions, the permittee must consider recent scientific publications about water and sediment quality effects in Quesnel Lake, including Hamilton et al. 2020. "Seasonal Turbidity Linked to Physical Dynamics in a Deep Lake Following the Catastrophic 2014 Mount Polley Mine Tailings Spill”, and clearly identify

how proposed monitoring will identify spill and mine related effects on receptors in and east of the West Basin of Quesnel Lake.

14) As recommended by Golder (2019c), a habitat survey by a qualified biologist must be completed, followed by targeted soil, water, and sediment sampling for any areas identified as providing valued habitat.

15) Rescreen of the surface water data under the Environmental Risk Assessment (ERA) must be completed (in advance of the habitat survey) using the new BC ENV Water Quality Guideline (WQG) for copper based on the biotic ligand model (BLM) to affirm the target screening concentration by area, indicating habitat quality for each area.

16) Provide additional support (incl. literature) for the soil/sediment copper screening value of 800mg/kg as it is based on limited data, and hence, has a high degree of uncertainty.

17) Provide a discussion of the available vanadium soil/sediment data relative to the BC ENV soil screening value of 150mg/kg in order to provide a better understanding of potential toxicity of vanadium.

18) MPMC must submit a plan for a quantitative wildlife study design by October 30, 2021 to determine wildlife recovery by area and reclamation type, which includes associated outcomes from the previous years as an attachment. The submitted study design and results should incorporate the following comments from the Government to Government Technical Working Group (G2G TWG) on the 2019 "Detailed Study Design for Terrestrial Wildlife Monitoring", the "Update to Wildlife Food Chain Model for Mount Polley Mine", and the "Amphibian Hazard Assessment":

    a. Continued monitoring in the study area for species abundance (e.g., tracks, scat, visual observations, etc.), by subarea, is required to determine how species are re-colonizing the area, as succession advances with continued rehabilitation.
    b. Outline specific objectives and endpoints of the monitoring components (e.g., vegetation, birds), in addition to guiding principles. The overall goal is to track natural ecological succession, but specific objectives can be presented on how this will be measured from the monitoring data collected. For example, objectives can be set to test for differences in songbird assemblages and species richness across the different treatment areas.
    c. Include reference areas (control sites), which correspond with the end land use objectives of the rehabilitated areas, in the bird and vegetation monitoring programs. This would add value to the monitoring and help to clearly understand the trends to natural ecological succession.
    d. Include analysis and reporting of songbird community indices. Songbird assemblages can be easily assessed for the treatment areas (including the control sites).

e. In addition to monitoring birds we recommend including the monitoring of soil invertebrates (specifically terrestrial arthropods) as indicators of ecosystem recovery every five years. This is because although bird surveys are relatively easy to conduct, they can also result in a highly variable dataset. Furthermore, it is unclear if the surveys will focus on year-round resident species and/or neotropical migrants that utilize breeding habitats in the area on a seasonal basis. If the latter, the ability to detect long-term trends may be challenging since most species are facing pressures outside of their breeding areas and overall trends in migratory bird populations are showing general declines. These larger scale attributes would have to be accounted for in any reporting.
f. Mount Polley had developed their wildlife monitoring program based on the results of a food chain model. Mount Polley interpreted the results of the model as there not likely being risk to wildlife from the tailings breach. The G2G had identified several uncertainties in the food chain model, and since the wildlife monitoring study design is based on the food chain conclusions, these uncertainties and comments need to be addressed. To ensure that the wildlife monitoring program does not miss potential effects and recovery from those, we recommend that the following food chain model uncertainties be addressed as indicated in the following bullets:
    i. Uncertainty in the application of the dietary absorption values for copper (40%) and vanadium (10%) to avian species should be further discussed, due to paucity of supporting literature for avian species. Further support should be provided for the application of these values to avian species.
    ii. Physiologically Based Extraction Test (PBET) values for soil were reviewed. Statistical metrics used in the Food Chain Model merit further support. To address this comment, and the comment above, it is recommended that for dietary and soil absorption, a sensitivity analysis of the implications of alternative values to those used in the ERA, relative to the hazard quotient (HQ), be provided to add context on the effect this could have on the HQ. As part of this, identification and discussion of the dominant exposure pathways (i.e., that have the greatest influence on the risk estimates) would be helpful, and will provide additional context for the data collected in the wildlife monitoring program (e.g., insectivorous wildlife species have the highest risk potential, and hence, are of greatest interest in the wildlife monitoring program).
    iii. Copper TRV was reviewed; while we do not completely agree with some of the detailed TRVs developed, listed species largely screen off at the Screening ERA stage. HQs for insectivores remain slightly elevated (American robin and Shrew). Completion of a sensitivity analysis (as indicated in previous bullet, above), will add insight into factors predominantly influencing risk levels for this receptor group.

19) As per the request by MPMC of November 11, 2020, the water quality sampling sites HAC-01 and EDC-01 are now replaced by EDC-01a, located 100m downstream of the

new confluence of Hazeltine and Edney Creeks. The sampling frequency must be monthly.

20) The hydrological station H3 is now replaced by H3a with the condition that manual flow measurements be conducted at H3a at least 5 times per year during the non-freezing period until a stable rating curve has been established (typically at least 6 unique measurements over a range of flows are required to establish a stable rating curve as per the Manual of BC Hydrometric Standards (ENV, 2018)). Once the rating curve has been shown to be stable, the measurements may be reduced to a minimum of 3 times per year.

If you have any questions regarding this letter, please contact Gabi Matscha at 250-312-6793 or Gabriele.Matscha@gov.bc.ca.

Yours truly,

Luc Lachance P.Eng.
for Director, Environmental Management Act

cc: Aaron Higginbottom, T'exelc (Williams Lake First Nation)
Edna Boston Xatśūll First Nation (Soda Creek Indian Band)

Memorandum

Prepared for:	Edna Boston, Natural Resources Manager, Xatśūll First Nation Aaron Higginbottom, Senior Manager, Natural Resources and Economic Development, Williams Lake First Nation	**Date:**	February 3, 2021
Prepared by:	Dr. Marc d'Entremont, R.P.Bio.		
Re:	Mount Polley Mine – Mammal Monitoring Plan	**Project:**	EA3583.B

LGL Limited completed a technical review of the Mount Polley Mine Mammal Monitoring Plan Hazeltine Creek Corridor (the plan) prepared by DWB Consulting Services Ltd., dated December 17, 2020. For this review, we cross-referenced the objectives of the plan with those stated in the Comprehensive Environmental Monitoring Plan (CEMP) and provide some recommendations that would improve the biological performance of the monitoring program.

The plan presents a one-year monitoring program using remote cameras (i.e., camera traps) to detect mammal species at strategic locations along the Hazeltine Creek corridor, which is intended to fulfill the requirements of Section 6.17 of the CEMP. The current objective of Section 6.17 is to document the presence of mammals and birds using or migrating through the mine site and adjacent areas. *This information is used for land use planning and to monitor the potential for effects of mine-related activities on animals in the area* (emphasis added).

The plan identifies 32 mammal species that are potentially found within the Hazeltine Creek Corridor, two-thirds of which have been previously documented at Mount Polley. In addition, the Post-Event Environmental Impact Assessment Report (PEIAR) only documented nine of these species. The camera trapping methods proposed will only capture certain mammal species and most of the smaller mammals would go undetected. Additional methods, such as live trapping, are recommended to target small mammal species using the corridor.

The plan states that seven cameras will be deployed at up to 28 potential locations. Cameras would be checked every 25-30 days and relocated "if needed". No clear rationale is provided that would direct the need to move a camera, other than the stated goal of maximizing the number of detections of mammal species (page 6). Although, simply fulfilling this goal will not allow for the collection of data to monitor the potential for effects of mine-related activities on animals in the area, as stated above. In this regard we recommend increasing the number of cameras deployed and reducing the frequency of changing locations. This would allow for a stronger time-series data set that can be used to assess mammal occurrence, distribution, and occupancy.

Section 1.3 of the plan states that the data gathered from this Project is not intended to be used to determine population metrics, such as relative abundance or species-habitat relationships, or to provide a statistically robust dataset. If this is the case it is unclear how the information could be used

for land use planning and to monitor the potential for effects of mine-related activities on animals in the area. We recommend this discrepancy between the intent of the plan and the objectives of the CEMP be addressed and corrected.

The camera trapping data and subsequent report is to provide an inventory of mammal species detected within the study areas and is intended to highlight any behaviours observed regarding how some species are using the Hazeltine Creek corridor (page 11). The methods outlined in the plan will allow for documenting whether a mammal species is detected or not, rather than a true inventory. While camera traps are a useful tool to document wildlife in certain areas, the data collected from these can also be used for analysis beyond simple detections. Data can be used to assess the effectiveness of restored habitats and to understand species-habitat relationships that are essential for land use planning and monitoring effects of mine-related activities.

In closing, the Mammal Monitoring Plan is simplistic, and its execution will be really easy to implement. However, the authors of the plan have made over-reaching statements without addressing the limitations of camera trap data. As such, the monitoring program's design does not instill confidence that the objective and intent of the CEMP will be effectively achieved.

Attachment D
Pre-Existing Wildlife Plans

Appendix B.3

Amphibian Design Concept

Golder Associates

TECHNICAL MEMORANDUM

DATE 9 August 2018 **Reference No.** 1894924-018-TM-Rev1-23182

TO Stephen Monninger
Mount Polley Mining Corporation

CC Colleen Hughes

FROM Blair McDonald and Barbara Wernick **EMAIL Blair_McDonald@golder.com; Barbara_Wernick@golder.com**

STUDY DESIGN CONCEPT: AMPHIBIAN COMPONENT FOR THE MOUNT POLLEY MINE COMPREHENSIVE ENVIRONMENTAL MONITORING PLAN

Introduction

Golder Associates Ltd. (Golder) understands that Mount Polley Mine is preparing a Comprehensive Environmental Monitoring Plan (CEMP) to integrate the monitoring components from a variety of regulatory processes applicable to the mine into a single document. One element of the regulatory process involved the submission of an Ecological Risk Assessment (the ERA; Golder 2017) which integrated the available chemical and biological information to provide an overall conclusion about the magnitude and extent of ecological risks associated with the deposit of tailings. The ERA was accepted by Ministry of Environment & Climate Change Strategy (ENV) on 31 January 2018, contingent on the implementation of additional monitoring in relation to specific areas of uncertainty identified in the ERA. One of the identified areas of uncertainty at the conclusion of the ecological risk assessment (Table 53 of the ERA) was that amphibians were not formally assessed. The ERA identified amphibians and reptiles as a relevant receptor group (Section 2.3.3.4 of Golder 2017) with western toad and common gartersnake identified as possible receptors. Western toad was selected as the receptor of potential concern for the broader amphibian and reptile community because it is also a listed species.

This purpose of this memorandum is to outline the monitoring concept proposed to address the uncertainty associated with the amphibian component for the Mount Polley CEMP. If this concept meets ENV expectations, a detailed study design document and specific work instructions will be prepared by Golder as the basis for executing this component as part of the Mount Polley-led CEMP process.

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Basis of Design

The basis of design consists of a summary of the available data and how those data were evaluated in the ERA, provided for the convenience of the reviewers. Copper and vanadium were retained as the contaminants of potential concern in the terrestrial ERA, and copper was retained as the contaminant of potential concern in the aquatic risk assessment. Although no amphibian-specific toxicity reference values were available, these contaminants of potential concern were selected by comparing the maximum observed concentrations conservative, regulatory-approved standards and guidelines. The maximum observed vanadium concentration was only marginally greater than the generic soil standard, and therefore, copper is expected to be the primary contaminant of potential concern for amphibians. Other data relevant to amphibians were described in Section 3.4 of Golder (2017) and consisted of:

- Substantial numbers of tadpoles were observed in 2015 in pooled water that formed throughout the Hazeltine Creek corridor. These tadpoles were confirmed to be western toad (*Anaxyrus boreas*) which is listed on Schedule 1 of the federal *Species at Risk Act*. More than 75,000 individual western toads (approximately 66,000 tadpoles, 9,000 juveniles, 300 sub-adults and 50 non-breeding adults) were subsequently salvaged from 40 different standing water depressions over a two-month period in 2016 prior to the start of rehabilitation. Long-toed salamanders (*Ambystoma macrodactyllium*) and Columbia spotted frogs (*Rana luteiventris*) were also salvaged (at lower numbers). Golder (2017) concluded that the salvage provided qualitative information that amphibians were able to successfully survive, grow and reproduce despite direct contact with tailings and surface water.

