Quinsam Coal
Annual Water Quality Monitoring Report 2015-2016

PREPARED BY: QUINSAM COAL CORPORATION

June 30, 2016

EXECUTIVE SUMMARY

In accordance with Effluent Permit PE-7008 issued under the *Environmental Management Act*, Quinsam Coal manages and monitors mine related water in the Middle Quinsam Sub-Basin and Iron River watershed(s) to evaluate mine related discharge on the receiving environment. This report summarizes and interprets the results of the 2015-2016 monitoring program.

Water quality attainment in the Middle Quinsam Sub-Basin remains a key management objective at the Quinsam Coal operation. Provincial water quality guidelines and Middle Quinsam Sub-Basin water quality objectives provide a suitable metric to evaluate aquatic health and overall operational performance and are therefore referenced in this report.

The North, South, and 7-South water management systems represent the cumulative mine related discharge to the Quinsam watershed. As such, strategic operation of all management structures ensures water emanating from each respective area is of suitable quality for discharge into the receiving environment. Strict permit limits for parameters of interest (POI) have been established and are closely monitored to ensure environmental protection.

Sulphate and arsenic (two primary POI) concentrations in Long Lake remained below guideline levels for all sampling events in 2015. This trend indicates successful management of surface (and groundwater) in the South Water Management System with an overall potential improvement of aquatic health in Long Lake. Other parameters of interest noted in the receiving environment during the monitoring period include; total manganese, total zinc, total and dissolved iron, total arsenic and dissolved aluminum. While some of these parameters are not attributed to mine related discharge (e.g. total zinc) it is still important to consider elevated concentrations in the context of aquatic effects. Accordingly, a discussion on observations (in relation to guideline and objective levels) as well as significant trending at key monitoring locations forms the main section of this report.

Overall, water quality in the Middle Quinsam Sub-Basin and Iron River is deemed to be in good condition. Throughout the monitoring period, Quinsam has demonstrated that mine water management system(s) and procedure(s) are an effective tool in reducing parameters of interest loading in the receiving environment.

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1.0 INTRODUCTION

The Quinsam Mine is located in the Quinsam River Watershed, approximately twenty-eight road kilometers southwest of Campbell River. The land reserved by the Quinsam mining operation consists of approximately 283 hectares and is owned by Hillsborough Resources Limited and operated by Quinsam Coal Corporation (QCC). Active mining operations were suspended in early 2016 due to ongoing poor market conditions and a decreased demand for thermal coal.

The coal produced at the Quinsam mining operation is High Volatile "A" Bituminous thermal coal. The coal is processed at an onsite preparation plant and transported by B-train highway trucks to the Middle Point Barge Terminal, north of Campbell River where it is shipped, via barge, to local customers and to Texada Island.

Due to the mine's location, adjacent to Middle Quinsam Lake, the Quinsam River, No Name Lake and Long Lake, stringent effluent quality standards have been established as part of the operational permits issued by the Ministry of Environment (MOE) and the Ministry of Energy, Mines (MEM). Accordingly, Quinsam has maintained an environmental management system defined by the requirements of Permit PE-7008 and has collaborated with regulators on key management aspects to minimize mine related effects in the receiving environment.

Sulphate concentrations in receiving environment surface waters (e.g. Long Lake) have continued to be a focal point for the monitoring program at Quinsam. Although there is only one permitted sulphate limit in PE-7008 (7SSD; 500mg/L); monitoring of sulphate at the designated water quality monitoring stations around the site is conducted on a routine basis. Quinsam continues to assess sources of sulphate and management options to mitigate concentrations in mine related discharge(s).

This report outlines the results of the 2015/16 Environmental Monitoring Program in accordance with the requirements of Effluent Permit PE-7008.

Water Management Systems and Monitoring

Settling ponds, sumps and ditches have been constructed to manage and treat mine contact water and ensure protection of the receiving environment. Water management at the Quinsam Mine is divided into three discrete areas; North, South and 7-South.

1.1 MINE RELATED DISCHARGE

1.1.1 *THE NORTH WATER MANAGEMENT SYSTEM*

The north water management system is designed to collect mine related runoff from the north disturbed surface areas and pumped water from the 2-North underground mine operations. Included in this system are catchment sumps and ditches, pipelines, a subaqueous PAG-CCR storage facility and Settling Pond 4 (WD).

The north subaqueous PAG-CCR facility (WP) contains waste rock from coal processing and is stored with at least 1.50m of water cover above to inhibit any acid generation from the stowed material. This water cover is sourced from underground pumps and maintained by Quinsam Coal personnel.

Based on the hydrogeology of the area and mine workings depth, the 2-North mine must be dewatered to allow operations underground. A series of underground pumps are used to move water to surface as needed. The underground 1 and 5 Mains are both each equipped with 2 x 200 HP surface pumps capable of pumping approximately 1500 gallons per minute respectively. The 6 Mains dewatering system consists of three pumps: 125 HP capable of pumping 500 gallons per minute, 200 HP capable of pumping 1500 gallons per minute and a third pump capable of pumping 750 gallons per minute. The 6 Mains system has been recently decommissioned as of June, 2016.

WD collects gravity fed water from Brinco Brook, which includes the disturbed surface runoff and underground water from the 2-North Portal Sump, 1, 5, and 6 Mains underground dewatering systems. WD acts as the final collection point before discharge into the receiving environment through a meadow/biomass system prior to entry into Middle Quinsam Lake. The pond encompasses approximately 2.4 hectares of marshland with an average depth is 1.5 metres and a storage capacity of approximately 30,000 m^3. It has been designed to receive a 1 in 10 year flood event and is designed with an emergency spillway to prevent structure failure during extreme flood events. WD is a source of wash plant water that is pumped to the wash plant for usage in coal processing. Used wash plant water is pumped to the tailings dam where it filters through the dam to the 2-North Portal Sump. Water in the 2-North portal sump is used for underground equipment, dust suppression and emergency firefighting. Excess water received in this sump is moved with a 65 HP pump that pumps water alongside the 2-North high wall via 12 inch pipe discharged into Brinco Brook.

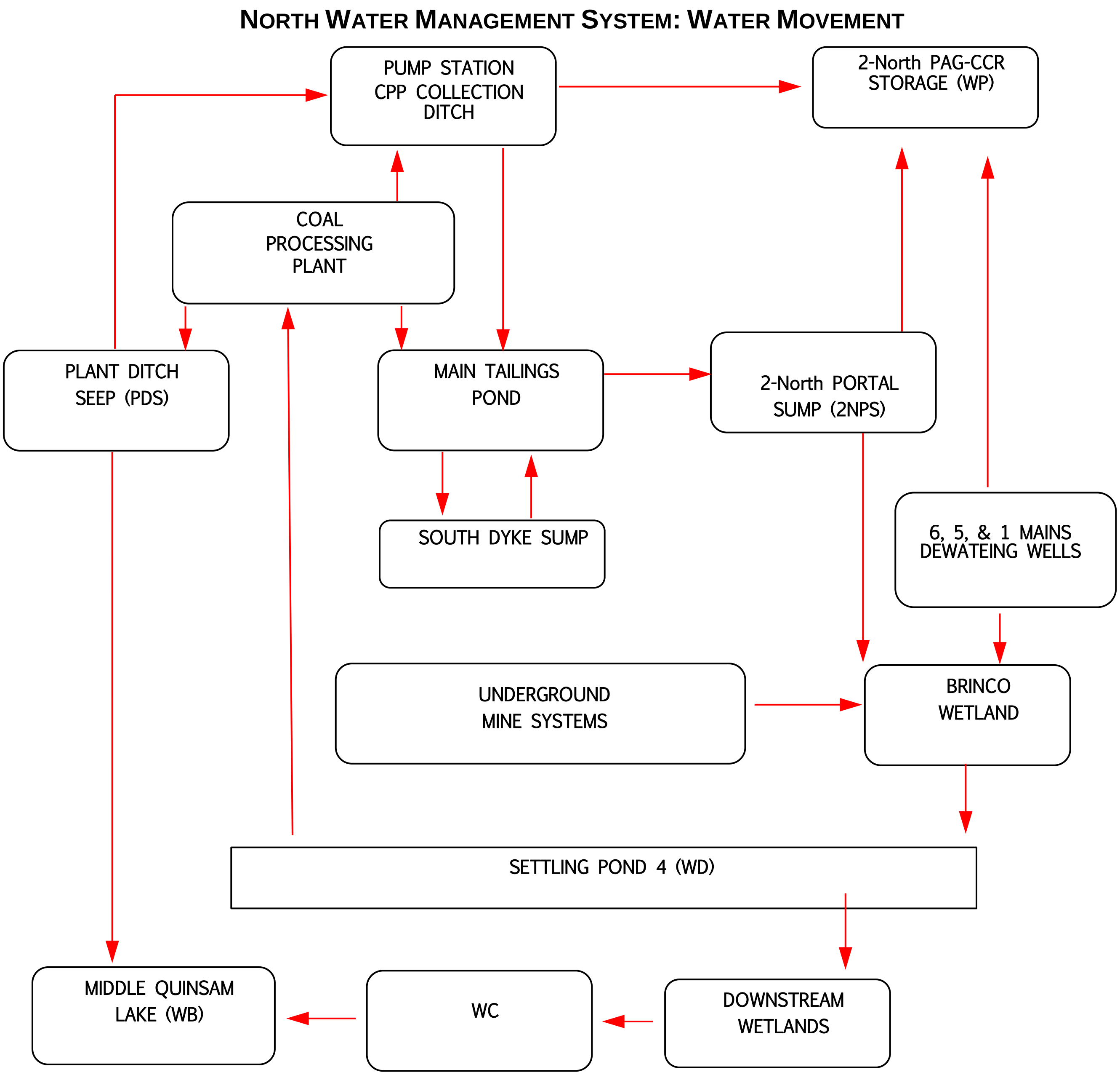

Figure 1: Water Movement and Flow Path in the North Management System

1.1.2 *The South Water Management System*

The South Water Management System is designed to collect mine related runoff from the south disturbed surface areas and manage water in the 2 and 3-South PAG-CCR Ponds, Long Lake Seep Passive Treatment System and 5-South mine workings.

Two long-term PAG-CCR facilities (2-South and 3-South) have been completed as part of the south water management system. The construction of the 2-South PAG-CCR containment pond included a clay-bentonite liner to retain water within the pit. Construction and storage of material carried on to completion in 2014 where water was diverted into the area. A series of ditches and pipes were installed to utilize local catchment as a source of water cover. Surface personnel control valves to direct fresh non-mine impacted water into the PAG-CCR facility or direct to No Name Lake. A minimum of 1.50 metre water cover is required in the 2-South PAG CCR which is sourced from local catchment and precipitation. Excess water from the 2-South PAG-CCR Pond overflows into a large waterway that leads into the 3-South PAG-CCR storage facility. This spill way was constructed in 2015. Water received from 2-South is used to provide adequate water cover over 3-South (1 metre). Excess water in 3-South is pumped via an 88 Hp pump capable of pumping 500 gallons per minute directly into the road side collection ditch that flows into SPD.

SPD receives a majority of water from the South Management system and is the controlled discharge point in which water quality is compared to permit limits for environmental compliance. It encompasses 1.8 hectares of wetland area and has an average depth of 1.5 metres. An emergency overflow ditch was built into the impoundment dam and is located on the north end of the pond. An effluent channel leads into a series of meadow/biomass system comprised of several meadows and wetlands before discharge into Long Lake. LLE is the last monitoring station prior to the effluent entering Long Lake, which is considered the receiving environment.

A siphon pipeline has been installed from SPD to the 3-South Pit in case of emergency situations to ensure 1 meter water cover over the potentially acid generating coarse coal refuse (PAG-CCR). In 2015, a pumping system was installed in the 5-South workings to reduce water levels over the 8-Mains plugs that separate the 5-South and 2-North mines. SPD receives the water pumped periodically from 5-South mine.

The Long Lake Seep Passive Treatment System (LLPTS) is designed to inhibit flow at the Long Lake seep by lowering the 2-South mine-pool via pumping where it is treated on surface. Effluent from this system is combined with SPD discharge at the location Biocell Downstream (BDS).

