PE:7008 Quinsam Coal Annual Water Quality Monitoring Report 2023-2024

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Glossary & Acronyms

B.C. British Columbia

CALA Calibration

CCR Coarse Coal Reject

COPC Contaminants of Potential Concern

CSR-AL Contaminated Sites Regulations for Freshwater Aquatic Life 2023

DL Detection Limit

DO Dissolved Oxygen

ENV Ministry of Environment and Climate Change Strategy

EMS Environmental Monitoring Station

MEMPR Ministry of Energy, Mines and Petroleum Resources

EPT Ephemeroptera, Plecoptera, and Trichoptera

Ha Hectares

Hp Horsepower

IDZ Initial Dilution Zone

km Kilometer

LLE Long Lake Entry

LLS Long Lake Seep

LLSM Long Lake Seep Middle

masl Metres above sea level

MDL Mean Detection Limit

MOE Ministry of Environment and Climate Change Strategy

PTS Passive Treatment System

PAG-CCR Potentially Acid Generating Coarse Coal Reject

PAH Polyromantic Hydrocarbons

PEP Provincial Emergency Program

PNC Permit Non-compliance

QA/QC Quality Assurance/Quality Control

QCC Quinsam Coal Corporation

RPD Relative Percent Difference

TDS Total Dissolved Solids

TSS Total Suspended Solids

VIO Vancouver Island Objective for Phosphorus in Streams

WQG British Columbia Ambient Water Quality Guidelines for Protection of Aquatic Life

WQO Water Quality Objectives for Middle Quinsam Lake Sub-Basin

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Executive Summary

In accordance with the February 15, 2024, amended permit PE-7008, issued under the *Environmental Management Act*, Quinsam Coal Corporation (QCC) operates water management systems designed to mitigate effects of mining activities on the Middle Quinsam Sub-Basin and Iron River watershed(s). This effluent permit provides the framework for the comprehensive monitoring program along with allowable levels of Parameters of Interest (POI) within water released from the permitted management systems. In addition, to surface water quality monitoring within management systems and receiving environments, local groundwater, and biological monitoring (in the lakes) was conducted at numerous stations for a more comprehensive understanding of effects inside and outside of the mine footprint.

The main objective of this report is to inform governing bodies and stakeholders on the effectiveness of management systems and compliance with the effluent permit for the 2023-2024 monitoring year (April 1st through March 31st). These include:

- Description of mine-site operations and their respective environmental management systems
- Report on environmental performance and compliance with the Effluent Permit PE-7008
- Provide updates on surface, groundwater and receiving environment water quality including biological health
- Provide insight and recommendations for future monitoring and best environmental practices

During the reporting period Quinsam Coal Corporation (QCC), "the Mine" maintained the environmental obligations of amended permits C-172 and PE:7008. The Mines Act permit (C-172) is held with the Ministry of Energy, Mines, and Low Carbon Innovation (EMLI), with PE:7008 held with the Ministry of Environment and Climate Change Strategy (ENV). The Mine continues to be operated in a "care and maintenance" mode with MNP Ltd. (formerly The Bowra Group Inc.) as the Receiver. The Mine has been in care and maintenance since May 29, 2019, ensuring the health and safety of the employees and environment while continuing to meet regulatory requirements.

Mine discharges released from the permitted locations were within permitted (7008) concentrations for all water chemistry samples.

Water quantity recorded at Settling Pond 4 was measured above the permitted annual average rate of discharge (0.08 m^3/s or 2,522,880 m^3) measured over 366 days this year. The 2023-2024 annual average rate of discharge was 0.08 m^3/s or 2,647,026 m^3 above the permitted annual average quantity by 4.9%. Appendix II, Graph 73 displays the cumulative, average, and maximum discharge rates recorded at Settling Pond #4.

The reader should note that concentrations for most parameters of interest were not elevated above BC Water Quality Guideline's Freshwater Aquatic Life (WQG) and Middle Quinsam Lake Subbasin Water Quality Objectives (WQO) in the receiving environment throughout the 5 in 30 sampling period. Those parameters that were above WQG's in the lakes, rivers and streams include the following: total arsenic (As-T) in the Iron River (summer 5 in 30), total aluminum (Al-T) downstream on the Quinsam River at IRQR (one occasion in fall), dissolved copper (Cu-D) upstream and downstream of mine influence, Hypolimnetic Dissolved Oxygen (DO) in Long Lake in the hypolimnion zone and dissolved lead at No Name Lake Outlet (one occasion in fall). The majority of the observations found outside WQGs were with dissolved copper. Appendix I, Tables 3 and 4 display all WQG observations above guidelines.

WQG's for dissolved copper are variable and calculated based on ambient site conditions such as pH, temperature, dissolved organic carbon and hardness. Throughout the monitoring period copper is elevated upstream of mine influence on the Quinsam river at WA, the Iron River, and No Name Lake including the outlet (NNO). Highest concentrations are observed at WA and NNO for most periods. As a result, the downstream monitoring locations also display concentrations above their respective guidelines. These include Middle Quinsam and Long Lakes, downstream on the Quinsam River (WB, QRDS1, 7SQR and IRQR), Long Lake Outlet (LLO) and Lower Quinsam Lake (LQL). Refer to Appendix I, Table 3 and Appendix III, Graphs 49 through 54.

Elevated parameters are observed on the Iron River for arsenic (low flow) and aluminum (high flow). This year arsenic was elevated at both sites (IR6 and IR8) trending above the chronic-WQG (0.005 mg/L) during summer. Normally total aluminum is elevated in fall due to higher flow rates (fall flush event). The fall flush event did not occur until later with no elevated aluminum observed.

For those locations (seeps) that are contributing to loading in the receiving environment, parameters such as arsenic, aluminum, boron, iron and dissolved sulphate were elevated above the WQG's.

Potential mine related seepage areas (S, S2A and S2B), display a declining trend in dissolved sulphate, indicating the groundwater is recharging with formation groundwater. Formation groundwater is elevated in arsenic within the host rock formations of some 2-North areas. The 2-North flooded mine void water contains low levels of arsenic. Monitoring has been performed to characterize seepage water quality and quantity, and capture influences in the Quinsam River.

For the Potential mine related seepage (S, S2A and S2B) - Total arsenic was elevated at the seepage locations (S, S2A and S2B) during all sampling events. Total aluminum was elevated at S2A (2 out of 12 events). Total boron was elevated at S (8 out of 11 events). Dissolved iron was elevated at S2A (4 out of 12 events).

For the Long Lake Seeps - EMS ID E292131 – Total aluminum was elevated at LLS (2 out of 7 events) and LLSM was elevated (1 out of 6 events) in winter. Dissolved iron was elevated at LLS (3 out of 7 events) and LLSM (1 out of 6 events), with total iron also elevated at LLS (1 out of 7 events). Dissolved sulphate chronic-WQG is calculated based on an average of 5 consecutive weeks of results. Only monthly samples are collected at LLS and LLSM and compared to a Chronic-WQG (302.6 mg/L). Dissolved sulphate was elevated above the chronic-WQG at LLS (6 out of 7 events) and LLSM (6 out of 6 events).

The site Long Lake Entrance near the outlet (LLE) displayed elevated dissolved sulphate (> 302.6 mg/L) on 10 out of 52 weeks of sampling in May, June and October. Dissolved iron was elevated on one occasion in June.

Decreases were observed for average dissolved sulphate in the Quinsam River with summer (low flow) decreasing from 57 mg/L in 2021 to 33 mg/L in 2022 and 11.24 mg/L in 2023. Peak average concentrations were observed in spring on the Quinsam River (23 mg/L) with summer and fall having similar average concentrations (<12 mg/L).

Other than dissolved copper site wide and total aluminum on one occasion, no other parameters were observed to be above the WQG's or WQO's on the Quinsam River during this monitoring year. Minimal concentration increases were observed for total arsenic, iron, total manganese, and dissolved sulphate between Middle Quinsam Lake Outlet (WB) and downstream at of all mine influence at site, IRQR. This could be attributed to changes in geology of the river, increased groundwater discharge zones around seepage areas and continuous dewatering of mine voids during low flow. Water quality continues to remain well below WQG's in the Quinsam River at all locations. Refer to Appendix I, Tables 44 to 46.

Sulphate concentrations at depth in Long Lake have continued to be a focal point for receiving environmental water quality as elevated levels have persisted throughout past monitoring. In 2023, average concentrations continue to decline with all seasons remaining below average WQG's of 128 mg/L, using a background hardness concentration of 30 mg/L. The bottom depth ranges from 20 to 22 metres and is sampled at 1 metre above bottom (1MB). Average results for Long Lake 1MB during spring (98.4 mg/L), summer (90.6 mg/L), and fall (88.0 mg/L) were not elevated. Average results for Middle Quinsam Lake 1MB during spring (18.8 mg/L), summer (16.6 mg/L), and fall (10.8 mg/L) were not elevated. Average results for spring, summer, and fall displayed little variation between depths with fall displaying the lowest results (8 mg/L to 10.8 mg/L) from surface to bottom (1m, 4m, 9m and 1MB), Appendix II, Graphs 29 and 35.

Anoxic conditions (low dissolved oxygen) were observed in Long Lake during summer and fall, with total manganese not elevated above guidelines.

The Passive Treatment System has been effective at reducing mine pool water levels in the 2-South mine, reducing sulphate concentrations from mine pool water pumped to surface and maintaining a water cover over the 2-South PAG-CCR facility. Annual average concentrations of dissolved sulphate have been entering the system from the flooded mine void, measured at the influent (INF), resulting in 617 mg/L, and leaving the system at the Sulphide Polishing Cell (SPCEFF) resulting in 437 mg/L with final discharge at measured at SPD averaging 364 mg/L. These results indicate dilution through the system is successful at reducing sulphate concentrations. Dewatering efforts from the 2 / 3 South mine void has resulted in declining seepage rates at the Long Lake Seeps. The flow at the seeps started in January 2023 flowing till June 2023 and then stopped flowing until January 2024. The period of no flow at the seeps has been extended this year, which may be a result of dewatering efforts averaging 8.00 L/s instead of 4.5 L/s. Overall, LLSM flowed for 149 out of 366 days and LLS, 189 out of 366 days.

Additional monitoring included in-situ and ex-situ groundwater wells, underground sumps and dewatering wells located in 2 / 3 North, 2 / 3 South, 4-South, 5-South and 7-South mine areas. Parameters of interest are compared to source terms derived for mine water within the mine footprint (in-situ) and British Columbia Contaminated Site Regulation (CSR) Aquatic life (CSR-AL) (Last amended March 1, 2023, by B.C. Reg. 133/2022), Schedule 3.2, are used to compare groundwater quality outside of the mine footprint (ex-situ). Certain parameters found in ex-situ groundwater continually result above the CSR-AL, these include the following dissolved parameters: arsenic, chloride, fluoride, and sulphide as Hydrogen Sulphide (H_2S) and occasionally selenium. Selenium is observed periodically in the ex-situ deep groundwater of QU1105D situated to monitor water quality and vertical gradients downstream of the 2-North Mine and River Barrier Pillar. Parameters of interest in the receiving environment (*i.e., Quinsam River)* such arsenic, iron, sulphate and selenium were all found in low concentrations and below WQG's, (expect the Iron River for arsenic). Quinsam is committed to monitoring and observing long term trends as an effective tool to identify and determine changes in the groundwater. Refer to Appenix VI for the Annual Groundwater Monitoring Report.

Lorax Environmental was retained by the Receiver to initiate a Phase 1 Water Balance Water Quality Model - Gap Analysis in support of developing geochemical source terms and a sitewide water balance / water quality model (WB/WQM). This was received on January 30, 2023. The objective of the study was to construct a WB/WQM that predicts post-closure water quality at mine discharge locations to the receiving environment and in the Quinsam River. To achieve this objective, the WB/WQM architecture needs to be sufficiently detailed to evaluate how the implementation of mitigation, management and closure options within specific mine areas will affect Quinsam River water quality. The objective of the Gap analysis was to review the water quality and flow data that is currently available to inform the WB/WQM and identify any gaps that may be addressed by on-site monitoring. Quinsam has received the Phase I, Gap Analysis and has compiled and submitted data as request. This information will be used to provide an updated model robust enough to provide predictions for different closure options. The Phase II, Work Plan and Cost Estimate was received on May 12, 2023. The gaps that were identified were mostly for pumping rates from underground workings. Flow meters were installed around the site at key locations with continuous data compiled, refer to Appendix II, Graph 78. The final report and model are projected to be completed in the fall of 2024.

1.0 INTRODUCTION

The Quinsam Mine, situated approximately 28 kilometers southwest of Campbell River in the Quinsam River Watershed, covers around 283 hectares. Owned and operated by QCC, the mine produced High Volatile “A” Bituminous thermal coal until May 2019 when operations were suspended.

During active mining, coal was processed on-site and transported by B-train highway trucks to the Middle Point Barge Terminal, from where it was shipped to local customers and exported via Texada Island. Given its proximity to ecologically sensitive areas like Middle Quinsam Lake, the Quinsam River, No Name Lake, and Long Lake (which drain into Lower Quinsam Lake), the mine adheres to stringent effluent quality standards set by permits (Effluent Permit PE-7008 and the C-172 Mines Act permit). QCC collaborates with regulators and stakeholders to minimize environmental impact.

Water Management Systems:

The North, South, and 7-South water management systems handle cumulative mine-related discharges to the Quinsam watershed.

Strategic operation ensures that discharge waters meet permit requirements and are suitable for release into the receiving environment.

Parameters of interest are closely monitored to ensure environmental protection.

Bioassays and Toxicity Testing:

Acute Rainbow trout bioassays are conducted on water from authorized discharge locations (Settling Ponds #1, Settling Pond #4, and 7SSD) during specific events.

Acceptable criteria for a Rainbow trout bioassay include no mortalities at 100% effluent concentration after 96 hours.

7-day *Ceriodaphnia dubia* chronic toxicity testing assesses acute and chronic exposure levels, determining if the effluent causes death or affects test organism reproduction over a 7-day period.

Receiving Water Quality

Water Quality Assessment:

QCC aims to achieve water quality in the Middle Quinsam Sub-Basin by comparing it to provincial Water Quality Guidelines (WQGs) and Middle Quinsam Sub-Basin Water Quality Objectives (WQOs). Although these guidelines lack legal standing, they serve as a basis for evaluating environmental health.

Sulphate Concentrations:

- Monitoring sulphate concentrations assesses mine influence on the receiving environment.
- Sulphate levels are compared to an average WQG of 128 mg/L (calculated using a background hardness of 30 mg/L).
- Other parameters of interest include total arsenic, dissolved aluminum, dissolved copper, total and dissolved iron, total manganese, and dissolved zinc.

Updated Copper Guidelines:

- In 2019, the dissolved copper WQG was updated from total to dissolved using a Biotic Ligand Model (BLM)[1].
- The BLM incorporates site-specific water chemistry data to derive more stringent and conservative guidelines.
- Quinsam now applies the dissolved copper WQG at all receiving environment locations.

Upstream of Mine Influence Monitoring:

- Sites upstream of mine influences (e.g., Iron River) show naturally elevated concentrations of dissolved aluminum during high flow and arsenic during low flow events. Upstream on the Quinsam River (WA), and at the outlet of No Name Lake (NNO) displays naturally elevated concentrations of dissolved copper.

Groundwater Quality

Groundwater Monitoring:

- QCC maintains a comprehensive groundwater monitoring program.
- Numerous groundwater wells, both in-situ (within the disturbance footprint) and ex-situ (outside mine workings), are monitored.
- Underground sump samples are used for comparison when groundwater well samples are unavailable.

Comparison and Standards:

- Results from ex-situ and in-situ wells are compared to Contaminated Sites Regulations for Protection of Freshwater Aquatic Life (CSR-AL).
- In-situ wells and sumps are also compared to source terms specific to mining areas.

Influence of Bedrock Chemistry:

- Bedrock chemistry affects groundwater quality.
- For example, realgar (arsenic sulphide) in the Dunsmuir Sandstone results in naturally higher dissolved arsenic in south area groundwater than CSR-AL.

[1]B.C. Ministry of Environment and Climate Change Strategy 2019. Copper Water Quality Guideline for the Protection of Freshwater Aquatic Life-Technical Report. Water Quality Guideline Series, WQG-03-1. Prov. B.C., Victoria B.C.

Parameters of Interest:

- Groundwater parameters of interest include arsenic, chloride, fluoride, sulphide (H2S), and sulphate.
- In-situ groundwater generally aligns with water quality predictions, while ex-situ groundwater trends below CSR-AL.

Exceptions:

- Geological formations (e.g., Dunsmuir Member sandstones, Cumberland Member No.1 Coal seam, mudstones) influence groundwater quality.
- Weathering processes within the mine footprint (e.g., mine wall oxidation and flushing) also impact parameters of interest.

Seepage Areas

Three new areas have been identified where potentially mine-impacted water is seeping into the Quinsam River. These areas are located near groundwater wells QU1109 (site name “S”) and QU1105 (site names “S2A,” and “S2B,”). An ongoing investigation aims to monitor seepage in comparison to groundwater and flooded mine void water elevations, considering both water quality and quantity.

Hydrogeological Investigation: QCC contracted Lorax Environmental Services LTD, (Lorax) to conduct a site-wide hydrogeological investigation in 2011. Seepage rates from mine areas into the Quinsam River were predicted as part of this investigation.

Current Efforts: Lorax is currently preparing an updated Water Quality Model and Water Balance (WQM/WB). This model will reevaluate seepage rates from mine voids compared to predicted rates. Cumulative effects assessment for different scenarios at Closure will also be determined using this model.

Parameters of Interest: The cumulative effects assessment considers various parameters, including aluminum, arsenic, sulphate, boron, cadmium, copper, cobalt, iron, manganese, nickel, selenium, and zinc.

Receiving Water Sediment and Biota

Biological Monitoring Program (2016)

QCC conducted a comprehensive program involving sediment and benthic invertebrate monitoring at 23 locations in the watershed. Sediment results were compared to generic Canadian Council of Ministers of Environment (CCME) guidelines and site-specific sediment quality objectives (SQOs) for Long Lake. Parameters of interest included arsenic, iron, manganese, and total polycyclic aromatic hydrocarbons (PAH).

The Quinsam River was assessed following the methods from Canadian Aquatic Biomonitoring Network (CABIN), an aquatic biomonitoring program used to assess the health of freshwater ecosystems in Canada. It focuses on benthic macroinvertebrates (organisms living at the bottom of water bodies) as indicators of ecosystem health. By collecting and analyzing these organisms, CABIN provides valuable information about water quality and ecological conditions.

Iron River Baseline Monitoring (2020):

- Baseline monitoring was performed at IR6 and IR8, including sediment and benthic invertebrate collection following the CABIN methodology.

Quinsam River Partial Program (2021):

- Sediment and benthic invertebrate samples were collected at four Quinsam River locations following the CABIN methodology.

Water Quality Assessment:

- Water quality in the Middle Quinsam Sub-Basin and Iron River largely meets guidelines and is considered a healthy aquatic ecosystem. Effective mine water management systems have reduced parameter loading in the receiving environment.

Benthic Invertebrates:

- Benthic macroinvertebrates were analyzed and input into the CABIN model.
- Their counts serve as indicators of freshwater ecosystem health.

Phytoplankton and Zooplankton:

- Routine sampling assesses phytoplankton and zooplankton abundance and species identification in the lakes (No Name, Long, Middle and Lower Quinsam Lakes).

Long Lake Seep Passive Treatment System (PTS)

Purpose and Design:

- The PTS consists of treatment cells designed to receive mine water pumped from the 2-South underground workings.
- Its goal is to reduce concentrations of pollutants of interest (POIs), including dissolved sulphate and iron.
- The system was initiated as part of a remediation plan to limit localized mine-water seepage on the south side of Long Lake (Long Lake Seeps), due to subsidence caused by nearby mining activities.
- Dewatering the 2-South Mine into the PTS reduces the water levels underground below the elevation of the Seeps and prolongs the period of "No flow" observed.
- This system aids in maintaining a water cover over 2-South Pit.

Sulphate Reduction:

- Historically the PTS demonstrated reduction in sulphate concentrations.

- Higher reduction occurs during warmer conditions, with historical efficiencies reaching up to 300 mg/L or 50% during optimal performance times.
- Molasses Addition:
- The addition of molasses (a carbon source) has shown some capability to enhance system performance.
- Due to molasses viscosity, the injection system requires continuous pump replacement.

Biochemical Reactor Cell:

- The substrate in the Biochemical reactor cell requires replacement as its efficiency has decreased.

Overall dissolved sulphate is reduced at the authorized discharge location, Setting Pond 1.

2.0 WATER MANAGEMENT SYSTEMS AND MONITORING LOCATIONS

Settling ponds, sumps and ditches have been constructed to manage and treat mine contact water to help mitigate any negative effects on the receiving environment. Water management at the Quinsam Mine is divided into three discrete areas: North, South, and 7-South. Appendix IX, Site Maps, displays underground mine locations, groundwater wells and surface monitoring sites. Appendix 1, Table 1 and Table 1, below, describes the within-mine releases monitoring sites and associated initial dilution zones.

Table 1: Description of Monitoring Sites: In-Mine Releases & Initial Dilution Zones

Description of Effluent, In-Mine Releases & Receiving Environment Monitoring Sites			
EMS ID #	**Monitoring Sites**	**Abbreviation (Station Code)**	***Type of Water (MW, FW or GW)**
	North Coal Mining Operation		
E207409	Settling Pond #4 Decant	WD	**Discharge (MW)**
E207411	Culvert, at Middle Quinsam Lake Road	WC	MW & FW
E283433	2-North Portal Sump (Adit Sump)	2NPS	MW
E207412	2-North Pit Sump CCR Cover	WP	PAG-CCR Water Cover - MW
	South Coal Mine		
E218582	Settling Pond #1 Decant	SPD	**Discharge (MW)**
E217014	Culvert, Downstream End at Access Road	SPC	MW & FW
E217015	South Pit Main Sump Water	3S	PAG-CCR Water Cover (MW & FW)
E292127	2-South Pit In Pit Water Cover (2-South Standpipe)	2S	PAG-CCR Water Cover (MW & FW)
	7-South Mining Operation		
E292069	7-South Surface Decant	7SSD	**Discharge (SW)**
E292110	7-South Adit Sump	7SPS	MW
	Seep Monitoring Sites		
E292131	Long Lake Seeps	LLS & LLSM	GW / MW
	Culvert that collects groundwater and Coal Main logging road water entering MQL (PDSR)	PDSR	GW / SW
	Possible Seepage Area by QU1109	S	GW/SW
	Possible Seepage Area by QU1105	S2	GW/SW
	Receiving Environment Monitoring Sites - Near Initial Zone of Dilution (NIDZ)		
Near Initial Dilution Zone (NIDZ) Monitoring Sites			
E292130	Long Lake Entrance (South end water entering Long Lake near the outlet)	LLE	NIDZ
E292109	Road Crossing Bridge on Stream 1 above the Lower Wetland (Downstream of 7SSD).The site name is Stream 1, 7S.	7S	NIDZ
	Receiving Water (Rivers & Lakes Monitoring Sites) 5 in 30 Monitoring Locations		
North Coal Mining Operation			
E0126402	Quinsam River at Argonaut Bridge	WA	FW
E206618	Middle Quinsam Lake Centre	MQL (1, 4, 9 & 1m from Bottom)	FW
E0900504	Outflow from Middle Quinsam Lake	WB	FW
South Coal Mine			
E217018	No Name Lake	NNL (1, 4, 9 & 1m from Bottom)	FW
E217017	No Name Lake Outlet	NNO	FW
E206619	Long Lake at Centre	LLM (1, 4, 9 & 1m from Bottom)	FW
E219412	Long Lake Outlet	LLO	FW
7-South Mining Operation (Areas 1 to 4)			
E286930	Quinsam River Upstream of 7-South Mining Operation	QRDS1	FW
E292113	Quinsam River Downstream of 7-South Mining Operation	7SQR	FW
E292118	Lower Quinsam Lake Centre	LQL (1, 4, 9 & 1m from Bottom)	FW
7-South Area 5 Mining Operation			
E297231	Iron River upstream of 7SA5 and 242 influence	IR6	FW
E297232	Iron River downstream of 7SA5 and 242 inputs	IR8	FW
E299256	Quinsam River downstream of confluence with Iron River	IRQR	FW
E292118	Lower Quinsam Lake Centre	LQL (1, 4, 9 & 1m from Bottom)	FW
Block 242 Mining Operation (Reclaimed / Not Monitored)			
E225798	Iron River upstream of the 242 influence	Not Monitored	FW
E225808	Iron River downstream of the 242 influence	Not Monitored	FW
N/A	Old portal sump used for collection of water from underground	Reclaimed	FW / GW
Long Lake Seep Passive Treatment System			
N/A	Groundwater well (2-South Mine Pool) influent to the Passive Treatment System (PTS)	QU11-11 (INF-EFF)	MW
N/A	Biochemical Reactor	BCR-EFF	MW
N/A	Sulphide Polishing Cell	SPC-EFF	MW
N/A	2-South Inflow (From Passive Treatment System)	2SI	MW
N/A	2-South Culvert into 3-South Pit (Seepage under liner and overflow from 2S-pit)	2SC	MW
*** MW= Mine Water, FW= Freshwater, GW =Groundwater NIDZ = Near Initial Dilution Zone**			

2.1 Mine Related Discharge

2.1.1 *The North Water Management System*

The Quinsam Mine employs a comprehensive water management system to handle mine-related runoff and underground water.