- Tissue samples were collected from three amphibians (species not identified) were collected by ENV in August 2016. Golder was not able to confirm the methods used for sampling, processing or analysis and did not review the certificate of analysis with respect to quality assurance/quality control measures. Tissue concentrations in two samples collected from impacted areas ranged from 56.4 to 871 mg/kg Cu dry weight. A tissue sample collected from Gavin Lake (considered by ENV to be a background area) was 12.4 mg/kg Cu dry weight. Data were compared to literature that indicated that copper tissue concentrations corresponding to a lowest-observed effect concentration (LOEC) or no-observed effect concentration (NOEC) ranged from 60 to 325 mg/kg dw (Attachment F, Appendix J of Golder 2017). The average concentration of the two impacted samples was also considered in the uncertainty analysis for the wildlife food chain model (i.e., would the risk conclusion be different if piscivorous birds and mammals had a diet consisting entirely of amphibians). Beyond these qualitative observations, data were not formally evaluated because methods and quality assurance/quality control practices could not be verified.

- Multiple lines of evidence in the ERA demonstrated that copper had low bioavailability. The lines of evidence included geochemical modeling and three different chemical surrogate measurements in tailings samples (water soluble fraction; humidity cell and leach tests; physiological-based extraction tests – see Section 3.2.2 of Golder 2017). Speciation modelling of copper in water showed most of the dissolved copper in Quesnel Lake water would be bound to carbonates which have lower bioavailability than copper ions (see Section 4.2.1.3 of Golder 2017). Golder concluded that the bioavailability of copper would be unlikely to be high for amphibians if there were multiple lines of evidence showing that copper bioavailability to other receptors was low.

Further Consideration of Uncertainty

The purpose of this section is to expand on the specific uncertainties identified in the ERA to be evaluated by focussed monitoring as outlined in this conceptual design document. Golder (2017; Table 53) provided an overview of the uncertainties to assist with future risk management decisions, but a one or two sentence summary does not necessarily convey sufficient detail to show how the design of the amphibian monitoring is linked to the findings of the ERA.

For amphibians, uncertainty is because of the absence of quantitative risk assessment for amphibians. Notwithstanding the value of the inferences and qualitative observations described above, there was only a limited amount of direct measurement of exposure or effects relevant to amphibians at the time the ERA was undertaken. From a practical perspective, rehabilitation of the riparian areas, and restoration of Hazeltine Creek was ongoing throughout the risk assessment process and therefore the habitat suitability for amphibians was considered low. Moreover, completion of the ERA for other major groups of receptors (e.g., mammals, plants) was needed to determine if further remediation activities, which would further disrupt habitat suitability, was needed to address the residual concentrations of copper in the deposited material. Therefore, Golder (2017) determined that it would be inappropriate to arrive at a risk conclusion at that time without further evaluation.

The ERA found that risks for the major groups of receptors were generally low to moderate (reflecting the low bioavailability of copper in tailings) and therefore, extensive additional intrusive works are less likely. Thus, it is appropriate to now consider a monitoring plan that will contribute to confirming that the risk conclusions for other major groups of receptors are also applicable to amphibians.

Conceptual Approach

The amphibian component is essentially a continuation from the problem formulation already completed (Golder 2017) (which identified amphibians as a relevant receptor). In brief, the proposed approach is to continue the risk assessment process by proceeding through the following tiers to the point needed to support an informed risk management decision. The tiering is described in Figure 1, and consists of the following main tasks:

1) Conduct a hazard evaluation – Screen existing soil, sediment and surface water chemistry data for different habitat units against a conservative amphibian-specific screening value. Eliminate habitat units from consideration if copper concentrations are sufficiently low (i.e., the 90th percentile and 95% upper confidence limit of the mean) that risks are not expected.

2) Conduct an exposure assessment – For those areas that are not screened out in Step 1, compare the distribution of soil (or sediment, or water) concentrations for that area to a multi-study concentration response profile for copper. Areas where the average concentrations (e.g., 95% UCLM) are less than the toxicity reference value (TRV) (e.g., geometric mean of chronic, relevant no-observed effect levels) will be excluded from evaluation. Areas that cannot be excluded will be prioritized according to their potential risks (e.g., based on the degree of overlap between the distribution of concentration data and the response profile).

3) Conduct a laboratory-based effects assessment – The exposure assessment above assumes that copper in tailings is equally bioavailable as the original toxicity test. This is unlikely to be true because the ERA had multiple lines of evidence that showed bioavailability of tailings were low. If Step 2 demonstrates the potential for unacceptable risks, then laboratory-based toxicity testing will be used to establish a site-specific copper TRV and the representative soil, sediment and surface water data will be re-screened. Laboratory testing will likely need to include the physical nature tailings as a variable.

4) Refine the application of the toxicity reference values – The evaluation in Steps 2 and 3 assume that all soils, sediment and surface water are representative of a potential amphibian exposure. There may be portions of the terrestrial zone that are unlikely to be suitable amphibian habitat because of their distance from water, substrates or other factors. Refinement of the screening process from Step 3 to focus on the potential areas of habitat may be considered.

5) Conduct a field-based effects assessment – A field-based effects assessment is not contemplated unless concentrations in relevant amphibian habitats exceed both the literature-based and site-specific TRVs. Field-based measurements focus on comparison of population-level or organism-level endpoints between impacted and reference amphibian habitats. A mesocosm study could also be considered (e.g., transplant amphibian larvae between enclosures established in reference and impacted habitats and measure survival and growth at end of chronic exposure)

6) Integrate toxicity and habitat data in a population model – If a copper concentration response relationship has been established, it could be used in a population model to determine the relative influence of copper and physical stressors in the context of natural stressors (e.g., low precipitation) and habitat quality. This assumes that there is adequate information about the population dynamics of the western toad.

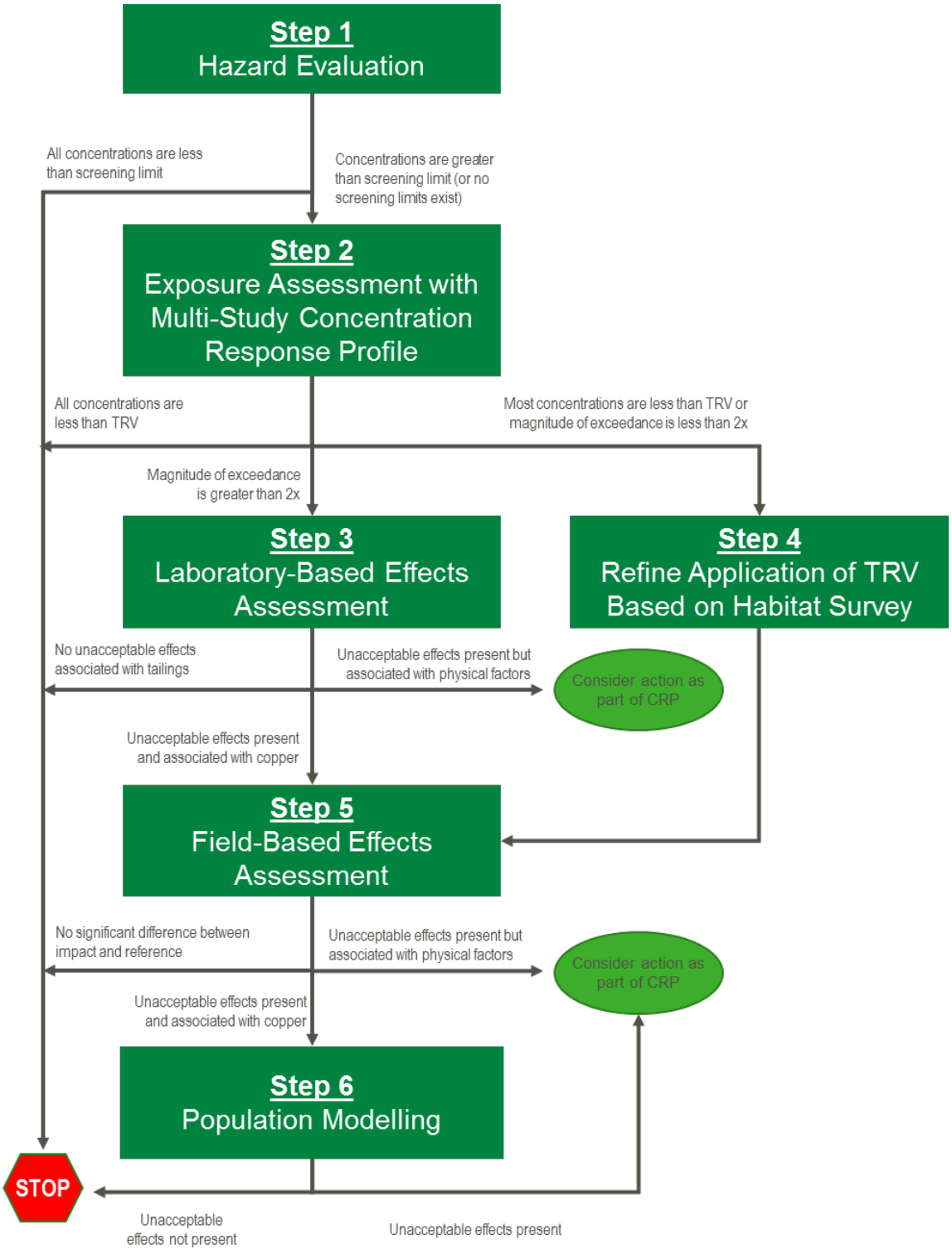

Figure 1: Proposed Tiering for Amphibian CEMP Component

Additional Information

This section expands on each tier in terms of potential sampling activities, levels of effort, and decision criteria. Further expansion of the rationale in the detailed study design is expected based on ENV feedback regarding the approach. The following guidance documents were reviewed as part of the development of this conceptual approach:

- FSCAP. 2016. Module 6: Ecological Risk Assessment for Amphibians on Federal Contaminated Sites. Draft (Not Approved as Guidance).
- Navfac (US Navy, Naval Facilities Engineering Command). 2004. Development of a standardized approach for assessing potential risks to amphibians exposed to sediment and hydric soils. TR-2245-ENV.

These documents provide amphibian-specific risk assessment information that was considered in the context of provincial guidance on conducted detailed ecological risk assessments at contaminated sites.

Step 1: Hazard Evaluation

FSCAP (2016) comment that there are relatively few summaries of amphibian toxicity data that provide generic screening limits. Golder will conduct a brief literature search to seek out amphibian-specific screening limits and review the available environmental quality guidelines to determine the degree to which they are protective of amphibians. The screening limits (if available) will be used to provide an initial evaluation of the soil, sediment and surface water data that is representative of the current-day exposure scenario for amphibians. The purpose of this initial hazard evaluation is to determine if portions of the site can be excluded from the amphibian assessment. An area will be excluded if: a) there is sufficient data to characterize the defined unit; and b) if the 90th percentile and 95% upper confidence limit of the mean concentrations in the unit are less than screening limit. If multiple screening limits are identified, an area will be excluded only if it has concentrations that are less than all limits. If no defensible screening limits are identified, we will proceed directly to Step 2.

Step 2: Multi-study Concentration Response Profile

FSCAP (2016) describe a process for integrating all available literature toxicity data into an overall concentration response profile for each media This “response profile” is then used to derive point-estimate screening limit (i.e., a single “safe” concentration) or effects-based TRVs (e.g., the range of values that correspond to a ECx effect). An example for zinc from FSCAP (2016) is provided in Figure 1.

Golder will develop multi-study concentration response profiles for copper in water and sediment/hydric soils consistent with FSCAP (2016). The overall process involves a literature review (with quality assurance procedures to eliminate unreliable data) consistent with ECO-SSL procedures. The general approach to integrating the literature data into a concentration-effect relationship is like that described by Allard et al. (2010) for wildlife TRVs. The ECO-SSL process is endorsed as a preferred approach in BC risk assessment by Technical Guidance 6 (guidance under the Contaminated Sites Regulation) and wildlife TRVs that consider the entirety of the available literature (instead of a single point estimate) are increasingly common in contaminated sites risk assessments.

Not all data have the same value in the derivation process:

1) Data that fail to meet basic test acceptability criteria (e.g., negative control are not present) will be rejected.

2) More weight will be given to North American species. Many toxicity studies use the African clawed toad (*Xenopus*) as a surrogate, but this species is not native to North America. Removing species that cannot be present at the site is consistent with provincial guidance about establishing site-specific water quality objectives (BCMOE 2013) and is also discussed by FSCAP (2016).

3) More weight will be given to studies that involved measured (instead of nominal) concentrations and/or involved field-collected samples instead of laboratory-spiked samples.