South Water Management System: Water Movement

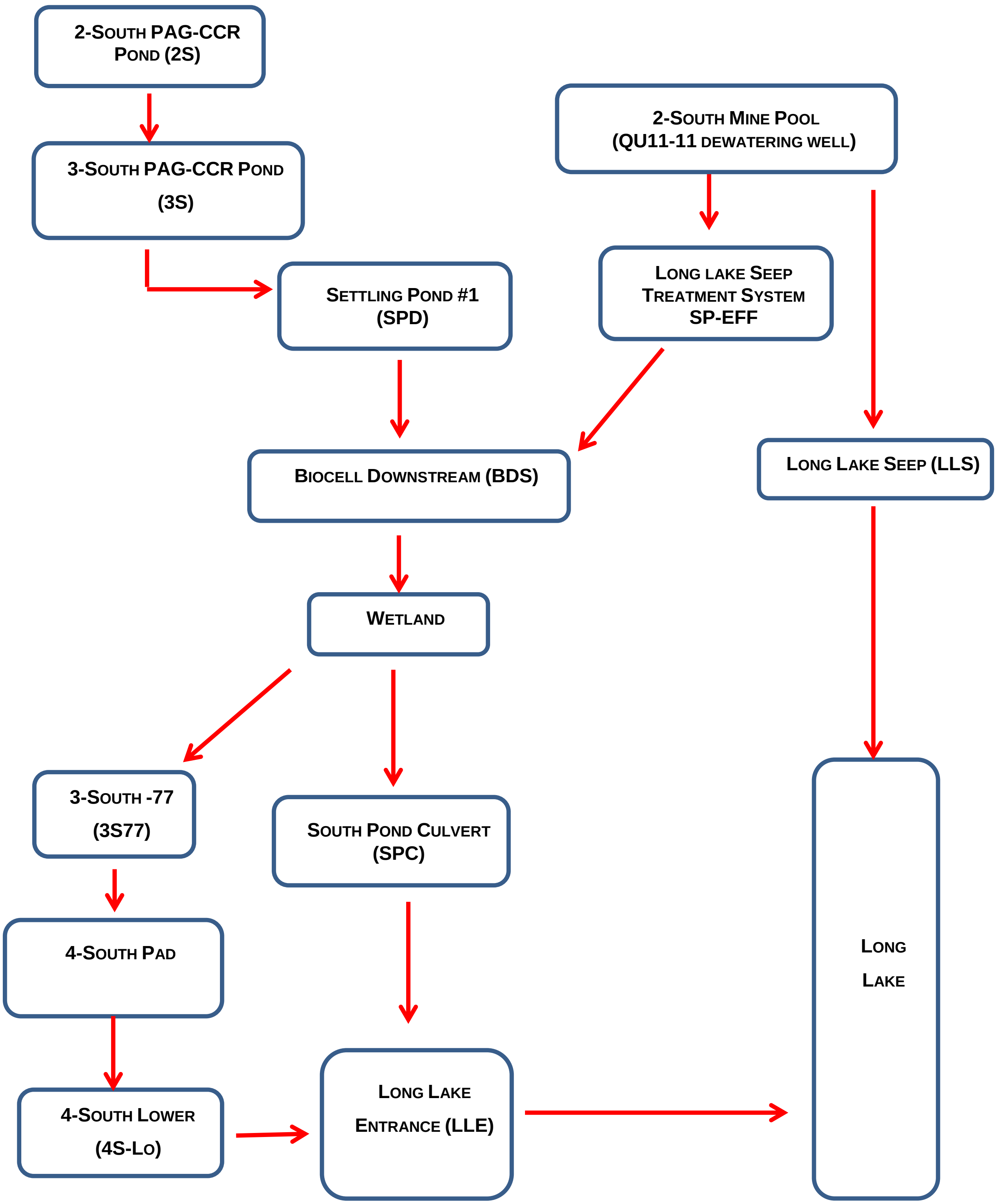

Figure 2: Water Movement and Flow Path in the South Management System

1.1.3 *7-South Water Management System*

The 7-South Water Management System include the 7-South Surface Decant Settling Pond (7SSD), 7-South-Portal Sump (7SPS), 7-South Containment Pond (7SCP), a site downstream named 7S Stream 1 (7S) and a series of ditches and drainage structures. Together, this system is designed to manage excess water from the 7-South catchment area and mitigate environmental impacts from disturbed surface locations related to mining and underground activity. Water is collected and stored in three main areas of the 7-South Mine catchment area.

7SPS contains water that is collected from dewatering processes during mining activity and the majority of the surface water from the coal storage pad is directed into the adit sump. Water is pumped from active mining areas and stored adjacent to the portal entrance. This water source is used for dust suppression on the mining equipment and forms a component of the fire suppression system. Water levels at 7SPS are monitored daily and when water levels rise beyond a desired storage capacity, excess water is pumped underground into the 5-South Mine.

7SCP collects surface runoff from the 7-South surface disturbance area, local groundwater and any infiltration of water from the coal pad. This pond allows suspended solids in the surface water to settle before the water enters 7SSD. When this pond reaches a certain capacity it discharges through a culvert into 7SSD. In 2015, the 7SCP was enlarged in order 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 does not eliminate any discharge from 7SSD but aids in the reduction of discharge. During times of heavy precipitation 7SSD must discharge.

7SSD is the main water collection pond for the 7-South Mine area with a cumulative catchment of 3.14 hectares. The ponded water at 7SSD is a mixture of infiltration of groundwater from the surrounding hillsides and the coal storage pad. This water is monitored for quality and quantity during discharge events. Water is discharged from the settling pond via a 2 inch discharge line that is equipped with a valve allowing environmental personal to set the discharge rate based on flow rates found at the downstream site 7S. Using water quality results and interpreting models indicate that an 8:1 ratio (7S:7SSD) is suitable to protect the receiving environment. It is noted that this is a conservative value and water quality downstream remained favourable with dilution ratios less than 8:1.

Discharge from 7SSD forms the headwaters of Stream 1. Monitoring location 7S is located on Stream 1 below the confluence with Stream 2 and, for the purposes of the effluent permit, is compared to British Columbia water quality guidelines which are used to evaluate potential effects on aquatic receptors at this location.

7-South Water Management Systems: Water Movement

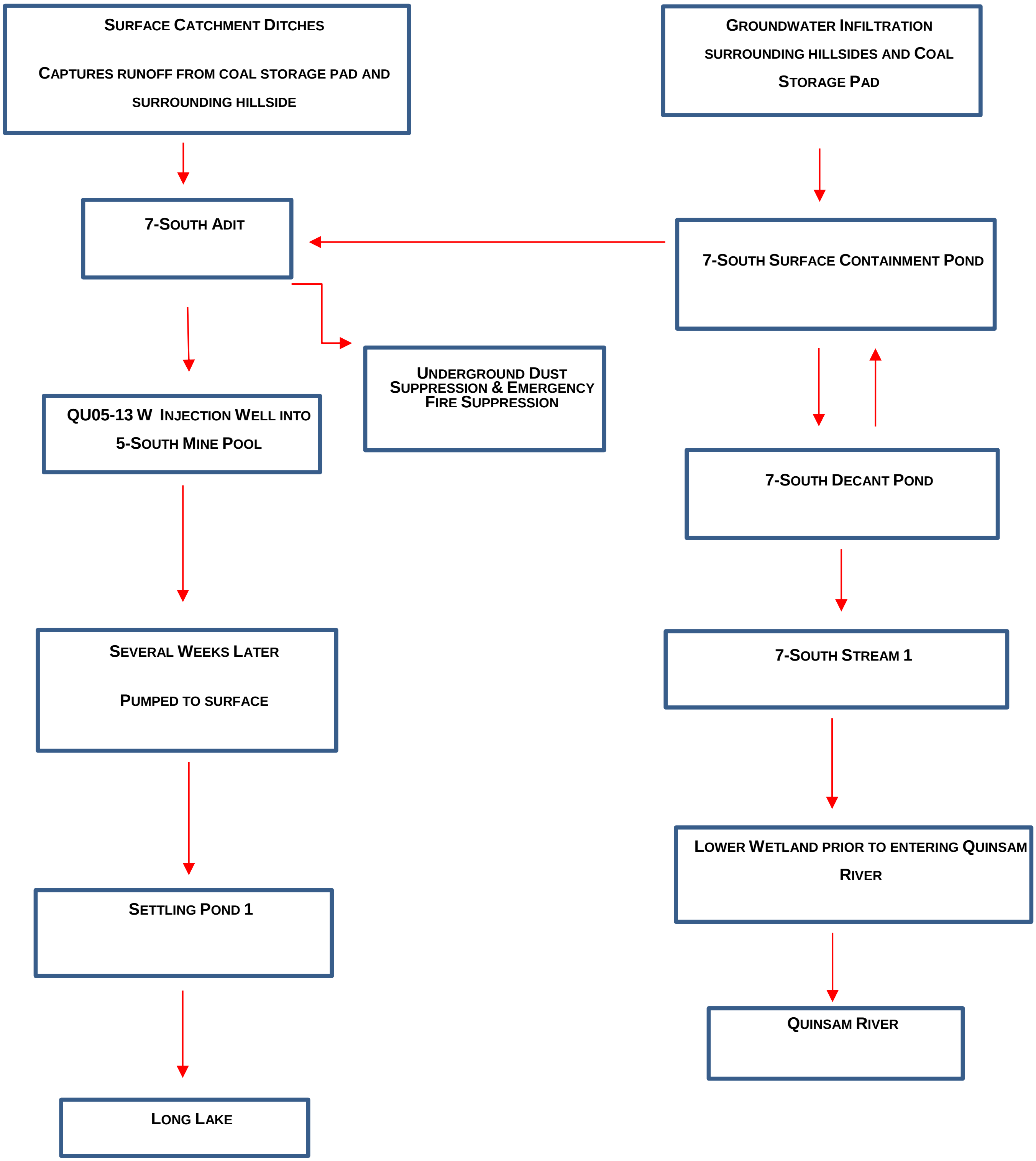

Figure 3: Water Movement and Flow Path at the 7-South Operation

1.2 Receiving Environment Stations

1.2.1 *River and Stream Monitoring Stations*

Effluent Permit PE-7008 identifies a number of river and stream monitoring stations which represent the receiving environment for various mine related discharge(s). The majority of these stations are monitored on a 5 in 30 sampling frequency during the Spring, Summer and Fall seasons.

Quinsam River Sub-Basin

- WA – Located above all mine related discharge and therefore represents background (baseline) conditions for water quality comparison.
- WB – Located at the outflow of Middle Quinsam lake and represents the combined discharge for both North and South water management systems.
- No Name Lake outlet (NNO) – Located at the outflow of No Name Lake and above all mine related discharge in the South. Therefore, the water quality at this station is used as a background for the South water management system.
- Long Lake Outlet (LLO) – Located at the outflow to Long Lake and captures all South mine related inputs (i.e. LLE and Long Lake Seep).
- QRDS1 – This station is located downstream of WB and thus captures any changes in water quality as a result of potential seepage from 2-North and 5-South mines.
- 7S – Represents the receiving environment monitoring location on Stream 1 for the 7-South operation.
- Lower Wetland Outlet (LWO) – Station is located on Stream 1 and represents the final water quality prior to combining with the Quinsam River.
- 7SQR – Located below Stream 1, LWO and Quinsam River confluence and therefore captures any incremental changes in water quality that may be attributed to 7-South operation.
- IRQR – Station located below the confluence of the Iron River and Quinsam River and will represent the cumulative mine related discharge for all current operations (upon development of 7-South Area 5).

Iron River

- IR1 – This station is located upstream of any mine related activity and represents baseline conditions.
- IR6 – This station is also located upstream of any mine related activity (currently) and reflects baseline conditions. The primary difference between IR1 and IR6 is the change is geologic formation(s) which influence water quality.
- IR8 – represents the downstream monitoring location on the Iron River and will be used to quantify potential influence of 7-South Area 5 (once developed).

1.2.2 *Lake Monitoring Stations*

Effluent Permit PE-7008 identifies a number of lakes comprising the receiving environment for various mine related discharge(s). All lakes are monitored on a 5 in 30 sampling frequency during the spring, summer and fall seasons.

The lake program focuses on:

- No Name Lake – Located within the South mine development area with the sampling location upstream of any known mine related surface and sub-surface discharge.
- Long Lake – Located within the South mine development area and receives both South water management discharge and Long Lake Seep discharge.
- Middle Quinsam Lake – Located adjacent to the North mine development area, this lake receives all discharge from the North water management system and upstream (non-mine related) inputs. Long Lake also flows into Middle Quinsam Lake at the South end via a small tributary stream (LLO).
- Lower Quinsam Lake – Located well below mine related discharge(s) Lower Quinsam Lake represents the combined Quinsam River and Iron River water quality.

1.3 ADDITIONAL MONITORING PROGRAMS

1.3.1 *BASELINE*

Quinsam frequently conducts additional monitoring to support permit amendment efforts or provide additional insight into water quality trends and observations. Although this information is not specifically included in this report the data may be used as part of future submissions to the Ministry of Environment.

1.3.2 *SEDIMENT AND BENTHIC MONITORING*

The upper and lower watershed sediment and benthic monitoring program will be conducted during late summer of the 2016-2017 reporting period in accordance with condition 4.2.7 (iii) of Permit PE-7008.

1.3.3 *GROUNDWATER*

The groundwater results have been compiled as a separate report titled "*Quinsam Coal Corporations Annual Groundwater Report for 2015"* submitted on March 31, 2015. This report outlines the sampling methods and analytical results of the 2015 monitoring program for all groundwater wells and underground sumps monitored.

1.4 INSPECTIONS

Quinsam environmental personnel conduct routine inspections of the North, South and 7-South mine water management systems.

For the North system, the inspections include:

- A visual inspection of the dewatering well pumps and discharge into Brinco Brook
- A visual inspection of the culvert under the main road (Brinco Brook to SP4) to ensure that water is flowing with no obstructions
- A visual inspection of the main dam (Settling Pond 4) to ensure the integrity of the structure
- A visual inspection of the automated sampler and the suction line installed at the WD decant for debris accumulation
- Confirming the WD flow meter is measuring and recording the level of the water as it is decanting
- Inspection of the tailing pump box, plant-site ditch and sump and their functionality
- Visual inspection of the tailings dam

For the South System, the inspection includes:

- A visual inspection of the 4-South reclaimed pad and culvert
- A visual inspection of the water level at 3-South PAG-CCR storage area and pump
- A visual inspection of 2-South PAG-CCR storage area, water levels pumps, channels and weather station
- A visual observation of the containment ponds, roadside sumps and ditches
- Visual inspection of the SPD main dam structure
- Confirming the SPD flow meter, automated sampler and suction line are operational and accurate
- Inspection of the passive treatment system and its functionality

For the 7-South System, the inspection includes:

- Observation of all ditches, sumps and ponds for water level and sedimentation accumulation

- Confirming pump operation during high precipitation events.
- Walking the 7SSD embankment to confirm structural integrity
- Observation of decant valve and flow measurement (if discharging)
- An inspection of the pipeline to QU05-13 injection well to ensure there are no leaks in the pipeline

1.5 MAINTENANCE

To ensure proper function of site wide water management systems maintenance of haul roads, roadside ditches, catchment ditches, ponds, culverts, pumps and water lines is performed on a routine basis.