North Water Management System (NWMS):

- Collects runoff from disturbed surface areas in the north.
- Also receives pumped water from the 2-North underground mine operations.
- Components include catchment sumps, ditches, pipelines, and Settling Pond #4.
- Settling Pond #4 to the Coal Processing Plant (CPP)
- Coal process water was pumped to the Tailings Dam.

2-North Mine Dewatering Components:

The 2-North Mine utilizes a network of pump systems. These include

- 1 Mains 2-North (1M2N),
- 5 Mains 2-North (5M2N)
- 3 Mains 2-North (3M2N)
- 2-North Portal Sump (2NPS)
- South Dyke Sump (SDS)

Table 2 below describes the underground and surface pumps systems and Figure 1 describes the 2-North pumping network.

Table 2: 2-North Pump System

Area	Type of Pump – Horsepower (Hp)	Total Pumping Capacity, Gallons per minute (GPM)
1M2N	1 x 125 Hp	750
5M2N	1 x 125 Hp	750
3M2N	2 x 250 Hp	Over 4500
2NPS	1 x 58 Hp (1 on standby)	800
SDS	1 x 58 Hp	800
Settling Pond #4 to CPP	1 x 125 Hp	2250
CPP to Tailings Dam	1 x 125 Hp	2250
Contingency		
3M2N	1 x 58 Hp feeding 1 x 250 Hp	2250

Purpose for the pumps Underground:

- Maintain water levels underground,
- Protect underground electrical equipment,
- Mitigate potential seepage from subsidence features.

Contingency Pumps:

- Additional pumps (1 x 250 Hp) are on standby in 3M2N.
- Dewater specific mine areas once water levels rise to the elevation of the pumps.

South Dyke Sump (SDS) and Redirected Water:

- SDS collects seepage water from the south side of the tailings dam.
- When 5-South dewatering pump was operating, combined 5-South and 7-South mine water was redirected into boreholes above 3M2N.

2-North Portal Sump, (2NPS) EMS #E283433:

Collects seepage water from the following:

- Tailings Storage Facility (TSF),
- 2-North Pit Sump,
- South Dam
- Underground 1Mains roadways,
- Combine water is pumped via 58 Hp into Brinco Brook or 2-North Pit Sump.

2-North Pit Sump, (WP) EMS #E207412:

- Subaqueous PAG-CCR facility.
- Contains waste rock from 5-South mine coal processing.
- Stored with at least 1.50 m of water cover to prevent acid generation.
- Permanent water cover sourced from 1M2N, 3M2N, or 2NPS.

Settling Pond #4 (SP4/WD) EMS #E207409:

- Authorized discharge location for NWMS, where water quality and quantity are compared to permit limits (PE:7008).
- Collects gravity-fed water from Brinco Brook
- Acts as the final collection point before discharge into a meadow/biomass system.
- Approximately 2.4 ha of marshland with a storage capacity of 30,000 m^3.

Culvert, at Middle Quinsam Lake Road (WC) EMS #E207411:

- Downstream location from SP4, discharge water from SP4 and meadow/biomass system.
- Last monitoring point before entering Middle Quinsam Lake near the inlet.

Figure 1: Water Movement and Flow Path in the North Management System, provides a flow chart describing the flow paths of water in the 2-North Water Management System.

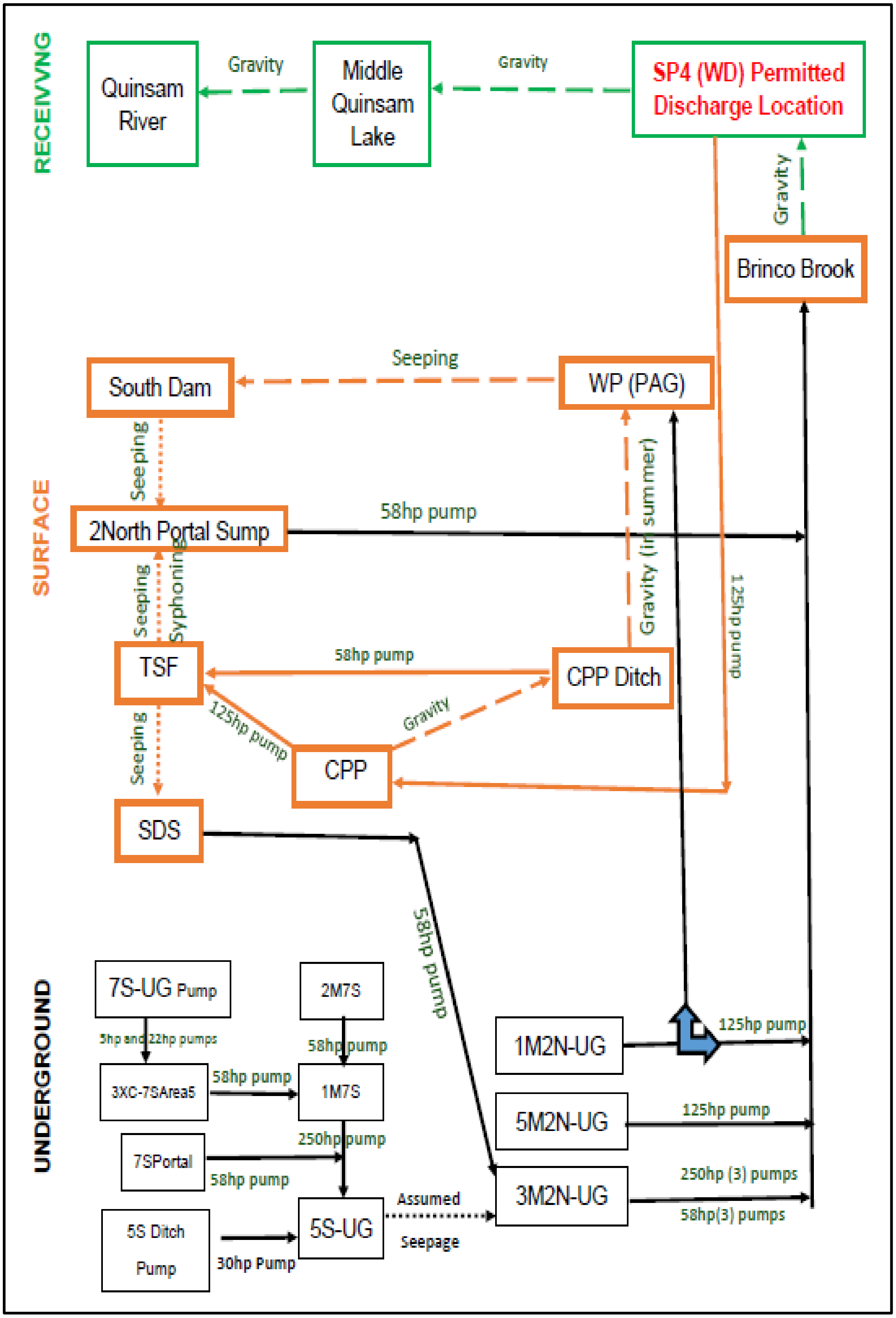

Figure 1: Water Movement and Flow Path in the North Management System

2.1.2 *THE SOUTH WATER MANAGEMENT SYSTEM*

South Water Management System (SWMS):

- SWMS collects mine-related runoff from disturbed surface areas in the south.
- It manages water in the 2-South and 3-South PAG-CCR containment pits and the Passive Treatment System.

2-South Pit (2S) EMS #E292127**:**

- Constructed in 2014, the 2S pit has a clay-bentonite liner to retain water.
- Water cover fed by ditches and pipes collects local catchment water.
- PTS discharge diverted into 2S pit to maintain permanent water cover (1.7m).
- Weekly measurements recorded for water level and continuous flow monitoring of inflow and outflow at 2SI and 2SC.

3-South Pit (3S) EMS #E217015**:**

- Excess water from 2S pit overflows into 3S pit.
- Seepage from under 2S pit liner directed to 3S pit.
- Continuous outflow from 2S pit recorded at H-Flume before entering 3S pit.

Pumps and Settling Ponds:

- In January 2021, a 58 Hp pump installed in 2S pit.
- Discharge from 58 Hp pump ties into 3S pipeline.
- Excess water in 3S pumped via an 88 Hp pump to Settling Pong #1
- Settling Pond #1 is the authorized discharge location before water enters Long Lake.

Passive Treatment System (PTS) and Decommissioned Ponds:

- Borehole QU11-11 (INF), dewaters 2-South flooded mine void via 15 Hp pump
- Objective is to lower mine-pool below the elevation of the Long Lake Seeps
- Water is pumped from INF to the Biochemical Reactor (BCR) and passively flows to the Sulphide Polishing Cell (SPCEFF)
- Only BCR and SPCEFF ponds currently operating; other pond (Aeration Lagoon and Settling Pond) decommissioned.
- BCR contains substrates and sulphate reducing microorganisms that reduce sulphate to hydrogen sulfide in the mine water through anaerobic respiration.
- SPCEFF contains iron filings that sequester the hydrogen sulfide for further reduction.
- Water from SPCEFF passively flows to the 2-South Inlet (2SI).

Settling Pond #1 (SP1) EMS #E218582 and Downstream:

- SP1 is the authorized discharge location for SWMS where water quality and quantity are compared to permit limits (PE:7008).
- SP1 channel leads into a series of meadow/biomass systems.
- Discharges at a pond / wetland (LLE) near the outlet of Long Lake.

Monitoring Locations:

- Monitoring location SPC (EMS #E217014) is downstream of the 4-South pad and 4S-Lo.
- SPC does not interact with effluent from 4-South but captures SP1 discharge.
- The final collection point LLE (EMS #E292130) is located at the downstream end of a culvert leading into Long Lake.
- LLE drains a wetland and discharges approximately 50 m upstream of Long Lake near the outlet.

Figure 2: South Water Management System, below provides a flow chart describing the SWMS.

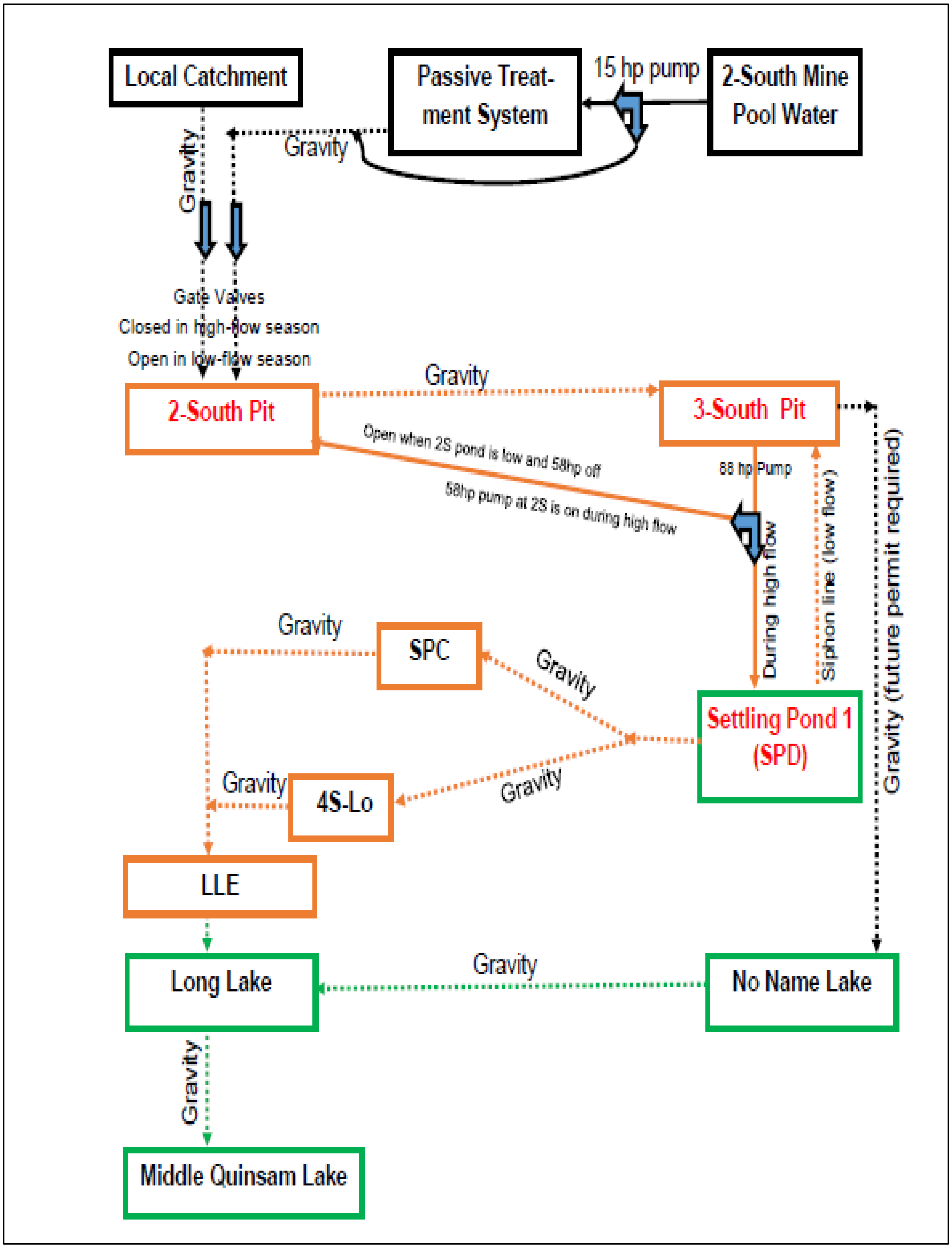

Figure 2: South Water Management System

2.1.3 *7-South Water Management System*

7-South Water Management System:

Includes Sump and Pond Locations:
- 7-South Surface Decant Settling Pond (7SSD) EMS #E292069
- 7-South-Adit Sump (7SPS) EMS #E292110
- 7-South Containment Pond (7SCP)

Receiving Environment Sites Downstream:
- Stream 1 (7S) EMS #E292109
- Lower Wetland Outlet (LWO) EMS #E292112 at the confluence of the Quinsam River.

Purpose and Design:
- Manages excess water from the 7-South catchment area.
- Mitigates environmental impacts from disturbed surface locations affected by mining and underground activity.

Main Ponds

7SPS:
- Collects surface water from the coal storage pad and 7S ponds (7SSD and 7SCP).
- 58Hp pump dewaters 7SPS into 5-South flooded mine void.
- Pumped underground 7S mine water (7SA5 and 1M7S) ties into the pipeline transporting 7SPS water into 5-South mine void.

7SCP:
- Collects surface runoff, local groundwater, and infiltration water.
- Suspended solids settle before water enters 7SSD.
- Enlarged in 2015.
- Additional pumps decrease 7SSD discharge.

Authorized discharge location, 7-South Surface Decant Settling Pond (7SSD) EMS #E292069 (Not Active):
- Permitted discharge location and main water collection pond.
- Receives water from groundwater infiltrated from hillsides and coal storage pad.
- Monitored for quality and quantity during discharge events.
- Discharged via 2-inch line with adjustable valve based on downstream flow rates.
- Protects Stream 1 receiving environment with an 8:1 dilution ratio

Water Flow and Management:
- Revised system pumps water from 7SSD and 7SCP to 7SPS, eliminating discharge from 7SSD.
- Automated float system at 7SCP keeps water levels below overflow channel into 7SSD.
- Secondary pump activated during high precipitation events.

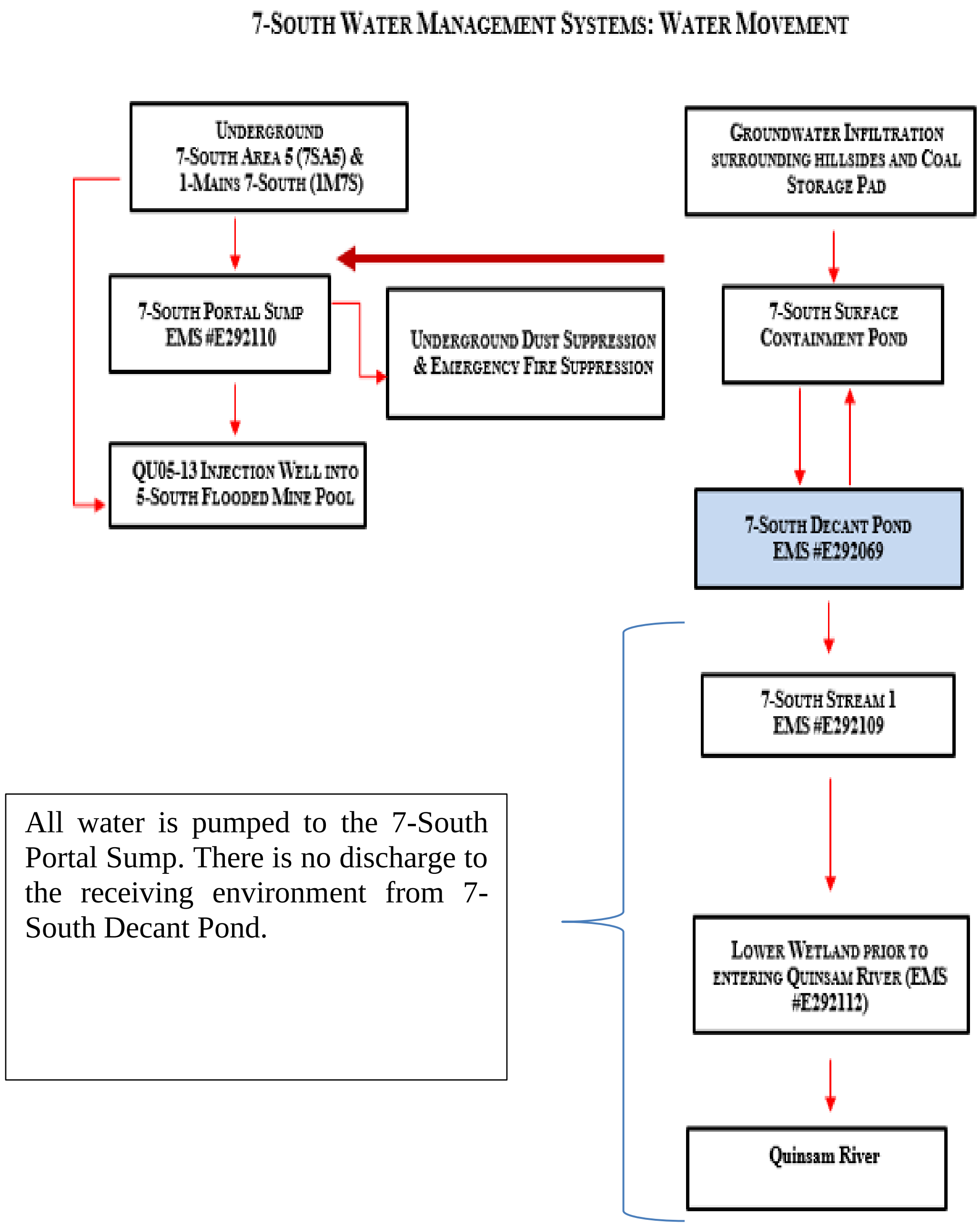

Figure 3: Water Movement and Flow Path at the 7-South Operation

2.2 Receiving Environment Sites

2.2.1 *River, Stream & Lake Monitoring Sites*

The Effluent Permit PE-7008, specifically Section 4.2.3, designates monitoring sites in rivers, streams, and lakes. These sites serve as representatives of the receiving environment for discharges related to mining activities. Monitoring occurs at most of these sites on a 5 in 30 sampling frequency, meaning five events within a 30-day period, during the spring, summer, and fall seasons. Table 3, lists the receiving water monitoring sites.

Table 3: Receiving Water (Stream and Lake) Monitoring Sites

Streams	Lakes
North Mining Operation	
Quinsam River at Argonaut Road (WA) (EMS # 0126402) Outflow from Middle Quinsam Lake (WB) (EMS # 0900504)	Middle Quinsam Lake Centre (EMS # 206618)
South Mining Operation	
Long Lake Outlet (LLO) (EMS # E219412) No Name Lake Outlet (NNO) (EMS # E217017)	Long Lake at Centre (LLM) (EMS #E206619) No Name Lake (NNL) (EMS # E217018)
7-South Mining Operation (Areas 1 to 4)	
Quinsam River upstream of 7 South Mining Operation (QRDS1) (EMS # E286930) Quinsam River downstream of 7 South Mining Operation (7SQR) (EMS # E292113) Lower Wetland Outlet at the confluence of Quinsam River (LWO) (EMS # E292112)	Lower Quinsam Lake (LQL) (EMS #E292118)
7-South Area 5 Mining Operation	
Iron River upstream of 7SA5 (IR6) (EMS # E297231) Iron River downstream of 7SA5 and 242 inputs (IR8) (EMS # E297232) Quinsam River downstream of confluence with Iron River (IRQR) (EMS # E299256)	Lower Quinsam Lake (LQL) (EMS # E292118)

RIVER AND STREAM SITES IN THE QUINSAM RIVER SUB-BASIN

Quinsam River at Argonaut Road (WA) EMS #0126402:
- Located upstream of all mine-related discharges.
- Represents background (baseline) conditions for water quality comparisons.

Outflow from Middle Quinsam Lake (WB) EMS #0900504:
- Located at the outflow of Middle Quinsam Lake.
- Represents the combined discharge from North and South water management systems.

No Name Lake Outlet (NNO) EMS #E217017:
- Located at the outflow of No Name Lake.
- Not presently influenced by surface mine-related discharge in the South.

Long Lake Outlet (LLO) EMS #E219412:
- Located at the outflow to Long Lake.
- Captures all South mine-related inputs on the surface and a percentage of groundwater (i.e., LLE and Long Lake Seep).

Quinsam River Downstream Site 1 (QRDS1) EMS #E286930:
- Located downstream of Middle Quinsam Lake Outflow (WB), the North Mining Operation, and upstream of the 7-South Mining Operation.
- Captures changes in water quality before the 7-South Mine and groundwater inputs related to mining.

Lower Wetland Outlet at the confluence of the Quinsam River (LWO) EMS #E292112:
- Located downstream of Stream 1 (7S).
- Represents final surface discharge quality prior to combining with the Quinsam River.

7-South Quinsam River (7SQR) EMS #E292113:
- Quinsam River downstream of QRDS1, LWO, and 7-South Mining Operation.
- Captures incremental changes in water quality that may be attributed to flooded 7-South PAG-CCR storage (2Mains).

Iron River –7-South Area

Iron River Upstream of 7-South and 242 groundwater influences (IR6) EMS #E297231:
- Located upstream of any mine-related activity.
- Reflects baseline conditions in an area with different geologic formations.
- Baseline water quality influences mainly include arsenic concentrations.

Iron River downstream of 7SA5 and 242 groundwater inputs (IR8) EMS #E297232:
- Downstream monitoring site on the Iron River.
- Will be used to monitor the potential influence of 7SA5

Quinsam River downstream of the confluence with the Iron River (IRQR) EMS #E299256:
- Represents the cumulative mine-related discharge.

LAKE MONITORING SITES - INCLUDING PERMIT AMENDMENTS

No Name Lake (NNL) EMS #E217018:

- Located within the South mine development area.
- Permit amendment: Reduced monitoring to spring 5 in 30 only, removed summer and fall.

Long Lake (LLM) EMS #E206619:

- Located within the South mine development area.
- Receives water from No Name Lake, 2 and 3 South flooded mine voids, and 3-South Pit as groundwater and surface water (Long Lake Seep).
- The outlet end receives seepage from 4-South flooded mine pool (estimated at 0.14 m^3/day) and south water management discharge (LLE).