The specific derivation of a screening limit or a TRV is ultimately dependent on the quality and quantity of toxicity data available. It is likely that there will be a wide range of effects associated with a given concentration (e.g., Figure 2, which is for lead), and therefore, a specific derivation rule cannot be proposed at this time. FSCAP (2016) recommends that the data set should be explored to determine if there are significant differences in toxicity profiles for different species, exposure duration, endpoints and life stage. A specific decision about what constitutes an acceptable effect was not proposed by FSCAP (2016), but realistically, screening limits or toxicity reference values that are meant to be protective of western toads would need to reflect a low risk (e.g., EC10 or EC20). Moderate-to-high risk limits (e.g., an EC50-based TRV) may also be derived to help provide further context. Golder will need to consider the totality of the available data and provide a rationale for the TRV proposed. The available soil data will be compared to the TRVs using the same approach as described in Step 1.

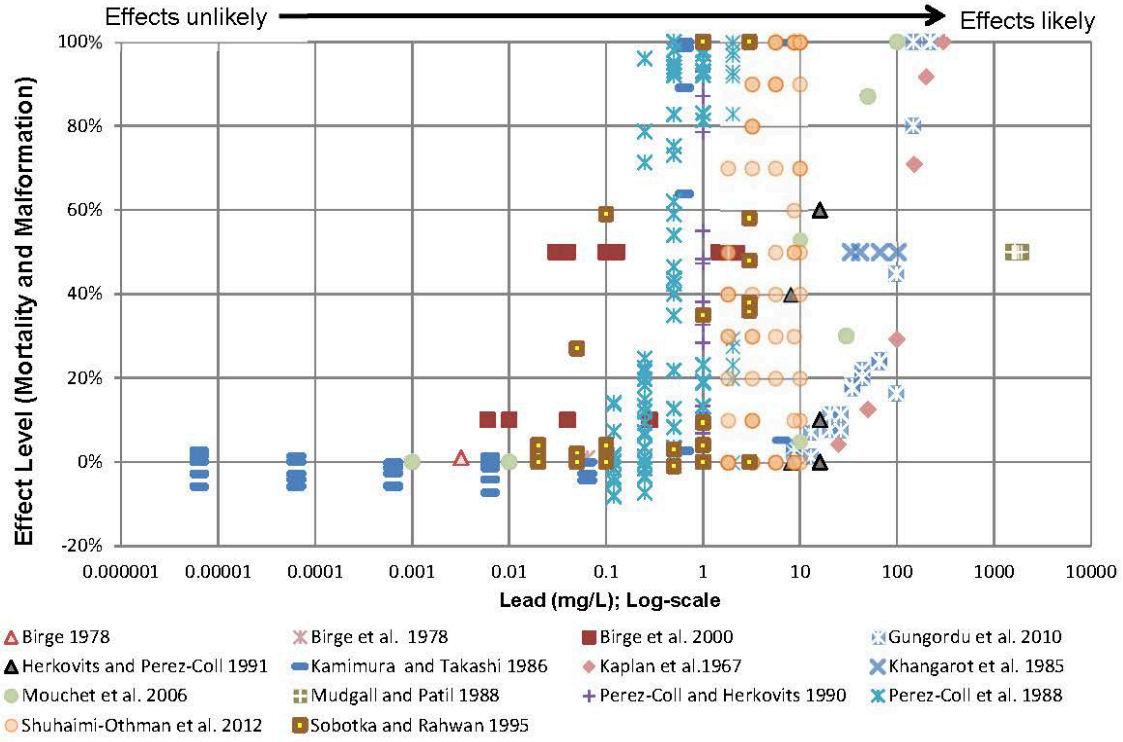

Figure 2: Example of a concentration-response profile (from FSCAP 2016)

Detailed reviewer comments were provided by ENV on May 29, 2018 and a teleconference was held on 9 July 2018 to discuss the conceptual approach and the reviewer comments. Golder understood from the teleconference that a topic of concern relates to how the results from the comparison of soil, sediment and surface water data to the amphibian-specific TRVs would account for amphibian habitat requirements.

Golder notes that there have been many soil samples collected from the site which were considered in the terrestrial risk assessment, and that additional soil sampling is being conducted in August 2018 as part of the supplemental terrestrial monitoring described under separate cover. Nevertheless, it would be a potential gap in the assessment if there were no data available regarding concentrations of copper in soil in areas that are important rearing or feeding habitat for amphibian species. Golder intends to present the data screening from Steps 1 and 2 in a manner that provides context for how the available data helps to inform hazards to amphibians. Specifically, a qualified biologist will provide a summary of habitat requirements for each of the individual amphibian species found in the area and will determine the extent of “high-quality” and “low-quality” habitat using existing information. This desktop-level review will help to place the hazard evaluation from Steps 1 and 2 in context. Further refinement of the hazard assessment based on a detailed habitat survey (Step 4) or a field-based assessment of effects (Step 5) will be considered based on the outcome of Steps 2 and 3.

Step 3: Site-specific Concentration-Response Relationship

A site-specific concentration response could be developed using amphibian toxicity testing in a manner similar to the approaches used for benthic organisms and plants in the ERA. Conceptually, the testing would include:

- Between 5 and 10 field-collected samples with varying copper concentrations that capture the range at which copper would be expected to exert a negative effect (based on Step 2).
- Additional negative controls to evaluate the physical nature of the tailings (e.g., low organic carbon; grain size and shape).
- Inclusion of spiked-copper samples (e.g., silica sand and natural soils spiked with a range of copper concentrations) to evaluate the difference in bioavailability between tailings and the typical literature values.

A detailed design for a laboratory-based toxicity test has not yet been developed, and there would need to be clarification from ENV about how the amphibian toxicity data would be used to make site management decisions before a suitable detailed design could be prepared. Amphibian toxicity testing is not a common approach and there are multiple laboratory-, organism- or sample-related factors that could lead to an unacceptable level of uncertainty in the results. For example:

- Nearly all available standardized protocols (ASTM, USEPA) use *Xenopus* which is not native to North America and it is not clear that this species is appropriate for the current application. Environment and Climate Change Canada (ECCC) is in the process of developing a standardized protocol with a relevant, Canadian species, but Golder understands that there are methodological challenges and organism supply issues yet to be resolved. The status of the draft method is unknown.

- Most standardized protocols are designed for spiked-water applications which would not necessarily provide value to the current application. One exception is NavFac (2004) which describes a method for exposing North American frog and toad tadpoles to field-collected sediment samples for a 10 to 14-day exposure. An ASTM test method is also available for sediment (but it uses *Xenopus*).
- It may be necessary to field-collect test organisms which would not be possible without applicable provincial scientific collection permits and/or federal permits under the Species at Risk Act.

Step 3 could provide value for site management decisions, but there are technical and regulatory issues to be resolved. Further development of a detailed study design for amphibian toxicity testing is not recommended until Step 2 has been completed, and only if there is consensus about how risk management decisions would factor in the possibility of high uncertainty associated with the use of a non-standard toxicity testing method. Ideally, an approved ECCC test method would be available at the time this step would be undertaken.

Step 4: Refinement of the TRV Application

A specific design for this step has not yet been developed. As a default, all soil, surface water and near-shore sediment data will be evaluated in Steps 2 and 3. The general concept for Step 4 is to refine how those TRVs are applied to different areas of the site based on whether the area provides (or will in the future) meaningful habitat for amphibians. The nearshore of the various waterbodies and their immediate riparian zones are likely amphibian habitat and would be included. Conversely, although western toads forage over relatively large areas and can use a range of different habitats (ECCC 2016), portions of the study area that are not suitable habitat for amphibians would then be excluded from the exposure estimates. Step 4 would involve a survey of the impacted area by biologists with specialized amphibian expertise. Areas of the site would be classified according to their suitability as amphibian breeding, hibernation, and foraging habitat (both at present, and in the future). This information would be used to refine how the TRVs are applied (e.g., exclude areas with minimal value to amphibians, and focus on understanding the risks in areas that are key to sustaining the amphibian population).

Step 5: Field-based Effects Assessment

From a risk assessment perspective, field programs provide valuable information because they provide a direct measurement of effects under field conditions. However, in the current application, direct measurement of effects does not necessarily help to differentiate the effects of the residual concentrations of metals associated with tailings from the physical effect of the tailings themselves. The physical alteration of habitat in the impacted areas was substantial, and as a result, a control-impact study design needs to account for the fact that risk management decisions will be different depending on whether the main stressor is physical or chemical.

FSCAP (2016) comments that amphibian risk assessment can incorporate field-based assessments and lists a number of standard methods for conducting field surveys for amphibians. Field assessment would involve a control-impact comparison (similar to the approach used for the benthic taxonomy studies in Quesnel and Polley Lake) and each type of area would preferably involve multiple locations to minimize the effect of natural variability of the risk management outcome. A variety of endpoints could be measured in a control-impact study design (e.g., number of egg masses per unit area; frequency of lesions or malformations per adult; abundance of amphibian larvae per unit catch effort).

Further development of a detailed study design for an amphibian field assessment is not recommended until Step 2 has been completed, and only if there is consensus about how risk management decisions would factor in the possibility of high uncertainty in its outcome. A key question is to determine the number of amphibian breeding sites within the impacted area, and to conduct a baseline survey to confirm that there is an adequate number of potential control sites available in the area. This baseline survey could be conducted as part of Step 4.

Step 6: Population Model

An additional line of evidence in an amphibian risk assessment is to combine the available toxicity and habitat data into a population model. A population model, in this context, simulates the stability of a given local population under a range of future conditions. The model is used to determine if reductions in survival, growth or reproduction from the physical or chemical stressors associated with tailings will impact the population as a whole. An example of a contaminant-habitat population model is provided for context.

Willson et al. (2012) used a population model (at a site unrelated to Mount Polley) to evaluate the impact of mercury on individual toads on the overall viability of population of American toads (*Bufo americanus*). The model simulated the population dynamics of toads to establish a baseline discrete-time model (e.g., how many toads will survive to each successive life-stage based on habitat quality; how big are the toads at reproductive age as a function of food availability; how many eggs will be produced as a function of adult toad size). The effect of mercury on the population was then added to the model as a reduction in the survival, growth and reproduction baseline as a function of mercury concentration. The net effect was a model that simulated how different concentrations of mercury would contribute to the stability of the toad population over time, and to determine which type (and how much) habitat enhancement was needed to off-set the influence of mercury.

In the current application, a model similar to Willson et al. (2012) would provide value by integrating the information from Steps 3, 4 and 5. However, a model like this would only be appropriate if there was evidence that copper was exerting an unacceptable effect which could not be readily remediated. Golder recognizes that habitat compensation to address residual contamination is a policy question that would need to be resolved, particularly for a listed species where the intent is to protect the individuals of the population, not just the population itself. There are also technical limitations to this type of model in terms of the quality and quantity of data available for parameterization. Golder assumes that there would be sufficient species-specific information for western toads because the species is listed and would be a priority for researchers (at least relative to other Canadian amphibians). It may also be reasonable to assume the population variables for western toads are similar to American toads.

Further development of a detailed study design for an amphibian population model is not recommended until Step 2 has been completed, and only if there is compelling evidence that there is a chemical-related impact that would be likely to cause an unacceptable outcome to amphibian populations. In the absence of a chemical-related impact, a model would not necessarily add any value (i.e., a decision to conduct habitat improvement to mitigate a physical stressor does not need to be based on a model).

Summary

This memorandum describes a proposed tiered approach for the amphibian component of the CEMP. Not all tiers are recommended for implementation, and there are significant technical and regulatory issues that would need to be resolved as part of the design and execution of Steps 3 onwards. However, Steps 1 and 2 provide a framework that is similar to a screening-level risk assessment for amphibians, and the process for accomplishing those steps has already been described by draft regulatory guidance (i.e., there is a basis for developing a clear process for those steps).

Golder recommends that Steps 1 and 2 should be completed as part of the current CEMP. No further action would be necessary if risks to amphibians can be shown to be low based on comparison of the relevant soil, surface water and chemistry data to toxicity reference values derived from the available literature. A preliminary review indicates that there will be sufficient data in the literature of suitable quality to support Step 2. If risks are found to be unacceptable at the conclusion of Step 2, further investigation following the tiered approach described in this memorandum may be necessary.

Closure

The reader is referred to the Study Limitations, which follows the text and forms an integral part of this memorandum.

Please do not hesitate to contact the undersigned if there are questions regarding this memorandum.