In general, some of the regular maintenance around the mine site includes the removal of debris from culverts, the replacement of silt fences and straw bales and the removal of sediment build-up from the catchment ditches and ponds. Pumps and water lines are inspected daily and maintained as part of the surface inspection.

2.0 Materials and Methods: Environmental Monitoring Program

For this reporting year (2015/16), all of the water samples collected were analyzed in accordance with Permit PE-07008. Field sampling was conducted in accordance with the methodologies as described in the most recent version of "*The British Columbia Field Sampling Manual for Continuous Monitoring of Air- Emissions, Water, Soil, Sediment, and Biological Samples.”*

Quinsam contracts Maxxam Analytics of Burnaby B.C. for the analysis of surface and ground water quality samples. The phytoplankton samples for species count and identity continue to be analyzed by Stantec. Zooplankton species count and identity are sent to Fraser Environmental in Burnaby for analyses.

2.1 Water Quality Analysis

Maxxam Analytical performs all of the laboratory analysis for QCC. Quinsam is required by permit PE-07008 to perform specific analysis on certain effluent samples. Each site has a different set of parameters required for analysis by permit.

The following represents a generalized list of parameters monitored at each station:

- Total suspended solids (TSS)
- Total dissolved solids (TDS) (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 nitrogen (mg/L)
- Nitrate/nitrite combined as nitrogen (mg/L)
- Dissolved Organic Carbon (mg/L)
- Total and dissolved phosphate (mg/L)
- Total and dissolved metals (mg/L)
- Oil and grease (for stations SPD and WD only) (mg/L)

- Rainbow trout bioassays (for stations SPD, WD and 7SSD only)
- 7 Day *Ceriodaphinia dubia* chronic toxicity test (at station 7S only)

The following parameters are specific to lake sampling:

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

The required metals analyses performed at Maxxam Analytics comply with the CCME/BC WQG analytical package for both total and dissolved fractions. The laboratory utilizes conventional and chromatography coupled Inductively Coupled Plasma Mass Spectrometry (ICPMS) equipment to provide superior sensitivity and specificity for parameters at trace concentrations. This analytical package is used for the analysis of both total and dissolved metals at all monitoring stations as per the recommendations of the MoE.

2.2 Environmental Monitoring Equipment

The following equipment has been used to conduct the 2015-2016 monitoring program at Quinsam Coal:

- ISCO 4210 flow meters equipped with a paper chart plotter and datalogger are connected to a sonic depth sensor to measure water height above decant. Water height is used to determine discharge by using provided weir/orifice equations. Continuous monitoring is achieved using a datalogger and interrogated using a PC with Flowlink software. Information is displayed in Appendix I, Tables 121 - 124.
- A Sitrans F M MAG 8000 CT electromagnetic flow meter is used to record discharge at 7SSD.

- ISCO 12-volt automatic samplers programmed to collect daily composite samples are deployed at all permitted discharge locations.
- A YSI Exo 1 multiparameter sonde and YSI Pro-Plus are used to obtain physical water quality parameters. Quinsam staff calibrates these units using proper calibration solutions prior to each sampling event and follows recommended manufacturer specifications for maintenance and handling.
- For routine monitoring of pH and conductivity, 2 handheld sondes (Eutech PC Tester 35) are employed.
- Levelogger pressure transducers are used throughout the mine-site for obtaining continuous water level measurements at Long Lake outlet, Middle Quinsam Lake Outlet and the Iron River, which, in turn, are used to create daily hydrographs.
- A 4 litre Beta sampler is employed to facilitate depth profiling water quality analysis. This devise is constructed with materials to minimize interferences of trace metal and the large volume allows staff to obtain all water quality samples using only one deployment per depth.
- A Davis Vantage Pro 2 weather station module is used for meteorological purposes. The Davis Vantage Pro 2 controller records rain, relative humidly, atmospheric pressure and temperature available for download via PC.
- A Campbell Scientific weather station is used to collect temperature, precipitation, wind, humidity, solar intensity and snow accumulation. This station was installed next to the 2-South pit in August of 2015 and was operational starting October 2015.

Although this list is not exhaustive of all equipment used on a day-to-day basis in the Environmental department it does provide an overview of the significant devices.

2.3 Quality Assurance/Quality Control

All Quality Assurance/Quality Control sampling was performed based on certain requirements of the British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air Emission, Water, Wastewater, Soil, Sediment, and Biological Samples, 2013 Edition.

Quality assurance practices have been integrated into the water sampling program to ensure the integrity, consistency and reproducibility of sampling techniques performed throughout environmental monitoring. Various samples including field blanks, trip blanks, equipment blanks, and replicates are used to evaluate methods along with any deficiencies that may result from sampler technique or 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 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 and are transported into field locations with samplers to determine if any contamination may occur due to the handling or storage of sample bottles during a trip.

- Equipment Blanks – Equipment blanks are samples of laboratory-grade, reverse osmosis, deionized water placed into a piece of equipment used for sampling. This water is treated as a normal sample with the equipment where it may be subject to possible contamination or interference from other substances. Water is deposited into a sample container at a representative location. Equipment blanks evaluate any contamination within the equipment and identifies deficiencies with sample procedures, equipment maintenance and 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 obtain the precision for each analyte analyzed within samples. Observed variance between replicates identifies any uncertainty in sampling, environmental heterogeneity and laboratory analysis.

Replicate samples are collected every sampling event accounting for approximately 10% of overall analyses requested from the laboratory. There are a number of different sampling events and if, for example, a monthly sampling event spans over two days then only one replicate sample is collected. The primary events at Quinsam include:

- Weekly, monthly and quarterly sampling for all permitted monitoring locations
- Receiving environment sampling for lakes, rivers and streams following a 5 in 30 three times per year schedule
- Long Lake Treatment System (Biocells) are sampled monthly and a field blank and replicate is collected quarterly

Relative Percent Difference (RPD) values between replicate samples are calculated in accordance with the British Columbia Field-Sampling Manual using the following calculation:

$$RPD = \frac{\text{(Sample Result - Duplicate Result) X 100}}{\text{(Sample Result + Duplicate Result) / 2}}$$

Calculation of RPD values between samples and their respective replicates are used to measure variance and overall integrity and representation of samples obtained. This calculation is only applied to results where at least one of the samples is reported as >5x the laboratory Method Detection Limit (MDL). Criteria for acceptable RPD values are stated in the *British Columbia Field Sampling Manual, 2013.* Values less than 20% are deemed acceptable; values between 20-50% identify a potential problem and values greater than 50% identifies a definite problem most likely due to sample misrepresentation or contamination, especially if repeatedly found with a particular site, method or piece of equipment. RPD calculations greater 20% and 50% are presented in Appendix I, Tables 135-139.

During this monitoring year, Quinsam collected 1997 surface and lake water samples. Of these samples 100 were replicates including analysis of 4003 parameters. Of the analyzed parameters 89 had an RPD greater than 20% and 45 parameters had an RPD greater than 50%. Therefore 2.2% of all replicate samples had an RPD greater than 20% and 1.1% of the replicate samples had an RPD greater than 50%.

Total manganese displayed the highest number of RPD’s greater than 20% followed by total aluminum, turbidity and dissolved iron. These parameters are present in the water chemistry and are always above detection limits; therefore because of their consistent reoccurrence they often qualify for an RPD comparison and are often found 5 times above detection limits making them more likely to fail than others. There does not appear to be a parameter that fails consistently and with enough magnitude to identify a serious problem needing immediate remediation. Quinsam

Coal will continue to adhere to sampling practices identified in the BC field sampling manual and promote best practices at all location.

Of the 89 samples that were considered failures, 66 of them were encountered on lakes. It is noted that the greatest number of replicates were taken on the lakes and therefore have the highest representation of replication of all sampling techniques. It is still suspicious that such a high number of failures were seen prompting an internal investigation on lake sampling techniques. Upon review of practice, it was deemed that greater cleanliness, care and storage of lake equipment may increase sampling integrity. The beta sampler was inspected and replaced in the expectations that QA/QC will improve and provide an explanation for the number of RPD's that failed. A more rigorous cleaning program of the equipment was established including the use of hydrochloric acid and deionized water after every lake site to limit cross contamination and accumulation of any particles. Furthermore, more frequent equipment blanks are collected.

In addition to a new beta sampler, a sonar depth finder was purchased to accurately obtain the current bottom depth of each lake sampling location rather than relying on previous data and readings from the sonde's pressure transducer. In addition to visually identifying the bottom depth, the sonar equipment allows the user to see the depth of the deployed equipment in real time. This unit allows greater control of sampling depth and reproducibility of week-to-week sampling elevations for more comparable lake data.

The acceptability criteria used for the field blank samples was calculated in accordance with the quality assurances guidelines of the BC Field Sampling Manual, which states that field blank contamination should not be significantly greater in concentration nor occurrence than laboratory method blanks contamination. Any analysis results that have been found to be greater than 2x's the laboratory MDL are identified and investigated to determine potential contamination.

Field blank and trip blank results were within the acceptable range for majority of sample analysis during this reporting period as displayed in Appendix I, Table 140. There were 8 field blank samples, all of which were analyzed for sulphate and metals. 2 out of 8 samples received analyses in which a parameter was greater than 2x the MDL. In each of these samples, there was only one parameter of the entire suite that exceeded 2x MDL (total zinc and dissolved strontium). It is noted that almost every other parameter reported was below detection limits. There were 6 trip blanks obtained this monitoring period analyzed for sulphate and metals. 1 out of 6 samples received analysis with only a single parameter greater than 2x's MDL. With such low results, it is inferred that sampling techniques are acceptable and there is no need for any remediation.

Methods used by Quinsam Coal for sampling and QA/QC, and the precision shown by the analytical laboratory methods give great confidence in the accuracy and consistency of monitoring results. Internal performance audits will be continued in the future and any deficiencies will be thoroughly investigated to make improvements in sampling protocol. All employees will be kept up to date with sampling procedures and provided with all training and equipment necessary.

3.0 Hydrology

3.1 North Water Management System

3.1.1 *Settling Pond #4 (WD)*

Flow rates did not exceed the permitted maximum discharge of $0.32m^3/s$ throughout the entire monitoring period. The highest rate of discharge at WD reached $0.241m^3/s$ during a heavy precipitation event in December 2015. Cumulative discharge throughout the monitoring year totaled 3,218,876 m^3 equating to an average flow rate of $0.102m^3/s$. This exceeded the permitted annual average discharge rate of $0.08m^3/s$ (2,522,880 m^3). Figure 4 represents the maximum daily discharge as well as the average annual discharge (displayed as a cumulative value) against permit limits. As depicted, the annual average discharge exceeded the permit limit of $0.08m^3/s$ (2,522,880 m^3 annually) for the reporting year.

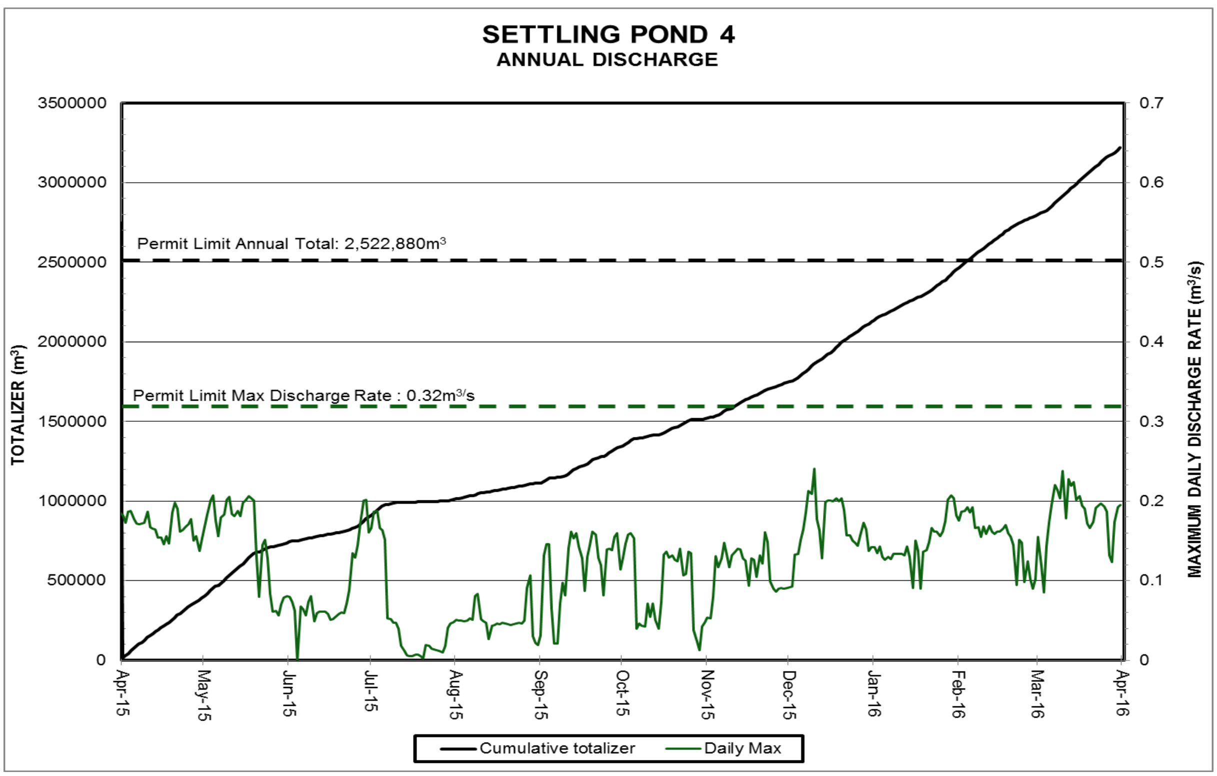

Figure 4: Settling Pond #4 Maximum Daily and Cumulative Discharge

Elevated discharge rates at WD are observed during the winter and spring periods which coincides with increased (seasonal) precipitation events. Consequently, higher surface runoff and enhanced underground dewatering efforts to maintain dry mine operations increases discharge at WD. Furthermore, cessation of coal processing limited water extracted from the pond and resulted in higher discharge rates.