Middle Quinsam Lake (MQL) EMS #E206618:

- Located adjacent to the North mine development area.
- Receives all discharge from the North water management system and upstream (non-mine related) inputs.
- Long Lake flows into Middle Quinsam Lake at the south end near the outlet (WB) via a small tributary stream (LLO).
- No changes to monitoring frequency.

Lower Quinsam Lake (LQL) EMS #E292118:

- Located well below mine-related discharges.
- Reflects the combined influences of Quinsam River and Iron River water quality.
- Permit amendment: Reduced to spring 5 in 30 only, removed summer and fall.

Sites with the frequency of monitoring reduced included:

- Long Lake Outlet (LLO) (EMS # E219412) Reduced monitoring to 5 in 30 spring, summer, and fall, only removed weekly SO4.
- Quinsam River downstream of 7 South Mining Operation (7SQR) (EMS # E292113) - reduced to 5 in 30 spring, summer, and fall, removed monthly.
- Quinsam River downstream of confluence with Iron River (IRQR) (EMS # E299256) - removed monthly.
- Iron River upstream of 7SA5 (IR6) (EMS # E297231) - removed monthly and spring monitoring.
- Iron River downstream of 7SA5 and 242 inputs (IR8) (EMS # E297232) - removed monthly and spring monitoring.

2.2.2 *Groundwater Monitoring Sites*

Numerous groundwater observation wells in the vicinity of pits 2N, 1S, 2S, 3S, 4S, Block 242, and 7S are monitored. Appendix I, Table 32 lists groundwater wells, location, and geological setting of these wells. For further information refer to Appendix I, Tables 33 to 37 for water chemistry and Appendix VI, *2023-2024 Annual Groundwater Monitoring Report*.

2.3 ADDITIONAL MONITORING PROGRAMS

QCC conducts a diverse environmental monitoring program governed largely by the effluent permit PE: 7008. Sediment and benthic invertebrate monitoring programs were conducted in 2016, 2020 and 2021. Details are included below.

2.3.1 *BASELINE MONITORING PROGRAMS*

An extensive baseline monitoring program was carried out to define existing conditions within the Quinsam River watershed. Fifteen different locations were sampled primarily between January 1983, and October 1984 and were analyzed for wide variety of physical, chemical and biological criteria.

The results of the baseline program are described in a report entitled Quinsam Coal Corporation - Baseline Monitoring and submitted to the Ministry of Environment on January 11, 1985.

Quinsam conducts additional monitoring to support permit amendment efforts and to provide additional insight into water quality trends and observations. Although this information is not specifically included in this report, the data may be used in future submissions to ENV.

2.3.2 *BIOLOGICAL MONITORING - QUINSAM WATERSHED FOR EFFLUENT PERMIT PE:7008*

In September 2021 sediment and benthic invertebrate monitoring was performed at four locations on the Quinsam River in to meet condition 4.2.7 (iii) of the amended Permit PE-7008 (dated June 24, 2015). This monitoring program was designed to supplement existing sediment and benthic monitoring performed in 2016 including continues water quality monitoring. These results evaluate historical sediment and chemistry with benthic biota in the Quinsam River that receive mine impacted discharges and reference sites with similar characteristics.

In 2016 a full program was carried out as described in Appendix VI of the *2016-2017 Annual Water Quality Monitoring Report*. The sampling sites included five lakes, one wetland, and one river system (Quinsam River) for a total of twenty-three sites. Table 4 below lists the waterbody type, waterbody name and site outlined in the study.

Table 4: Sediment and Benthic Monitoring Sites

Waterbody Type	Waterbody Name	Site
Lakes	No Name Lake (NNL)	No Name Lake Inlet, NNLI (EMS # E224246) No Name Lake Deep, NNLD (EMS # E217018) No Name Lake Near Seep (EMS # E292114) No Name Lake Outlet (EMS # E217017)
	Middle Quinsam Lake (MQL)	Middle Quinsam Lake Inlet (EMS # E206901) Middle Quinsam Lake Deep (EMS # E292115) Middle Quinsam Lake Near Seep (EMS # E292116) Middle Quinsam Lake Outlet (EMS # 0900504)
	Lower Quinsam Lake (LQL)	Lower Quinsam Lake Inlet (EMS # E292117) Lower Quinsam Lake Deep 1 (EMS # E29118) Lower Quinsam Lake Deep 2 (EMS # E292119) Lower Quinsam Lake Outlet (EMS # E292120)
	Long Lake (LL)	Long Lake Inlet (EMS # E292121) Long Lake Deep (EMS # E292122) Long Lake Near Seep (EMS # E292123) Long Lake Outlet (EMS # E219412)
	Gooseneck Lake (GNL)	Middle Gooseneck Lake (EMS # 1132502)
Wetland	Lower Wetland	Lower Wetland Inlet (EMS # E292124) Lower Wetland Middle (EMS # E292125) Lower Wetland Outlet (EMS # E292112)
Quinsam River	At Argonaut Road (WA)	(EMS # 0126402)
	Upstream of 7 South Mining Operation (QRDS1)	(EMS # E286930)
	Downstream of 7 South Mining Operation (7SQR)	(EMS # E292113)

In 2021, only a partial assessment was performed on the Quinsam River with the mine in care and maintenance after bankruptcy. This included a habitat assessment, collection of benthic invertebrate organisms, water, and sediment chemistry. Table 5 below lists the waterbody type, waterbody name and site outlined in the 2020 and 2021 monitoring program conducted on the Iron and Quinsam Rivers.

Table 5: 2020 and 2021 Sediment and Benthic Monitoring Sites

Waterbody Type	Station Name	Site
Iron River	Iron River Upstream of 7SA5 (IRN-06)	IR6 (EMS # E297231)
	Iron River downstream of 7SA5 and 242 inputs (IRN-08)	IR8 (EMS # E297232)
Quinsam River	Argonaut Road (WA)	WA (EMS # 0126402)
	Upstream of 7 South Mining Operation (QRD-02) and (QRD-03)	QRDS2 and QRDS3
	Downstream of 7 South Mining Operation (7SQR)	7SQR (EMS # E292113)

Sediment quality and the benthic invertebrate community in the Iron River and Quinsam River were studied to meet conditions of amended Permit PE-7008, dated June 23, 2015. The permit requires sediment and benthic invertebrate monitoring in the Quinsam River every three to five years. Baseline monitoring is required once, prior to mine development, on the Iron River. Studies were conducted in 2020 (Iron River) and 2021 (Quinsam River) to meet these permit conditions. Additional sediment sampling was conducted at a potential seep location to investigate probable inputs from mine-affected groundwater to the Quinsam River. The next Sediment and Benthic Invertebrate monitoring program will depend on the QCC's situation and is currently unknown.

Results of the study were provided in Appendix X of the 2021 - 2022 AWQMR.

2.3.3 *Passive Treatment System (PTS)*

The Passive Treatment System (PTS) consists of a series of treatment cells designed to receive mine-water pumped from the 2-South underground workings to reduce POI's concentrations including dissolved sulphate and iron. This system was initiated as part of a remediation plan to limit localized mine-water seepage on the south-side of Long Lake because of subsidence caused by mining within close proximity and establishing an evident hydrologic connection.

Historically the PTS demonstrated a reduction in sulphate concentrations throughout the system. Higher reduction is observed during warmer conditions, with reduction efficiencies upwards of 300 mg/L or 50% presented during optimal performance times. Recent result sulphate reduction rates have been low, indicating these separate or combined possibilities:

- Substrate requires replacement,
- An additional nutrient source is required,
- Pumping rates are too high for effective efficiency and reduction.

Overall, the entire SWMS is effectively reducing sulphate and iron concentrations including seepage from the Long Lake Seeps.

2.4 Maintenance & Reclamation Activities

To ensure proper functioning of site wide water management systems, haul roads, roadside ditches, catchment ditches, ponds, culverts, pumps, and water lines are maintained on a routine basis. Regular maintenance activities include removal of debris from culverts, replacement of silt fences and straw bales, and removal of sediment build-up from catchment ditches and ponds. Pumps and water lines are inspected daily and maintained as part of the surface inspection. Maintenance and repair occurred within the water management systems of the North and South Water Management Areas.

Maintenance Activities:

- Tree removed from under the powerlines and on water dams
- Road work and grading on potholes and ruts.
- Electrical repairs
- 1M2N dewatering pump replaced November 23, 2023
- Road repairs for QU1109
- Long Lake Seep stairs replaced

Reclamation

There were limited reclamation activities completed during 2023 (see the *Annual Reclamation Report for 2023, Mines Act Permit Number C-172* for further details).

3.0 Chemical Reagents and Waste Storage

Waste oil and solvents are stored in sealed containers or tidy tanks at secure locations and removed from site for recycling by Terrapure Nanaimo. Scrap metal at the mine site is collected in designated containers and recycled. There were no waste oil / solvents removed from site or metal recycled in 2023-2024.

4.0 Incidents - Permit Limit Exceedances, Bypasses & Permit Non-Compliances

All water permitted parameters at the authorized discharge locations (SP1 and SP4) remained within specific permit limits. Please refer to Appendix 1, Table 2 for a summary of all non-compliances for permit limit exceedances (P) and permit non-compliances (PNC). These are specific to missed samples, parameter analysis, and missing flow data. Appendix VII provides the non-compliance reports. All spill and excursion reports are submitted to the Environmental Emergency Program website at: and SpillReports@gov.bc.ca.

There are three areas where mine related discharge is bypassing the authorized works. These include:

- E292131 - Long Lake Seeps discharge to Long Lake, bypassing E218582 - SPD
- Groundwater with mine related influence referred to as (S, S2A and S2B) discharge to Quinsam River, bypassing E207409 – WD

The Long Lake Seeps are directly related to the 2-South mine water elevations. The other newly discovered "potential" seepage areas are still under investigation. These areas are more complicated and correlation with 2-North mine water elevations and chemistry is still being developed. The site S2B seems to be closely related to underground water elevations.

Seepage areas are sampled monthly for water chemistry and flow, with E292131 monitored weekly for flow. Water chemistry from E292131 (LLS and LLSM) is elevated in sulphate and iron, above WQG's. Refer to Sections 6.2.3 and 8.2.3 and Appendix I, Tables 2 through 5, 21 and 30 and Appendix II, Graphs 22 to 25, 55 and 67 and Appendix VI – Annual Groundwater Monitoring Report.

Water chemistry from S, S2A and S2B exhibit elevated arsenic on all occasions with S demonstrating elevated boron and S2A occasionally elevated aluminum and iron. Elevated conductivity and sulphate are primary parameters used as an indication of a mine related signature. However, the No. 1 coal seam has a sodium / chloride signature resulting in high conductivity. Slightly elevated dissolved sulphate was observed ranging from 120 mg/L to 160 mg/L at S, 20 mg/L to 130 mg/L at S2A and 56 mg/L to 80 mg/L at S2B.

Concentrations of sodium (ranging from 92 mg/L to 258 mg/L) and chloride (ranging from 18 mg/L to 52 mg/L) were highest at S where flows are lowest. Discharge was continuous from sites S and S2A, with S2B correlated with 2-North mine water elevations producing intermittent flows in winter from January to March. This groundwater is interacting with the stratigraphic section (possibly No. 3 Seam) containing elevated arsenic where it is mobilized in the receiving environment. Arsenic remains in low concentrations in the Quinsam River. Refer to Appendix I, Tables 2, 3 and 35 to 37 for water chemistry results.

One spill occurred on March 27, 2024, to April 2, 2024. A borehole (QU14-10) located above, 7-South 2-Mains, leaked mine water into the Quinsam River. The river was sampled upstream and downstream of the source. There were no observed environmental impacts from the discharge. The discharge was limited and diluted with surface water prior to flowing into the river. Please refer to Appendix VII, End Spill Report Dangerous Goods Incident Report # DGIR 241338 for further information.

5.0 MATERIALS AND METHODS: ENVIRONMENTAL MONITORING PROGRAM

All water samples were collected in accordance with methods described in "*The British Columbia Field Sampling Manual for Continuous Monitoring of Air- Emissions, Water, Soil, Sediment, and Biological Samples*" (BC.2024)[2]. This includes the following specified field protocols: use of field duplicates, split samples, and method blanks and checking for transcription errors.

Bureau Veritas Laboratories (BV labs) located in Burnaby B.C., a Canadian Association for Laboratory Accreditation (CALA) designated laboratory, conducted the analysis of surface,

[2] BC. 2024. "The British Columbia Field Sampling Manual for Continuous Monitoring of Air- Emissions, Water, Soil, Sediment, and Biological Samples". Available at: https://www2.gov.bc.ca/assets/gov/environment/research-monitoring-and-reporting/monitoring/emre/manuals/field-sampling-manual/bc-field-sampling-manual-part-e1-surface-water-2024-03-08.pdf

groundwater, and sediment samples. Phytoplankton samples were analyzed by Stantec Consulting Ltd. (Burnaby B.C.). Zooplankton samples were analyzed by Fraser Environmental (Surrey, B.C.). Benthic Invertebrate samples were sent to Cordillera Consulting Inc. (Summerland, B.C.).

5.1 WATER QUALITY ANALYSIS

PE-7008 identifies the parameters to be analyzed in effluent. Each site has specific requirements for parameters to be analyzed. The following parameters are generally monitored at each station:

- Total suspended solids (TSS) (mg/L)
- pH-Field (standard units)
- Conductivity-Field (uS/cm)
- Alkalinity (mg/L as $CaCO_3$)
- Hardness (mg/L as $CaCO_3$)
- Sulphate (mg/L)
- Ammonia as nitrogen (mg/L)
- Nitrate/nitrite combined as nitrogen (mg/L)
- Dissolved Organic Carbon (mg/L)
- Total phosphorus and dissolved phosphate (mg/L)
- Total and dissolved metals (mg/L)
- Oil and grease (for sites SPD and WD only) (mg/L)
- Rainbow trout bioassays (for sites SPD, WD and 7SSD only)
- 7 Day *Ceriodaphinia dubia* chronic toxicity test (at site 7S only)

The following parameters are specific to lake sampling:

- Dissolved oxygen (mg/L)
- Temperature (Celsius)
- Oxidation reduction potential
- Biological
  - Phytoplankton (chlorophyll "a" and phaeopigment)
  - Phytoplankton (counts and identification to species)
  - Zooplankton (counts and identification to species)

All surface and groundwater samples were filtered through a 0.45 µm filter and preserved on site. BV Labs analyzed dissolved and total metals samples using the CCME/BC WQG analytical package to provide suitable detection limits for comparison with guidelines and as per ENV requirements. This included use of conventional and Inductively Coupled Plasma Mass Spectrometry (ICPMS) equipment.

5.2 ENVIRONMENTAL MONITORING EQUIPMENT

The following equipment was used to conduct the surface monitoring program at Quinsam Coal:

- A maidlabs technology, Flowmaid with an ultra-sonic depth sensor at Settling Pond #1
- An ISCO signature flow metre with an ultrasonic sensor (Settling Pond #4).
- A maidlabs technology, Flowmaid with an ultra-sonic depth sensor replaced the ISCO 4210 at Settling Pond #1
- A Sitrans F M MAG 8000 CT electromagnetic flow metre to record discharge at 7SSD.

- ISCO 12-volt automatic samplers programmed to collect daily composite samples for analysis of TSS deployed at all permitted discharge locations.
- A YSI Exo 1 multiparameter sonde and YSI Pro-Plus, to obtain physical water quality parameters, and calibrated prior to each sampling event following manufacturer specifications for maintenance and handling.
- Two handheld sondes (Oakton PC Tester 35), for routine monitoring of pH and conductivity.
- Level logger pressure transducers, used to obtain continuous water level measurements at Long Lake Outlet, Middle Quinsam Lake Outlet and the Iron River, with data used to create daily hydrographs.
- A 4-litre Beta sampler, to collect lake water samples; the sampler is constructed with materials to minimize interference cross contamination of metals and the 4 litre volume provides sufficient water for all required analyses in one deployment per depth.
- A Campbell Scientific weather site, to record temperature, precipitation, wind, humidity, solar intensity, and snow accumulation data (installed next to the 2-South pit in August 2015, became operational in October 2015).
- An Eckman grab sampler, for collection of sediment and benthic invertebrate samples.
- Hydro-lift used for collection of groundwater samples
- Portable Bladder pump used for collection of groundwater samples
- Peristaltic pump used for collection of groundwater samples

Although this list is not exhaustive, it provides an overview of the equipment used for environmental monitoring.

5.3 Quality Assurance / Quality Control

Quality Assurance / Quality Control (QA/QC) sampling followed protocols described in BC.2024. QA/QC practices were integrated into the water sampling program to maintain the integrity, consistency, and reproducibility of sampling techniques and results of environmental monitoring. Various samples, including field blanks, trip blanks, equipment blanks, and replicates, are used to evaluate methods and identify potential issues related to sampling techniques and equipment. Each sample type serves a specific purpose:

- Field Blanks – Samples of laboratory-grade, reverse osmosis, deionized water deposited into sample containers in the same location in which a field sample is collected. These samples are carried and treated in the same manner as a field sample to assess any potential cross-contamination that may occur due to sampler technique.
- Trip Blanks – Samples of laboratory-grade, reverse osmosis, deionized water deposited into sample containers in a laboratory setting are transported into field locations with samplers to determine if any cross-contamination occurs due to the handling or storage of sample bottles.
- Equipment Blanks – Samples of laboratory-grade, reverse osmosis, deionized water placed into a piece of equipment at a sampling station to identify potential cross-contamination associated with equipment (e.g., Beta sampler), sampling procedures, or general cleanliness.
- Replicates – Samples collected at the same location and time by the same sampler using the same techniques and equipment. Replicates samples are used to assess precision for each analyte analyzed. Observed variance between replicates identifies uncertainty in sampling, environmental heterogeneity, and laboratory analysis.

Field replicate samples are collected during every sampling event, accounting for approximately 10% of analyses requested from the laboratory. One sampling event may span two or more days. The primary sampling events are:

- Weekly, monthly, and quarterly sampling for all permitted monitoring locations,
- 5 in 30-day programs, three times per year for receiving environment sampling for lakes, rivers, and streams,
- Groundwater wells.

For all replicates collected Relative Percent Difference (RPD) values were calculated for the analytical results from the sample and its respective replicate. In accordance with the British Columbia Field-Sampling Manual, the calculation was applied as stated below:

$$RPD = Absolute \frac{(Sample\ Concentration - Replicate\ Concentration)}{\left(\frac{Sample\ Concentration + Replicate\ Concentration}{2}\right)}\ x\ 100\%$$

RPD calculations were only practical for results where concentrations were found at or greater than five times the reported detection limit (RDL) as there is considerable uncertainty at low levels. In addition, mathematical calculations for RPD appear exaggerated with low values where absolute differences may be relatively low. It is expected to see variation between a sample and its respective field replicate for several reasons. Some considerations include redox reactive parameters, inconsistent sample stream at sampling locations; heterogeneity of water at sampling location; the possibility of minor contaminations; laboratory sample preparation and accuracy of analytical instrument and the laboratory mean detection limits for the results are different to name a few.

Taking these possibilities into consideration, RPD values less than 20% are deemed "acceptable" and indicate proper sampling methodology with representative results. It has been acknowledged that RPD values greater than 20% indicate a potential problem with sampling integrity whereas values greater than 50% indicate a definite problem.

Appendix I, Tables 49 to 50 display the results of the RPD calculations.

During the 2023/2024 monitoring year, there were a total of 3400 parameters analyzed for replicate samples. Of the analyzed parameters in these parent samples and their replicate samples, 105 were outside the RPD limit. With 57 out of 3400 (1.67%) having a RPD greater than 20% and 48 out of 3400 (0.21%) having an RPD greater than 50%. Duplicate analyses for total suspended solids, Sulphide as H_2S, phosphorus, aluminum, alkalinity and turbidity, and were the most common accounting for the most frequent instances of RPD greater than 20%.

The parameters that were found with an RPD greater than 50% do not seem to be displaying enough RPD magnitude to identify any issues requiring attention. Only 0.21% of the parameters displayed an RPD greater than 50%.

The RPD for field blank sample concentrations should not be significantly greater nor occur more frequently than for laboratory method blanks (BC.2024). Results greater than two times the laboratory MDL are identified and investigated to determine potential contamination.

There were no field blanks or trip blanks collected this year. Equipment blank results of laboratory grade deionized water were within the acceptable range for samples analyzed in 2023/2024.

Results of QA/QC review indicate confidence in the ability of QCC to collect and analyze samples that meet required accuracy and precision requirements. Internal performance audits will continue, and any identified deficiencies will be investigated to adjust sampling protocol. All employees will be kept up to date with sampling procedures and provided with any training and equipment necessary. QCC will continue to adhere to sampling practices identified in BC (2024) and promote best practices at all locations.

A variance analysis to identify outliers is performed prior to uploading analytical data into the database. Any results outside 95% confidence intervals (within 4 standard deviations) of previous results are investigated, and if needed BV's is contacted and the results are rerun, with a new report issued that include a review of BV's internal investigation.

BV laboratory performs internal QA/QC on all sample sets that are analyzed. This is included in the laboratory report provided by BV and reviewed by QCC. The internal QA/QC performed by BV meets laboratory standards. BV internal QA/QC involves the following procedures with every sample set analyzed:

- Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
- Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.
- Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Field Filtering

Since the initiation of field filtering and preserving dissolved metal samples, dissolved iron displays an increase in concentrations signifying the importance of field filtering. Mine water high in iron concentrations has the highest observed effect from the transition of laboratory filtering compared to field filtering. This is most noticeable at the Long Lake seeps and other mine discharge water like 1M2N and 5M2N. These areas were perceived to have less than detection limits in most samples for dissolved iron. Once field filtering was introduced dissolved iron resulted in elevated concentrations.

6.0 HYDROLOGY

6.1 NORTH WATER MANAGEMENT SYSTEM

6.1.1 *AUTHORIZED DISCHARGE RATES AT SETTLING POND #4 (SP4/WD) E207409*

Maximum authorized rates of discharge at SP4 are 0.32 m^3/s (instantaneous) and 0.08 m^3/s (annual average) or 2,522,880 m^3 over a period of 366 days. Maximum discharge rates were below 0.32 m^3/s throughout the entire monitoring period. This year the cumulative discharge was calculated as 2,647,026 m^3 lower compared to last year (2,968,704 m^3). This is equivalent to an annual average discharge rate of 0.08 m^3/s; higher than the authorized average rate of discharge by 4.9% (0.08 m^3/s or 2,522,880 m^3). Discharge occurred for 328 days with no discharge occurring for 38 days from July 12^{th} to August 18^{th}. During this time all water was being directed into WP to maintain a water cover and limit discharge during periods of low flow and dilution.

Appendix I, Table 26 displays discharge rates and Appendix II, Graph 73 displays cumulative and daily discharge rates compared to the cumulative annual authorized rate of discharge.

6.2 SOUTH WATER MANAGEMENT SYSTEM

6.2.1 *AUTHORIZED DISCHARGE RATES AT SETTLING POND #1 (SP1/ SPD) E218582*

Maximum authorized rates of discharge at SP1 are 0.46 m^3/s (instantaneous) and 0.10 m^3/s (annual average) or 3,153,600 m^3 over a period of 365 days. Both annual maximum flow (0.197 m^3/s) and annual average flow (0.032m^3/s) were well below the permitted rates with the cumulative flow rate recorded as 804,800 m^3 lower compared to last year (768, 726 m^3).

Discharge occurred for 316 days this reporting year with one day of no flow recorded.
Appendix I, Table 27, display discharge rates and Appendix II, Graph 72 displays cumulative and daily discharge rates compared to the cumulative annual authorized rate of discharge.

6.2.2 *South Water Management System Entrance into Long Lake (LLE) E292130*

Flow monitoring is required weekly at LLE, which discharges near the outlet of Long Lake. Discharge at LLE represents the combined flow from the South water management systems along with groundwater from the 4-South coal pad area and non-mine related surface water from the upstream wetland and drainage features. As such, this site provides cumulative flow data representing all discharges from the South water management system prior to entering Long Lake near the outlet.

Flow at LLE is well correlated with precipitation events and, historically, experiences a seasonal dry period during summer. This year there was no flow from July 1st through to September 27th, 2024. Appendix I, Table 20 displays flow rates and Appendix II, Graph 68 discharge versus precipitation at LLE.