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BM/BW/cr

Attachment: Study Limitations

https://golderassociates.sharepoint.com/sites/10023g/documents_1894924/2. issued/018-tm-23182-amphibiandesignconcept/rev1/1894924-018-tm-rev1-23182-amphibiandesignconcept_09aug_18.docx

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Study Limitations

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Appendix B.4

Reference Lake Study Design

Golder Associates

31 October 2019 Reference No. 1894924-111-L-Rev0-23185

Mr. Don Parsons
Mount Polley Mining Corporation
Box 12
Likely, BC V0L 1N0

STUDY DESIGN FOR DEVELOPING REFERENCE CONDITIONS FOR POLLEY LAKE – MOUNT POLLEY MINE

Dear Mr. Parsons,

Golder Associates Ltd. (Golder) is pleased to provide Mount Polley Mining Corporation (MPMC) with this study design for characterizing reference conditions for Polley Lake. This study design was prepared in response to a condition set by the Ministry of Environment and Climate Change Strategy (ENV) for approval of the Comprehensive Environmental Monitoring Plan (CEMP), specifically:

> *An updated study design must be provided, which includes the monitoring location, frequency, and methods for assessing reference conditions for Polley Lake, and which includes a description of the process for characterizing the relative differences between Bootjack Lake, Polley Lake, and the newly identified reference location.*[1]

1.0 OBJECTIVES

Polley Lake is adjacent to the Mount Polley Mine, and environmental monitoring is undertaken to assess the potential for mining activities to affect biological communities in the lake. At the present time, the reference lake for Polley Lake is Bootjack Lake, on the opposite side of the mine site from Polley Lake. Because there is potential for mine-contact water to enter Bootjack Lake in the future, ENV requested that MPMC identify one or more alternate lakes to function as references and to begin data collection early on to provide temporal and spatial continuity to the program. The purpose of this letter is to provide a decision framework and methods for selecting candidate alternate reference lakes for Polley Lake.

[1] 9 November 2018 letter from D. Hill, ENV, to D. Reimer, MPMC, "Approval of the August 15, 2018 Comprehensive Environmental Management Plan (CEMP) – Mount Polley Mine Permit PE-11678".

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2.0 IDENTIFICATION OF CANDIDATE LAKES

The decision framework for identifying potential candidate reference lakes is illustrated in Figure 1. The primary variables expected to have an influence on hydrodynamics and biological communities in a given lake, and which can be characterized at a desktop level, are: biogeoclimatic zone, size, depth, surrounding land use, and underlying geology. Ideally, reference areas will have as similar characteristics to the exposed area as is reasonably practicable. Once a subset of lakes is identified, collection of sediment and water samples will be needed to select the final candidate reference lake(s).

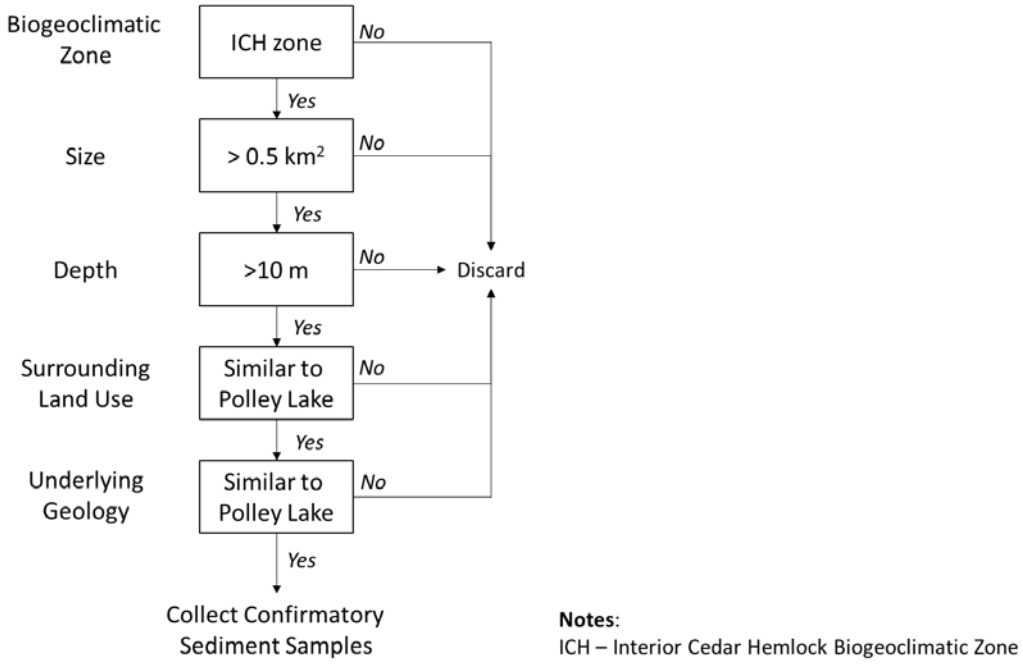

Figure 1: Decision Framework for Selection of Candidate Reference Lakes

Following this approach, Table 1 provides a summary of an initial subset of candidate reference lakes. Jacobie Lake was sampled in 2018 and the results confirm that the underlying geology is likely too dissimilar to Polley Lake to provide a suitable reference. It is also expected that Spanish Lake is unsuitable because it is in a wet subzone (wk2) of the Interior Cedar Hemlock (ICH) zone, has notably different underlying geology (arsenic and selenium is enriched in rocks on the opposite shore of Quesnel Lake), and is subject to mineral exploration and planned mine development (and therefore potential future mine-related activities).

Morehead and Gavin Lakes are both in the moist cool subzone (mk3) of the ICH zone, and Morehead coincides with at least one geological unit (LT_{Nvl}) that is similar to Polley Lake. Geological mapping will be further reviewed to evaluate similarity in the composition of the underlying geology vis-à-vis similarity to be a source of primary metals/metalloids of concern (e.g., copper, selenium, arsenic). However, Morehead Lake receives drainage from Bootjack Lake.

Table 1: Characteristics of Polley Lake and Candidate Reference Lakes

Lake	Elevation (m) [(a)]	Area (km^2) [(a)]	Depth: max (mean) (m) [(a)]	Underlying Geology [(b)]	Biogeoclimatic Zone [(c)]	Activities
Polley Lake	920	3.9	35 (18)	LT_{Nvl}, LT_{MPic}, LT_{Nav}	■ ICHmk3	■ Adjacent to Mount Polley Mine ■ Recreation (camping, fishing)
Bootjack Lake	983	2.6	15	LT_{Nvl}, LT_{Npt}	■ ICHmk3	■ Adjacent to Mount Polley Mine ■ Recreation (camping, fishing)
Jacobie Lake	1,122	0.86	20 (7)	LT_{Npv}, LT_{Nvb}	■ ICHmk3	■ Recreation (camping, fishing)
Morehead Lake	916	2	17	$LT_{Nvl,}$ Qal	■ ICHmk3	■ Recreation (camping, fishing)
Gavin Lake	963	0.94	24	MJ_{Qm}, LT_{Ns}	■ ICHmk3	■ Recreation (camping, fishing)
Spanish Lake	919	4.6	72.5 (29.6)	MLT_{Ns}	■ ICHwk2	■ Mineral exploration ■ Recreation (camping, fishing)

Notes:

(a) Activities, elevation and area identified from various angler and recreational use information websites.

(b) BC Forest Service Biogeoclimatic Ecosystem Classification System (ftp://ftp.for.gov.bc.ca/HRE/external/!publish/becmaps/PaperMaps/field/DHO_HorseflySubunit_Cariboo-ChilcotinResourceDistrict_CaribooRegion__field.pdf).

(c) BC EMPR Geoscience Map 2007-1 Regional Geology of the Mount Polley Area, central British Columbia (http://cmscontent.nrs.gov.bc.ca/geoscience/PublicationCatalogue/GeoscienceMap/BCGS_GM2007-01.pdf).

ICH: Interior Cedar Hemlock.

LT_{MPic}: Hydrothermal altered intrusive carapace holocrystalline monzonitic intrusions and volcaniclastic wall rock.

LT_{Nav}: Pink-white analcime pyroxene+/-olivine basalt breccia, flows and tuffs.

LT_{Npt}: Plagioclase phyric, pyroxene lapilli tuff, breccia and minor flows.

LT_{Npv}: Green and maroon pyroxene porphyry breccias, pyroxene-olivine basalt flows, and crystal-rich sediments.

LTNs: Grey siltstone, normal graded sandstone and cherty shale with pyroxene and plagioclase-rich crystal sandstones.

LTNvb: Massive, coarse polymictic volcanic breccias, graded sandstones, siltstone and rare limestone breccia horizons.

LTNvl: Red-brown, massive, polymictic breccia, feldspar, and hornblende crystal tuff.

MLTNs: Graphitic and quartzose phyllite, shale, siltstone and sandstone.

MJQm: Hornblende-biotite quartz monzonite.

mk3: moist cool zone.

wk2: wet cool zone.

3.0 VERIFICATION OF SUITABLE REFERENCE LAKE

Prior to the 2021 benthic invertebrate sampling program for Polley Lake, five sediment samples will be collected from lakes with similar geology to Polley Lake and analyzed for metals and grainsize distribution. Water samples will be collected from two locations and two depths (surface and depth) and analyzed for metals, hardness, total and dissolved organic carbon, and nutrients. At each of the two sampling locations, field measurements of pH, temperature, dissolved oxygen and conductivity will be recorded at 1 m intervals. Sampling methods (including quality assurance/quality control procedures) as outlined in the CEMP will be followed.

The resulting physico-chemical data will be compared to data from Polley Lake and Bootjack Lake. The comparisons may be made visually using graphs; through screening against sediment quality guidelines; and/or using statistical tests such as principle components analysis (PCA) or non-metric multidimensional scaling NMDS). The specific tests will be determined at the time of analysis, as factors such as variance and distribution (normal/non-normal) of the data and proportion of detectable versus non-detectable concentrations will need to be taken into account.

Sampling of the benthic invertebrate community of the selected lake will be conducted in 2021, along with sampling in Polley Lake.

4.0 CLOSURE

We trust that this letter provides sufficient information for your present needs. If you have any questions, please do not hesitate to contact the undersigned at 604-296-4200.

The reader is referred to the Study Limitations section, which follows the text and forms an integral part of this memorandum.

Yours very truly,

Golder Associates Ltd.

ORIGINAL SIGNED

Barbara Wernick, M.Sc., R.P.Bio.
Principal, Senior Environmental Scientist

ORIGINAL SIGNED

Lee Nikl, M.Sc., R.P.Bio.
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Attachment: Study Limitations

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Appendix C

Combined Monitoring Schedule 2023

Mount Polley Mining Corporation

Monitoring Schedule for February 2023

Task	Monday	Tuesday	Wednesday	Thursday
			1	**2**
			GH, DS, MJ	***GH, DS, MJ***
Lakes				
Surface Water			Monthly HAC (DO all locations): HAC-10, POF-5, HAC-13, HAC-14, HAC-05a, HAC-08, EDC-01a + Field Blank BAC-01 (1st floor dry)	Stored water: E8, E10, E11c + EKc, E24, E1a WIP pit lake sampling
Reclamation				
Hydrology				
Groundwater				
Weather			Snowpack min 2x/month	
Inspections			Pipeline inspection	Mill Potable/CP Totalizer
Soil/Sediment				
	6	**7**	**8**	**9**
	GH DS, MJ	***GH, DS, MJ***	***GH, DS, MJ***	***GH, DS, MJ***
Lakes				
Surface Water	Quarterly W sites: W1, W1b, W8, W8z + WHz, W12, W21	E19, HAD-3 + acute and quarterly toxicity samples BAC-02 (2nd floor sink)	Stored water: E8, E10, E11c, E24, E1a + Filter Blank	Monthly W sites: W4a, W4b, W5
Groundwater			Wight Pit GW SWLs: GW16-7, GW16-8, and GW05-01 sample + Travel Blank	
Reclamation				
Hydrology				
Weather				DL wildlife cams
Inspections	Waste inspection	Monthly inspections **and quarterly samples** incl: E4, E13, E14, E15 + EO, E17, E18, E19a, E20, E21, E22, E24, E26, LD, SERD, JCP, STD, COW Drain, US Drain, East MTD, West MTD		
Soil/Sediment	ABA (if dumping NAG waste)			
	13	**14**	**15**	**16**
	GH, DS, MJ	***GH, DS, MJ***	***GH, DS, MJ***	***GH, DS, MJ***
Lakes				
Surface Water		E19, HAD-3 + ES, WTP wastes (liquid and sludge) BAC-03 (3rd floor admin) + BAC-C	Stored water: E8, E10, E11c, E24, E1a + Field Blank WIP pit lake sampling	
Groundwater	Quarterly GW (+ GW-LF + GW-GF+ dups)			
Hydrology			Wight Pit GW SWLs **and Samples**: GW16-7, GW16-8 and GW05-01	
Weather	Snowpack min 2x/month			
Inspections	Waste inspection			
Soil/Sediment	ABA (if dumping NAG waste)			
	20	**21**	**22**	**23**
	Family Day STAT	***GH, DS, MJ***	***GH, DS, MJ***	***GH., DS, MJ***
Lakes				
Surface Water		E19, HAD-3 BAC-04 (Enviro trailer or other sink) Quarterly seeps: NEZ Seep 1, Boundary Seep 2, MDC + 1343, PAG Seep 15, SERD Seep 13	Stored water: E8, E10, E11c, E24, E1a + Travel Blank	
Groundwater		GW14-1 BAC sample	Wight Pit GW SWLs: GW16-7, GW16-8, and GW05-01 sample	
Hydrology		Non-CEMP flows: H5, JCP, NW Ditch, STD, MTD's, COW Drain, US Drain, Diversion Ditches (N&S)		
Weather				
Inspections		Waste inspection		
Soil/Sediment		ABA (if dumping NAG waste)		
	27	**28**		
	GH, DS, MJ	***GH, DS, MJ***		
Lakes				
Surface Water		E19, HAD-3 Remaining monthly/quarterly samples TBD Stored water: E8, E10, E11c, E24, E1a		
Groundwater		Wight Pit GW SWLs **and Samples**: GW16-7, GW16-8 and GW05-01		
Reclamation				
Weather		DL weather stn data		
Inspections		Weekly and monthly waste inspection, trailer inventory		
Soil/Sediment	ABA (if dumping NAG waste)			