A summary of WD discharge is displayed in Appendix I, Tables (123-124).

3.2 South Water Management System

3.2.1 *Settling Pond #1 (SPD)*

The annual maximum flow was 0.198m^3/s and the annual average flow was 0.0386m^3/s, both well below the permitted maximum daily discharge of 0.46 m^3/s and annual average discharge of 0.10 m^3/s. Figure 5 represents the maximum daily discharge as well as the average annual discharge (displayed as a cumulative value) against permit limits.

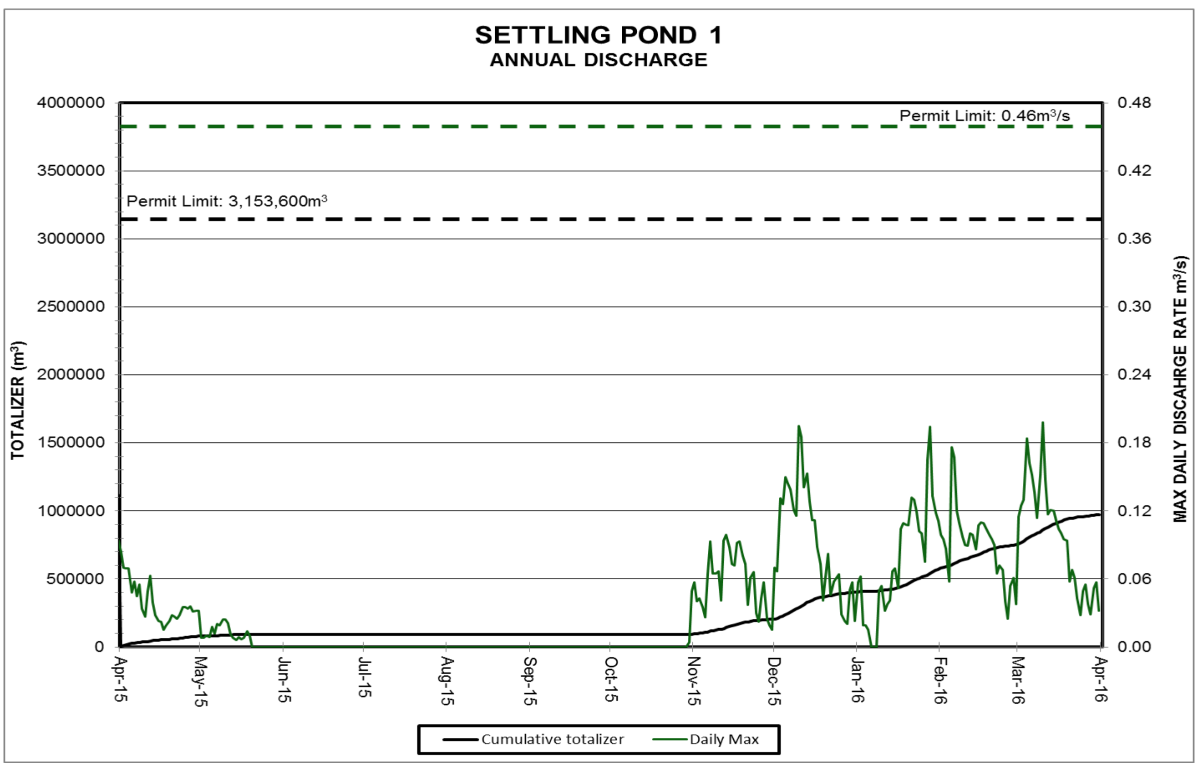

Figure 5: Settling Pond #1 Maximum Daily and Cumulative Discharge

Daily discharge peaked at SPD multiple times coinciding with heavy precipitations resulting in increased surface runoff and pumping from the 3-South pit and 5-South underground. The maximum observed rate of discharge was seen in March 2016. The spring and summer of 2015 received low accumulated precipitation and there was no flow recorded from mid-May through late October.

A summary of SPD discharge is displayed in Appendix I, Tables (136-137).

3.2.2 *LLE*

Discharge at LLE represents the combined flow from the South water management system (SPD and SPEFF, along with contact water from the 4-South portal area, and non-mine related surface water from the upstream wetland and drainage features. As such, this station provides cumulative flow data from the aforementioned sources representing all permitted discharges from the South water management systems.

Flow at LLE is well correlated with precipitation events and, historically, would experience a seasonal dry period. However, since the commencement of the Long Lake Seep treatment system a base flow (corresponding with treatment system discharge) is present.

Appendix II, Graph 107 displays discharge versus precipitation at LLE.

3.2.3 *Long Lake Seep*

The flow recorded at Long Lake Seep indicates a dependency on mine pool (void) water levels as depicted in Figure 6. Mine pool water levels correlate with seasonal precipitation with the highest levels observed in March 2016. As mine pool levels decrease below a certain elevation in late spring, flow at the seep decreases significantly and eventually stops. In 2015, no flow was recorded in June through November. It is determined that seep flow is most closely related to water level at the monitoring well MW004 and the threshold level for seep flow is approximately 303.5 mASL. This trend will continue to be observed and verified in year after year observations.

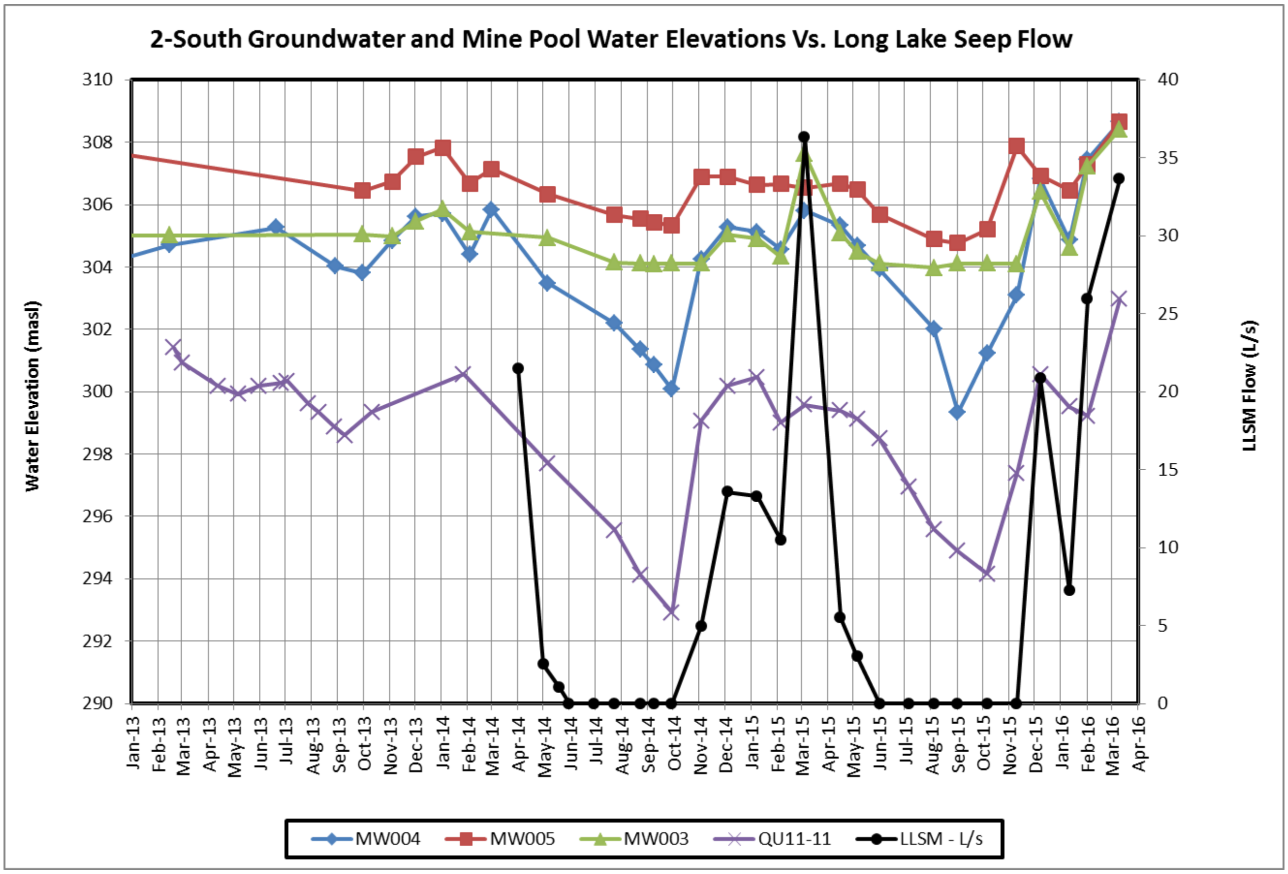

Figure 6: Groundwater and Mine Pool water elevations vs. Long Lake Seep Flow

In late 2014, upgrades were made at LLSM to include more representative weir flow measurements using a sonic water level device and flowmeter. This data is obtained via flow monitoring software and compared to precipitation as displayed in Appendix II, Graph 106. This system is currently out of operation and manual flow measurements are obtained weekly. This system will be reestablished in the near future.

3.3 7-South

The maximum authorized discharge from settling pond 7SSD is 0.005m^3/s (5 L/s). However, discharge quantity is dependent on assimilative capacity of Stream 1 and therefore dynamic in nature. To facilitate determination of the appropriate discharge level at 7SSD a flow rating curve was developed for monitoring station 7S. This rating curve allows for instantaneous flow levels at 7S by reading the installed staff gauge. Figure 7 below depicts this curve.

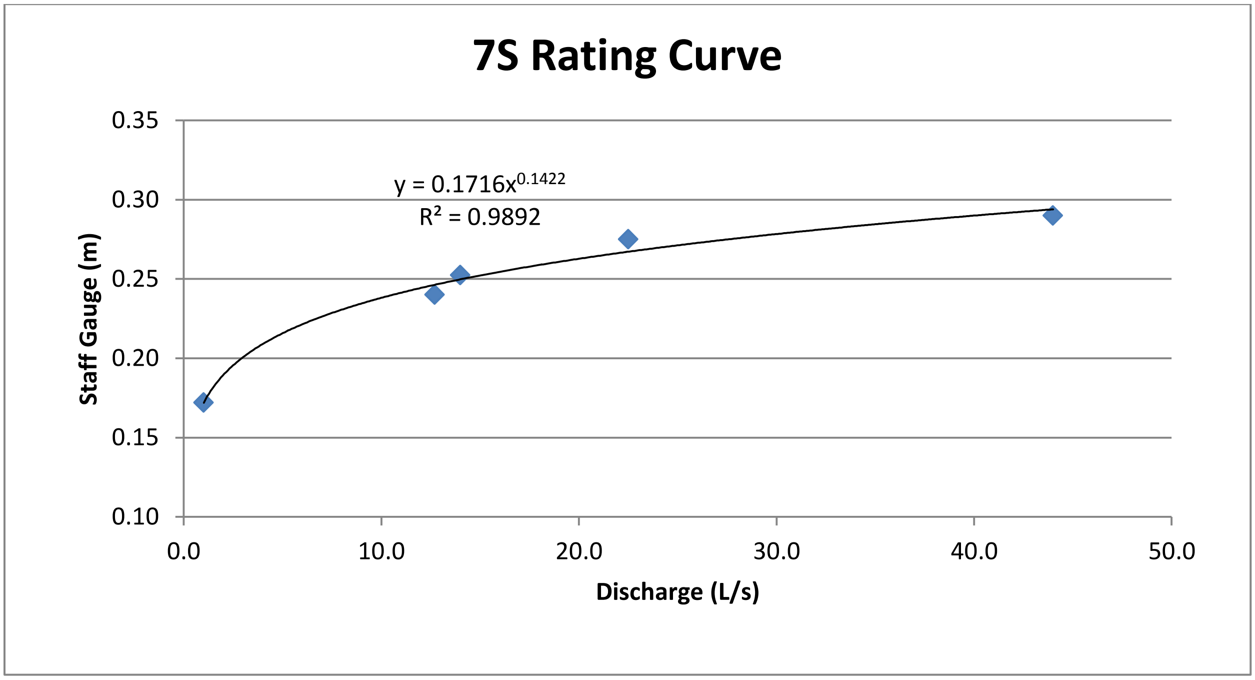

Figure 7: Monitoring Station 7S Stage Discharge Curve

Initially, an 8:1 dilution ratio was targeted to maintain desirable water quality in the receiving environment downstream of 7S. However, throughout the 7-South operational period Quinsam has demonstrated that the 8:1 dilution ratio can be amended while maintaining water quality guidelines in the receiving environment (station 7S). The dynamics of this system are still being monitored and measured; as a more robust dataset is developed the information will be evaluated to ensure discharge is optimized to achieve protection of sensitive aquatic receptors and facilitate mine operations.