6.2.3 *Seep Monitoring Sites, Long Lake Seep (LLS/ LLSM) – E292131*

Manual flow measurements are obtained weekly at the two sites LLS and LLSM. At LLS a staff gauge is used to obtain a level at the weir. LLSM is equipped with an H-Flume, flow meter and sensor providing more accurate monitoring of seep discharge. Staff gauge measurements are obtained weekly and compared to the meter levels and are adjusted accordingly. The flow information is available in Appendix I, Table 30 and Appendix II, Graph 67. The flow recorded at Long Lake Seep's indicates a dependency on mine pool (void) water levels. As mine pool levels decrease in late spring, flow at the seep decreases substantially and temporarily ceases during summer to fall.

Flow at the seeps started in January 2023 until June 2023 and then stopped flowing until January 2024. The period of no flow at the seeps has been extended this year, which may be a result of dewatering efforts averaging 8.00 L/s instead of 4.5 L/s. Overall, LLSM flowed for 149 out of 366 days and LLS, 189 out of 366 days.

6.3 **7-South Mining Operation Decant (7SSD) - E292069**

The maximum authorized discharge from settling pond 7SSD is 0.005m^3/s (5 L/s). However, discharge is dependent on assimilative capacity of Stream 1 (7S) and, therefore, dynamic in nature. To facilitate determination of the appropriate discharge level at 7SSD, a flow rating curve was developed for monitoring site 7S (Figure 4: Monitoring Site 7S Stage Discharge Curve) to allow instantaneous flow levels at 7S to be measured by reading the installed staff gauge.

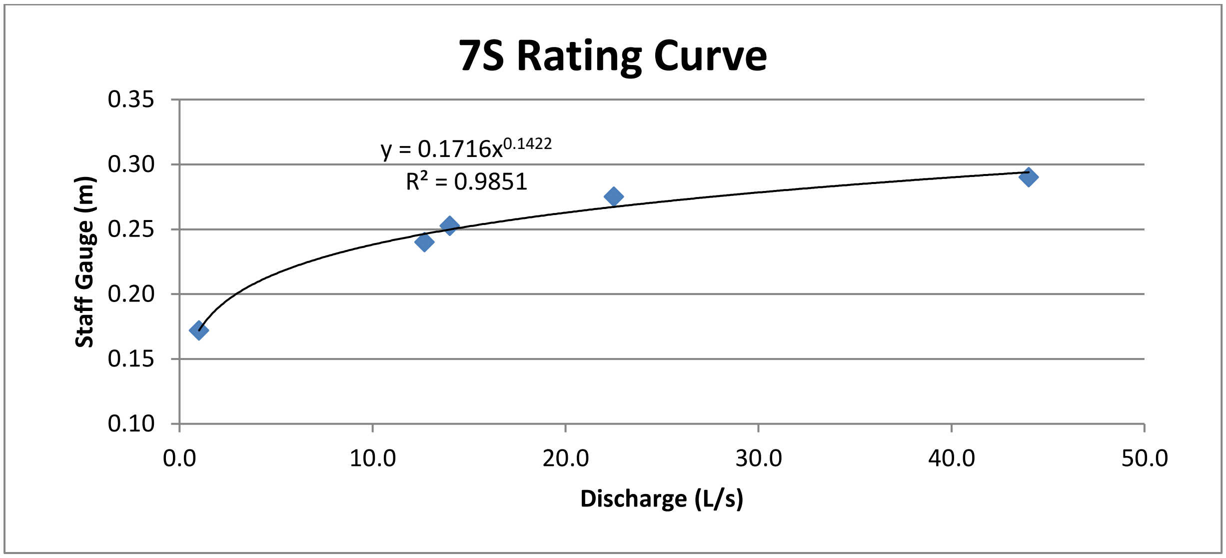

Figure 4: Monitoring Site 7S Stage Discharge Curve

Initially, an 8:1 dilution ratio was identified to maintain desirable water quality in the receiving environment, monitored at downstream site Stream 1 (7S). However, throughout the 7-South operational period, a lower dilution ratio has been shown to allow WQG's to be met in the receiving environment (site 7S). The dynamics of this system are still being monitored and measured; as a longer-term dataset is developed, the information will be evaluated to optimize discharge rates, while continuing to protect aquatic life.

In 2015, modifications were made to minimize discharge from 7SSD. The containment pond (7SCP) that delivers water into 7SSD was enlarged to accommodate more water. Additional pumps were placed at 7SSD and 7SCP to decrease 7SSD discharge and assist environmental personnel in water management. The revised system pumps water from 7SSD and 7SCP to 7SPS. The pump at 7SCP runs on an automated float system where water levels are kept below the overflow channel into 7SSD. During high precipitation events, a secondary pump can be activated to assist in pumping water to 7SPS. This pump can also be relocated to 7SSD, where any accumulated water can be diverted into 7SCP. This system has eliminated all discharge from 7SSD.
No discharge occurred during 2023-2024, Appendix I, Table 28 and Appendix II.

7.0 Receiving Environment Hydrology

Hydrometric stations in the receiving environment monitor hydrological conditions at key locations affected by QCC operations. Stage discharge curves for these stations have been developed using various methods (e.g., staff gauge, pressure transducer, manual measurements) and are periodically updated to ensure that the full range of flow is captured. The information is used to evaluate water quality and, in turn, determine assimilative capacity of the receiving environment with respect to mine related discharge. Moreover, flow is well correlated with lake flushing and turnover events, which directly influence concentrations of certain parameters (e.g., sulphate).

Flow data for WA is obtained from the Environment Canada monitoring station "Quinsam River at the Argonaut Bridge"; the data is currently subject to revision and has not been approved. The flow for WA is controlled upstream by the BC Hydro diversion dam to Gooseneck Lake; therefore, the volume of water diverted for hydro generating purposes influences flows at WA and WB. Accordingly, water levels at these two stations are not as closely correlated with precipitation as they are for other receiving environment stations.

Flow monitoring stations on the Iron River, Stream 1, and Long Lake system(s) are directly influenced by precipitation and the hydrographs typically show a pronounced peak following a precipitation event. This increase generally represents additional dilution and, therefore, assimilative capacity (for most parameters) in the receiving environment.

Appendix I, Table 30 and Appendix II, Graphs (65, 66, 69 to 71) display flows compared to water level measurements and precipitation for the receiving environment hydrometric stations (WA, WB, LLO, 7S and IR8).

8.0 WATER QUALITY: IN-SITU MINE RELEASES & WATER MANAGEMENT SYSTEMS

This section presents results of water quality monitoring program for the North, South, and 7-South e.g. (within) mine releases and water management systems for the major monitoring locations (e.g., settling ponds, discharges), permitted parameters and parameters of interest, to provide context for evaluating receiving environment water quality. The water chemistry data for 2023-2024 monitoring stations are presented throughout Appendix I of the Tables section.

Appendix I, Table 47 and 48 provide a five-year statistical summary (year over year, minimum, maximum, average, median, geometric mean, count, count < detection limit (DL), standard deviation, first quartile, third quartile) for 23 parameters measured in the settling ponds, applicable receiving environment monitoring stations, and ex-situ groundwater wells. Monitoring years 2018 to 2024 are presented, where data is available. Table 6: List of Monitoring Stations, Parameters and Statistics includes those parameters used in this evaluation.

For a summary of permit non-compliances please refer to Appendix I, Table 2 and Appendix VIII to review the Annual Status Form prepared for PE-7008.

Table 6: List of Monitoring Stations, Parameters and Statistics

Monitoring Stations		
WA	LLS	QU0516W
WD	LLSM	QU0813A
MW001D	MW002	QU0813B
MW001S	QU1009D	QU0821GD
MW006D	QU1009S	QU0821GS
MW006S	SPD	QU1010D
WC	LLE	QU1010S
MQL1	LLM1	QU1011D
MQLB	LLMB	QU1011S
NNL1	LLO	QU1105S
NNLB	WB	QU1109S

NNO	7SSD	7SQR
Parameters		
Arsenic (As-T)	Iron (Fe-T)	Sulphate (SO4-D)
Arsenic (As-D)	Iron (Fe-D)	Zinc (Zn-T)
Aluminum (Al-T)	Manganese (Mn-T)	Zinc (Zn-D)
Aluminum (Al-D)	Manganese (Mn-D)	Phosphorous (P-T)
Alkalinity (Alk-T)	Hardness (Hard-T)	Phosphorous (P-D)
Cadmium (Cd-T)	Nickel (Ni-T)	Nitrate & Nitrite combined (N-NO2,3)
Cadmium (Cd-D)	Nickel (Ni-D)	Ammonia Nitrate (N-NH3)
Copper (Cu-T)	Lead (Pb-T)	
Copper (Cu-D)	Lead (Pb-D)	
Statistics		
Count	Geometric Mean	1st Quartile
Minimum	Count <DL	Median
Maximum	Standard Deviation	3rd Quartile

8.1 North Water Monitoring Sites

8.1.1 *Settling Pond #4 (WD) EMS #E207409*

Results for the 2023/2024 monitoring program demonstrated that water quality for all permitted parameters were within permit limits listed in Table 7: Permit Limits Applied to Settling Pond #4. Appendix I, Tables 6 and Appendix II, Graphs 1 through 10 provide water quality results for Settling Pond #4. On November 1, 2019, authorization was received from ENV to reduce daily composite TSS sampling to weekly and incorporate dissolved metals monthly.

Table 7: Permit Limits Applied to Settling Pond #4

Parameters	Limit	Unit
Total Suspended Solids (daily composite)	25	mg/L
Total Suspended Solids (hourly composite)	35	mg/L
pH	6.0-8.5	mg/L
Ammonia (as N)	1.0	mg/L
Phosphorus (as P)	0.03	mg/L
Oil and Grease (total)	10	mg/L
Aluminum, dissolved	0.5	mg/L
Copper, dissolved	0.02	mg/L
Iron, dissolved	0.3	mg/L
Lead, dissolved	0.05	mg/L
Zinc, dissolved	0.1	mg/L
Rainbow Trout Bioassay (*Oncorhynchus mykiss*)	No mortalities at 100% effluent concentration after 96 hour	96LC50

8.1.2 General Parameters

pH

Field pH values displayed little variance, ranging between 7.15 to 8.13 and averaging 7.64. The water is pH neutral to alkaline. Appendix II, Graph 3 displays the pH values compared to permit limits.

Total Suspended Solids (TSS)

TSS is used as an indicator coupled with observations with respect to precipitation, dewatering system operations, and pond turbidity. Concentrations of TSS and metals will continue to refine best practices and minimize TSS concentrations in WD. TSS was below permit limits this monitoring period. Results ranged from <1.0 mg/L to 15 mg/L, averaging 2.63 mg/L.

Hardness and Dissolved Sulphate

Total hardness ranged from 185 mg/L to 343 mg/L (averaging 277 mg/L), while weekly sulphate ranged from 160 mg/L to 570 mg/L (averaging 372 mg/L). Sulphate concentrations were variable throughout the year with average peak concentrations occurring in January (460 mg/L) associated with pumping from underground. The lowest average concentrations were observed in September (165 mg/L) with 5M2N being the main contribution. Sulphate continues to be one of the primary parameters of interest from mine related discharges, as it is a common and traceable parameter associated with coal mining. Concentrations have been on a declining trend since June 2021. Refer to Appendix II, Graphs 1 and 2.

8.1.2.1 *Metals and Geochemical Source Terms*

Since commencement of underground mining in 1992, dissolved aluminum, copper, lead and zinc concentrations have remained below permit limits, with minor, irregular fluctuations noted. Iron is the only permitted metal that displays elevated concentrations related to mine void dewatering areas. This year dissolved metal parameters remained below permit limits. Refer to Table 8: Summary Statistics for Parameters of Interest at for summary statistics. Peak concentrations were observed in August for both arsenic (0.00417 mg/L) and iron (0.23 mg/L), related to extremely low water levels and no discharge from July 12th to August 18th from the Settling Pond.

Parameters of interest are displayed graphically in Appendix II, Graphs 4 through 10, respectively.

Table 8: Summary Statistics for Parameters of Interest at SP4

Stn.Code EMS. ID	Statistic	As-D	Al-D	Alk-T	Cd-D	Cu-D	Fe-D	Mn-D	Hard-T	Ni-D	Pb-D	SO4-D	Zn-D
	Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
SP4	Average	0.00175	0.00737	420	0.000005	0.000248	0.0484	0.0858	277	0.00099	0.0001	372	0.0025
E207409	Count	12	12	12	12	12	12	12	6	12	12	49	12
	Minimum	0.00096	<0.0030	360	<0.000010	<0.00020	0.0086	0.0083	185	<0.0010	<0.00020	160	<0.0050
	Maximum	0.00417	0.0366	570	<0.000010	0.00056	0.23	0.237	343	0.0033	<0.00020	570	<0.0050
	Geometric Mean	0.00163	0.00374	416	0.000005	0.0002	0.031	0.057	268	0.0008	0.0001	353	0.0025
	Count <DL	0	6	0	12	5	0	0	0	7	12	0	12
	Standard Deviation	0.00084	0.01056	63	0	0.000169	0.0611	0.0677	73	0.00083	0	105	0
	1st Quartile	0.00134	0.0015	377	0.000005	0.0001	0.0164	0.0235	213	0.0005	0.0001	340	0.0025
	Median	0.00154	0.0024	405	0.000005	0.000225	0.0342	0.0857	305	0.0005	0.0001	380	0.0025
	3rd Quartile	0.00181	0.00702	430	0.000005	0.000295	0.0399	0.1178	334	0.00125	0.0001	440	0.0025

8.1.3 *Culvert into Middle Quinsam Lake (WC) EMS #E207411*

Monitoring station WC represents the cumulative surface water discharge from WD prior to entering Middle Quinsam Lake. Concentrations for parameters of interest are typically slightly lower at WC than at WD, likely attributed to the attenuation that occurs along the WD-WC flow path that includes an expansive wetland. The exception observed is with dissolved sulphate concentrations during summer when discharge and dilution are lowest, and evapo-concentration is thought to occur. Dissolved sulphate ranged from 170 mg/L to 470 mg/L averaging 309 mg/L at WC. Refer to Table 9: Summary Statistics for Parameters of Interest WC, below. It is important to remember that after passing WC, the discharge water enters another large wetland before entering near the inlet of Middle Quinsam Lake approximately 350 m downstream of WC.

Table 9: Summary Statistics for Parameters of Interest WC

Stn.Code EMS. ID	Statistic	As-D	Al-D	Cd-D	Cu-D	Fe-D	Mn-D	Hard-T	Ni-D	Pb-D	SO4-D	Zn-D
	Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
WC	Average	0.00066	0.0086	0.0000058	0.000343	0.0174	0.0097	218	0.00070	0.000100	309	0.00250
E207411	Count	6	6	6	6	6	6	6	6	6	13	6
	Minimum	0.00056	0.0033	<0.000010	<0.00020	0.0095	0.0044	135	<0.0010	<0.00020	170	<0.0050
	Maximum	0.00093	0.0223	0.000010	0.00079	0.0261	0.0185	333	0.0017	<0.00020	470	<0.0050
	Geometric Mean	0.00065	0.0071	0.0000056	0.000285	0.0164	0.0085	206	0.00061	0.000100	294	0.00250
	Count <DL	0	0	5	1	0	0	0	5	6	0	6
	Standard Deviation	0.00015	0.0069	0.0000020	0.000239	0.0061	0.0056	78	0.00049	0.000000	95	0.00000
	1st Quartile	0.00056	0.005	5.00E-06	0.000242	0.0131	0.0053	155	0.0005	0.0001	210	0.0025
	Median	0.00058	0.0065	5.00E-06	0.000265	0.018	0.0086	210	0.0005	0.0001	340	0.0025
	3rd Quartile	0.0007	0.0082	5.00E-06	0.00037	0.0203	0.0127	265	0.0005	0.0001	360	0.0025

8.2 South Water Monitoring Sites

Water quality results for the monitoring locations in the South mine area are provided in Appendix I, Tables (10 - 21).

8.2.1 *Settling Pond #1 (SP1/SPD) EMS #E218582*

Settling Pond #1 represents the cumulative mine related discharge from the South water management system. Permit limits applied to SPD are shown in the table below. All parameters remained within permit limits at SPD during this reporting period.

Table 10: Permit Limits Applied to SPD, below represents the permit limits applied to the discharge waters at SPD. Refer to Appendix I, Table 11 for water chemistry results at SPD. Appendix II, Graphs (11 through 17) display the parameters of interest for SPD.

Table 10: Permit Limits Applied to SPD

Parameters	Limit	Unit
Total Suspended Solids (daily composite)	25	mg/L
Total Suspended Solids (hourly composite)	35	mg/L
pH	6.0-8.5	mg/L
Ammonia (as N)	1.0	mg/L
Phosphorus (as P)	0.03	mg/L
Oil and Grease (total)	10	mg/L
Aluminum, dissolved	0.5	mg/L
Copper, dissolved	0.02	mg/L
Iron, dissolved	0.5	mg/L
Lead, dissolved	0.05	mg/L
Zinc, dissolved	0.2	mg/L
Rainbow Trout Bioassay (*Oncorhynchus mykiss*)	mortalities at 100% effluent concentration after 96 hour	96LC50

8.2.1.1 *General Parameters*

pH

All pH readings remained neutral and within the permit limits. Appendix II, Graph 13 displays historical to present pH at SPD. Discharge water at SPD in the fall and winter can be described as having circumneutral pH (6.5 to 7.5) related to discharge conditions *i.e., pumping from 3-South pit*. Slightly lower conditions are observed in winter with more neutral to alkaline conditions in spring and summer. Results ranged from 6.6 to 8.33 and averaged 7.55.

Total Suspended Solids (TSS)

Composite samples for TSS analysis were collected on a weekly basis depending on discharge rates. Most results were less than the detection limits of 1.0 mg/L. Results ranged from <1.0 mg/L to 4.8 mg/L and averaged 1.36 mg/L.

Hardness and Dissolved Sulphate

Hardness concentrations ranged from 180 mg/L to 550 mg/L, averaging 395 mg/L. Increased concentrations are observed with lower flow rates. Sulphate concentrations in Settling Pond #1 have varied, depending on pumping rates from 3-South Pit and historically 5-South underground during high flow. Since the 5-South Mine pool water was redirected to 2-North mine at the end of 2017, the main contributor to sulphate is water pumped from 3-South pit.

Dissolved sulphate concentrations ranged from 93 mg/L to 580 mg/L and averaged 364 mg/L. Concentrations were highest from summer through fall (low dilution) and lowest during winter (higher flow and high dilution) as shown in Appendix II, Graph 12. Typically, there is low flow at SPD from summer to early fall as there is limited pumping from 3-South Pit.

8.2.1.2 *Dissolved Metals*

All permitted dissolved metals (Al-D, Cu-D, Fe-D Pb-D and Zn-D) concentrations at SPD remained below SPD permit limits. Appendix II, Graphs (14 through 17) display permitted parameters at SPD. Besides slightly elevated sulphate and occasionally elevated iron, the water quality at SPD has remained in good condition. It is expected this trend will continue in the future. Refer to Table 11: Summary Statistics for Parameters of Interest SPD.

Table 11: Summary Statistics for Parameters of Interest SPD

Stn.Code EMS. ID	Statistic	As-D	Al-D	Alk-T	Cd-D	Cu-D	Fe-D	Mn-D	Hard-T	Ni-D	Pb-D	SO4-D	Zn-D
	Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	Average	0.00153	0.01705	92.8	0.0000050	0.000381	0.0875	0.02682	395	0.00050	0.000100	364	0.00270
	Count	13	13	12	13	13	13	13	6	13	13	47	13
SPD	Minimum	0.00097	<0.0030	47	<0.000010	<0.00020	0.0203	<0.0010	180	<0.0010	<0.00020	93	<0.0050
E218582	Maximum	0.00250	0.0632	120	<0.000010	0.00138	0.250	0.0729	550	<0.0010	<0.00020	580	0.0051
	Geometric Mean	0.00149	0.00809	90.6	0.0000050	0.000281	0.0711	0.01724	368	0.00050	0.000100	334	0.00264
	Count <DL	0	3	0	13	3	0	1	0	13	13	0	12
	Standard Deviation	0.00040	0.01927	18.7	0.0000000	0.000354	0.0608	0.01991	148	0.00000	0.000000	138	0.00072
	1st Quartile	0.00125	0.0031	88.5	<0.000010	0.00021	0.0605	0.011	301	<0.0010	<0.00020	265	<0.0050
	Median	0.00161	0.0062	94	<0.000010	0.00024	0.0657	0.0311	418	<0.0010	<0.00020	350	<0.0050
	3rd Quartile	0.00172	0.0337	100.2	<0.000010	0.00039	0.116	0.0353	514	<0.0010	<0.00020	505	<0.0050

8.2.2 *Long Lake Entrance (LLE) EMS #E2922130*

Appendix I, Table 20 provides the full set of data collected at LLE and Appendix II, Graphs 18 through 21 display parameters of interest. LLE is the most downstream monitoring station in the South Water Management System and represents cumulative mine water discharge into Long Lake (excluding the seeps and groundwater inputs). This station is located at the outflow of a culvert discharging from a wetland, where discharge water flows through an approximately 50 m long channel before entering Long Lake. LLE is not defined as a receiving environment station but rather constitutes the upstream segment of a mixing zone defined as the initial dilution zone (IDZ) in the permit (7008). For observation purposes, results for LLE are compared to WQG's to assess overall water management system performance and influence on Long Lake.

Sulphate and iron are two main parameters of interest at LLE, both are frequently above WQGs as displayed in Appendix II, Graphs 18 to 20. Peak concentrations are observed in summer and early fall (during low flow periods). Dissolved sulphate ranged from 82 mg/L to 530 mg/L and averaged 227 mg/L. Annual average hardness concentration at LLE was 240 mg/L.

It should also be noted that during the summer low flow period LLE discharge may not be flowing into the lake before it is evaporated. This year there was no beaver activity blocking the culvert. Discharge at LLE is extremely low to zero during summer and early fall.

Both total (1.00 mg/L) and dissolved (0.35 mg/L) iron exceeded the WQG in monthly sampling events. Dissolved iron had one result above Acute-WQG (0.35mg/L) in June, (0.931 mg/L) when flow rates were low. Total iron peaked at 0.981 mg/L, nearing the Acute-WQG (1.00 mg/L) in October with increased flow rates.

Elevated iron is observed during low flow periods when anoxic conditions occur in the wetland and during high flow conditions causing the mixing of iron-rich bottom waters to be discharged at LLE. High flows may inhibit the typical redox reactions and iron precipitation processes that reduce dissolved iron to particulate iron.

8.2.3 *Long Lake Seeps (LLSM and LLS) EMS# E292131*

The bedrock groundwater seeps into Long Lake originate from the flooded mine voids of 2 and 3 South. These seeps play a crucial role in the overall water quality and quantity assessment for Long Lake. Specifically, we focus on two seep sites: LLS (the smaller seep) and LLSM (the larger seep). LLSM, due to its higher and more variable flows, is considered the primary seep.

The water chemistry of these seeps is intricately linked to groundwater levels in the 2 / 3 South mining area. Seasonal variations, driven by local precipitation and infiltration, lead to periodic "flushing" events of the underground oxidized mine walls.

At LLSM, a hydrometric station equipped with an H-Flume, a sonic depth sensor, and a flow meter is established. This station allows precise measurements of continuous flow rates and water levels.

LLSM exhibits a consistent pattern: high flows during winter and spring, followed by reduced or no flows in summer and early fall. Flow initiation occurs when the mine pool recharges with surface water infiltration. Conversely, flow ceases when the mine water level falls below approximately 303 meters above sea level (Masl), as measured at groundwater well MW004.

Flow at the seeps started in January 2023 until June 2023 and then stopped flowing until January 2024. The period of no flow at the seeps has been extended this year, which may be a result of dewatering efforts averaging 8.00 L/s instead of 4.5 L/s. Overall, LLSM flowed for 149 out of 366 days and LLS, 189 out of 366 days.

Dissolved Sulphate: All sampling events at the seeps exceeded the Chronic-WQG (302.6 mg/L). LLSM's dissolved sulphate ranged from 340 mg/L to 440 mg/L (average: 403 mg/L), while LLS showed concentrations between 450 mg/L and 590 mg/L (average: 495 mg/L), with lowest results observed in winter due to dilution.

Other parameters monitored include aluminum, arsenic, iron, and manganese. These metals exhibit seasonal trends, with peak concentrations corresponding to flow rates. Total aluminum exceeded the Acute-WQG (< 0.0180 mg/L) in 2 out of 7 events for LLS and 1 out of 6 events for LLSM. Total arsenic remained below the Chronic-WQG (0.005 mg/L), averaging 0.00037 mg/L for LLSM and 0.0015 mg/L for LLS. Peak concentrations of total iron exceeded the Acute-WQG (1.00 mg/L) in 1 out of 7 monthly samples at LLS (1.77 mg/L) and were well below the WQG at LLSM (0.435 mg/L). Dissolved iron results were above the Acute-WQG (0.35 mg/L) for 3 out of 7 monthly samples at LLS and 1 out of 6 samples at LLSM.