C = cast + secchi S = sample

P = profile + secchi

Special Sampling:

1) Chlorophyll a, phytoplankton, [zooplankton - POL only] (Jun/Aug)

3) Zooplankton, chlorophyll *a* , phytoplankton, surface sample

QA/QC Sampling:

Field Blank - 2x monthly minimum

Travel Blank - 2x monthly minimum

Equipment Blank KEM2 - monthly; GW - quarterly

Duplicates - 2x monthly minimum

Quarterly Wells (SWL):

~~GW96-1a~~	GW96-2a	GW14-01
GW96-4a	GW16-2a,3a,4a,5a	GW05-01
GW00-1a	GW96-3a	GW95R-1
GW00-2a	GW00-3a	

Flows:

Purple:Bucket Black: Tracker

Photos of staff gauge when taking flows/ sampling

QUL Sample Depths (m):

QUL-18 0, 20, 50, 100

QUL-2a 0, 20, 40, 60

QUL-58 If detect plume: Middle of plume (MP) + 5m above (AP) + 5m below (BP) (all sites)
If can't detect plume: S, 1m above thermo , 1m below thermo [or MID if no thermo], bottom
* write sample depths in field book
**4x per year: T.Hg taken at QUL-58 (depth at which plume expected), QUL-2a (close to same depth as QUL-58), & HAD-3
*** write field parameters for each sample taken and indicate if discharging in field book

Special Analyses (Quarterly MDMER sampling):

T.Hg - 40ml glass vial with 1x HCl

Ra-226 - 1L plastic with 6x HNO3

QUL-120a: 0, 40, 80, 120, 140
well-mixed: 0, 80, 190

BJ + POL Sample Depths (m):

S, 1m above thermo , 1m below thermo [or MID if no thermo], bottom
* write sample depths in field book
** monthly profiles between spring and fall overturns

Toxicity:

a) 96h LC50 RBT, 48h LC50 *D. magna*
b) 7 dav ELS RBT
c) 7d C. dubia S&R
d) 7d RBT S&G
e) 30d ELS RBT
f) 30d ELS top-up (100L)
g) 72h algal (MMER)
h) 7 day duckweed (MMER)

Appendix D

Site Matrix

Mount Polley Mining Corporation

Mount Polley Mining Corporation

Comprehensive Environmental Monitoring Plan
Sample Site Matrix

Sampling Site	UTM	Monitored Since	Site Description	Site Location	Access or Safety Concerns	Rationale for Monitoring
W1 Morehead Creek	E 0587262 N 5826275	1990	Meandering creek with lots of willows and grass, no distinct trail. Large marsh to the North.	Drive to km 4.5 on Bootjack Road to a small opening in the trees and walk down the bank on the south side for 50 m. Trail and site marked with orange flagging tape.	Radio communication must be used on the Bootjack Road (Channel RR-25). Ensure that vehicle is parked to the side of the road out of the way of traffic. Watch for wildlife. Watch for rotten logs while approaching site. Follow working in/near water procedures.	Downstream of Mine impacted area. Provides opportunity to monitor potential changes in POCs in Bootjack Lake.
W1b Morehead Creek	E 0588920 N 5825173	2003	Meandering creek that flows under a bridge.	Drive to approx. km 7 on Bootjack Road and turn south onto side road for approx. 90 m until you reach a bridge. Walk down an embankment on the upstream side of the bridge to the creek.	Radio communication must be used on Bootjack Rd (Channel RR-25). Watch for wildlife. Watch your footing when walking down embankment. Follow working in/near water procedures.	Monitoring flow out of Bootjack Lake.
W4a North Dump Creek	E 0593152 N 5824689	2014	Small stream that flows under the Wight Pit Road through a culvert.	Drive towards the Wight Pit, before entering pit there will be one last runaway lane on the left-hand side, park vehicle on right side of the road. The sample site is located over the berm and down an embankment; there is a large log on the hillside to indicate the sample location.	Watch for wildlife. Watch your step while descending the embankment to monitoring location; there are loose rocks. Follow working in/near water procedures.	Downstream of Mine impacted areas. Provides opportunity to monitor for non-contained seeps or run-off collection ditches.

Sampling Site	UTM	Monitored Since	Site Description	Site Location	Access or Safety Concerns	Rationale for Monitoring
W5 Bootjack Creek	E 0594481 N 5820782	1990	Small stream runs through culvert	Drive to the TSF Perimeter Embankment on the Tailings Access Road and turn left at the central collection sump. Turn left onto deactivated logging road across from SERD outlet pipe. At top of hill, turn right and at the valley in the road park truck. Trail down to the creek is on the upstream side of creek. Site trail is indicated by fallen tree across path. Alternative access walking around far side of the SERD sump until an old access road is visible, follow until the dip in the road.	Contact Pit Shifter prior to entering haul roads. Drive with caution on haul roads and give heavy equipment the right-of-way. Use 2-way radio communication (Channel 5 – Pit Ops 1). Watch for wildlife. Slippery slopes with quite a few willows and one fallen tree. Old logging road can be very rough and muddy, recommend 4X4 or walk in during snowy conditions. Follow working in/near water procedures.	Downstream of Mine impacted areas. Provides an opportunity to monitor for seepage from the SERD.
W8 Edney Creek Tributary	E 0597005 N 5817606	1995	Small stream with easy access from the road.	Turn S at the main embankment onto a narrow road. Drive for roughly 2 km through the South Till Borrow, until you come to a small stream flowing under road through a culvert. Monitoring site is located on the downstream side of the road.	This road can be very muddy, recommend 4X4 or walk in during snowy conditions. Look for old orange ribbon. Watch for wildlife. Follow working in/near water procedures.	Downstream of Mine impacted area. Provides opportunity to monitor for potential seepage from TSF.
W8z Edney Creek Tributary (control)	E 0593290 N 5817920	1997	Small creek flows under road through a culvert. Many trees down over stream and many willows.	Drive to Gavin Lake Rd and turn right. Drive a few kms to about km 15 board, just before a junction with a deactivated logging road. The monitoring location is on the right-hand side of the road (upstream side of the road) just before the second landing. Take sample near the culvert.	Look for pink ribbon. Park to the side of the road. Short steep incline to access the monitoring site. Watch your step; there is not much room near the creek. Watch for wildlife. Follow working in/near water procedures.	Upstream of mine. Allows for monitoring of seasonal variability of surface water.
W10 Edney Creek	E 0601183 N 5816862	1995	Lower Edney Creek underneath a bridge.	Turn left onto Gavin Lake Rd. Continue and turn right on Ditch Rd towards Horsefly. Travel to the second bridge crossing. On the right-hand side of the road past the bridge (upstream side of the creek), there is a path down to the creek.	Watch for public traffic on the road and ensure vehicle is parked out of the way. Flows may be high during freshet. Ice can build up on edges of creek in winter conditions. Watch for wildlife. Follow working in/near water procedures.	Outside of Mine impacted area. Allows the opportunity to monitor for changes in newly constructed creek downstream and to monitor for seasonal variability.
W12 6K Creek (Tributary to Morehead Creek)	E 0588360 N 5825961	1990	Small stream that enters a marsh at the end of an old overgrown road. Small fish present in the stream.	Drive to km 5.5 on Bootjack Rd., to the chain-up pullout. Walk down old road on the NE side of Bootjack for roughly 150 m.	Radio communication must be used on the Bootjack Rd (Channel RR-25). Ensure that vehicle is parked to the side of the road out of the way of traffic. Watch for wildlife. Follow working in/near water procedures.	Upstream of mine. Allows for monitoring of seasonal variability of surface water.

Sampling Site	UTM	Monitored Since	Site Description	Site Location	Access or Safety Concerns	Rationale for Monitoring
W20 Un-named Tributary to Bootjack Lake	E 0592161 N 5821586	2013	Small creek on the NE side of Bootjack Lake, lots of grass, willow, alder and fallen trees. Creek flows roughly parallel to the West Ditch.	Walk in or boat access only. Drive midway on the West Ditch Rd. between the Booster Station and Mine Drainage Creek Sump. Park and walk W to the creek. Follow creek to the lakeshore. Monitoring location is in the creek channel approx. 15 m from the lakeshore. Look for orange ribbon at monitoring location.	If accessing by boat, follow safe boating SOP. If walking, watch for wildlife. Watch for Devil's Club. Walk with caution, as there are lots of blowdown. Ensure vehicles are parked out of the way. Follow working in/near water procedures.	Downstream of Mine impacted area. Provides the opportunity to monitor for any seepage from the west ditch.
W21 Un-named Tributary to Bootjack Lake	E 590194 N 5824644	2011	Culvert under New Access Road at 8.3 km	Travel out the New Access Road to the culvert on the right side of the road at 8.3 km.	Radio communication must be used on the Bootjack Rd. Ensure that vehicle is parked to the side of the road out of the way of traffic.	
Long Ditch	E 0594812 N 5820557	2008	Water flows out of a black pipe about 1 m above a ditch. Must use swing sampler.	Drive from corner 5 to corner 1, turn left at corner 1. Drive about 500m down, where there is a small road on the right-hand side. Only drive in a few metres with truck – there is a big drop off at about 10m. Walk to the far side to obtain samples.	Use caution while sampling at times of high flow. Watch your step while walking down to the pipe.	Monitoring water quality on site, including runoff, collected in the Long Ditch as this is a proponent of WTP source water.
SERDS Ditch	E 0594843 N 5820535	2012	Water flows out of black pipe and meets with LD water effluent	Drive down TSF haul road, towards Polley Lake weir, turn left at the central collection sump and drive about 400 m, where there is a small pullout. Park vehicle and walk to the right when facing the ditch. It is a short walk to the pipe to sample.	Use caution while sampling at times of high flow. Watch your step while walking down to pipe. Use caution when travelling down the TSF haul road and keep in radio contact with haul trucks and other equipment.	Monitoring water quality on site, including runoff, collected in the SERDS Ditch as this is a proponent of WTP source water.
E1a Tailings Storage Facility	E 0594431 N 5819646	1997	TSF Supernatant	Drive along the TAR to the TSF. Enter the TSF near corner 5 and follow road to the barge. Walk over the metal bridge to the pump house, samples are taken on the left or the rear of the barge.	Use radio communication when travelling on haul roads and contact Pit Shifter prior to entering haul roads and TSF area (switch from Channel 5 to Channel 1 (Tailings) when entering TSF area). Give right-of-way to heavy equipment. Follow working in/near water procedures. Watch for slippery surfaces in freezing conditions.	Monitoring supernatant WQ in the TSF.
E4	E 0595849 N 5818347	2001	South side of pond West of ABR. Enclosed by fence, key needed to unlock gate.	Drive to the Gavin Lake Road at the Main Embankment and turn right. After a few hundred metres the Main Seepage Pond is enclosed by a fence on the North side of the road. E4 is located on the South side of the pond.	Watch your step. Grass can be slippery. Sample in the pump house when pond is frozen. Use radio communication at the TSF.	Monitoring water quality on site, including runoff, collected in the Main Seepage Pond as this is a proponent of WTP source water.