In 2015, attempts were made to minimize discharge from 7SSD. The containment pond that delivers water into 7SSD (7SCP) was enlarged in order 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 does not eliminate all discharge from 7SSD but significantly reduces discharge frequency and aids in management during times of heavy precipitation.

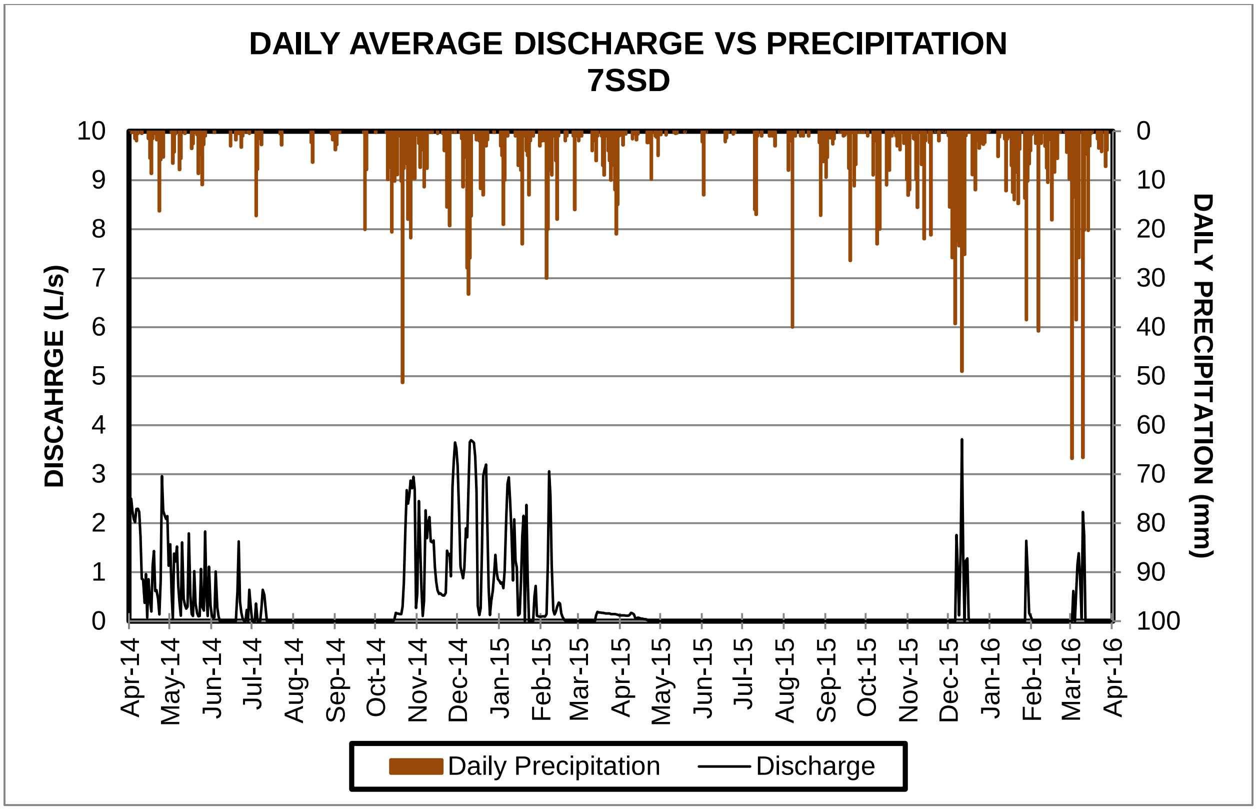

Figure 8: 7SSD Discharge

Figure 8 depicts 7SSD discharge rates along with local precipitation. It is noted that significantly less discharge occurred during the 2015-2016 monitoring period compared to previous years with zero discharge from May to December. 7SSD is discharge is exclusively influenced from groundwater inputs and precipitation. Appendix I, Table 125, displays cumulative flow measured at 7SSD for this reporting year with an annual average flow rate of 0.07L/s totalling 2,204m^3. Maximum discharge rates did not exceed the maximum permitted discharge (5 L/s) during the entire period and a dilution ratio of >8:1 was maintained at all times. Appendix I, Tables 126-127, provide the 7SSD and 7S dilution ratios for 2015-16 reporting year while Appendix II, Graph 109 compares the 7SSD Discharge vs Precipitation.

4.0 RECEIVING ENVIRONMENT

Hydrometric stations have been established in the receiving environment to monitor hydrological conditions at key monitoring locations associated with the Quinsam Mine operational area. Hydrographs (stage discharge curves) for these stations have been developed using various methodologies (e.g. staff gauge, pressure transducer, manual measurements, etc.) and are continuously updated to ensure that the full range of flow is captured.

This 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 influences certain parameter concentrations (e.g. sulphate).

Flow data for WA has been provided by Environment Canada for the Quinsam River at the Argonaut Bridge; the data is currently unapproved and subject to revision. The upstream flow for WA is controlled 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 other receiving environment stations.

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

Appendix II, Graphs (104, 105, 108, 110 and 111) display the flows compared to water level measurements and precipitation for all receiving environment hydrometric stations (WA, WB, LLO, 7S, LIR).

5.0 Mine Related Discharge Results & Discussion

This section includes a discussion on the North, South, and 7-South water management systems with respect to significant monitoring locations (e.g. settling ponds) and covers the primary parameters of interest to provide context for evaluating receiving environment water quality compared to mine related discharge.

Complete 2015/16 water quality data for the North, South and 7-South water quality monitoring stations are presented in Appendix I, Tables (4-25, 118-120 and 128-130). Weekly field pH and conductivity results are displayed in Appendix I, Tables (131 -134).

Summary statistics for the previous 3 years have been prepared for Settling Ponds (1, 4 & 7SSD) and the applicable downstream monitoring locations (LLE, WC & 7S). The statistics includes a comparison of year over year annual averages for parameters of interest at LLE, WC & 7S including: alkalinity (alk-T), sulphate (SO_4^-), arsenic (As), cobalt (Co), copper (Cu), iron (Fe), hardness (Hard.), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), silver (Ag) & zinc (Zn). Refer to Appendix 1, Tables (147-152) to review the results for the annual averages calculated for Settling Ponds, LLE, WC and 7S.

A six year statistics summary for the Settling Ponds includes minimum, maximum, average, median, geometric mean, count, count < detection limit (DL), standard deviation, 1st quartile, 3rd quartile & standard error for all Settling Ponds and applicable receiving environments pertaining to monitoring years 2010-11 to 2015-16 where applicable. The parameters included for the Settling Ponds are: SO4, As-T, As-D, Al-D, Cu-D, Fe-D, Mn-D, Mn-T, Pb-D, and Zn-D. Refer to Appendix 1, Tables (153 -162) to review the six year summary statics calculated for Settling Ponds.

For a summary of permit limit exceedances please refer to Appendix I, Table 1 and Appendix VIII to review the Annual Status Form prepared for PE-07008.

5.1 North

The two primary monitoring locations in the North water management system are located at the sedimentation pond decant (WD) and the final discharge point above Middle Quinsam Lake (WC). Accordingly, the following discussion will focus on those two stations. Results for the additional monitoring locations in the North mine area can be referenced in the Appendix I, Tables (5 -10, 128, 130,131 -134).

5.1.1 *Settling Pond # 4 (WD)*

The monitoring program conducted over this reporting period demonstrated that water quality for all permitted parameters was in compliance with only one parameter on one sampling occasion exceeding permit limits. A marginal TSS exceedance (30.5 mg/L) was observed on December 16th – an isolated event with preceding and subsequent results well below the permitted level. This was reported as a spill and the corresponding spill report number is DRG-152826 (refer to Appendix VII).

Refer to Appendix I, Tables (4, 118, 128 and 131 -134) for Settling Pond #4 water quality results.

Table 1. 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*	0.5	mg/L
Copper*	0.02	mg/L
Iron*	0.3	mg/L
Lead*	0.05	mg/L
Zinc*	0.1	mg/L
Rainbow Trout Bioassay (Oncorhynchus mykiss)	**	96LC50

*Dissolved
**No mortalities at 100% effluent concentration after 96 hour

5.1.1.1 General Parameters

pH

This reporting year, field pH values displayed little variance with measurements receiving a neutral to slightly alkaline designation ranging from 7.60 to 8.40. Starting in April 2013, field measurements (instead of lab) were used for improved accuracy and reliability. Consequently, a slight decline in reported pH was observed compared to historic results as depicted in Appendix II, Graph 4.

Weekly field pH results are can be found in Appendix I, Tables 131 -134.

Total Suspended Solids (TSS)

The trend of low TSS concentrations continued from previous reporting years and validates proper management practices and controls implemented throughout the North mining area. Although one exceedance was noted, the impact of this exceedance in the receiving environment is deemed to be negligible as downstream TSS concentrations at WC were below laboratory detection limits.

A spill report summarizing the TSS exceedance is provided in Appendix VII.

Hardness and Dissolved Sulphate

Both hardness and sulphate at WD depict a pronounced decreasing trend (since 2000) as displayed in Appendix II, Graphs 1 and 2. During the reporting period, concentrations of hardness ranged from 269 mg/L to 375 mg/L (averaging 295 mg/L), while sulphate ranged from 258 mg/L to 820 mg/L (averaging 526 mg/L).

As reported in previous years, seasonal sulphate concentrations follow a cyclic pattern with lower concentrations generally occurring during late winter early spring and higher concentrations occurring during summer and early fall. Sulphate continues to be the primary parameter of interest from mine related discharge as it is found in elevated concentrations at all discharge locations. Appendix II, Graph 2 displays the average monthly sulphate results at WD.

5.1.1.2 *Dissolved Metals*

Since commencement of underground mining in 1992, the permitted dissolved metal concentrations have remained well below permit limits with minor fluctuations noted. Concentrations resulting from laboratory analysis are most often below detection limits. Appendix II, Graphs 6 through 10 presents the concentrations of the permitted metals and also those parameters of interest. All of the permitted dissolved metals (aluminum, copper, iron, lead and zinc) were well below permitted levels during the reporting period. Lead was removed as most results were below detection limits.

5.1.2 *Culvert into Middle Quinsam Lake (WC)*

Monitoring station WC represents the cumulative water chemistry emanating from the North mining area prior to entering Middle Quinsam Lake. Concentrations for parameters of interest at WC are typically slightly lower that that observed at WD. This is likely attributed to the attenuation that occurs along the WD-WC flow path which includes an expansive wetland. For example, the average sulphate concentration at WC for the reporting period was 504 mg/L, 22 mg/L lower than that recorded at WD.

5.2 **South**

The primary monitoring locations in the South water management system are sites that directly influence water quality in Long Lake including: Settling Pond #1 decant (SPD), Biocell Downstream (BDS), Long Lake Entrance (LLE), and Long Lake Seep (LLS). The biocell downstream monitoring station represents an additional location established under the '*Authorization to Bypass the Works*' and intended to capture the combined discharge of the Long Lake Seep Treatment System (SPEFF) and SPD. Accordingly, permit limits for SPD have been applied to this station.

Results for the additional monitoring locations in the South mine area (e.g. SPC) can be referenced in Appendix I, Tables (11 through 21).

5.2.1 *Settling Pond #1 (SPD) and Biocell Downstream (BDS)*

These two stations represent the cumulative mine related discharge from the South water management system and, as such have been combined for ease of comparison.

All parameters were below permit limits through this reporting period with the exception of TSS on January 23rd (26 mg/L) at SPD.

Appendix I, Tables (11, 119, and 128, 131-134,147 & 153-162) contain results pertaining to Settling Pond #1 water quality while Tables (13,128,130,131-134) contain results pertaining to BDS. Appendix II, Graphs 11 through 20 displays the parameters of interest for stations SPD and Graphs 32 through 34 compare sulphate, iron and arsenic concentrations at SPD, SP EFF and BDS.

Table 2. Permit Limits Applied to SPD and BDS

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*	0.5	mg/L
Copper*	0.02	mg/L
Iron*	0.5	mg/L
Lead*	0.05	mg/L
Zinc*	0.2	mg/L
Rainbow Trout Bioassay (Oncorhynchus mykiss)	**	96LC50
*Dissolved **No mortalities at 100% effluent concentration after 96 hour		

5.2.1.1 *General Parameters*

pH

All pH readings were within the applicable permit criteria range during this reporting year at both stations. Weekly field conductivity and pH are displayed in Appendix I, Tables 131 to 134.

Average field pH results were 7.83 and 7.70 for SPD and BDS, respectively. Appendix II, Graph 14 displays a decline in pH occurring in the fall once discharge commenced corresponding to pumping from 3-South and 5-South underground.

Nutrients

Dissolved phosphorous remained below permit limits of 0.03 mg/L at BDS at SPD this reporting year. All other samples reported below the applicable permit criteria for nutrients during this reporting year at SPD and BDS.

Total Suspended Solids (TSS)

TSS samples collected for this report period were a combination of grab samples and composite samples depending on discharge rates and sampling criteria. Of the 137 TSS were results collected, 1 reported above the applicable permit criteria for TSS (25.0 mg/L) at Settling Pond #1 with majority of results less than the detection limit of 4.0 mg/L. During the winter season, pumping from 5-South underground increased TSS concentrations with most samples reporting above detection limits of 4.0 mg/L. TSS ranged from <4.0 mg/L to 26 mg/L and averaged 8.0 mg/L. Appendix II, Graph 15 displays the last six years of data for SPD..