The observed increase in concentrations during spring is attributed to oxidation and leaching of the mine void walls. As the mine void recharges with groundwater after summer depletion, iron-rich sediment deposits form. Iron transitions from ferrous (Fe^{2+}) to ferric (Fe^{3+}) states, influenced by oxygen. Sample collection at these locations is challenging due to the sediment, necessitating careful flow path management during routine sampling.

Iron occurs naturally in water in soluble form as the ferrous iron (bivalent iron in dissolved form Fe2+ or Fe (OH)+) or complexed form like the ferric iron (trivalent iron: Fe3+ or precipitated as Fe (OH)3). The iron rich sediment deposited from the water makes sample collection extremely difficult at these locations and insurances are made so the flow path is not disturbed prior to sampling (as is routine everywhere). If any of the sediment is disturbed due to higher flow conditions or extremely low flow conditions the results will display elevated levels of iron. As a result, iron has a higher percentage of exceedances occurring here due to the flow path the water is taking over the iron rich sediment, sample collection and nature of the water.

Iron rich sediment will also draw arsenic out of water where it is adsorbed by iron. All the natural iron oxide minerals (magnetite, hematite and goethite) as well as an iron rich lateritic soil are effective in adsorbing arsenic from solution[3]. Iron nanoparticles, which bind easily to arsenic and have high surface areas, have been recognized and used as an effective means to sequester, or neutralize, the contaminant[4].

8.2.4 *Passive Treatment System (PTS)*

The PTS operated consistently throughout the year, with only minor power interruptions in December lasting four days. At the mine dewatering well (known as QU11-11 or INF), pumping rates varied between 3.70 L/s and 8.60 L/s, averaging 7.00 L/s.

To maintain the mine pool below the Seeps' elevation (300 Masl) pumping rates were adjusted seasonally. During wet seasons, rates exceeded 4.50 L/s, while in dry seasons, they dropped below 4.00 L/s. The water was then divided: approximately half flowed into the PTS at the BCR, while the other half entered the 2SI. The 2SI represents the combined discharge from both the PTS and the untreated 2/3 South mine water. 2SI allows monitoring of water quality and quantity before it enters the 2-South pit.

The flooded mine void water level underwent significant changes during the year. In April 2023, it measured 10.6 meters (301.6 meters above sea level, Masl), decreasing to 3.7 meters (294.7 Masl) by October 2023. However, by December, it rose to 14.3 meters (305.3 Masl). Refer to Figure 6, below.

When underground mine water levels exceeded 304 Masl, seepage occurred from the LLSM. Since the pumping rate increased in April 2022, seepage historically beginning in November, did not start until January for both 2023 and 2024. Increased dewatering efforts successfully lowered the mine void water elevations for an extended period. Seepage ceases at a mine water elevation of 303 Masl and resumes at 304 Masl, as measured at groundwater well MW004. For further details, refer to Figure 6 and Table 12 below.

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[3] Sonia Aredes, Bern Klein, Marek Pawlik,
The removal of arsenic from water using natural iron oxide minerals, Journal of Cleaner Production, Volumes 29–30, 2012, Pages 208-213, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2012.01.029.
(https://www.sciencedirect.com/science/article/pii/S0959652612000492)
[4] W. Zhang et al. Arsenic removal from contaminated water by natural iron ores Miner. Eng.
(2004)

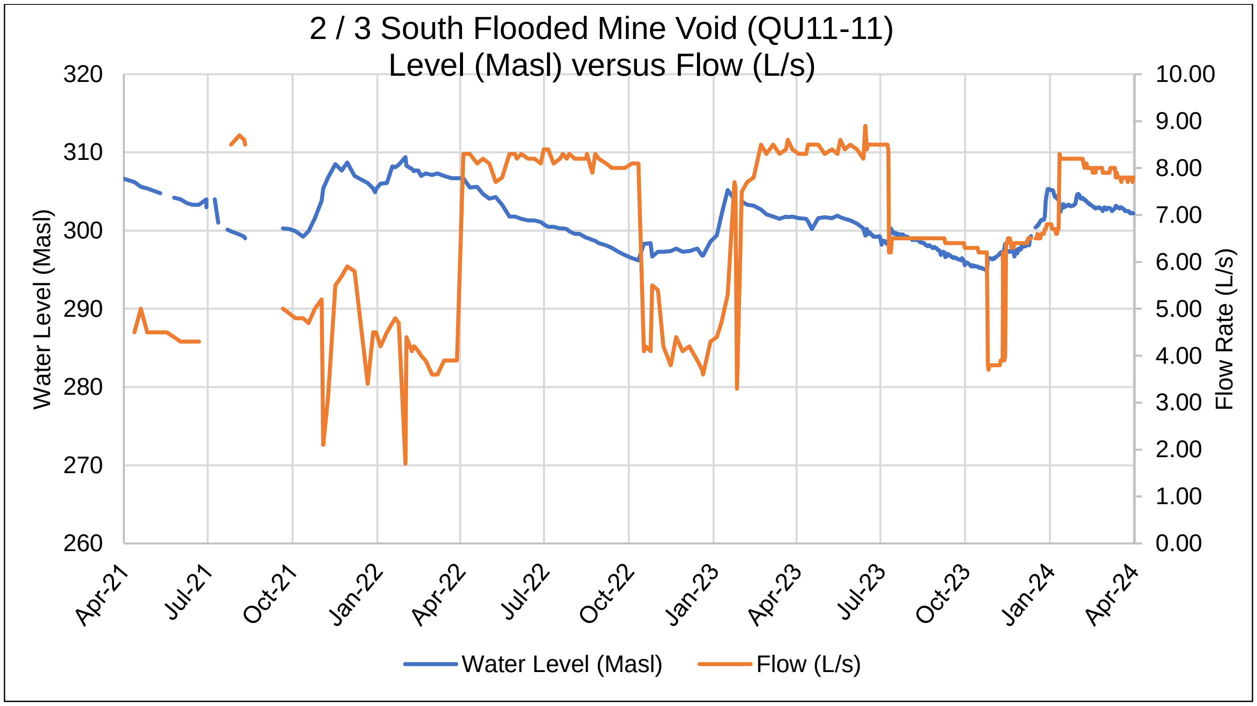

Figure 5: 2/ 3 South Flooded Mine Void (QU11-11 versus Level and Flow

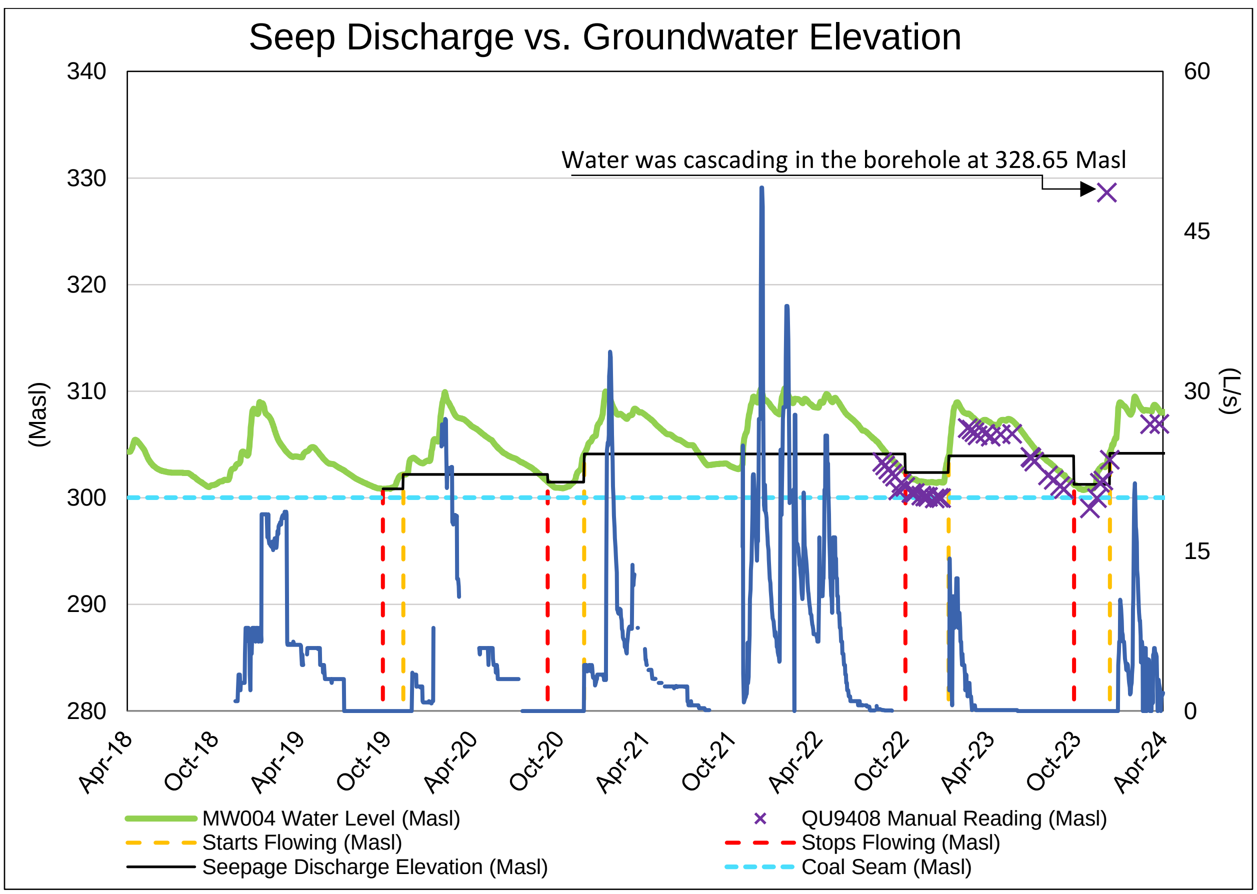

Figure 6: Long Lake Seep Discharge versus Groundwater Elevation (Masl)

Table 12: Seep Discharge versus Mine Water Elevation

Date	MW00-4 Elevation (Masl)	H-Flume	Long Lake Seep Middle (LLSM)	Long Lake Seep (LLS)	Above the Coal Seam
06-May-24		No Flow	Flow	Flow	
02-Apr-24	308.061	Flow	Flow	Flow	8.061
04-Mar-24	308.180	Flow	Flow	Flow	8.180
05-Feb-24	309.183	Flow	Flow	Flow	9.183
02-Jan-2024	308.907	Flow	Flow	Flow	8.907
11-Dec-2023	304.183	No Flow	Flow	Flow	4.183
06-Sep-2023	**302.033**	No Flow	No Flow	No Flow	2.033
09-Aug-2023	303.166	No Flow	No Flow	Flow	3.166
08-Jun-2023	306.206	No Flow	Flow	Flow	6.206
05-Jan-2023	304.080	Flow	Flow	Flow	4.080
04-Jan-2023	303.938	No Flow	Flow	Flow	3.938
04-Oct-2022	**302.358**	No Flow	No Flow	No Flow	2.358
06-Sep-2022	303.596	No Flow	Flow	Flow	3.596
24-Oct-2021	303.124	Flow	Flow	Flow	3.124
18-Oct-2021	302.753	No Flow	No Flow	Flow	2.753
29-Sep-2021	302.950	No Flow	No Flow	Flow	2.950
16-Aug-2021	303.080	No Flow	Flow	Flow	3.080
23-Nov-2020	304.115	Flow	Flow	Flow	4.115
09-Nov-2020	302.385	No Flow	No Flow	Flow	2.385
08-Sep-2020	**301.455**	No Flow	No Flow	No Flow	1.455
08-Jul-2020	303.458	Flow	Flow	Flow	3.458
25-Nov-2019	303.719	Flow	Flow	Flow	3.719
06-Nov-2019	302.176	No Flow	Flow	Flow	2.176
21-Oct-2019	**301.213**	No Flow	No Flow	No Flow	1.213
01-Oct-2019	**300.861**	No Flow	No Flow	No Flow	0.861
24-Sep-2019	**300.825**	No Flow	No Flow	No Flow	0.825
12-Aug-2019	301.478	No Flow	No Flow	Flow	1.478
16-Jul-2019	302.183	No Flow	Flow	Flow	2.183
11-Jun-2019	303.158	Flow	Flow	Flow	3.158
17-Dec-2018	305.884	Flow	Flow	Flow	5.884
06-Nov-2018	302.536	No Flow	Flow	Flow	2.536

**Coal seam at 300 MASL
There is delay between flow at LLSM and flow at the H-Flume

4.01	> 4.0m above the coal seam
1.90	< 2.0m above the coal seam

Annual average concentrations of dissolved sulphate have been entering the system from the flooded mine void, measured at the influent (INF), resulting in 617 mg/L, and leaving the system at the Sulphide Polishing Cell (SPCEFF) resulting in 437 mg/L with final discharge at measured at SPD averaging 364 mg/L. Refer to
Figure 7: Annual Average Sulphate in the South Mine Area (mg/**L)**.

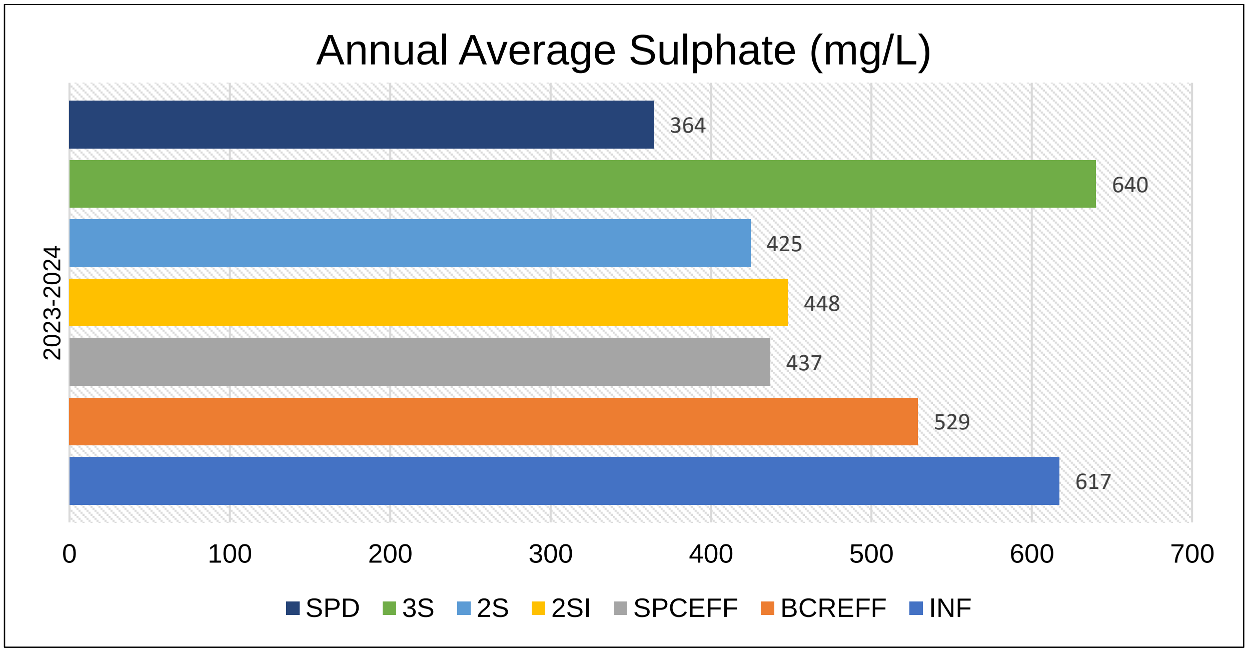

Figure 7: Annual Average Sulphate in the South Mine Area (mg/L)

Figure 8: Annual Sulphate Reduction through the Water Management System, below displays annual average sulphate reductions through the PTS including the sites 2SI and SPD. As displayed the greatest reduction is observed between INF to SPD, resulting in 253 mg/L. This indicates that the water management system is working at reducing the concentrations of sulphate pumped from the mine pool into the treatment system and discharged at SPD.

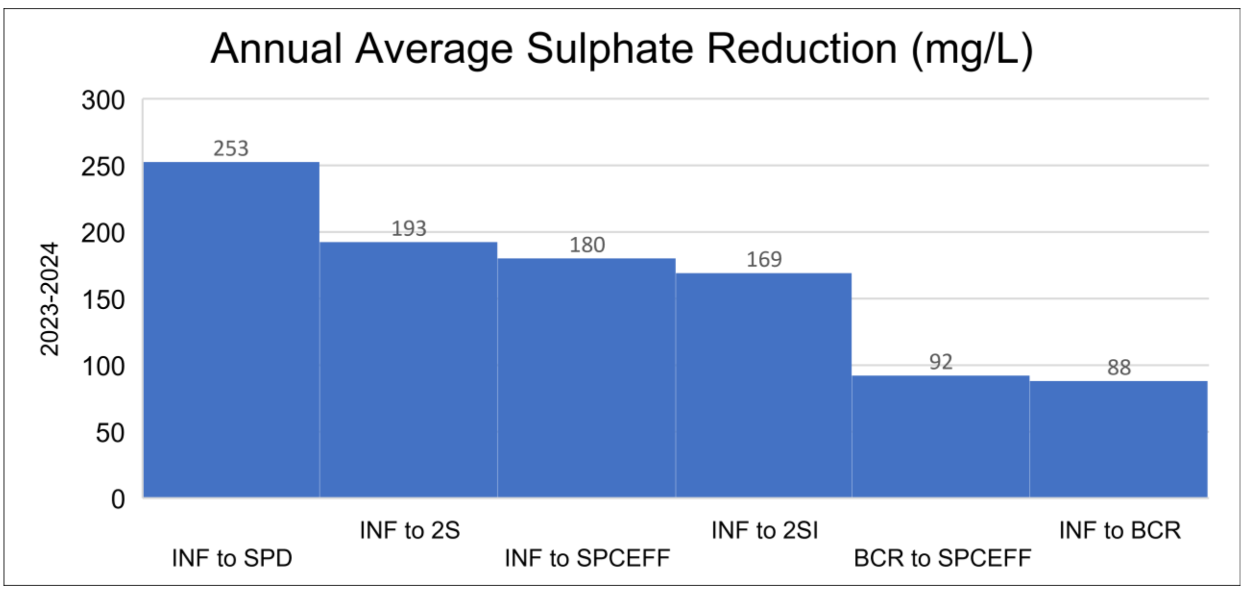

Figure 8: Annual Sulphate Reduction through the Water Management System

The PTS displays the greatest reduction in sulphate between INF and SPCEFF resulting in 180 mg/L. Between the Influent (INF) and Biochemical Reactor cell (BCR) mg/L reduction was low resulting in 88 mg/L. Warmer ambient temperatures normally increase microbial metabolic activity within the BCR and SPC during summer and early fall. The low average reduction rate between INF and BCR in summer could indicate that the substrate requires replacement, or the retention time is not long enough in the BCR. In winter, cooler ambient temperatures decreased microbial activities and sulphate reduction rates were lower. Overall, an annual average sulphate reduction of 253 mg/L was attained between INF and SPD. The original reduction goal for the PTS was to reduce sulphate concentrations to 300 mg/L. This was almost achieved overall between INF and SPD (annual average of 357 mg/L and reduction of 202 mg/L). Table 13 displays a summary for 2023-2024.

Table 13: Summary of Sulphate Concentrations and Reduction Rates

2023-2024	INF	BCREFF	SPCEFF	2SI	2S	3S	SPD
Average	617	529	437	448	425	640	364
Count	51	51	51	50	11	11	47
Minimum	500	440	86	55	220	510	93
Maximum	730	650	620	650	580	800	580
	INF to BCREFF	**BCREFF to SPCEFF**	**INF to SPCEFF**	**INF to 2SI**	**INF to 2S**	**INF to 3S**	**INF to SPD**
Sulphate reduction	88	92	180	169	193	-23	253

The PTS is effective at maintaining water cover over the PAG-CCR in the 2-South pit and reducing discharge at the Seep into Long Lake during low flow periods. This is accomplished by decreasing the elevation of the mine pool below the elevation of the seep (303 MASL). The period of “no flow” at the Middle Seep into Long Lake (LLSM) has been observed to be extended by dewatering the flooded mine void.

Further monitoring of the PTS continues and includes the 2-3 South systems and groundwater well MW004. A relationship between MW004, Seep flow and the elevation of the mine pool at the INF location continues to be developed with observations noted every quarter.

8.3 7-SOUTH WATER MONITORING SITES

The 7-South water management system is comprised of several structures (Section 2.1.3) to manage local water in and around the disturbed area, with the most substantial structure being the 7-South settling pond (7SSD). This structure represents the authorized discharge location for 7-South operations regulated under PE-7008. Table 14, outlines the applicable permit limits at 7SSD for each controlled parameter.

Table 14: Permit Limits Applied to 7SSD EMS #E292069

Parameters	Limit	Unit
Total Suspended Solids (daily composite)	25	mg/L
Total Suspended Solids (hourly composite)	35	mg/L
pH	6.0-8.0	mg/L
Sulphate	500	mg/L
Aluminum dissolved	0.1	mg/L
Cadmium dissolved	0.000045	mg/L
Copper dissolved	0.014	mg/L
Iron dissolved	0.35	mg/L
Selenium dissolved	0.016	mg/L
Rainbow Trout Bioassay (*Oncorhynchus mykiss*)	No mortalities at 100% effluent concentration after 96 hour	-

8.3.1 *7-South Settling Pond (7SSD) EMS #E292069 and Steam 1, (7S) EMS #E292109*

There was no discharge from this location in 2023-2024. Complete water chemistry of the supernatant can be found in Appendix I, Table 23.

Water quality has improved from previous years, resultant of adopted water management practices that are effective at reducing impacts downstream at 7S. These methods include pumping all mine related water from 7-South into 5-South flooded mine void, aiding in flooding the 5-South Mine for closure. In Appendix I, Table 24 provides water quality at 7S and Appendix II, Graph 70 provides flow versus staff gauge measurements at Stream 1, 7S.

8.4 Bioassays

An LC50 (median lethal concentration) is the concentration of material (in this case, effluent) in water that is estimated to be lethal to 50% of the test organisms. The LC_{50} and its 95% confidence limits are usually derived by statistical analysis of percent mortalities in several test concentrations, after a fixed period of exposure. The duration of exposure must be specified (e.g., 96-h LC50).

PE-7008 indicates that rainbow trout (*Oncorhynchus mykiss*) LC_{50} bioassays are required once per year (fall flush) at Settling Pond #1, EMS# E218582 and at Settling Pond #4, EMS# E207409. The bioassays are performed using 100% (non-diluted) discharge water to assess the potential survival of rainbow trout over a period of 96-hours. A successful test sees no mortalities throughout the 96-hour period. Discharge was collected from Settling Pond #1 and Settling Pond #4 on November 6, 2023, respectively.

If discharged, section permit requires a 96-hour LC_{50} test on rainbow trout to be completed using 7SSD EMS# E292069 effluent and, concurrently, a 7-day *Ceriodaphnia dubia* test from water obtained from 7S, EMS# E292109. This is required twice per year; once during the spring freshet and once during the fall flush, when discharging is occurring from 7SSD. The discharge from 7SSD pond did not occur and this resulted in omitting the spring freshet and fall flush samples.

All rainbow trout bioassays had 100% survival (Appendix III). This indicated that mine related discharges at Settling Pond #1 and Settling Pond #4, are compliant, and not acutely toxicity.

9.0 WATER QUALITY IN THE RECEIVING ENVIRONMENT

Preamble – Water Hardness

In this report, water quality in the receiving environment is compared to British Columbia's (B.C.) Water Quality Guidelines for freshwater aquatic life (WQG-FWAL). Specifically, focusing on acute and chronic guidelines.

For hardness-related parameters (*i.e.,* dissolved sulphate), a conservative approach is applied based on background hardness (~30 mg/L) at lake, river and stream receiving environment stations.

Calculated guidelines for total aluminum (Al-T) and dissolved copper (Cu-D) were derived using ambient water quality data from the receiving environment sites.

The B.C. WQG equation for Al-T in freshwater ecosystems is:

$$\text{B.C. WQG } (\mu g/L) = \frac{\exp(0.645\ln(DOC)+2.255\ln(hardness)+1.995pH-0.284\ln(hardness)\cdot pH-9.898)}{3}$$

For Al-T, the chronic-WQG's are derived from individual results for parameters (Al-T, pH, dissolved organic carbon and hardness) rather than averages over a specific period (5 weeks). These guidelines aim to protect aquatic organisms from chronic exposure to elevated aluminum levels. Refer to Appendix II, Graph 54.