Sampling Site	UTM	Monitored Since	Site Description	Site Location	Access or Safety Concerns	Rationale for Monitoring
E8 Cariboo Pit	E 0592200 N 5823200	1998	Cariboo Pit Dewatering	Travel down into the bottom of the Cariboo Pit ramp and the monitoring location is anywhere accessible at the base of the main ramp. Sample can also be collected @ West Ditch Pipe Outlet when dewatering the Pit.	Contact the Pit Shifter prior to entering and leaving the Cariboo Pit. Use caution when walking under highwalls.	When not storing water from other sources on site: source terms. When storing water from other sources on site: monitoring for potential discharge quality.
E10 Wight Pit	E 592871 N 5825306	2006	Wight Pit Dewatering.	Drive along Wight Pit haul road towards the Wight Pit. Turn right at the third road on the right-hand side. Sample may be taken from the dewatering pipe into the Long Ditch just before Joe's Creek Pipe. Watch for large rocks and the uneven berm on the road. (Joe's Creek Pipe is the second pipe on this road. It is just before the ditch crossing.)	Watch for wildlife. Ensure that the sample is taken from the correct pipe. Park vehicles out of traffic way.	When not storing water from other sources on site: source terms. When storing water from other sources on site: monitoring for potential discharge.
E11 Springer Pit	E 0591701 N 5823327	2011	At the bottom of the Springer Pit.	Travel down into the bottom of the Springer pit ramp and the monitoring location is near the pipes coming out of the springer pit.	Contact the Pit Shifter prior to entering and leaving the Springer Pit. Use caution when walking under highwalls.	When not storing water from other sources on site: source terms. When storing water from other sources on site: monitoring for potential discharge.
E13	E 0590791 N 5823587	2012	Sample taken from sump below the Temporary PAG Dump. Sample is taken from the armored NW sump below the road.	Drive down the Springer Pit Main Ramp to the junction of the Waste Haul Road and the PAG Access Ramp. Cross the haul road and turn left through the berm on a light duty traffic road. Proceed +/- 800m to the NW Sump (E13).	Contact the Pit Shifter before proceeding. Drive with caution. Use caution while collecting sample out of the sump. Watch for wildlife. Watch for fallen rocks on the road.	Monitoring water quality on site, including runoff, collected in the Northwest Sump. This is a proponent of WTP source water.
E14	E 0591832 N 5822173	2013	West Ditch Sump	Travel down the access road along the West Ditch dewatering line across the TSF light vehicle road from the Booster Station. The MDC sump (E14) is located on the right side of the road.	Roads may be slippery and are only one vehicle width. Watch for wildlife.	Monitoring water quality on site, including runoff, collected in the Mine Drainage Creek Sump. This is a proponent of WTP source water.
E15	E 0593781 N 5820995	2014	Bootjack Creek Sump	Travel along the new TSF Haul Road. Approximately 800m from the Waste Haul Road turn E down a light vehicle ramp to the sump.	Use caution around steep sump walls. Use caution and radio communication as necessary with haul trucks, equipment and the Pit Shifter.	Monitoring water quality on site, including runoff, collected in the Bootjack Creek Sump. This is a proponent of WTP source water.
E17	E 0590437 N 5824147	2014	9 km sump, swing sampler may be helpful to collect sample.	Contact the Pit Shifter before proceeding. Drive down the Springer Pit Main Ramp to the junction of the Waste Haul Road and the PAG Access Ramp. Cross the haul road and turn left through the berm on a light duty traffic road. Proceed +/- 1 km to the 9 km Sump.	Drive with caution. Use caution while collecting sample out of the sump. Watch for wildlife.	Monitoring water quality on site, including runoff, collected in the 9km Sump. This is a proponent of WTP source water.

Sampling Site	UTM	Monitored Since	Site Description	Site Location	Access or Safety Concerns	Rationale for Monitoring
E18	E 0594972 N 5820204	2014	Central collection sump	Travel down the TSF haul road towards the Perimeter Embankment, turn left, then turn right at the first road into the Central Collection Sump. Collect sample on little peninsula on the right side of the pumps.	Drive with caution while on the haul road; keep in radio communication with the pit shifter and any haul trucks you may encounter. Watch your footing while collecting sample.	Monitoring water quality on site, including runoff, collected in the Central Collection Seepage Pond. This is a proponent of WTP source water.
E19	E 0595760 N 5819760	2015	Water Treatment Plant Influent	Travel down the TSF haul road towards corner 2 of the TSF. Approx. halfway to corner 2 there is a road on the left that goes to the WTP. Monitoring site is located inside facility at the influent pipe at the main entrance to plant.	Use caution when driving on haul roads; contact the Pit Shifter prior to traveling to and from WTP. Watch for haul trucks on haul roads. Give the right-of-way to heavy equipment and used 2-way radio communication.	Provides ability to monitor efficacy of water treatment plant.
HAD-3	E 0595772 N 5823583	2015	Water Treatment Plant Effluent	Travel down the TSF haul road towards corner 2 of the TSF. Approx. halfway to corner 2 there is a road on the left that goes to the WTP. Current monitoring site is located outside just downstream from the WTP facility at the effluent pipe. A sampling port has been attached to the pipe (sample port is covered with plywood box to protect from elements during winter months). This sampling port will be used while a rental WTP is use. An additional sample port is located inside the SE corner of WTP and will be used when the rental WTP is no longer in use.	Use caution when driving on haul roads; contact the Pit Shifter prior to traveling to and from WTP. Watch for haul trucks on haul roads. Give the right-of-way to heavy equipment and used 2-way radio communication.	Compliance point for discharge to environment.
East MTD	E 0595732 N 5818447	2010	Sample port in the toe and foundation drain building at the Main Seepage Pond.	Follow directions to E4 (above) and enter the building beside the discharge tank. Close all valves on the right side of the discharge port. Sample from the pipe labelled “East MTD” by opening the sample valve. Ensure all valves have been reopened once sampling is complete.	Do not change the direction of MTD flow (to the Main Seepage Pond) using the valves.	Monitoring water quality on site, including runoff, collected in the East MTD. This is a proponent of WTP source water and WQ is an indicator of TSF stability.
West MTD	E 0595732 N 5818447	2013	Sample port in the toe and foundation drain building at the Main Seepage Pond.	Follow directions to E4 (above) and enter the building beside the discharge tank. Close all valves on the right side of the discharge port. Sample from the pipe labelled “West MTD” by opening the sample valve. Ensure all valves have been reopened once sampling is complete.	Do not change the direction of MTD flow (to the Main Seepage Pond) using the valves.	Monitoring water quality on site, including runoff, collected in the West MTD. This is a proponent of WTP source water and WQ is an indicator of TSF stability.

Sampling Site	UTM	Monitored Since	Site Description	Site Location	Access or Safety Concerns	Rationale for Monitoring
STD	E 0595084 N 5818222	2011	Pipe from inside TSF discharging into a ditch.	Travel on the Gavin Lake Road approximately 850m past E4 (see above). Sample the water discharging from a pipe into the N roadside ditch.	Watch for wildlife. Drive with caution and use 2-way radio communication if blocking the Gavin Lake Road during sampling.	Monitoring water quality on site, including runoff, collected in the STD. This is a proponent of WTP source water and WQ is an indicator of TSF stability.
Gavin's Ditch	E 0593341 N 5823909	2013	Clean water diversion ditch above Wight Pit Road.	Drive down the Wight Pit haul road. On the left-hand side, just before the second runaway lane, turn onto the underground escape raise road. Park on the road and walk along the armored ditch on both sides (for inspections). The sample site is on the downstream side of the road, follow the ditch until the end pit, sample water here ideally or anywhere possible along this section in dry conditions.	Use caution when driving on haul roads; contact the Pit Shifter prior to traveling to and from WTP. Watch for haul trucks on haul roads. Give the right-of-way to heavy equipment and used 2-way radio communication. Watch for wildlife in the area.	Monitor water quality on site, including runoff, for potential Mine influence.
TSF Clean Water Diversion	E 0594351 N 5818496	2013	Clean water diversion ditch along the South Embankment of the TSF.	Travel west along the Gavin Lake Road until just past the South Seepage Pond and look for culverts under the road. Sample the water discharging from the flagged site within the N roadside ditch.	Watch for wildlife. Drive with caution and use 2-way radio communication if blocking the Gavin Lake Road during sampling.	Monitor water quality on site, including runoff, for potential Mine influence in the undisturbed area west of the TSF.
Wight Pit Clean Water Diversion	E 0592683 N 5825737	2014	Clean water diversion ditch around the Wight Pit high wall.	Drive along Wight Pit haul road towards the Wight Pit. Take the dirt road on the right side of the haul road that goes up the hill towards the cabins. The sample site is collected from the flagged ditch that flows into a small sump on the left side of the road, at the top of the hill. Must sample during freshet because flow is minimal during the rest of the year.	Contact the Pit Shifter prior to entering the Wight Pit area. Watch for wildlife.	Monitor water quality on site, including runoff, for potential Mine influence in the undisturbed area north of the Wight Pit.
Boundary Pit	E 0591777 N 5825442	2012	Boundary Pit	Drive down the Wight Pit haul road. On the left-hand side, just before the second runaway lane, turn onto the underground escape raise road. Follow road until the end. The sample site can be taken anywhere along the water line of the small pit full of water next to the Bootjack Forest Service Road. Alternative access via Bootjack Forest Service Road at 10km marker.	Contact the Pit Shifter prior to entering the Wight Pit area. Watch for wildlife. Use caution when driving on Bootjack Forest Service Road. Park vehicle to the side of road. Call km boards on the radio while traveling in both directions.	Monitor water quality on site, including runoff, for potential Mine influence in the Boundary Zone.
JCP	E 0592334 N 5824488	2010	Joe's Creek Pipe. Black pipe winds down narrow, rocky road and discharges into the top of the Long Ditch.	Drive along Wight Pit haul road towards the Wight Pit. Turn right at the third road on the right-hand side. Drive up to stream crossing. Sample from the labeled pipe outlet in the ditch to the right.	Watch for wildlife. Ensure that the sample is taken from the correct pipe. Park vehicles out of traffic way.	Representative waste rock sample for the North Bell Dump and monitored for seepage water quality.

Sampling Site	UTM	Monitored Since	Site Description	Site Location	Access or Safety Concerns	Rationale for Monitoring
Boundary Seep 2	E 0591906 N 5825223	2013	Representative Boundary Dump seep.	Drive to roughly 12km on the Bootjack Forest Service Road just past a cut block area in the trees. Walk down the bank on the north side of the road for 50 m through the trees. Site is marked with orange flagging tape near a rock pile.	Use caution when driving on Bootjack Forest Service Road. Park vehicle to the side of road. Call km boards on the radio while traveling in both directions. Contact the Pit Shifter/ Gatehouse designate prior to entering area. Give the right-of-way to heavy equipment and use 2-way radio communication. Watch your footing on loose rocks. Watch for wildlife.	Representative waste rock sample for the Boundary Dump and monitored for seepage water quality.
NEZ Seep 1	E 0593992 N 5822803	2013	Representative NEZ Dump seep.	Travel along the TAR towards Corner 1 at the TSF. Turn left at the Central Collection Seepage Pond (E18) and follow the Wight Pit to Tailings Road past the SERDS sump roughly 2km. The sample site is located at the end of the dirt road on the N side of the main road. Collect sample at weir above the sump at the base of the NEZ Dump.	Use caution when driving on haul road. Give the right-of-way to heavy equipment and use 2-way radio communication. Follow working in/near water procedures. Watch your footing on loose rocks. Watch for wildlife.	Representative waste rock sample for the NEZ Dump and monitored for seepage water quality.
MDC	E 592143 N 5822127	2015	Mine Drainage Creek Culvert representative seep below the Waste Haul Road	Travel along the main Cariboo/Springer Pit haul road and park off to the side of the haul road, directly across from the helipad. There is an old access road opening in the berm, following down the hill to the end. Collect sample from flagged rock area/culvert opening at the toe of the haul road. Alternative access via uphill side road on the long ditch, just before E14, coming from the booster station side.	Use caution when driving on haul road. Contact the Pit Shifter/ Gatehouse designate prior to entering area. Give the right-of-way to heavy equipment and use 2-way radio communication. Watch your footing on loose rocks. Watch for wildlife.	Representative waste rock sample for the Waste Haul Road and monitored for seepage water quality.
PAG Seep 15	E 0590602 N 5824132	2014	Representative Temporary NW PAG Dump seep.	Drive to roughly 8.5km on the Bootjack Forest Service Road and turn left to access the west ditch road. Follow the road and park at the second sump (E17). Walk uphill towards the PAG dump toe through the cleared path. Collect sample at flagged site flowing underneath a rock pile.	Use caution when driving on Bootjack Forest Service Road. Contact the Pit Shifter/ Gatehouse designate prior to entering area. Use 2-way radio communication. Watch your footing on loose rocks. Watch for wildlife.	Representative waste rock sample for the Temporary NW PAG Dump and monitored for seepage water quality.
SERD Seep 13	E 0594170 N 5822279	2013	Representative SERDS Dump seep.	Travel along the TAR towards Corner 1 at the TSF. Turn left at the Central Collection Seepage Pond (E18) and follow the Wight Pit to Tailings Road past the SERDS sump roughly 1km. The sample site is located on the N side of the road. Walk 75m through the terrain towards a thicket of trees at the base of the SERDS dump. Site is flagged, collect	Use caution when driving on Bootjack Forest Service Road. Contact the Pit Shifter/ Gatehouse designate prior to entering area. Give the right-of-way to heavy equipment and use 2-way radio communication. Follow working in/near water procedures. Watch your footing on loose rocks. Watch for wildlife.	Representative waste rock sample for the SERDS Dump and monitored for seepage water quality.