Hardness and Dissolved Sulphate

Prior to 2015, the 2 and 3-South Pits were the main contributors of sulphate to Settling Pond #1 discharges. As water management is now crucial in the 5-South mine pool, excess water is pumped into Settling Pond #1; increasing concentrations.

Settling Pond #1 (and BDS) demonstrates variations in sulphate concentrations dependent on pumping from 5–South underground and 3-South Pit during times of heavy precipitation. Higher sulphate values are expressed during the early spring through winter period (higher flow). Concentrations decease slightly though the late spring and increase again during summer with no discharge and pumping from 3-South Pit or 5-South.

Discharge ceased on May 19th, 2015 at SPD until October 31st, 2015 equating to zero sulphate loading. As such, sulphate concentrations measured at BDS are directly related to SPEFF with 100% of the flow at this station emanating from the treatment system. During 2015-16, sulphate at SPD (Appendix II, Graph 12) exhibited the highest concentrations through spring and summer with January through March continuing to display elevated concentrations. Annual average sulphate concentration was 337 mg/L.

Sulphate levels (BDS, SPD, and SPEFF) are compared in Appendix II, Graph 32. Increases in sulphate observed over the reporting year at SPD are primarily attributed to inputs from 3-South (and indirectly 2-South) and 5-South during pumping events throughout the fall and winter months. Although there is no distinct seasonal variation, a slight increase in sulphate was observed at SPD from 2012 to present. This trend will continue to be monitored considering the recent flooding of the 2S PAG-CCR facility and dewatering from 5-South. Dewatering occurs in order to maintain the water level in the underground workings and alleviate the pressure on the concrete bulk heads that are installed separating 2-North from 5-South.

Appendix I, Table (128) displays weekly sulphate results.

5.2.1.2 *Dissolved Metals*

All permitted dissolved metals (aluminum, copper, iron, lead and zinc) were below the respective limits during this reporting year for SPD and BDS.

5.2.2 *Culvert into Long Lake (LLE)*

The Long Lake Entry monitoring location represents the final point of discharge in the South water management system and is therefore an indication of overall mine influence entering Long Lake. It is important to note that this station is located at the outflow of a culvert with approximately 50m of channel downstream prior to ultimate discharge into Long Lake. Therefore, it is not considered the receiving environment but rather constitutes the upstream segment of a mixing zone. For the purpose of this report water quality guidelines have been applied at LLE as a mechanism to assess overall system performance and Long Lake loading.

Sulphate and iron are the two primary parameters of interest at LLE; both of which are typically elevated above their respective WQG. This monitoring period, sulphate exceeded the applied 128 mg/L average guideline in all samples taken (rolling averages) while iron exceeded the dissolved guideline in one monthly sampling event on January 7th, 2016 (0.406 mg/L). TSS exceeded the WQG-Max on one (1) occasion with a result of 39 mg/L on March 1, 2016 during a high flow event after a heavy precipitation.

Total phosphorous exceeded the Vancouver Island Objective in streams of 0.01 mg/L (applied from May through September). Exceedances occurred during low flow conditions on two occasions, in one in June the other in September with results of 0.0105 mg/L and 0.0121 mg/L, respectively. The elevated concentration is most likely attributed to treatment system discharge but further investigation and sample results will clarify. Lake sampling events performed during July and August did not reveal any elevated phosphorous in the Long Lake.

Sulphate, iron and TSS are influenced by precipitation events and source loading from the multiple disturbance areas within the South mining area. Accordingly, in 2014 Lorax was contracted to perform a loading assessment for LLE wetland to investigate the potential influence of the 4-South portal area on two parameters, sulphate and iron. The recommendations of this assessment were discussed at the ETRC agency meeting held on December 10th, 2015. Quinsam is in the process of completing the last steps of the study with the expectation that the results provide a greater level of understanding for elevated iron and sulphate occurring at LLE wetland. Quinsam has provided a written response to the seven recommendations in the Lorax report titled "*4-South Portal Area Loading Assessment*" in the 3rd Quarterly report submitted on January 30th, 2016 to the MOE.

During October 2015, the old corrugated steel pipe culvert (designated sampling location for LLE) was replaced with a new high density polyethylene pipe to improve water flow, bank stability and to minimize any water quality sampling interferences. During March through April, 2015 reclamation work was performed at the 4-South Pad. Reclamation activities at the 4-South Portal Area consisted of:

- Removal of mine related infrastructure and all coal pad related material
- Creating a water diversion ditch diverting water from flowing under the pad
- Backfilling / recontouring the highwall, portals and pad with till
- Recontouring the area with topsoil
- Planting Red Alder seedlings
- Application of bunch grass seed and fertilizer

It is expected that the new culvert and reclamation work performed on the 4-South Pad will minimize interaction of local drainage with the coal pad and reduce the loading of iron and sulphate on the LLE wetland. Supplemental information and water quality results will be included in future monitoring reports to gain a better understanding. As displayed in Appendix I, Table 148 the annual average of most parameters of interest have decreased compared to last year at LLE.

Annual average concentrations of total and dissolved iron displayed the greatest reduction over three years resulting in 0.418 mg/L and 0.155 mg/L, respectively. This reporting year, there were no exceedances of total iron and only one exceedance of dissolved iron indicating that water quality has improved significantly from previous years. The parameters that were observed to display a slight increase include total copper, dissolved copper and dissolved aluminum resulting in 0.00131 mg/L, 0.0008 mg/L and 0.0344 mg/L, respectively.

Appendix I, Tables (19, 129, 131-134 & 148) provide the full set of data collected at LLE and the three annual averages. Appendix II, Graphs (35 & 36) display dissolved iron and sulphate versus discharge and Graph 107 displays discharge versus precipitation at LLE.

5.2.3 *Long Lake Seep*

The seep into Long Lake is a bedrock groundwater seep, which is monitored for water quality and quantity to assess overall loading in Long Lake. Long Lake seep water chemistry is influenced by groundwater levels in the 2 and 3-South mining area(s) and is considered to be representative of 2-South mine pool. Seasonal 'flushing' events due to local precipitation are observed in the mine void which subsequently influences water chemistry.

Two seep stations are monitored on a continuous basis – LLS and LLSM. LLSM is considered the primary seep, as flows at this station are typically an order of magnitude greater than at LLS; as such, the hydrological station is located on this segment.

Overall, water chemistry remained consistent with that observed during previous reporting periods at both stations. A similar pattern of high flow during winter and no flow through summer and early fall was observed in 2015; however, this year the dry period was extended to five and a half months compared to the previous year's four month dry period. The seep stopped flowing from May 27, 2015 until November 17th, 2015. This occurred when the mine pool water level fell below the elevation of approximately 303.5 metres above sea level (mASL) (measured at MW004).

Dissolved sulphate concentrations at the middle seep are elevated with an increase observed from November through February and a slight decrease through spring. The smaller seep displays a trend of elevated concentrations during the winter and spring and slightly lower concentration's displayed during summer and early fall period. Although results are available for LLS, the cumulative flow at this station was negligible. The increase in sulphate concentrations observed during winter 2015-2016 may be attributed to oxidation (and leaching) of the mine void walls as displayed in Appendix II, Graph 37.

Other parameters of interest include arsenic, iron and total manganese; both arsenic and iron have exhibited a decreasing trend in recent years with total manganese remaining fairly stable. Appendix II, Graphs 38 - 40 displays the concentrations of dissolved arsenic, iron and manganese since 2011, respectively. As depicted, concentrations of dissolved arsenic are slightly decreasing since 2011 with concentrations typically remaining below 0.004 mg/L with one event above 0.005 mg/L in 2012. Dissolved iron has decreased significantly and remained stable since mid-2012 when QCC transitioned from field filtering to laboratory filtering of dissolved metals. Total manganese has remained below the WQG of 0.8 mg/L from 2011 to present.

During this reporting period, monthly water quality samples were collected from the seeps with results included in Appendix I, Tables 20-21 and 131-134. Appendix II, Graphs 37 through 40 displays concentrations of dissolved sulphate, arsenic, iron and total manganese at the seeps from 2011 to present.

5.3 7-SOUTH

The 7-South water management system is comprised of a number of structures (section 2.3) to manage local water in and around the disturbed area with the most significant structure being the 7-South settling pond (7SSD). This structure represents the point of discharge for 7-South operations and is therefore regulated under PE-7008. Table 3 below outlines the applicable permit limits at 7SSD for each controlled parameter.

Table 3. Permit Limits Applied to 7SSD

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*	0.1	mg/L
Cadmium*	0.000045	mg/L
Copper*	0.014	mg/L
Iron*	0.35	mg/L
Selenium*	0.016	mg/L
Rainbow Trout Bioassay (Oncorhynchus mykiss)	**	-

*Dissolved

**No mortalities at 100% effluent concentration after 96 hour

5.3.1 *7-South Settling Pond (7SSD)*

The following discussion highlights parameters of interest at 7SSD with respect to discharge water quality and potential influence in the receiving environment. A discussion of settling pond performance and validation of actual effluent water quality compared to the water quality prediction model using actual flow and water quality data is discussed.

The full water chemistry dataset can be found in Appendix I, Tables (22- 23, 128 &131-134 & 151,153-162).

Appendix II, Graphs (21 through 31) displays the parameters of interest for 7SSD compared to 7S. Appendix II, Graph (109).

5.3.1.1 *General Parameters*

pH

The permit limit range for pH is set at 6.0 – 8.0 and pH levels throughout the monitoring period generally remained within this range. pH was found slightly above 8.0 for field measured pH during three sampling events. Alkaline conditions were recorded as these exceedances ranged from 8.1-8.3.

Weekly pH & conductivity values for 7SSD are displayed in Appendix I, Tables (131 to 134).

Total Suspended Solids (TSS)

TSS was elevated but remained within permit limits at 7SSD as a result of high surface erosion and low pond retention time during times of high precipitation. This reporting year concentrations of TSS did not exceed permit limits at 7SSD and concentrations of ranged from <4.0 mg/L to 15 mg/L averaging 6.1 mg/L. Improved water management strategies stated earlier in this report have aided greatly in reducing TSS and overall discharge quantities. There was one occasion where a TSS sample was missed due to the discharge value being closed in the morning and a TSS composite sample was not collected.

Appendix I, Table 120 & Appendix II, Graph 25 and display the daily TSS results at 7SSD.

Dissolved Sulphate

Compared to the previous reporting years, concentrations of Sulphate have decreased significantly and continue to decline into 2016. For example, the average sulphate concentration over the 2014-2015 reporting period was 117.4 mg/L whereas the average concentration over this reporting year was 35.3 mg/L. This trend reflects the effectiveness of management measures employed at the 7-South operational footprint to mitigate overall loading.

5.3.1.2 DISSOLVED METALS

There were no permit limit exceedances for any metals at 7SSD. The settling pond only discharged for 43 days this monitoring year with discharge occurring in April (21 days) and December through March (22 days). No discharge occurred from April 22 through to Dec 8th, 2015. Table 4 and Table 5 below display the water quality prediction models for parameters of interest at 7SSD and 7S. As depicted in Table 4, dissolved arsenic is the only parameter that is displaying elevated concentrations above the worst case prediction. As these elevated concentrations are found in the summer, low pond water levels and decreased dilution from precipitation may be the culprit. It's important to note the pond was not discharging at the time of collection and all samples were collected from the ponded water. When discharge commenced in December, the arsenic concentrations were low at both 7SSD and 7S (downstream) as depicted in Appendix II, Graph 27.

Concentrations of sulphate, aluminum, cadmium, copper, iron, nickel and selenium were below expected case. Concentrations of cobalt, manganese and zinc were found to be above the expected values but not at worst case and therefore categorized as in-between. Out of the eleven parameters included in this model, the annual average concentrations of seven parameters were below the expected case, three were in-between, one was at expected and one was above the worst case. This is a marked improvement from previous years. Water quality at 7S compared to the model also displays excellent water quality as all results are below the expected values. This indicates that during 2015-16 monitoring year QCC had a negligible impact on water quality at 7S.

Table 4: Water Quality Prediction Model-Best and Worst Case Scenarios at 7SSD

7SSD WQ (2015-16 Averages)				
Parameter	**Expected Case (mg/L)**	**Worst Case (mg/L)**	**Actual (mg/L)**	**Result**
Fluoride	0.122-0.134	0.150-0.161	N/A	
Sulphate	56-71	139.3-180.5	35.3	**Below Expected**
Aluminum	0.040-0.041	0.110-0.113	0.0147	**Below Expected**
Arsenic	0.001	0.002	0.00225	**Above Worst Case**
Boron	0.069-0.082	0.152-0.186	0.03	**Expected**
Cadmium	0.000012-0.00013	0.000037-0.000040	0.0000049	**Below Expected**
Cobalt	0.00015-0.00017	0.00161-0.00211	0.00025	**In-between**
Copper	0.004	0.006	0.00093	**Below Expected**
Iron	0.034	0.130-0.133	0.0184	**Below Expected**
Manganese	0.016-0.017	0.054-0.066	0.0382	**In-between**
Nickel	0.001	0.003-0.004	0.0007	**Below Expected**
Selenium	0.00193-0.00194	0.00612-0.00632	0.00008	**Below Expected**
Zinc	0.003	0.006	0.0031	**In-between**

***When calculating averages, 0.5 of the method detection limit values were used.**

Table 5: Water Quality Prediction Model-Best and Worst Case Scenarios at 7S

7S WQ (2015-16 Averages)				
Parameter	**Expected Case (mg/L)**	**Worst Case (mg/L)**	**Actual (mg/L)**	**Result**
Fluoride	N/A	N/A	N/A	
Sulphate	6.49-7.80	15.4-17.8	4.3	**Below Expected**
Aluminum	0.043	0.055-0.056	0.03960	**Below Expected**
Arsenic	0.0002	0.0003	0.00015	**Below Expected**
Boron	0.052-0.063	0.061-0.063	0.02700	**Below Expected**
Cadmium	0.000010	0.000013	0.000004	**Below Expected**
Cobalt	0.00046-0.00047	0.00062-0.00065	0.00025	**Below Expected**
Copper	0.001	0.001	0.00055	**Below Expected**
Iron	0.020-0.021	0.030-0.031	0.00980	**Below Expected**
Manganese	0.0026-0.003	0.007	0.00050	**Below Expected**
Nickel	0.001	0.001	0.0005	**Below Expected**
Selenium	0.00028-0.00030	0.00070-0.00075	0.00006	**Below Expected**
Zinc	0.005	0.005	0.00250	**Below Expected**

***When calculating averages, 0.5 of the method detection limit values were used.**

5.4 Middle Point Facility

All of the water samples collected for the 2015/16 monitoring year indicates that TSS, pH and oil and grease were below the permit limits at the Middle Point Facility.