For Cu-D, the calculated site-specific acute and chronic WQGs are based on parameters (hardness, pH, temperature, and dissolved organic carbon), from individual sampling events. The individual Cu-D results are uploaded to the British Columbia Copper Biotic Ligand Model (BML) database. The BLM predicts the toxicity of Cu-D under specific water chemistry conditions.

As a result, the acute short-term and chronic long-term WQG's vary between sites. Appendix II, Graphs 49 to 55 display the acute and chronic Aquatic Life – WQG's derived for copper compared to individual results from receiving environment sites during spring, summer, and fall. Refer to Appendix II, Graphs 49 to 53.

Guidelines and Objectives: Receiving environment water quality is compared to the British Columbia Ambient WQG for Protection of Aquatic Life for most parameters. The exceptions are hypolimnetic DO (using a WQO based on a site-specific conditions), total cobalt and total lead (using more recently established site-specific Water Quality Objectives (WQO)[5]), and total phosphorus in streams (using the Vancouver Island objective[6]). Table 15 lists the WQG, WQO and VIO used to screen receiving water quality. Water quality at locations outside of the Middle

[5] Campbell River Area Middle Quinsam Lake Sub-Basin Water Quality Assessment and Objectives. Ministry of Environment. 1989

[6] Guidance Document for Phosphorous Management in Vancouver Island Streams. Ministry of Environment. 2012

Quinsam Lake Sub-basin, such as the No Name Lake, Iron River, and 7-South (7SQR / IRQR), Lower Quinsam lake are compared exclusively to the WQG.

Table 15: Water Quality Guidelines and Objectives Applied to Receiving Environment Stations

Parameter	Lakes (mg/L)		Streams (mg/L)	
	Maximum	5 in 30-day Avg	Maximum	5 in 30-day Avg
Phosphorus - total	0.007 summer avg - Long Lake		0.01	0.005**
	0.006 summer avg - Middle Quinsam Lake		(May-September)	
Turbidity	n/a	n/a	5.0 NTU	1.0 NTU
Non-filterable residue or TSS	25	5	n/a	n/a
Hypolimnetic DO	3 mg/L minimum during June-August		n/a	n/a
pH	6.5 – 9	n/a	6.5 – 9	n/a
Aluminum (total)***	variable	variable	variable	variable
Arsenic (total)	n/a	0.005	n/a	0.005
Cadmium (dissolved)*	0.00017	0.000088	0.00017	0.000088
Cobalt (total)	0.05	0.004	0.05	0.004
Copper (dissolved)***	variable	variable	variable	variable
Iron (total)	1.0	n/a	1.0	n/a
Iron (dissolved)	0.35	n/a	0.35	n/a
Lead (total)	0.005	0.003	0.005	0.003
Manganese (total)	0.8	0.7	0.8	0.7
Mercury (total)	0.0001	n/a	0.0001	n/a
Nickel (total)	0.025	n/a	0.025	n/a
Silver (total)	0.0001	n/a	0.0001	n/a
Zinc (total)	0.03	n/a	0.03	n/a
Sulphate dissolved*	n/a	128	n/a	128

*Any hardness dependent guideline uses background hardness (30 mg/L)
** Average based on monthly samples from May to September
***Using WQG for total aluminum (chronic), and dissolved copper (acute and chronic)

9.1 Lakes

The monitoring program for the Middle Quinsam Lake Sub-basin employed a 5 in 30 sampling approach at No Name Lake (NNL), Long Lake (LLM), Middle Quinsam Lake (MQL), and Lower Quinsam Lake (LQL). There are four depths monitored at each lake:

- 1 metre below surface (1m)
- 4 metres below surface (4m)
- 9 metres below surface (9m)
- 1 metre above bottom (1mb)

Monitoring occurred during three separate periods:

- Spring – April / May 2023 at NNL, LLM, MQL and LQL
- Summer – July / August 2023 at LLM and MQL
- Fall – October 2023 at LLM and MQL

A summary table is provided in Appendix I, Table 3, 4 and Tables 38 - 43 display the depth profiles and water chemistry results compared to guidelines with Table 47 and 48 providing a statistical summary for parameters of interest. Appendix II, Graphs (26 through 51) illustrate parameter trends at each lake.

9.1.1 *Seasonal Trends*

Spring and fall sampling events are timed to cover lake turnover when water circulates freely in the water column and nutrients become more available for phytoplankton growth (Wetzel 2001)[7]. Water is most dense at 4ºC, and during winter, the surface water (epilimnion) is typically colder than 4ºC and the deeper water (hypolimnion) is at about 4ºC (displaying inverse stratification). Spring turnover occurs when the surface water warms to 4ºC and begins to mix with the deeper water. The lake circulates freely throughout the water column for several days (Wetzel 2001). Through the spring and summer, surface temperatures increase, establishing a thermocline (region of rapid temperature change), with warmer water above and cooler water below. Temperatures cool in late summer, and eventually the thermal stratification breaks down, leading to fall overturn and to mixing of the water column. As surface waters continue to cool, a colder layer overlies the dense bottom water (4ºC), and inverse stratification persists from late fall to spring. During periods with distinct stratification, it has been observed that water chemistry often displays variable concentrations throughout the water column. During overturn, nutrients associated with decomposition of organic matter that has sunk to the bottom are brought into surface waters, where they are available for phytoplankton growth. The timing and duration of spring and fall turnover depend on the size and depth of the lake.

[7]Wetzel, R.G. 2001. Limnology, Third Edition. Academic Press, San Diego CA.

9.1.1.1 *Spring*

The spring sampling program is scheduled to capture the lake turnover that typically occurs in conjunction with warmer temperatures, snowmelt, and increased precipitation. Spring sampling occurred from April 4th through May 2nd. The sampling regime commenced during the spring turnover event with warming ambient temperatures of greater than 4 ºC. From March 1st through to May 2nd, 196 mm of precipitation was received at the mine site comparable to last year during the same period, where 220 mm of precipitation was received.

No Name Lake (NNL), Long Lake (LLM), Middle Quinsam Lake (MQL) and Lower Quinsam Lake (LQL) are monitored during Spring. Appendix 1, Table 3 and 4 provides a summary of those parameters observed above WQG's for spring monitoring. Only Cu-D was elevated above the WQG's during spring.

Average results for pH ranged from 6.54 to 7.05 at NNL for all depths sampled. Average pH was above the chronic minimum WQG of 6.5, an increase from historical results. Refer to Appendix II, Graphs 27, 33, 34, 37, 38, and 46 for depth profiling results of conductivity compared to pH and temperature compared to conductivity for spring.

Cu-D was elevated above the Acute WQG (0.0002 mg/L) in No Name at 1 meter from bottom on one sampling event, resulting in 0.00035 mg/L. Average Cu-D results were observed above the chronic WQG's in all lakes. Individual results above the Chronic-WQG's in all four lakes, ranged from 0.00029 mg/L to 0.00101 mg/L. Averaged results above Chronic-WQG's in all lake's, ranged from 0.00036 mg/L to 0.000712 mg/L. There were 68 out of 86 lake samples above the Chronic-WQG's. Lower Quinsam Lake displayed the highest average concentrations at 4m (0.000528 mg/L) compared to Chronic WQG (0.0005 mg/L). Refer to Appendix 1, Table 4 and Appendix II, Graph 49.

Noteworthy observations resulting from the lake monitoring program include:

- Average dissolved sulphate concentrations measured below the chronic WQG (128 mg/L) in all lakes. Refer to Appendix II, Graphs 28, 29, 35 and 44.
- Average dissolved sulphate concentrations resulted in 80 mg/L at 9 m and 77 mg/L at 1 metre from bottom (1MB), in Long Lake
- Sulphate in MQL remained well below average guideline levels throughout the lake, averaging 18.4 mg/L to 18.8 mg/L at 1m, 4m, 9m and 1MB.
- NNL did not display acidic conditions with an average pH above the minimum guideline of 6.5 at all depths.
- Dissolved copper was elevated in all lakes, possibly related to spring turnover.

9.1.1.2 *Summer*

The summer sampling program is scheduled to capture the period of low flow and lake stratification. The summer program spanned July 18th through August 15th. The summer program represents the lake's seasonal thermal stratification and a time when deeper lakes naturally develop anoxia in deeper waters. Results from this sampling period represent low dilution conditions when the lakes display minimum assimilative capacity and mine related surface discharges and groundwater infiltration have the greatest influence.

From June 1st through August 31st, there were high ambient temperatures and lower precipitation levels of accumulated precipitation (44.70 mm). As a result of drought conditions, there was limited mine related surface discharge. Authorized discharge locations (WD and SPD) had limited flow through July and August. Long Lake Seep's (LLS and LLSM) were also dry for summer months. Both the Lakes (LL and MQL) inflow rates remained low with Long Lake (LL) having zero inflow from July through September.

The Upper Quinsam River flows into MQL. These flow from the Quinsam River have been regulated since 1957 when a diversion dam upstream from Middle Quinsam Lake diverted roughly 72% of the flow of the Quinsam River into the Campbell River system via Gooseneck Lake. Middle Quinsam and Long Lake have rapid flushing rates. The estimated mean residence time for Middle Quinsam Lake water is approximately 17 days; for Long Lake it is approximately 34 days[8], during high flow.

The summer lake monitoring program includes LLM and MQL. Cu-D was the only parameter above Chronic-WQG's. Individual results for Cu-D were observed in lowest concentrations at 1 metre from bottom depth in Long Lake (0.00024 mg/L) and highest concentrations at 1 metre from bottom depth in Middle Quinsam Lake (0.00089 mg/L). Refer to Appendix I, Table 4, Results above the Chronic WQG's for the site wide summary and Appendix II, Graph 50 for Lake's Summer, Cu-D results and averages compared to WQG's.

Hypolimnetic dissolved oxygen (3 mg/L) was outside of the range for the WQO, in Long Lake. Anoxic conditions occurred four out of five weeks in summer at depths between 14-to-20-meters where results fell below 3 mg/L.

Refer to Appendix II, Graphs 33, 34, 37 and 38 for depth profiling results from LLM and MQL for conductivity compared to pH and temperature compared to conductivity for summer.

Temperature gradients were observed in both lakes as stratification occurred. In MQL, the epilimnion occurred from depths between 1-to-5-meters. The metalimnion occurred at depths between 6-to-9-meters and hypolimnion occurred at depths between 10-to-13-meters. In LLM, the epilimnion occurred from depths between 1-to-4-meters. The metalimnion occurred at depths between 5-to-8-meters and hypolimnion occurred at depths between 9-to-20-meters.

In LLM pH ranged between 6.5 and 8.0 and conductivity results increased in the metalimnion to hypolimnion at depths between 6-to-20-meters.

[8] Ambient Water Quality Assessment and Objectives For Middle Quinsam Lake Sub-Basin Campbell River Area. MOE. 1989

In MQL, pH results were above 9 and peaking at 9.53, observed in the metalimnion at depths between 6-to-9-meters. Water chemistry did not indicate elevated alkalinity or hardness concentrations. Both parameters were averaging around 30 mg/L for depths 1m, 4m, 9m and 1 metre from bottom (1MB), in MQL. The YSI-meter used to analyze water quality was recalibrated to confirm accurate results for pH.

Noteworthy observations resulting from the summer lake monitoring program include:

- Average sulphate concentrations were measured below the chronic WQG (128 mg/L) in both lakes.
- Average sulphate resulted in 45 mg/L at 1m, 46 mg/L at 4m, 74 mg/L at 9m and 91 mg/L at 1MB, in Long Lake
- Average sulphate results for Middle Quinsam Lake were 10 mg/L at 1 m and 4m, with 9m, and 1MB averaging 17 mg/L and 16 mg/L.
- Hypolimnetic dissolved oxygen (minimum 3 mg/L during June, July, and August) fell below 3 mg/L in the hypolimnion zone (14-to-20-meters depths).
- Conductivity in Long Lake increases between the epilimnion (surface) to metalimnion (middle).
- Middle Quinsam Lake pH was above 9 on individual results in the metalimnion.

9.1.1.3 *Fall*

The fall sampling program is scheduled to capture the period of elevated precipitation following the summer dry season, representing fall overturn and a ‘fall flushing’ event that is correlated with elevated surface water metal concentrations resulting from localized weathering and mobilization. The lakes turn over in the fall as the water temperatures decrease and high inflows return. In 2023, the fall monitoring program spanned October 4th through October 30th during a time of light precipitation (202 mm from September 1st through October 30th).

During the fall turn over the deeper portions (hypolimnion) have normally been replenished with dissolved oxygen as the lake turns over. This is evident in MQL as it is a long, shallow lake (12m to 15m) with inputs controlled by the upstream dam on the Quinsam River.

Long Lake is deeper (19m to 22m) and shorter in length with inputs received from No Name Lake and groundwater inputs including Long Lake seeps and mine related discharge at the outlet (LLE). In LLM turnover was slow as temperature gradients were differing 9 degrees Celsius from surface (epilimnion), middle (metalimnion), to bottom (hypolimnion) depths during the first week compared to the last week with a 1 Degree Celsius difference between surface and bottom depths, refer to Appendix II, Graph 34.

When there is limited inflow at the inlet (from No Name Lake) and ambient temperatures remain warm, lake stratification is extended in LL compared to MQL. In LL, turnover occurs late in the fall, with stratification remaining into November and dissolved oxygen levels depleted (<3 mg/L) in the hypolimnion, referred to as anoxic conditions. Anoxic conditions at depth causes manganese concentrations to increase at the sediment / water interface. Anoxic conditions were observed during the fall sampling events in the hypolimnion zone (16 m to 20 m), but this year manganese was not elevated at the 1 metre from bottom depth (1MB). Concentrations were higher than other depths (1, 4 and 9 meters) but none measuring above acute-WQG's. There were 2 out of 5 individual results measured above the Chronic-WQG's of 0.737 mg/L but the 5 in 30 average remained below this WQG.

In MQL, turnover was apparent, distinguished by a less pronounced temperature gradient of less than 1-degree Celsius epilimnion to hypolimnion during the last 4 weeks, with week 5 displaying the lowest temperatures. Refer to Appendix II, Graph 37.

Dissolved sulphate concentrations in both lakes remained below the chronic WQG (128 mg/L). Refer to Graph 29 and 35, showing both lakes (LL and MQL), 5 in 30 average dissolved sulphate over time. For Long Lake, dissolved sulphate concentrations have been declining over time because of dewatering efforts creating less loading from the mine contact groundwater (Long Lake Seeps). Concentrations of sulphate are much higher in LL compared to MQL ranging from 73 mg/L to 93 mg/L. The 9m metre depth (93.25 mg/L) displayed higher concentrations than the 1MB depth (87.25 mg/L), possibly due to the influence of groundwater infiltration within that elevation or temperature gradients causing sulphate to sink from surface and stratify within that zone.

Dissolved sulphate in MQL remained below 10 mg/L throughout the lake during fall. This was a result of limited discharge during this period due to dry conditions on site and the 1 Mains 2 North pump not operating until late November. This is the lowest average dissolved sulphate recorded throughout the lake, since the 5 in 30 monitoring began (2013).

Noteworthy observations resulting from the fall monitoring program include the following:

- Average dissolved sulphate in MQL was well below the chronic WQG (128 mg/L) at all depths resulting in 7.85 mg/L to 9.95 mg/L from surface to 1 metre from bottom during fall.
- Average dissolved sulphate in LL was below the chronic WQG (128 mg/L) at all depths averaging 72 to 73 mg/L at 1 meter and 4 meters, 93 mg/L at 9 meters and 87 mg/L at 1MB depths.
- The fall turnover was apparent in MQL, observed through temperatures remaining consistent per depth.
- Stratification was still apparent during the first four weeks in LLM, again observed through temperature gradients. Turnover was starting to occur during week five.
- Dissolved oxygen (DO) was below 3 mg/L in Long Lake in the hypolimnion zone resulting in anoxic conditions at depth, but Mn-T was not observed to be elevated above WQG's.
- Low DO is correlated with lake stratification depleting DO where manganese is released at the sediment / water interface.
- LL displays elevated conductivity, increasing with depth ranging from 195 µs/cm to 494 µs/cm, increases are observed between 6-meter and 7-meter depths.
- MQL does not have elevated conductivity like LL ranging from 76 µs/cm to 128 µs/cm, throughout the five weeks of sampling.

- The Long Lake Seeps stopped flowing by the end of June with no flow in Q3 until the last week of December only from the smaller seep (LLS), indicating LL had no surface influence from the seeps during this period.
- LLE displayed low flow rates during October while lake sampling was occurring.

9.1.2 *Conclusion*

Water quality in the lakes (NNL, LL, MQL, and LQL) is meeting WQG's apart from dissolved copper, which exceeds upstream and downstream of mine influence.

Dissolved sulphate, one of the main parameters of interest (POI) remained below the WQG of 128 mg/L in all lakes at all depths sampled (1m, 4m, 9m and 1MB).

In spring, average dissolved sulphate results at NNL were < 3 mg/L and LQL < 15 mg/L at all depths sampled. Average dissolved sulphate throughout spring, summer and fall in Long Lake were lower on surface at depths 1m and 4m (<70 mg/L) and moderately elevated at depth (9m and 1MB) but remaining < 100 mg/L, with MQL remaining <20 mg/L in all sampling events. Appendix II, Graphs 28, 29, 35 and 44 display average dissolved sulphate in the Lakes.

Anoxic conditions represented by low DO levels in deep waters are common during summer and early fall in Long Lake and (historically) Lower Quinsam Lake. Anoxic conditions result in mobilization of iron in Lower Quinsam Lake and manganese in Long Lake and occasionally Middle Quinsam Lake. Concentrations of manganese at LLM (1MB) were not elevated above averaged chronic and acute WQG's of (0.737 mg/L and 0.8706 mg/L), respectively during periods of low dissolved oxygen in summer and fall (Appendix II, Graph 31).

9.2 **River and Stream Sites**

A summary table is provided in Appendix I, Table's 3 and 4 with Table's 44 through 46 displaying water chemistry results compared to guidelines. Appendix I, Table 47 and 48 provides statistical summaries for parameters of interest. Appendix II, Graphs (52 through 64) illustrate parameter trends for the rivers (total aluminum, arsenic, iron and manganese and dissolved copper, sulphate and iron) in the Quinsam and Iron River Sub-basins.

9.2.1 *Middle Quinsam Lake Inflow (WA) EMS #0126402 and Outflow (WB) EMS #0900504*

Comparing Middle Quinsam Lake's upstream river site, sampled at the Argonaut bridge (WA) EMS # 0126402 as the "*inlet"* and "*outlet*" (WB), EMS #0900504 offers an opportunity to assess potential mine-related effects on Middle Quinsam Lake water quality. Additionally, water quality results from WA are considered "baseline" for the Middle Quinsam sub-basin receiving environment stations as the site is situated upstream of any mine related discharge. Data obtained from WB (outlet of Middle Quinsam Lake) provides information on lake water quality after the addition of discharges from the South water management system, shallow and deep groundwater, Long Lake Outlet (LLO), mine related discharge from Settling Pond #4, and other anthropogenic sources (e.g., logging, and historical Argonaut mine).

Appendix II, Graphs (52 through 61) display parameters of interest or those found elevated above WQGs (total aluminum, arsenic, iron, manganese, and dissolved copper, iron and sulphate) in the

Quinsam Sub-basin. Appendix II, Graph 65 displays Middle Quinsam Lake daily inflow obtained upstream on the Quinsam River at the Argonaut bridge hydrometric station. Appendix II, Graph 66 compares water levels for discharge at Middle Quinsam Lake Outlet, WB.

TSS results at WA and WB remained at or just above detection limits (<1.0 to 1.6 mg/L) throughout all sampling events, as reported in previous years, and are expected to continue at low concentrations. Samples for WB are collected below the Coal Main Road crossing on the Quinsam River and the low TSS results reflect the efforts made in reducing sediment and erosion at this location.

The pH values were similar at WA and WB, pH at WA and WB was weakly alkaline and within the range of 6.18 to 8.13; pH values averaged 7.15 at WA and 7.42 at WB. Conductivity at WB reflected the mine influences (elevated conductivity and sulphate are considered signatures of mine influence). For example, average conductivity values were 47 µs/cm at WA and 106 µs/cm at WB.

Increases of average sulphate and hardness concentrations are observed between WA and WB. With average dissolved sulphate results at WA (1.09 mg/L) and WB (15.7 mg/L), remain below the WQG of 128 mg/L at both stations (Appendix II, Graph 57). Like sulphate, annual average hardness concentrations display an increase from WA to WB with average concentrations of 19 mg/L and 29 mg/L, respectively. Concentrations of sulfur are also notably higher between the two stations with WA averaging 1.50 mg/L and WB averaging 5.58 mg/L.

Dissolved copper was more elevated at WA than WB average concentrations of 0.00055 mg/L and 0.00049 mg/L, respectively. Dissolved copper was above Acute-WQG ‘s of 0.0006 mg/L and 0.0003 mg/L resulting in 0.00066 mg/L and 0.00059 mg/L, on 2 out of 5 sampling events in fall.

WA has displayed elevated concentrations for copper throughout all seasons on the Quinsam River exceeding Chronic-WQG throughout spring, summer, and fall, and acute WQG’s in fall. Although WQG’s are lowest at this location, refer to Appendix II, 52 through 54.

Dissolved metals displaying an observable increase in annual average concentrations between WA and WB include iron and manganese, likely attributed to mine related discharge. All total and dissolved metals (except dissolved copper at WA) remained below WQGs. Deceases in parameters are observed between WA and WB for aluminum and copper as expressed in bold below.

Station Code		pH-F	Cond-F	SO4-D	TSS	Al-T	As-T	B-T	Cu-D	Hard-T	Fe-T	Fe-D	Mn-D	S-D	Zn-D
		pH Units	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Upstream QR (WA)	Average	7.15	46.7	1.09	0.50	0.0188	0.000116	0.0250	0.00055	18.6	0.017	0.0119	0.00054	1.50	0.00250
MQL Outlet (WB)	Average	7.42	106.2	15.7	0.57	0.0125	0.000160	0.0250	0.00049	29.0	0.032	0.0197	0.0026	5.58	0.00250
Increase / Decrease		0.27	59.5	14.61	0.07	**-0.0063**	0.000044	0.0000	**-0.00006**	10.4	0.015	0.0078	0.00206	4.08	0.0000

9.2.2 *No Name Outlet (NNO) EMS # E217017 and Long Lake Outlet (LLO) EMS # E219412*

Flow from No Name Lake (NNO) enters the west end of Long Lake and exits Long Lake at the site known as LLO. LLO discharges to Middle Quinsam Lake upstream of Middle Quinsam Lake outlet (WB). Water quality monitoring at NNO and LLO provides information on changes in water chemistry in both Long Lake and the channel connecting the two lakes. The sampling location on No Name Lake is outside of direct mine discharge but could be influenced by groundwater. Therefore, changes in water chemistry between NNO and LLO represent the incremental mine loading into Long Lake from various inputs, including shallow and deep groundwater (e.g., emanating from 2S and 3S mine areas), Long Lake Seep discharge, mine related discharge from the South water management system, and other anthropogenic sources (e.g., logging).

Average TSS concentrations for LLO and NNO remained below 3.5 mg/L during the three monitoring periods (spring, summer and fall). Both NNO and LLO exhibited similar pH, averaging 6.93 at NNO and 7.07 at LLO.

Conductivity, sulphate and hardness levels increase between NNO and LLO, reflecting mine-related influences on Long Lake. Annual average conductivity was 51 µs/cm at NNO and 174 µs/cm at LLO. Annual average sulphate was 2.04 mg/L at NNO and 48.40 mg/L at LLO. Sulphate concentrations at LLO are cyclic, normally highest during spring, with increased pumping and mine influence. Concentration also increases with decreasing flows and less dilution in summer. Appendix II, Graph 56, displays the average dissolved sulphate results from NNO compared to LLO. Like sulphate, water hardness increases from NNO (average of 15.8 mg/L) to LLO (average of 60 mg/L). Concentrations of sulfur also display a significant increase between the two sites related to mine discharges with averages of 1.50 mg/L at NNO and 17 mg/L at LLO.