Sampling Site	UTM	Monitored Since	Site Description	Site Location	Access or Safety Concerns	Rationale for Monitoring
				sample from water flowing through the wooden weir.		
H1 Hazeltine Creek	E 0597030 N 5818978	2015	Mid Hazeltine Creek hydrology station approximately 100 m downstream of Gavin Lake Bridge.	Travel to Gavin Lake Rd and turn left. Cross the Gavin Lake bridge and park off to the side. Walk approx. 100 m downstream of the bridge to hydrological monitoring station and is marked with staff gauge and metal pipes.	Park vehicle to the side of road. Watch footing when walking to hydrology station – some loose rocks. Use caution in high flow times – do not complete task if flow is too strong. Follow working in/near water procedures. Watch for wildlife. May need hip waders.	To monitor hydrology of mid Hazeltine Creek.
H2 Hazeltine Creek	E 0601024 N 5817253	2015	Lower Hazeltine Creek hydrology station.	Travel to the Gavin Lake Rd and turn left. Continue road until you reach the Ditch Rd and turn right towards Horsefly. Before the Ditch Road bridge, turn left through the gate. The station is approx. 200m from the gate. Hydrology station is marked with staff gauge and metal pipes.	Park vehicle to the side of road. Watch footing when walking to hydrology station – some loose rocks. Use caution in high flow times – do not complete task if flow is too strong. Follow working in/near water procedures. Watch for wildlife. May need hip waders.	To monitor hydrology of lower Hazeltine Creek.
H3 Edney Creek	E 0601538 N 5817123	2015 Removed Replaced by H3a	Edney Creek Hydrology station.	Travel to the Gavin Lake Rd and turn left. Continue road until you reach the Ditch Rd and turn right towards Horsefly. Drive past the Ditch Road bridge and turn left through the gate. Drive approx. 300 m and the hydrology station is marked with staff gauge and metal pipes on the right side of the road.	Park vehicle to the side of road. Watch footing when walking to hydrology station – some loose rocks. Use caution in high flow times – do not complete task if flow is too strong. Follow working in/near water procedures. Watch for wildlife. May need hip waders.	To monitor hydrology of Edney Creek.
H3a Edney Creek	E 0601376 N 5817077	2020	Edney Creek Hydrology station.	Travel to the Gavin Lake Rd and turn left. Continue road until you reach the Ditch Rd and turn right towards Horsefly. Drive past the Ditch Road bridge and turn left through the gate. Drive approx. 250 m and park. Walk ~100m to the hydrology station. It is marked with staff gauge and metal pipes on the right in Edney Creek.	Park vehicle to the side of road. Watch footing when walking to hydrology station – some loose rocks. Use caution in high flow times – do not complete task if flow is too strong. Follow working in/near water procedures. Watch for wildlife. May need hip waders.	To monitor hydrology of Edney Creek.
H4 Hazeltine Creek	E 0595892 N 5819997	2015	Upper Hazeltine Creek hydrology station at Polley lake weir.	Drive down the TSF haul road to Polley lake weir. Hydrology station is marked by staff gauge approx. 50 m downstream, of the weir.	Use caution when driving on haul roads, radio contact the Pit Shifter prior to entering area. Give the right-of-way to heavy equipment and use 2-way radio communication. Watch for wildlife. Use caution in high flow times. Follow working in/near water procedures. Watch footing on loose rocks down to the creek. May need hip waders.	To monitor hydrology in upper Hazeltine Creek and out of Polley Lake.

Sampling Site	UTM	Monitored Since	Site Description	Site Location	Access or Safety Concerns	Rationale for Monitoring
HAC-05a Hazeltine Creek	E 0596916 N 5819074	2015	Upper Hazeltine Creek just upstream of Gavin Lake bridge.	Travel as described above to H1. Monitoring location is the upstream side of Gavin Lake bridge.	Use caution when driving on TSF haul road. Contact the Pit Shifter prior to entering area. Give the right-of-way to heavy equipment and used 2-way radio communication. Watch your footing on loose rocks. Watch for wildlife. Use caution in high flow times and winter conditions. Follow working in/near water procedures.	Monitor WQ downstream of the effluent discharge - when discharging. To monitor WQ post creek reconstruction - when not discharging.
HAC-08 Hazeltine Creek	E 0600723 N5817290	2015	Lower Hazeltine Creek just upstream of Ditch Road bridge.	Travel as described above to H2, but instead of turning left before the bridge, drive to the bridge and park to the side. Monitoring location is just upstream of the Ditch road Bridge.	Park vehicle to the side of road. Watch for wildlife. Call km boards on the radio while traveling in both directions. Use caution in high flow times. Use caution in freezing conditions as ice can build up – may need swing sampler in these conditions. Follow working in/near water procedures.	This site was established to monitor WQ below the canyon. As Hazeltine Creek remediation continues there are opportunities to monitor the effect of remediation on the creek.
HAC-10 Hazeltine Creek	E 0595793 N 5820738	2015	Upper Hazeltine Creek monitoring site just downstream of Polley Lake weir.	Travel as described above to H4. Sample location is just downstream of Polley lake weir, from a large rock on the west side bank.	Use caution when driving on haul roads, radio contact the Pit Shifter before entering area. Give the right-of-way to heavy equipment and used 2-way radio communication. Watch for wildlife. Use caution in high flow times and winter conditions. Follow working in/near water procedures.	Monitor the surface WQ of Polley Lake as the water flows out of the lake and into Hazeltine Creek. The data from this site provides quick feedback on important parameters for fish habitat in the creek (pH, DO, and temperature).
HAC-13 Hazeltine Creek upper settling pond	E 0595892 N 5819997	2015	Upper Hazeltine sample site, near water treatment plant.	Travel to the WTP as described above and take a road to the left of the WTP building. This road winds behind the building past two groundwater wells. Follow the road to the end, park and walk in approximately 75m to the west side bank of the creek in a settling pool area. Site is flagged.	Use caution when driving on haul roads. Watch footing when walking to sample site and watch for wildlife. Use caution in high flow times.	Monitor the WQ at the End of Reach 1 in Hazeltine creek.
HAC-01c Hazeltine Creek outflow	E 0601661 N 5817598	2015 Removed from program	Hazeltine Creek outflow to Quesnel Lake.	Travel as described to HAC-12, and then drive towards Quesnel Lake. Monitoring Site is located at the outflow of Hazeltine Creek into Quesnel Lake.	Park vehicle to the side of road. Watch for wildlife. Call km boards on the radio while traveling in both directions. Use caution in high flow times and icy conditions as ice can build up on edges. Follow working in/near water procedures.	Monitor WQ at the mouth Hazeltine creek at Quesnel Lake once the discharge pipeline is complete. It will replace HAC-12 as the outflow site when it is removed from the sampling program.
HAC-14 Hazeltine Creek	E 0598742 N 5817299	2017	Mid Hazeltine Creek monitoring site above the canyon.	Drive as described to H1 but continue down Gavin Lake Road to approx. km 5.5 and turn right on the creek access road and continue for approx. 2 km and turn right at the second road on the right-hand side. Monitoring site is located at the bottom of the	Use caution when driving on haul roads, radio contact the Pit Shifter before entering area. Give the right-of-way to heavy equipment and used 2-way radio communication. Watch for wildlife. Use caution in high flow times and winter conditions as ice can build up on edges of creek. May need	Monitor WQ of Hazeltine creek above the canyon.

Sampling Site	UTM	Monitored Since	Site Description	Site Location	Access or Safety Concerns	Rationale for Monitoring
				ramp marked by a red and white stripped flagging tape.	snowshoes in winter. Follow working in/near water procedures.	
EDC-01 Edney Creek	E 0601811 N 5817445	2015 Removed Replaced by EDC-01a	Lower Edney Creek Sample site approx. 20 m upstream of the flood channel.	Follow travel instructions as described above to H3. Follow Edney Creek downstream towards Quesnel Lake and the monitoring location is approx. 20 m upstream from the flood channel.	Park vehicle to the side of road. Watch footing over loose rocks to the creek. Use caution in high flow times and freezing conditions as ice can build up on edges of creek. Watch for wildlife. Follow working in/near water procedures.	Monitor WQ of Edney Creek post reclamation of the lower section and its input to Quesnel Lake.
EDC-01a Edney Creek	E 0601694 N 5817324	2020	Lower Edney Creek ~100 m downstream of Hazeltine confluence	Travel to the Gavin Lake Rd and turn left and continue on road until you reach the Ditch Rd and turn right towards Horsefly. Turn left through the gate before the Ditch Road Bridge. Drive approx. 300 m and walk east for ~150m to Edney Creek near the wetland.	Park vehicle to the side of road. Watch footing over loose rocks to the creek. Use caution in high flow times and freezing conditions as ice can build up on edges of creek. Watch for wildlife. Follow working in/near water procedures.	Monitor WQ of Edney Creek below the Hazeltine Creek confluence post reclamation of the lower section and their combined input to Quesnel Lake.
B1 Bootjack Lake	E 0590049 N 5823528	2001/2007	Bootjack lake north WQ monitoring site	Drive on the Bootjack Forest service road to the Bootjack Lake campsite at km 8 on the access road.	Follow Safe Boating SOP. Contact Pit Shifter and Front Gate person when leaving mine site. Call kms on Channel RR-25 on the Bootjack FSR. Watch for wildlife. Follow working in/near water procedures.	Monitor WQ for potential mine influence in Bootjack Lake.
B2 Bootjack Lake	E 0591263 N 5821647	2001/2007	Bootjack Lake south WQ monitoring site	Drive on the Bootjack Forest service road to the Bootjack lake campsite at km 8 on the access road.	Follow Safe Boating SOP. Contact Pit Shifter and Front Gate person when leaving mine site. Call kms on Channel RR-25 on the Bootjack FSR. Watch for wildlife. Follow working in/near water procedures.	Monitor water WQ for potential mine influence in Bootjack Lake
B4 Bootjack Lake	E 0591141 N 5822832	For Closure only	Bootjack Lake (potential zone of influence from seepage from Springer Pit)	Drive on the Bootjack Forest service road to the Bootjack Lake campsite at km 8 on the access road.	Follow Safe Boating SOP. Contact Pit Shifter and Front Gate person when leaving mine site. Call kms on Channel RR-25 on the Bootjack FSR. Watch for wildlife. Follow working in/near water procedures.	Monitor water WQ for potential mine influence in Bootjack Lake
P1 Polley Lake	E 0593708 N 5824693	2001/2007	Polley Lake north WQ monitoring site	Drive down the TSF haul road to Central collection sump near corner 1. Turn left as if going to the central collection sump but then drive approx. 500 m and then turn right onto Polley lake boat launch.	Follow Safe Boating SOP. Contact the Pit Shifter prior to traveling on Haul roads. Use caution on Haul roads, give the right-of-way to heavy equipment and use 2-way radio communication. Watch for wildlife. Follow working in/near water procedures.	Monitor WQ water quality for potential mine influence in Polley Lake