Results are presented in Appendix I, Table 146.

5.5 Bioassays

Rainbow trout (*Oncorhynchus mykiss*) bioassays are required to be performed one time per year during the fall flush at both SPD and WD while 7SSD requires samples to be obtained during spring freshet and fall flush. The bioassays are performed using 100% (non-diluted) discharge water to assess the potential impact on rainbow trout over a 96 hours period; the criterion for passing the test is established as no mortalities.

The permit requires a 96 hour LC_{50} (on *Oncorhynchus mykiss*,) to be completed using 7SSD effluent water and, concurrently, a 7 day *ceriodaphnia dubia* test of water obtained from 7S. The discharge valve at 7SSD was closed on April 21, 2015 with all water directed to underground 5-South. The discharge from this pond was minimal, and due to the lack of precipitation throughout the quarter, these samples could not be collected. Additional precipitation was anticipated during the latter part of the quarter, which did not occur resulting in insufficient discharge required to obtain a representative sample. The 7 day *ceriodaphnia dubia* test was not performed on water collected from monitoring station 7S (receiving environment) during spring as unseasonably dry conditions resulted in a negligible stream flow earlier than anticipated.

During fall the discharge from 7SSD pond was minimal and it was anticipated that it would increase. The samples were not collected as limited discharge occurred from this pond during fall. During fall 7SSD did not commence discharging until December 8th, 2015 where it discharged for 9 days throughout the quarter. It was anticipated to have a greater discharge rate; the samples were not collected as a result.

These missed samples are considered permit non-compliances and are specified as such in Appendix 1, Table 1 and Appendix VIII, Annual Status Form.

The results from the bioassays performed at Settling Pond 1 and 4 indicate that mine related discharge had 100% survival rates and are therefore compliant for those discharge points, Appendix (III).

5.6 SPILLS

There were two reportable total suspended solid spills as a result of mine related discharge during the 2015-16 reporting year, one occurred in the 3rd quarter and one occurring in the 4th quarter at WD and SPD, respectively. Spill reports are included under Appendix (VII).

6.0 Receiving Environment Results and Discussion

Preamble – Water Hardness

For the purpose of this report the water quality guideline(s) for hardness dependent parameters has been derived using background levels of hardness (i.e. monitoring location WA ~30 mg/L). Quinsam coal has adopted this approach to provide an overly conservative comparison of receiving environment water quality.

Guidelines and Objectives: Receiving environment water quality is compared to the British Columbia Water Quality Guidelines (WQG) and, where applicable, Water Quality Objectives (WQO)[1]. Most parameters are compared to the WQG with the exception of:

- hypolimnetic DO, which is a WQO based on a site specific conditions,
- total cobalt and total lead, where the Objective is more recent than the Guideline and,
- total phosphorus which is a Vancouver Island objective for phosphorous in streams

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

Table 6. Overview of Water Quality Guidelines and Objectives Applied to Receiving Environment Stations

Parameter	Application			
	Lakes (mg/L)		Streams (mg/L)	
	Max	5 in 30 day Avg	Max	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)	
Periphyton biomass	-	-	-	-
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 min during June-August		n/a	n/a
pH	6.5 - 9	n/a	6.5 - 9	n.a
Aluminum (dissolved)	0.1	0.05	0.1	0.05
Arsenic (total)	0.005	n/a	0.005	n/a
Cadmium (dissolved)	0.00017	0.000088	0.0017	0.000088
Cobalt (total)	0.05	0.004	0.05	0.004
Copper (total)	0.007	0.002	0.007	0.002
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
	0.5 mg/kg maximum total Hg in fish muscle (wet weight)			
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

* Values represent Middle Quinsam sub-basin water quality using WA hardness. Iron River guidelines will be different based on seasonal hardness at IR1 ** Average based on monthly samples from May to Sept

Those locations outside of the Middle Quinsam Lake Sub-basin, such as Iron River and 7-South (7S and LWO) are compared exclusively to the WQG.

It is important to note that both guidelines and objectives do not have any legal status; they are aimed at providing resource managers direction in order to protect the water bodies in question.

6.1 Lakes

The lake monitoring program employed a 5 in 30 sampling approach at 4 lakes including No Name Lake (NNL), Long Lake (LLM), Middle Quinsam Lake (MQL) and Lower Quinsam Lake (LQL). There are 4 depths monitored at each lake these include:

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

Monitoring occurred at 3 separate periods in spring, summer and fall:

- Spring – April/May 2015
- Summer – July/August 2015
- Fall – October/November 2015

Appendix I, Tables (2 & 3) summarizes the parameters above Provincial Ambient Water Quality Guidelines (WQG) and Water Quality Objectives for Middle Quinsam Lake Sub-basin (WQO) for 2015-16 monitoring year. Tables (27 through 30) display the depth profiling and field results with Tables 31 through 78 displaying the water chemistry results compared to guidelines. Tables (166-181) provide a statistical summary for parameters of interest. Appendix II, Graphs (41 through 90) illustrate parameter trending at each lake.

6.1.1 *Seasonal Trending*

Spring

The spring sampling program is scheduled to capture the lake turnover that typically occurs in conjunction with warmer ambient temperatures, snowmelt and increased precipitation. Lake turnover is the process of a lake's water turning over from top (epilimnion) to bottom (hypolimnion).

The spring sampling event was not ‘triggered’ by significant precipitation as only 113mm and 32.95mm of precipitation was experienced during March and April 2015, respectively. Comparatively, in 2014, Quinsam experienced 111.60mm and 52.64mm in March and April.

Noteworthy observations resulting from the spring lake monitoring program include:

- Sulphate remained below the water quality guideline (128mg/L) in all lakes at all depths
- Sulphate in Long Lake continues to decrease
- Naturally elevated total zinc concentrations (at surface) in NNL and LQL (1m) and at depth in MQL (1mb). Elevated zinc was also experienced during 2014 at various stations and will continue to be monitored in an attempt to identify potential source(s).
- Lake stratification was captured and apparent starting in week 3 of 5.
- NNL continues to experience low pH values that decrease with depth.
- MQL experienced lower pH values at depths 10-13 metres mostly during the first week of sampling.
- Dissolved cadmium was elevated in MQL above Max WQG at 1mb; this exceedance is thought to be attributed to an artifact in the sample or an outlier as cadmium results are typically below detection limits.

The reader will note that concentrations for most parameters of interest were not elevated above water quality guideline levels throughout the 5 in 30 sampling period, with the exception of a few parameters.

Summer

The summer sampling program is scheduled to capture the period of ‘low flow’ and lake stratification. Consequently, results from this sampling represent low dilution conditions and therefore minimum assimilative capacity. This is also considered the period when mine related discharge would represent the greatest influence in the receiving environment.

The receiving environment monitoring program spanned July 28th through September 1st. These events were completed during the summer low flow period (July through September) with high ambient temperatures and (206.8 mm) accumulated precipitation for the typically dry months.

Noteworthy observations resulting from the lake monitoring program include:

- Sulphate remained below the water quality guideline (128 mg/L) in all lakes and depths in summer 2015 with concentrations lower than summer 2014 monitoring events.
- Sulphate in LLM continues to depict a slight decreasing trend at depths 9m and 1mb but displayed an increasing trend at near surface samples of 1m and 4m below surface.
- Lake stratification was apparent for all lakes during the summer 5 in 30 period with temperature gradients becoming less apparent for the metalimnion and hypolimnion during the last week of sampling in the shallower lakes.
- Total and dissolved iron concentrations continued to exhibit elevated concentrations at 1mb samples on LQL.
- Total Iron was elevated in MQL (above the max WQG) at 1m for one sampling event.
- LLM continues to exhibit elevated concentrations of total manganese above the max and average WQG of (0.8 mg/L and 0.7 mg/L) at 1 metre above bottom.
- Three out the four lakes displayed slightly acidic conditions at depth throughout the summer 5 in 30 sampling program, with NNL displaying the most acidic conditions at depth.
- Hypolimnetic DO was observed to be below 3 mg/L in LLM during all events

Fall

The fall sampling program is scheduled to capture the period of elevated precipitation following the summer dry season. Increased precipitation represents a ‘fall flushing’ event that is correlated with elevated surface water metal concentrations as a result of localized weathering and mobilization.

The fall monitoring program spanned October 5th through November 10th. These events were completed during the early “fall flush” period (October to early November) with a somewhat low 151.4 mm of accumulated precipitation.

Noteworthy observations resulting from the fall monitoring program include:

- Sulphate remained below the water quality guideline (128 mg/L) in all lakes and depths in fall 2015 with concentrations lower than fall 2014 monitoring events.

- Sulphate in Long Lake continues to depict a decreasing trend at depths 9m and 1mb but is displaying an increasing trend at near surface samples of 1m and 4m depths with results averaging 92 mg/L.
- The fall turnover was apparent in two of the four lakes (MQL and LQL).
- Stratification was still apparent for LL and NNL during the fall sampling period
- Temperature gradients were becoming less apparent for the metalimnion and hypolimnion during the last 2 weeks of the ‘5 in 30’ period in LL and NNL.
- Total and dissolved iron concentrations continued to exhibit elevated concentrations in samples collected at 1mb on LQL and MQL.
- Total manganese was elevated at 1mb samples in LL, MQL and LQL. In both LL and MQL manganese was elevated above maximum and average guidelines. In LQL manganese was elevated above maximum guidelines.
- Long Lake 1mb exhibited the highest concentrations of total manganese in its measured history, which is correlated with lake stratification causing low dissolved oxygen (DO) at depth releasing manganese at the sediment water interface.
- DO was the lowest ever observed in LL at the 1mb depth.
- LQL 1mb exhibited one elevated dissolved arsenic result above the maximum water quality guideline of 0.05 mg/L.
- Three out the four lakes displayed slightly acidic conditions at depth throughout the fall ‘5 in 30’ sampling program, with NNL continuing to display the lowest pH conditions at depth.

6.1.2 *Discussion*

6.1.2.1 General Parameters

pH

Lakes that are deeper and thermally stratified normally have pH that ranges from alkaline on the surface (epiliminon) to slightly acidic at bottom depths (hypolimnion). This trend is typically more pronounced during the summer period when lake stratification occurs and surface temperatures increase.

During 2015, No Name Lake exhibited numerous occurrences where pH fell below the minimum water quality guideline of 6.5, those include:

- Spring (19/55) cumulative depths profiled
- Summer (20/55) cumulative depths profiled
- Fall (23/55) cumulative depths profiled

There are a number of factors that may contribute to the overall acidic conditions observed throughout the water column those include:

- Natural conditions-the western end of the sub-basin is surrounded by a vast wetland, organic wetland soils tend to be acidic
- Limited turnover-temperature gradients are not drastic during the spring and this lake is relatively shallow (~12m)
- Anthropogenic sources i.e. mining & logging

No Name Lake has a shallow basin (11 to 12 metre depth) encompassing a vast drainage area. Since monitoring began in 2012, the lake has displayed slightly acidic conditions throughout the water column during spring, summer and fall sampling events with the majority of readings below the guideline of 6.5. Appendix II, Graph (45) displays pH values from 2012 to present at depths 1m, 4m, 9m and 1mb. The sampling location on No Name Lake has been considered outside of mine related discharge and low pH values are not believed to be attributed to mining activities. There has been no known direct surface mine discharge location to No Name Lake found historically, although mining activities have been influencing the groundwater, surface waters and surrounding area for over 30 years. During 2013-2015, clear cut logging has occurred on the south-west side of the lake with the potential to increase nutrient/sediment loading as this area supports one of the main tributaries to No Name Lake. Measurements of conductivity values at NNL and NNL outlet (NNO) are low indicating limited mine impact as indicated in Appendix II, Graph (117); however, further investigation has been required to support this assumption.

A review of historical data suggests that there were occasions when this lake's water quality was mine impacted. This is observed in historical sulphate concentrations recorded for No Name Lake Outlet (NNO) (Figure 9) as well as a sampling event at No Name Lake during 2012 where sulphate concentrations reached up to 20 mg/L at depth (Figure 10).