Average concentrations of metals observed between NNO and LLO remained low, with many below laboratory DLs. Increases between the sites (NNO to LLO) are observed for all parameters except aluminum, copper and iron expressed in bold below. Most total and dissolved metals were below their respective WQG's except chronic dissolved copper at both sites. Results for dissolved copper and lead were above Acute-WQG's at NNO during fall for 1 out of 5 sampling events' resulting in 0.00043 mg/L and 0.00727 mg/L, respectively.

Individual results for dissolved copper were elevated above the Chronic-WQG's during summer and fall at NNO and LLO with fall averages above the Chronic-WQG's of 0.0002 mg/L and 0.0003 mg/L, averaging 0.00048 mg/L and 0.00035 mg/L for NNO and LLO, respectively. The water levels were low for the fall flush event.

Station Code		pH-F	Cond-F	SO4-D	TSS	Al-T	As-T	B-T	Cu-D	Hard-T	Fe-T	Fe-D	Mn-D	S-D	Zn-D
		pH Units	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
NNO	Average	6.93	51.5	2.04	0.95	0.0257	0.00032	0.0250	0.00046	15.8	0.070	0.0432	0.0218	1.50	0.00250
LLO	Average	7.07	173.6	48.4	0.74	0.0196	0.00039	0.0328	0.00035	59.9	0.045	0.02750	0.0336	17.0	0.00250
	Increase / Decrease	0.14	122.1	46.36	**-0.21**	**-0.0061**	0.00007	0.0078	**-0.00011**	44.1	**-0.025**	**-0.0157**	0.0118	15.5	0

Water quality data for sites LLO and NNO are presented in Appendix I, Tables (43 to 46) with comparison to WQGs. Appendix II, Graph's 52 through 56 and display total aluminum, dissolved sulphate and copper. Appendix II, Graph 69 compares discharge with precipitation at LLO and Graph 77 compares level with staff gauge readings at NNO.

9.2.3 *Stream 1 – (7S) EMS # E292109*

Results are displayed in Appendix I, Table 25 and Appendix II, Graph 70 displays discharge and level at 7S. The headwaters of Stream 1 are formed by the discharge of 7SSD, which combines with Stream 2 above sampling location 7S. Downstream of site 7S, Stream 1 enters the Lower Wetland then flows into the Quinsam River. Given the aquatic values (fish habitat) in the Quinsam River, the 7S station has been defined as the initial dilution zone for 7-South discharge water. This receiving environment site is used to evaluate the influence of 7-South operations on aquatic receptors. The Lower Wetland Outlet (LWO) station was established to monitor the cumulative water quality in Stream 1, and to understand overall contributions to the Quinsam River. The Lower Wetland Outlet station has not been representative of water quality from 7SSD nor from 7S. The November 1, 2019, permit amendment removed this site from the monitoring program.

There has been zero discharge from 7SSD since 2017, with only 24 hours and 12 days in 2016/2017; representing the limited amount of surface loading from 7SSD discharge to the Lower Wetland.

Average sulphate was 4.1 mg/L and TSS was 0.50 mg/L at 7S, well below the WQG (128 mg/L), reflecting the water management measures employed at 7SSD sedimentation pond and surrounding 7-South operations are working. All total and dissolved metals were below WQGs at 7S.

9.2.4 *Quinsam River Downstream Sites*

Appendix I, Tables (3, 4 and 44 through 46) and Appendix II, Graphs (52 to 55 and 57 to 61) display parameters above WQG's and relevant parameters of interest for these sites.

Quinsam River Downstream Site 1 (QRDS1) EMS # E286930 is located approximately 2 km downstream from the Middle Quinsam Lake outlet (sampling site WB) and upstream of surface inputs associated with 7-South operations. QRDS1 was established to monitor groundwater inputs from the underground disposal of 7-South tailings into the 2-North mine, underground sub-aqueously stored PAG-CCR material from processing of 5-South coal stored in the river barrier pillar and underground sub-aqueously stored PAG-CCR material from processing of 7-South coal stored in the 2-Mains 7-South Mine. Any incremental loadings associated with stored material and groundwater inputs is observed between WB and QRDS1.

The 7-South Quinsam River monitoring station (7SQR) EMS # E292113 is located approximately 4 km downstream of QRDS1. 7SQR water quality is used to evaluate the influence of 7-South mine related discharge to the Quinsam River downstream of the LWO, and groundwater inputs to the Quinsam River from sub-aqueously stored PAG-CCR in 2-Mains, 7-South mine. This site captures cumulative mine related discharge from all mine areas.

Average dissolved sulphate concentrations were not elevated above Chronic - WQG's at any locations on the Quinsam River. Average concentrations have been declining since 2021 results during spring, summer and fall. Seasonal averages were below 25 mg/L for spring, summer and fall. A decrease in average dissolved sulphate concentrations of 2.8 mg/L was observed between WB and 7SQR in spring. Summer was observed to have a slight increase between the sites of 1.2 mg/L and fall remained similar between sites with a difference of 0.2 mg/L.

Average dissolved sulphate concentrations between sites (WB, QRSD1, 7SQR and IRQR) for spring, summer and fall were:

- Spring ranged from 23 mg/L, 23 mg/L, 21 mg/L and 13.12 mg/L at WB, QRDS1, 7SQR and IRQR, respectively.

- Summer ranged from 10.04 mg/L, 11.24 mg/L, 11.24 mg/L and 11.00 mg/L at WB, QRDS1, 7SQR and IRQR, respectively.

- Fall ranged from 11.28 mg/L, 14.92 mg/L and 11.58 mg/L and 11.64 mg/L at WB, QRDS1, 7SQR and IRQR, respectively.

Marginal concentration increases on the Quinsam River were observed between upstream (WB) and downstream (7SQR) for arsenic (T). Incremental contributions from both mine, groundwater and/or changes in geology on the river are observed. All results remained below WQG's for both arsenic and iron.

Average total arsenic increases noted between WB to 7SQR were 0.000346 mg/L, 0.000582 mg/L, 0.000268 mg/L during spring, summer, and fall, respectively. Average arsenic concentrations between sites (WB, QRSD1, 7SQR and IRQR) for spring, summer and fall were:

- Spring ranged from 0.000144 mg/L, 0.000482 mg/L, 0.00049 mg/L and 0.000668 mg/L at WB, QRDS1, 7SQR and IRQR, respectively.

- Summer ranged from 0.000162 mg/L, 0.00033 mg/L, 0.000768 mg/L and 0.000824 mg/L at WB, QRDS1, 7SQR and IRQR, respectively.

- Fall ranged from 0.000186 mg/L, 0.000728 mg/L, 0.00043 mg/L and 0.000618 mg/L at WB, QRDS1, 7SQR and IRQR, respectively.

Average dissolved iron increases noted between WB to 7SQR were 0.027 mg/L, 0.038 mg/L, 0.043 mg/L during spring, summer, and fall, respectively.

There were minimal increases / decreases observed between sites for dissolved copper. Average dissolved copper concentrations decreased in spring between WB to 7SQR resulting 0.000018 mg/L and increased in summer and fall with changes resulting in 0.000004 mg/L and 0.000154 mg/L, respectively. Higher concentrations were observed in fall upstream at WA, indicating limited loading from mine contributions. Dissolved copper measured above Acute-WQG (0.00040 mg/L) at 7SQR on 1 out of 5 events in fall, resulting in 0.00049 mg/L. Average copper was above the Chronic-WQG at WA, 7SQR and IRQR in summer and all sites in fall. Average concentrations between sites (WB, QRSD1, 7SQR and IRQR) for spring, summer and fall were:

- Spring ranged from 0.000502 mg/L, 0.000594 mg/L, 0.00049 mg/L and 0.000652 mg/L at WB, QRDS1, 7SQR and IRQR, respectively.
- Summer ranged from 0.000544 mg/L, 0.000434 mg/L, 0.000548 mg/L and 0.000466 mg/L at WB, QRDS1, 7SQR and IRQR, respectively.
- Fall ranged from 0.000406 mg/L, 0.00043 mg/L, 0.00056 mg/L and 0.00066 mg/L at WB, QRDS1, 7SQR and IRQR, respectively.

Quinsam River Downstream of the confluence with Iron River (IRQR) EMS # E299256 is located about 5 km downstream of 7SQR and captures the full mixing of the Iron and Quinsam rivers.

Contributions of arsenic from the Iron River are normally found in the highest concentrations at IRQR compared to upstream Quinsam River. Average total arsenic was 0.000668 mg/L, 0.000824 mg/L and 0.000618 mg/L during spring, summer, and fall, respectively. All results remained below Chronic-WQG's of 0.005 mg/L.

At IRQR parameter concentrations remained below WQG's except for average dissolved copper (0.00045 mg/L) measuring above Chronic -WQG of 0.0003 mg/L, and total aluminum 0.0885 mg/L measuring above Chronic -WQG of 0.0870 mg/L during fall.

9.2.5 *Iron River*

The Iron River Baseline Summary Report was submitted to the ENV on March 31, 2016. The report reviewed the monitoring data at all sites in the Iron River, summarizing trends and parameters found to be naturally elevated due to the watershed geology and contact with the Benson/Dunsmuir members of the Comox Formation.

As part of the 7-South Area 5 permit application, baseline water quality data were collected at ten stations on the Iron River to gain an understanding of existing water quality and local influences. Additionally, six tributaries were monitored to identify incremental loading.

One year of monthly baseline samples was obtained at all sites to maximize interpretation of seasonal variations and trending on the Iron River. Post-baseline monitoring in 2019/2020 continued to consist of 5 in 30 and monthly sampling until November 1, 2020 at three stations on the Iron River (IR1, IR6 and IR8) and one station on the Quinsam River, downstream of the confluence of the Iron River (IRQR).

November 2019 permit amendment removed monitoring location IR1 and reduced the frequency of sampling at IR6, EMS # E297231 and IR8, EMS # E297232 to summer and fall, 5 in 30, only. Monthly sampling has occurred at these sites since 2014 with a strong historical dataset available. The two seasons of worst water quality are summer and fall, so this reduction will provide the information necessary to compare baseline data and conditions at other sites.

Most general parameters (e.g., TSS and sulphate) had low concentrations at the two stations (IR6 and IR8) and remained well below WQGs. Hardness showed seasonal variability, with lower levels in spring and fall (higher flow) than in summer (low flow). A conservative approach was taken when calculating hardness dependent WQGs (using a background hardness of 30 mg/L).

Aluminum (Al) and arsenic (As) are the two primary parameters displaying a trend related to flows in the Iron River. An inverse relationship between Al and As has been identified: Al is elevated during periods of higher flow while As is elevated at times of low flow. Appendix II, Graph's 55, 62 and 63 display concentrations of aluminum.

As-T concentrations were elevated above Chronic-WQGs (0.005 mg/L) in summer at IR6 for 3 out of 3 results and at IR8 for 3 out 5 results. Summer averages were 0.01154 mg/L and 0.01465mg/L at IR6 and IR8, respectively. Concentrations increased from IR6 to IR8 (downstream) as displayed in Appendix II, Graph 64. Due to hazardous conditions IR6 was only sampled for 3 weeks out of 5 and IR8 was collected downstream for the last 2 weeks.

Individual Cu-D was elevated above the Chronic-WQG (0.0006 mg/L) during summer at both IR6 and IR8, for one result, 0.00085 mg/L and 0.00035 mg/L, respectively. Average dissolved copper was elevated above the Chronic-WQG (0.0005 mg/L) at both sites during fall, resulting in 0.00086 mg/L and 0.00089 mg/L, respectively. Appendix II, Graph 53 and 54.

All other parameters of interest were below WQG's at IR6 and IR8 and there were no further parameters above WQG's observed at IRQR. Therefore, mixing of the Quinsam and Iron River's continues to provide sufficient dilution to maintain a healthy watershed.

Appendix II, Graph 71 displays the flow on the Iron River measured at IR8.

9.2.6 *Conclusion*

Water quality within Quinsam subbasin is of good quality, meeting WQGs and WQOs on most sampling dates in 2023 in the Quinsam and Iron rivers and in the four lakes (No Name, Long, Middle Quinsam and Lower Quinsam Lakes).

Dissolved copper concentrations were above the variable Acute-WQG's (0.0002 mg/L to 0.0481 mg/L) and Chronic-WQG's (0.0002 mg/L to 0.0007 mg/L) throughout the watershed at certain locations. Notably upstream of the Mine influences at sites WA and NNL. Refer to Appendix II, Graphs 49 to 54.

Dissolved copper was elevated in all lakes in spring with QR sites remaining below WQG's, including upstream at WA. NNL 1 metre from bottom sample was above the acute WQG on one occasion.

In summer, upstream WA, and downstream on the Quinsam river (7SQR and IRQR) were above Chronic-WQG's. Low flow was observed at NNO and LLO with only 3 out 5 samples collected as a result. Both MQL and LL were below WQG's in summer.

In fall, with increased flow, all streams (NNO and LLO) and river locations (both QR and IR) were above the Chronic-WQG's, and the lakes (LL and MQL) were elevated at depth. Acute WQG's were elevated on one occasion at sites WA, NNO and downstream QR at 7SQR.

Historical sediment samples collected on the Quinsam River resulted in the highest concentrations of copper at WA that were above the ISQG (35.7 mg/kg). This indicates there is either naturally elevated copper in the environment or an upstream source of contamination (i.e., above WA the historical Argonaut mine).

Average dissolved sulphate concentrations remained below the Chronic-WQG (128 mg/L) applying a background hardness of 30 mg/L in all lakes and river sites, throughout spring, summer and fall. Average sulphate concentrations remained at 1.3 mg/L during spring, summer and fall, upstream of mine influence, increasing to 21 mg/L at 7SQR and 13 mg/L downstream of the confluence with the Iron River (IRQR) in spring. A declining trend has been observed since summer 2021 (average 56 mg/L) compared to 2023 summer and fall averages of less than 12 mg/L at both 7SQR and IRQR.

An increasing trend has been observed on the Quinsam River between sites WB and 7SQR for POI such as total arsenic and manganese. Concentrations remained well below the WQG of 0.005 mg/L and 0.737 mg/L for As-T and Mn-T, respectively, for all monitoring periods.

Average concentrations of arsenic increased in 2021 with averaged results peaking in spring of 2021 at IRQR (0.0009 mg/L), related to water elevations in the 2-North mine void and increased groundwater discharge rates. In spring 2023, average arsenic concentrations declined in spring to 0.00067 mg/L at IRQR. In 2023, the summer and fall averages for IRQR were 0.00082 mg/L and 0.00062 mg/L, similar to 2022 averages for summer (0.00087 mg/L) and fall (0.00059 mg/L) with peak concentrations occurring in summer.

Concentrations increase from upstream to downstream between QRDS1 and IRQR with average concentrations remaining below 0.001 mg/L, for all seasons. IRQR normally has the most elevated concentrations with contributions from the Iron River, expect in spring of 2021, when average concentrations were marginally higher at QRDS1 and 7SQR.

Sampling during high and low flow rates plays a significant role in observations related to seasonal trends and concentration of POI. Refer to Appendix II, Graphs 58.

On the Iron River, arsenic was elevated during summer low flow at both IR6 and IR8 during 3 monitoring events. The IR8 samples for weeks 4 and 5 were collected downstream, resulting in lower concentrations of arsenic. Total aluminum was not elevated during fall as flows did not increase until late in December. The sediment and benthic invertebrate sampling results collected in 2020 demonstrated elevated arsenic and copper within the sediment. Appendix II, Graph 55.

10.0 BIOTA MONITORING IN THE RECEIVING ENVIRONMENT

Phytoplankton and zooplankton are monitored every year at one station in each of No Name, Long, Middle Quinsam, and Lower Quinsam lakes. The sampling sites are shown in Appendix IX, Figure 1. This section of the report describes sampling objectives, methods, QA/QC, and results for phytoplankton and zooplankton. Refer to Appendix IV for all historical and present phytoplankton data.

10.1 PHYTOPLANKTON

Phytoplankton are photosynthetic microorganisms that live in lakes at depths to where adequate sunlight can penetrate. They are the main primary producers in lakes, converting sunlight, CO_2, and water into organic matter, and are the foundation for the aquatic food web (Wetzel 2001). Phytoplankton includes algae and cyanobacteria, both of which contain at least one form of chlorophyll (chlorophyll *a*), the major photosynthetic pigment. They are sensitive to changes in water quality (Wetzel 2001). Many lakes have a spring and fall phytoplankton bloom (peak growth period) following the seasonal "overturns" or mixing of the water column, which redistribute nutrients through the water column.

Phytoplankton are monitored annually at one station each in No Name, Long, Middle Quinsam, and Lower Quinsam lakes, in the deepest area of the lakes, where routine water quality monitoring is conducted. From 2013 to 2019, phytoplankton samples have been collected at the four lakes once each during the spring, summer and fall 5 in 30-day water sampling periods defined in amended Permit PE 7008. From the 1990s to 2012, Permit PE 7008 required sampling at 1, 4, and 9 m depth in April through September at Long Lake and Middle Quinsam Lake, with No Name Lake added in 2012 and Lower Quinsam Lake added in 2013. From November 2019 amended Permit PE 7008 removed No Name and Long Lake from the summer and fall 5 in 30-day sampling periods.

10.1.1 *Methods*

10.1.1.1 Field Methods

In 2023, samples were collected from 1 m depth using a 4 L Beta sampler. Chlorophyll *a* sample were collected as 1 L raw water samples, shipped to BV laboratory (Burnaby B.C.) and laboratory filtered for analysis. A 250 mL sample was preserved with Lugol's in the field and analyzed for community composition, *i.e.*, counts and identification to lowest practical level (Stantec Consulting Ltd., Burnaby B.C.). Field replicates were collected for QA/QC in May, July and October 2023, from Lower Quinsam, Long and Middle Quinsam Lakes, respectively.

10.1.1.2 Laboratory Methods

Organisms were identified to the lowest practical level (species where possible) using an inverted microscope. A 27 mL volume of lake water was settled in a chamber. Counts were made at 100X, 400X, and 1000X magnifications, to record the size range of phytoplankton.

10.1.2 *Results*

10.1.2.1 Chlorophyll a

Samples were collected and sent to the laboratory during spring for all four lakes, then summer and fall for Middle Quinsam and Long Lake.

Chlorophyll *a* concentrations provide an indication of overall phytoplankton biomass at any given time and provide a basis for comparing primary production among lakes. Table 16 provides data for samples collected from 1 m depth in 2023. Concentrations ranged from 0.52 µg/L to 0.56 µg/L, for all four lakes during the spring.

Table 16: Chlorophyll a Concentrations, 1 m Depth, Quinsam Lakes System, 2023

Lake	Chlorophyll *a* (µg/L)		
	Spring	Summer	Fall

No Name Lake (NNL)	0.53	N/A	N/A
Long Lake (LL)	0.53	1.1	0.61
Middle Quinsam (MQL)	0.52	0.53	0.68
Lower Quinsam (LQL)	0.56	N/A	N/A

Concentrations of Chlorophyll *a* were below the range reported in 2022 for all four lakes (NNL, LL, MQL and LQL) during spring. In summer and fall results were slightly declined from previously observed (between 0.52 µg/L to 1.1 µg/L).

Historically, chlorophyll *a* concentration reported for these lakes reflected oligotrophic conditions (mean of 1.7 µg/L, maximum of 4.5 µg/L), and low total phosphorous concentrations (mean of 8 µg/L, maximum of 18 µg/L), according to the trophic classification system for lakes developed by Vollenweider and Kerekes (1982; cited in Environment Canada 2004)[9]. Permit PE 7008 does not require nutrient analysis for the lakes, and nitrate, and ammonia data were not available to confirm this trophic classification.

Appendix IV and Figure 9, below provides data for 2013 through 2023. Chlorophyll *a* results for 2023 spring, summer, and fall were within the range reported from 2013 to 2022 (0.40 to 2.68 µg/L).

[9] Vollenweider, R. and J. Kerekes. 1982. Eutrophication of Waters. Monitoring Assessment and Control. Organization for Economic Co-operation and Development (OECD) Paris. 55 pp. cited in Environment Canada 2004. Canadian Guidance Framework for the Management of Phosphorus in Freshwater Systems. Report No. 1-8. http://publications.gc.ca/collections/Collection/En1-34-8-2004E.pdf

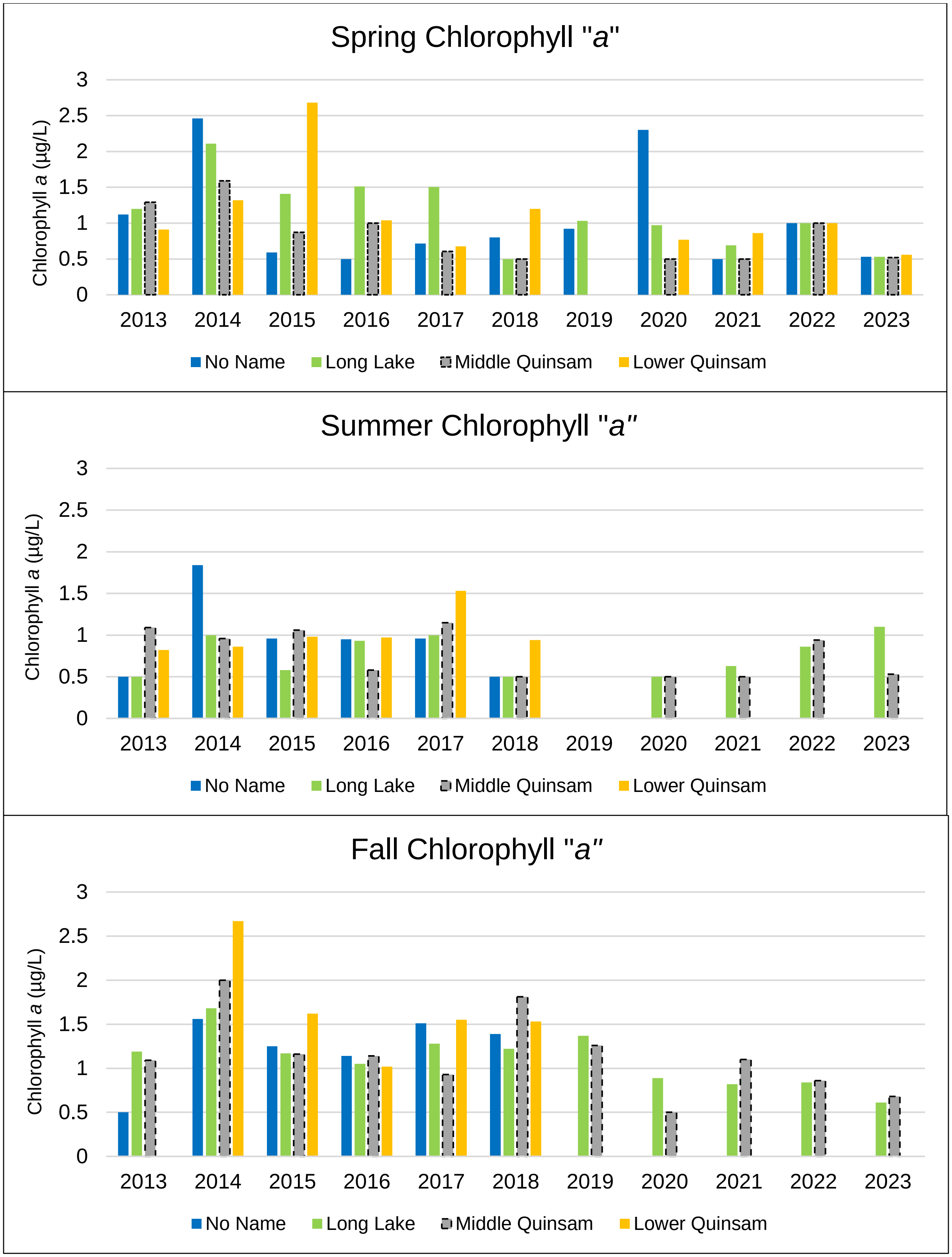

Figure 9: Chlorophyll a (µg/L) at 1 m Depth, Quinsam Lakes System, 2013 – 2023

10.1.2.2 *Phytoplankton Communities*

Phytoplankton taxonomy reports are included in Appendix IV and results are summarized below. Duplicate samples collected in May, July, and October, showed good agreement for the paired samples (within 20% of duplicate samples).

Abundance is summarized in Table 17 as total and by size fraction (identified at 1000X, 400X, and 100X magnifications, with the smallest size fraction less than 5 µm. Total abundance ranged from 870 to 2,800 cells/mL in 2023.