Sampling Site	UTM	Monitored Since	Site Description	Site Location	Access or Safety Concerns	Rationale for Monitoring
P2 Polley Lake	E 0595348 N 5821863	2001/2007	Polley Lake south WQ monitoring site	Drive down the TSF haul road to Central collection sump near corner 1. Turn left as if going to the central collection sump but then drive approx. 500 m and then turn right onto Polley lake boat launch.	Follow Safe Boating SOP. Contact the Pit Shifter prior to traveling on Haul roads. Use caution on Haul roads, give the right-of-way to heavy equipment and use 2-way radio communication. Watch for wildlife. Follow working in/near water procedures.	Monitor WQ for potential mine influence in Polley Lake
QUL-2a Quesnel Lake	E 0607988 N 5817214	2014	Quesnel Lake post-breach and effluent discharge monitoring site.	Quesnel Lake is accessed via the boat launch near the effluent discharge (see access description for HAC-12), at Mitchell Bay, or at Cedar Creek (Likely).	Follow Safe Boating SOP. Call the Pit Shifter and Front Gate person when leaving mine site. Use caution when hauling the boat. Watch for wildlife.	Monitor WQ upstream of diffuser ports in Quesnel Lake.
QUL-120a Quesnel Lake	E 0618271 N 5818030	2014	Quesnel Lake background WQ monitoring site.	Quesnel Lake is accessed via the boat launch near the effluent discharge (see access description for HAC-12), at Mitchell Bay, or at Cedar Creek (Likely).	Follow Safe Boating SOP. Call the Pit Shifter and Front Gate person when leaving mine site. Use caution when hauling the boat. Watch for wildlife.	Monitor Quesnel Lake WQ at background site.
QUL-18 Quesnel Lake	E 0600795 N 5819749	2014	Quesnel Lake post-breach and effluent discharge monitoring site.	Quesnel Lake is accessed via the boat launch near the effluent discharge (see access description for HAC-12), at Mitchell Bay, or at Cedar Creek (Likely).	Follow Safe Boating SOP. Call the Pit Shifter and Front Gate person when leaving mine site. Use caution when hauling the boat. Watch for wildlife.	Monitor WQ downstream of diffuser ports in Quesnel Lake
QUL-57 Quesnel Lake	E 0601667 N 5817972	2015	Quesnel Lake initial dilution zone monitoring site.	Quesnel Lake is accessed via the boat launch near the effluent discharge (see access description for HAC-12), at Mitchell Bay, or at Cedar Creek (Likely).	Follow Safe Boating SOP. Call the Pit Shifter and Front Gate person when leaving mine site. Use caution when hauling the boat. Watch for wildlife.	Monitor the initial dilution zone of the effluent plume in Quesnel Lake.
QUL-58 Quesnel Lake	E 0601791 N 5818025	2015	Quesnel Lake effluent discharge monitoring site.	Quesnel Lake is accessed via the boat launch near the effluent discharge (see access description for HAC-12), at Mitchell Bay, or at Cedar Creek (Likely).	Follow Safe Boating SOP. Call the Pit Shifter and Front Gate person when leaving mine site. Use caution when hauling the boat. Watch for wildlife.	Monitor the initial dilution zone of the effluent plume in Quesnel Lake. Default WQ monitoring site when not discharging.
QUL-59 Quesnel Lake	E 0601825 N 5817874	2015	Quesnel Lake initial dilution zone monitoring site.	Quesnel Lake is accessed via the boat launch near the effluent discharge (see access description for HAC-12), at Mitchell Bay, or at Cedar Creek (Likely).	Follow Safe Boating SOP. Call the Pit Shifter and Front Gate person when leaving mine site. Use caution when hauling the boat. Watch for wildlife.	Monitor the initial dilution zone of the effluent plume in Quesnel Lake.
QUL-ZOO-1 Quesnel Lake	E 0601058 N 5819925	2015	Quesnel Lake zooplankton and WQ monitoring site.	Quesnel Lake is accessed via the boat launch near the effluent discharge (see access description for HAC-12), at Mitchell Bay, or at Cedar Creek (Likely).	Follow Safe Boating SOP. Call the Pit Shifter and Front Gate person when leaving mine site. Use caution when hauling the boat. Watch for wildlife.	Monitor WQ and zooplankton community and tissue in the West Basin of Quesnel Lake.
QUL-ZOO-7 Quesnel Lake	E 0612469 N 5816656	2015	Quesnel Lake zooplankton and WQ monitoring site.	Quesnel Lake is accessed via the boat launch near the effluent discharge (see access description for HAC-12), at Mitchell Bay, or at Cedar Creek (Likely).	Follow Safe Boating SOP. Call the Pit Shifter and Front Gate person when leaving mine site. Use caution when hauling the boat. Watch for wildlife.	Monitor WQ and zooplankton community and tissue near Horsefly River in Quesnel Lake.
Weather Station #1	E 0592792 N 5823182	2012	HOBO weather monitoring station.	Drive along the Wight Pit Haul Road and turn left onto the road to the Leach Pad. Park beside the leach pad and walk up the grassy hill between the sulphur pile and the research tree plots. Weather station is located at the top of the hill.	Call the Pit Shifter prior to traveling on Haul roads. Give right-of-way to heavy equipment. Watch for wildlife. Use caution near sulphur pile and watch footing walking up hill. Snowshoes may be required in winter.	Monitor wind speed/gust/direction, rain, solar radiation, and min/mean/max temperature continuously for water balance monitoring on site.

Sampling Site	UTM	Monitored Since	Site Description	Site Location	Access or Safety Concerns	Rationale for Monitoring
Weather Station #2	E 0591092 N 5819976	2012	HOBO weather monitoring station.	Drive along light duty road towards the Orica site. Drive up the Orica site road (approx. 30 m) and park slightly off the road as to not block access. The Weather Station is located on top of a small hill on the right-hand side of the road.	Call the Pit Shifter prior to traveling on Haul roads. Give right-of-way to heavy equipment. Watch for wildlife. Watch footing walking up hill.	Monitor wind speed/gust/direction, rain, solar radiation, and min/mean/max temperature continuously for water balance monitoring on site.
Snow Course Site: Weather Station #1	E 0592792 N 5823182	1997	Snow course monitoring site.	Follow instructions as described above for Weather Station #1.	Call the Pit Shifter prior to traveling on Haul roads. Give right-of-way to heavy equipment. Use caution when driving in winter conditions. Watch for wildlife. Use caution near sulphur pile and watch footing walking up hill. Snowshoes may be required.	Monitor snowpack-water equivalent for water balance monitoring on site.
Snow Course Site: JCP	E 0593632 N 5823895	2012	Snow course monitoring site.	Drive along Wight Pit haul road towards the Wight Pit. Turn right at the third road on the right-hand side. Drive up to stream crossing. May need to walk in snowy conditions approx. 100 m to clearing on the left-hand side. Snowpack course site is in that clearing.	Call Pit Shifter prior to traveling on haul roads and give right-of-way to heavy equipment. Used Caution when driving in winter conditions. Watch for wildlife. Snowshoes may be required.	Monitor snowpack-water equivalent for water balance monitoring on site.
Snow Course Site: TSF	E 0594092 N 5819976	1997	Snow course monitoring site.	Drive as described above to Weather Station #2, but instead of turning at the Orica site, drive past it approx. 100 m. Pull over to side of road when a small clearing in the trees is reached on the right-hand side. A ditch indicates the site.	Call Pit Shifter prior to traveling on haul roads and give right-of-way to heavy equipment. Used Caution when driving in winter conditions. Watch for wildlife. Snowshoes may be required.	Monitor snowpack-water equivalent for water balance monitoring on site.
Snow Course Site: PAG	E 0590835 N 5823537	2015	Snow course monitoring site.	Contact the Pit Shifter before proceeding. Drive down the Springer Pit Main Ramp to the junction of the Waste Haul Road and the PAG Access Ramp. Cross the haul road and turn left through the berm on a light duty traffic road. Alternatively, you can access from the 9km gate on the Bootjack FSR road and drive in until you reach the Northwest Sump and park to the left of the sump.	Call Pit Shifter prior to traveling on haul roads and give right-of-way to heavy equipment. Used Caution when driving in winter conditions. Watch for wildlife. Snowshoes may be required.	Monitor snowpack-water equivalent for water balance monitoring on site.

Notes:
POC – Parameters of Concern
TAR – Tailings Access Road
TSF – Tailings Storage Facility
WTP- Water Treatment Plant
WQ – Water Quality

Appendix E

Declaration of Competency Forms

BRITISH COLUMBIA | Ministry of Environment and Climate Change Strategy

Declaration of Competency

The Ministry of Environment and Climate Change Strategy relies on the work, advice, recommendations and in some cases decision making of qualified professionals[1], under government's professional reliance regime. With this comes an assumption that professionals who undertake work in relation to ministry legislation, regulations and codes of practice have the knowledge, experience and objectivity necessary to fulfill this role.

This declaration of competency is collected for the purposes of increasing government transparency and ensuring professional ethics and accountability. It will be disclosed to the public.

1. Name of Qualified Professional BARBARA WERNICK

   Title SENIOR ENVIRONMENTAL SCIENTIST

2. Are you a registered member of a professional association in B.C.? ☑ Yes ☐ No

   Name of Association: COLLEGE OF APPLIED BIOLOGY (#1171)

3. Brief description of professional services:

   DEVELOPMENT OF APPROACH TO SELECTION OF REFERENCE LAKES, SUMMARIES OF AMPHIBIAN & TERRESTRIAL STUDY COMPONENTS

Declaration

I declare that I am a qualified professional with the required knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X BWernick

Print Name: BARBARA WERNICK

Witnessed by:

X L. Nikl

Print Name: Lee Nikl

Date signed: 30 OCTOBER 2019

[1] *Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

a) *is registered in British Columbia with a professional association, is acting under that organization's code of ethics, and is subject to disciplinary action by that association, and*

b) *through suitable education, experience, accreditation and knowledge, may reasonably by relied on to provide advice within his or her area of expertise, which area of expertise is applicable to the duty or function.*

BRITISH COLUMBIA

Ministry of
Environment and
Climate Change Strategy

Declaration of Competency

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1. Name of Qualified Professional Blair McDonald

   Title Associate, Senior Environmental Scientist

2. Are you a registered member of a professional association in B.C.? ☒ Yes ☐ No

   Name of Association: College of Applied Biology Registration # 1528

3. Brief description of professional services:

   Environmental toxicology and ecological risk assessment

This conflict of interest disclosure statement is collected under section 26(c) of the *Freedom of Information and Protection of Privacy Act* for the purposes of increasing government transparency and ensuring professional ethics and accountability. By signing and submitting this statement you consent to its publication and its disclosure outside of Canada. This consent is valid from the date submitted and cannot be revoked. If you have any questions about the collection, use or disclosure of your personal information please contact the Ministry of Environment and Climate Change Strategy Headquarters Office at 1-800-663-7867.

Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

x [signature]

Print Name: Blair McDonald

Witnessed by:

x [signature]

Print Name: NEIL McQUITTY

Date signed: 29 Oct 19

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BRITISH COLUMBIA

Ministry of Environment and Climate Change Strategy

Declaration of Competency

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1. Name of Qualified Professional Pierre Stecko

   Title Senior Aquatic Scientist

2. Are you a registered member of a professional association in B.C.? ☑ Yes ☐ No

   Name of Association: College of Applied Biology Registration # 1709

3. Brief description of professional services:

   Aquatic environmental assessment, water quality, sediment quality, aquatic ecotoxicology

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X

Print Name: Pierre Stecko

Date signed: October 24 '19

Witnessed by:

X K Batchelar

Print Name: Katharina Batchelar

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BRITISH COLUMBIA

Ministry of Environment and Climate Change Strategy

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1. Name of Qualified Professional Katharina Batchelar

   Title Aquatic Scientist

2. Are you a registered member of a professional association in B.C.? ☑ Yes ☐ No

   Name of Association: College of Applied Biology Registration # 3103

3. Brief description of professional services:

   Aquatic ecotoxicology, aquatic environmental monitoring, sediment quality, metal toxicology

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X K Batchelar

Print Name: Katharina Batchelar

Date signed: October 24, 2019

Witnessed by:

X

Print Name: Pierre Stecko

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BRITISH COLUMBIA | Ministry of Environment and Climate Change Strategy

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1. Name of Qualified Professional Alicia Lalonde

   Title Intermediate Environmental Scientist

2. Are you a registered member of a professional association in B.C.? ☑ Yes ☐ No

   Name of Association: BCIA Registration # 2893

3. Brief description of professional services:

   Water resource planning and management

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

x Alicia Lalonde

Print Name: Alicia Lalonde

Witnessed by:

x Jesse Laframbroise

Print Name: Jesse Laframbroise

Date signed: March 1, 2023

[1] *Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

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