Table 17: Phytoplankton Abundance (cells/mL) in Quinsam Lake Systems, 2023

Lakes 2023	Date	Abundance (cells/mL) at 1 m depth			
		Total	<5 µm (1000 X)	5 to 25 µm (400 X)	>25 µm (100 X)
Long	May 3/4	2,800	2,700	170	2
Middle Quinsam		1,100	940	120	1
No Name		1,900	1,800	160	1
Lower Quinsam		1,300	1,100	180	22
Lower Quinsam Rep.		1,200	1,100	120	7
Long	Jul 18	960	850	120	1
Long Rep.		870	740	130	2
Middle Quinsam		1,200	530	710	0
Long	Oct 11	1,100	990	140	7
Middle Quinsam		1,300	1,200	150	25
Middle Quinsam Rep.		1,400	1,200	140	28

In 2023, abundance was greatest in spring samples collected from Long (2,800 cells/mL) and No Name Lake's (1,900 cells/mL). Total abundance was lowest in samples collected from Long Lake in summer (870 cells/mL and 960 cells/mL) and fall (1,100 cells/mL). Middle Quinsam remained consistent throughout spring, summer and fall samples with results of 1,100 cells/mL, 1,200 cells/mL and 1,400 cells/mL, respectively. Peak abundance and chlorophyll *a* concentration did not always coincide, likely related to changes in size of abundant taxa over the sampling periods.

There were two sets of samples collected during spring 2022 (April and May), samples were collected during the first and last week of the 5 weeks of sampling. Results displayed a decrease between weeks 1 and 5 in lakes, Middle Quinsam and No Name in total abundance and the <5 µm cells/mL, and >25 µm cells/mL. Increases were observed for all lakes for the 5 to 25 µm cells/mL. The difference in size factions could be related to the growth of the organisms and fish grazing pressures.

Variation in total abundance among lakes and through the three seasonal sampling periods for 2013 through 2023 is shown in Figure 10: Total Phytoplankton Abundance, 1 m Depth, Quinsam Lakes

System, 2013 – 2023. As noted for chlorophyll *a*, high variability among seasons, years, and lakes between 2013 and 2023 was likely related to variation in timing of spring and fall overturn and nutrient concentrations. Phytoplankton data for spring 2023 at Long Lake displayed increased abundance compared to 2021 and 2022. No Name results were within the same range as the previous year. Results for Middle and Lower Quinsam were relatively similar and lower than 2022 results.

Results for Long and Middle Quinsam lakes were similar and comparable to the last two years (2021-2022) in summer. Middle Quinsam had the greatest abundance in fall.

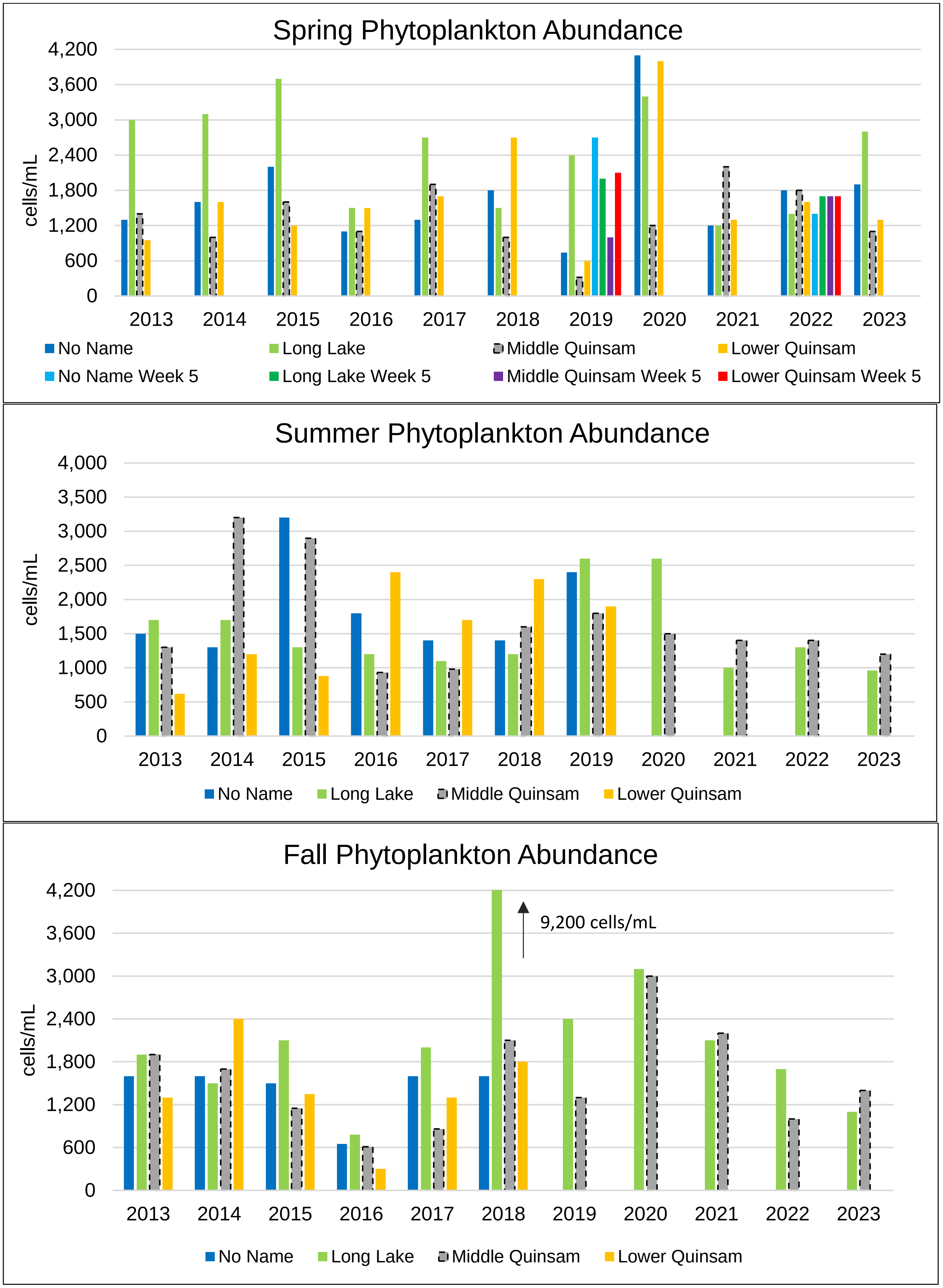

Figure 10: Total Phytoplankton Abundance, 1 m Depth, Quinsam Lakes System, 2013 – 2023

10.1.2.3 Species Composition

Spring

Species composition data for the May 2023 samples are contained in Attachment IV. The most abundant phytoplankton in the four lakes were the very small (less than or equal to 5 µm) chrysoflagellates (*Ochromonas spp*. and *Chromulina spp*.). Although these ultra-nanoplankton species were very abundant numerically, they usually contribute little to algal biomass. The most abundant of the larger algae were the chrysophyte *Ochromonas spp*. (predominant in the four lakes), cryptophyte *Rhodomonas minuta* (common in Long Lake and No Name Lake), and chrysophyte *Dinobryon cylindricum* and diatom *Cyclotella glomerata* (common in Lower Quinsam Lake). The May 2023 samples were similar in composition and abundance to samples collected during the spring in recent years.

Summer

Species composition data for the July 2023 samples are contained in Attachment IV. The most abundant phytoplankton in Long Lake were the very small (less than or equal to 5 µm) chrysoflagellates (*Ochromonas spp.* and *Chromulina spp*.). Although these ultra-nanoplankton species were very abundant numerically, they usually contribute little to algal biomass. These were not the most abundant taxa in Middle Quinsam Lake; *Dictosphaerium pulchellum* was predominant. In Long Lake, the most abundant of the larger algae were the cryptophytes *Cryptomonas spp*. and *Rhodomonas minuta*, with the *chrysophyte Ochromonas spp*. common. In Middle Quinsam Lake, the colonial chlorophyte *Dictyosphaerium pulchellum* was predominant and small chrysophytes and *Ochromonas spp*. were common. The July 2023 samples were similar in composition and abundance to samples collected during the summer in recent years.

Fall

Species composition data for the October 2023 samples are contained in Attachment IV. The most abundant phytoplankton in Long Lake and Middle Quinsam Lake were the very small (less than or equal to 5 µm) chrysoflagellates (*Ochromonas spp. and Chromulina spp*.). Although these ultra-nanoplankton species were very abundant numerically, they usually contribute little to algal biomass. In both Long Lake and Middle Quinsam Lake, the most abundant of the larger algae were the chrysophytes *Ochromonas spp*., with the chrysophyte *Dinobryon cylindricum* and the cryptophytes *Cryptomonas spp*. and *Rhodomonas minuta* were common. In Long Lake, the chrysophyte *Mallomonas cf. akrokomas* was also common. The October 2023 samples were similar in composition and abundance to samples collected during the autumn in recent years.

10.2 ZOOPLANKTON

Zooplankton form the second trophic level in the water column of lakes (secondary producers), grazing on phytoplankton, consuming organic matter, and providing a food source for juvenile fish (Wetzel 2001). Abundance and composition of the zooplankton community vary among lakes due to variation in water chemistry, lake characteristics, and grazing pressures from fish (Wetzel 2001).

According to PE:7008, zooplankton are monitored in the Quinsam mine receiving environment three times per year at one station in Middle Quinsam and Long Lakes. Lower Quinsam and No Name Lakes are monitored once a year (spring) as of Permit amendment in November 2019. Since 2014, zooplankton samples have been collected once in the spring, summer, and fall during the 5 in 30 water quality sampling periods.

10.2.1.1 *Field Methods*

Zooplankton were collected from No Name, Long, Middle Quinsam, and Lower Quinsam lakes historically three times per year (once during each 5 in 30-day period). In 2019 there was an extra set of samples collected in spring at each lake. In the fall only Middle Quinsam and Long lakes were sampled pursuant to a permit amendment received on November 1st, 2019. Samples were collected using a Wisconsin Plankton Sampler (63 µm net) in a 10 m vertical tow, with one sample collected per lake. Samples were preserved with ethanol and sent to Fraser Environmental Services (Surrey B.C.) for taxonomic analyses.

10.2.1.2 *Laboratory Methods*

Organisms were counted and identified to the lowest practical level.

10.2.2 *RESULTS*

Detailed zooplankton taxonomic composition results are provided in Appendix IV, Tables 1 through 3 and are summarized below. Abundance is the relative representation of a species in a particular ecosystem. It is usually measured as the number of individuals found per sample. Peak abundance ranged from 5,981 organisms/sample (Long Lake, July rep.) to 5,764 organisms/sample (Middle Quinsam Lake, July). The lowest abundance among the four lakes was 843 organism/sample in fall at Middle Quinsam Lake (replicate). Middle Quinsam and Long Lake display an increase for both summer and fall compared to the previous years (2020 through 2022) excluding the October rep for Middle Quinsam. Results for No Name (857 organisms/sample to 1391 organisms/sample) and Lower Quinsam Lakes (494 organisms/sample to 1026 organisms/sample) both increased in abundance from last year.

Zooplankton organism abundance per sample collected in 2023 is displayed in Table 18, and Figure 11, below. The most abundant of the Zooplankton were as follows:

- In No Name Lake spring samples *Cyclopoida* were least abundant, *Cladocera* and *Rotifera* displayed similar results and *Calanoida* was most abundant.
- In Long Lake samples *Cladocera* and *Rotifera* were consistently most abundant, and *Cyclopoida* remained the lowest.
- In Middle Quinsam Lake, *Cladocera* were most abundant in spring and summer, and *Rotifera* most abundant in the fall, except for the replicate. The lowest total count for Middle Quinsam was *Cyclopoida* in fall.
- In Lower Quinsam Lake *Calanoida* were most abundant in spring samples, with *Cladocera, Cyclopoida* and *Rotifera* having similar results.

Table 18: Zooplankton Abundance (Organisms/sample)

Lakes 2023	Month	Abundance (organisms/sample)				
		Total	Cyclopoida	Calanoida	Cladocera	Rotifera
No Name	May	1,391	92	577	351	371
	August	N/A	N/A	N/A	N/A	N/A
	October	N/A	N/A	N/A	N/A	N/A
Long Lake	May	1,512	45	252	691	524
	July	4,901	80	610	1581	2631
	July Rep.	5,981	37	1309	2031	2604
	October	1,337	122	210	794	211
Middle Quinsam	May	1,729	264	504	889	48
	July	5,764	586	1156	3647	360
	October	5,878	114	409	634	4665
	October Rep.	843	173	174	266	175
Lower Quinsam	May	955	183	300	363	109
	May Rep.	1,026	234	360	108	306
	August	N/A	N/A	N/A	N/A	N/A
	October	N/A	N/A	N/A	N/A	N/A

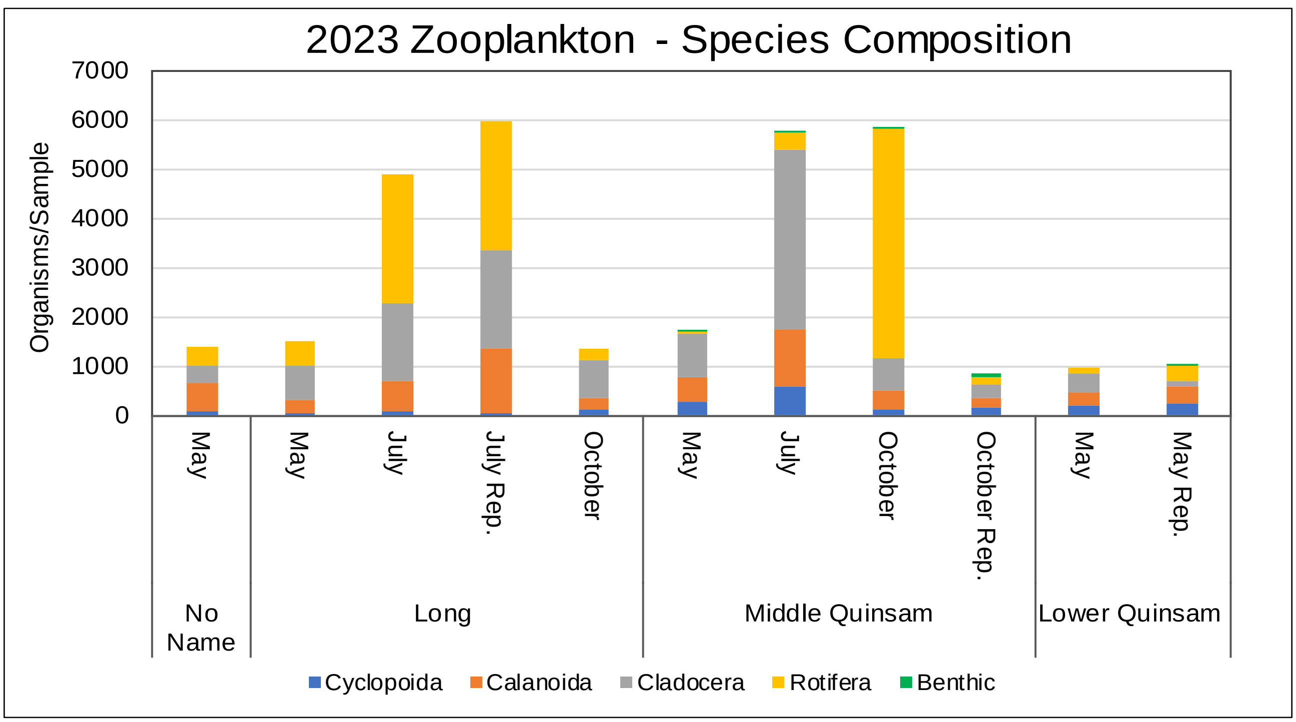

Figure 11: 2023 Total Abundance

Seasonal and spatial trends are displayed in Figure 12, below, for samples collected from 2014 through 2023. Results from the spring 2019 sampling had 2 sets submitted and displayed below in the Spring Zooplankton chart. There has been high variability among lakes, seasons, and years. In general, abundance is highest for the summer samples, following peaks in levels of phytoplankton and organic matter; however, including low abundance in No Name Lake in summer 2014, 2017 - 2018 and peak abundance in Lower Quinsam Lake in fall 2015.

Variations in total abundance when comparing lake phytoplankton abundance may be related to the month sampled and phytoplankton blooms. For example, spring sampling should occur during the last weeks of the 5 in 30 with summer and fall sampling occurring during the first week of the 5 in 30 for a better representation. Some spring and fall samples were collected too early in the spring or too late in the fall, when the water is cooler, which is represented by the lowest species abundance and counts. This is mainly observed in Middle Quinsam lake during fall sampling events (2016, 2018 and 2019).

Differences in taxonomic composition are related to seasonal conditions, including food supply (phytoplankton and organic matter) and grazing pressures from fish. The larger Copepods and Cladocerans provide preferred food sources for fish. All four lakes are known to be fish bearing (e.g., salmon and trout species), but there is not enough information about fish populations to estimate grazing pressures on zooplankton.

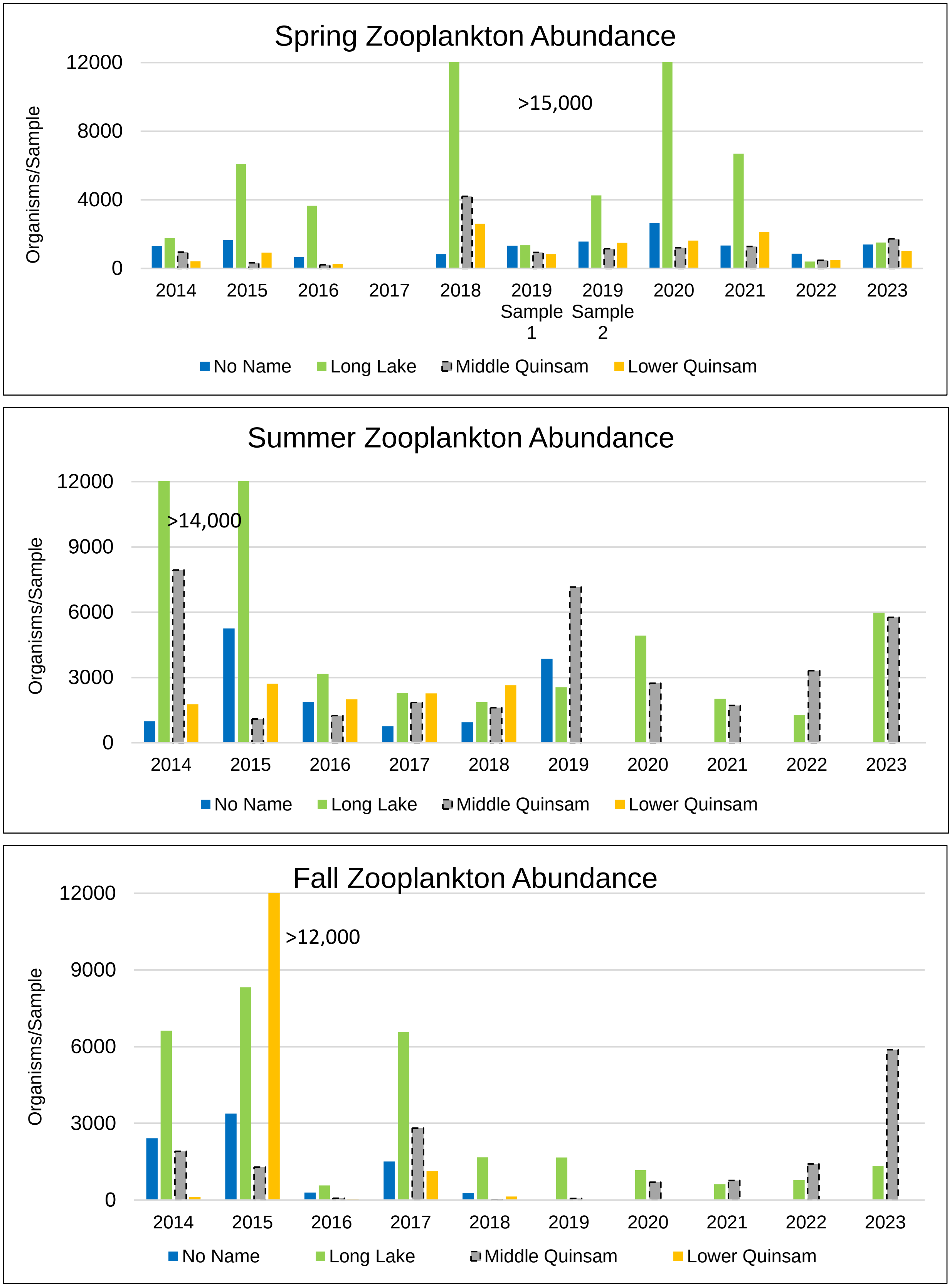

Figure 12: Total Zooplankton Abundance (0 to 10 m Vertical Tows), Quinsam Lakes System, 2014 – 2023

10.2.3 *CONCLUSION*

No Name, Long, Middle Quinsam, and Lower Quinsam lakes support phytoplankton communities typical of oligotrophic conditions and distinct zooplankton communities in each lake that provide typical prey for fish. There were no indications of adverse effects of mine discharges on the plankton communities of lakes (density, taxonomic richness, composition) in the spring for all four lakes and summer and fall for Long and Middle Quinsam Lakes. Both No Name and Lower Quinsam Lake's species abundance and composition for zooplankton and phytoplankton were within historical ranges. All four lakes display a lower production during the spring compared to summer, historically and since 2020 with Long and Middle Quinsam Lakes.

Long Lake had the highest counts for phytoplankton abundance during spring, with Middle Quinsam having the highest counts for summer for fall. Middle Quinsam had the highest zooplankton abundance during spring and fall with Long Lake most abundant during summer. Seasonal variation for phytoplankton and zooplankton abundance and species compositions is observed between lakes.

11.0 CLOSING

Water quality in the Middle Quinsam Sub-Basin remained consistent with previous years and is in good condition with little appreciable impact associated with coal mining. Most parameters of concern were below Provincial Guidelines and Objective levels indicating minimal health risk to sensitive aquatic receptors. For example, average dissolved sulphate concentrations were recorded below the most conservative guideline (128 mg/L) during all sampling events in all four lakes sampled and in all surrounding rivers and streams. This trend signifies water management features and controls at the mine site are effective. Appendix II, Graphs 29 and 35 display average dissolved sulphate in the Lakes. Total arsenic has displayed a slight increase in the Quinsam River compared to historical trends (pre-2021) but is declining since the peak observed in spring 2021. Results remain well below WQG's. Dissolved copper is elevated throughout the watershed and possibly throughout the Province in comparison to the derived WQG's applied to this parameter. There were multiple exceedances upstream and downstream of mine influence.

Parameters of interest and those displaying slightly elevated concentrations in Long Lake include total manganese (LLM 1MB) associated with anoxic concentrations at depth. The relationship between low DO and elevated manganese in Long Lake 1MB and historically iron in Lower Quinsam Lake at 1MB has been demonstrated in Appendix II, Graphs (31, 47 and 48). This pattern of elevated manganese and iron at depth in these lakes has become more evident since the initiation of the 5 in 30 monitoring in 2013. Previously, there were occasional exceedances occurring during monthly sampling over summer and fall and all events were associated with low DO. This year the average 5 in 30 Mn-T at LLM 1MB was nearing the chronic WQG of 0.737 mg/L.

No Name and Long Lakes normally displayed slightly lower pH conditions (< 6.5) at depth, mostly observed in No Name Lake during spring. However, there is little concern as slightly acidic conditions are likely naturally occurring and are consistent with historical trends. The opposite trend was observed for Middle Quinsam Lake in summer with pH increasing above 9 in the metalimnion between 6m to 9m depths, indicating alkaline conditions. This occurred for all 5 weeks of sampling. Laboratory pH and alkalinity results did not correlate with the field results.

The Iron River system experiences naturally elevated concentrations (above water quality guidelines) of aluminum during high flow and arsenic during low flow. Aluminum is present throughout the system (i.e., from IR1 through IR8) whereas arsenic is primarily detected below the sandstone unit of the Dunsmuir member contact represented by monitoring location IR6. This year Al-D was not elevated due to lower flow rates on the river. As-T was elevated during summer above the chronic-WQG at both IR6 and IR8.

Quinsam Coal will continue to focus on site wide water management with a target of mitigating parameters of interest concentrations in the receiving environment. To date, Quinsam has demonstrated that the existing mine related controls and features implemented have been effective at maintaining water quality below guidelines. This trend is expected to persist and will be highlighted by future monitoring programs.

In closing, Quinsam trusts the information herein addresses the environmental responsibilities and provisions applicable to effluent permit PE: 7008.

Should you have any questions or concerns please contact the Quinsam Coal Environmental Department 250-286-3224 Ext 225.