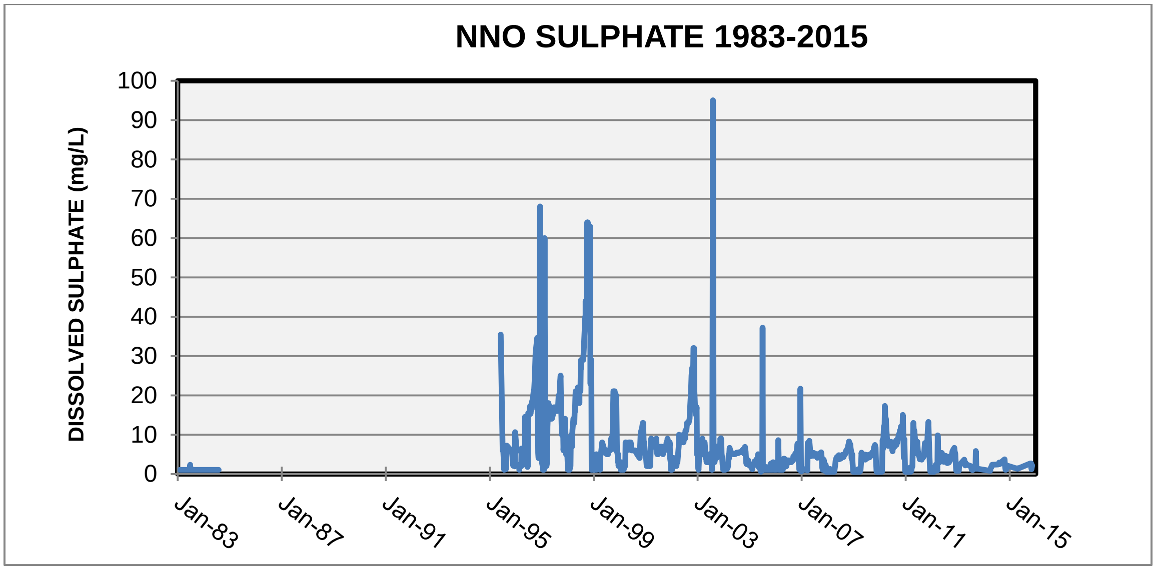

Figure 9: Historical Sulphate at No Name Lake Outlet (NNO)

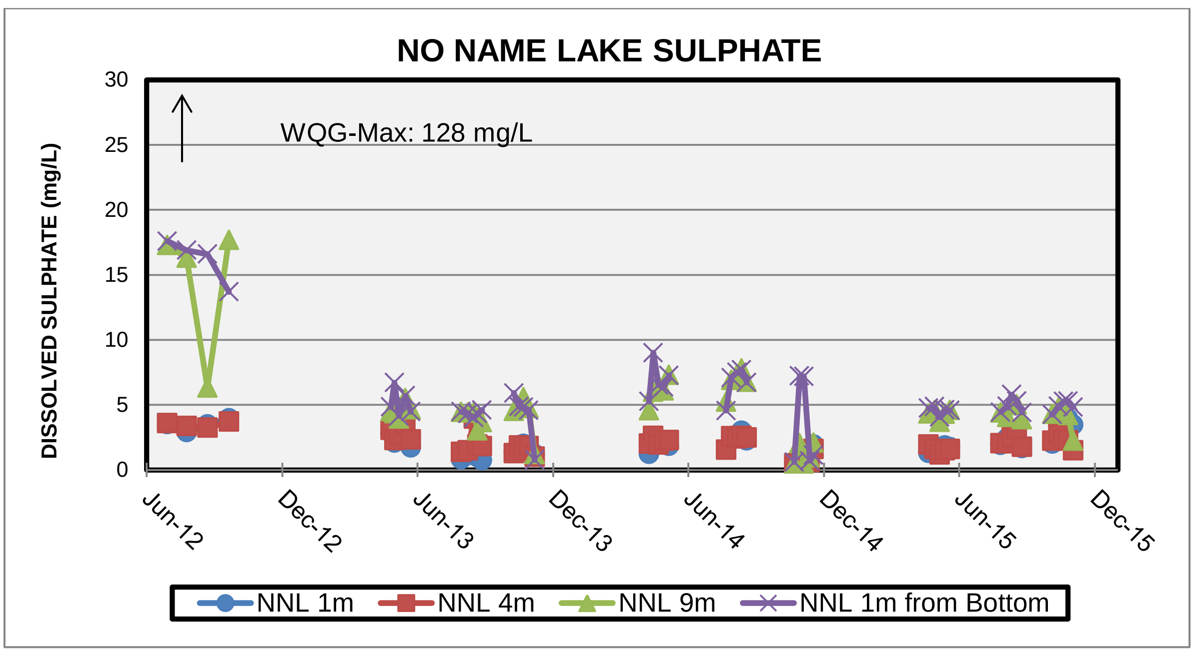

Figure 10: No Name Lake Sulphate (2012 – 2015)

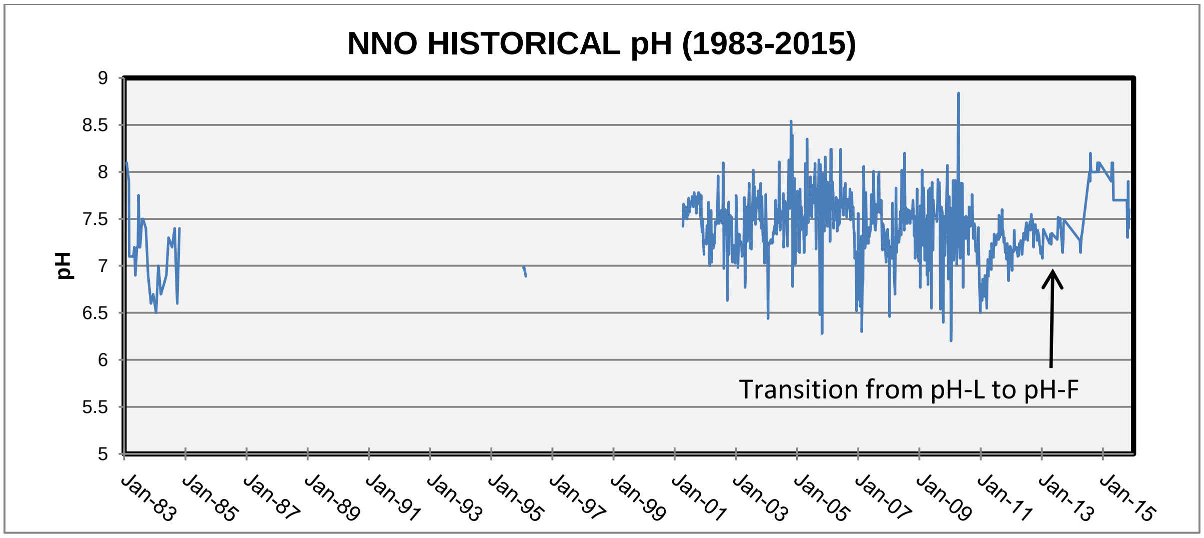

Figure 11: Historical pH at NNO

Figure 11 displays historical pH collected at NNO and as observed pH values have dropped below WQG of 6.5 on a several occasions during fall and winter. Figure 11 above displays the transition from laboratory pH to field pH after January 2013.

Figure 12 depicts historical pH values obtained from baseline monitoring performed by Environment Canada on June 21, 1983 and Quinsam Coal baseline study 1984. Quinsam collected six samples during May and July, 1984. These results indicate one sampling event (July 12, 1984) resulted in a lower pH (6.4) at maximum depth (unknown). The historical pH values ranged from 6.4 to 7.3.

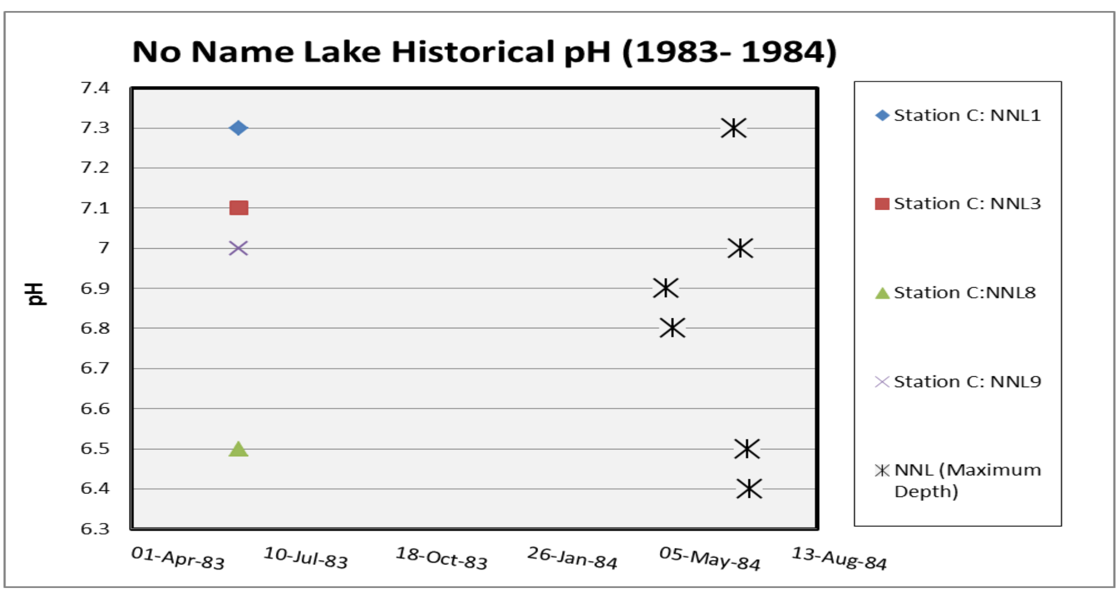

Figure 12: NNL Historical pH (1983-1984)

No Name Lake and No Name Lake Outlet will continued to be monitored for pH and future monitoring will indicate if low pH values persist.

Seasonal trends for pH exhibit slightly acidic pH at bottom depths in Long Lake falling just below the WQG of 6.5 in 2013 and in the spring of 2014. This trend continued through the spring of 2015 at bottom depths but pH remained above the lower end of guideline (6.5) with the lowest value resulting in 6.54. As the lake began to stratify pH became more neutral at all depths.

Summer stratification period revealed neutral pH conditions in LLM throughout the lake during four out of five sampling events. pH values fell below the guideline of 6.5 in the hypolimnion for (6/95) cumulative depths profiled on one occasion. Mostly circumneutral conditions were observed at depths with pH ranging from 6.42 to 7.71. During the fall turnover period, pH conditions remained neutral in the epilimnion and metalimnion strata's with slightly acidic conditions observed in the hypolimnion. Throughout the 5 weeks of sampling pH dropped just below 6.5 in the hypolimnion (15 to 19 metres) for (14/95) cumulative depths profiled. Circumneutral conditions were observed at most depths with pH ranging from 6.42 to 7.27. Historically pH in the hypolimnion and metalimnion display similar trends; this fall the conditions were wide-ranging between 9m and 1mb depths. Results are displayed in Appendix I, Table (28) & Appendix II, Graph (57).

Middle Quinsam Lake is generally neutral to alkaline throughout the spring, summer and fall. During spring 2015, pH values fell below the guideline of 6.5 in the hypolimnion for (4/65) cumulative depths profiled. These results are typical of previous years as both WA and WC exhibit neutral pH. Results are displayed in Appendix I, Table (29) & Appendix II, Graph (71).

Lower Quinsam Lake pH exceedances were observed exclusively in the hypolimnetic zone again with an overall near neutral to alkaline pH throughout the water column for the majority of the year. During the summer stratification period, pH fell marginally below the guideline at (7/80) cumulative depths profiled in the hypolimnion zone. During the fall turnover event, pH fell below the guideline on one occasion in the hypolimnetic zone (16m). Results are displayed in Appendix I, Table (30) & Appendix II, Graph (83).

Hardness

Both No Name Lake and Lower Quinsam Lake display characteristically soft water while Middle Quinsam Lake and Long Lake generally present moderate to hard water; particularly at depth. With the exception of Long Lake, concentrations remained fairly static in all lakes during spring, summer and fall sampling events indicating the lakes received minimal flushing or dilution from rain and/or runoff since the spring.

Long Lake exhibits the greatest concentration of hardness for all lakes at depths 1m, 4m, 9m and 1mb. The 1m and 4m depths display an increasing trend observed in 2015 while the 9m and 1mb depth(s) remain comparable to previous years. A more pronounced difference at the surface 1m & 4m depths in hardness was observed during the summer stratification period for Long Lake with the fall turnover event displaying an apparent decrease in concentrations at the surface depths (1m & 4m) Appendix II, Graph (56). Middle Quinsam Lake continues to display low concentrations of hardness with all depths remaining fairly consistent and stable throughout the water column during all seasons. Appendix II, Graph (70). No Name Lake displays low concentrations throughout all depths with little seasonal variation. Lower Quinsam Lake displays an increase in hardness during summer at 1m, 4m, and 9m depths and a decline during the fall.

Sulphate

Sulphate remained below the average guideline level (128 mg/L) in all lakes, during all seasons. Sulphate levels depict a depth dependency in LLM, MQL & NNL as concentrations increase throughout the water column and appear to be correlated with thermal stratification. In LQL the opposite trend is observed as concentrations are higher at surface and decrease at depth.

Long Lake is displaying an increasing trend at surface 1m and 4m depths during summer and fall of 2015 compared to previous years. Concentrations peaked during summer and declined slightly into the fall; however they remain higher than pervious year’s. A decreasing trend continues to be observed at depth (9m and 1mb) from spring through fall.

During the fall of 2014, sulphate concentrations in MQL 1mb depth decreased from above 128 mg/L to below 20 mg/L after a flushing event. Sulphate concentrations have remained below 60 mg/L throughout the entire monitoring year in 2015. The spring sampling displayed an increase in sulphate with a decline into summer and fall. The 2015 annual average sulphate concentrations at 1mb were 45.6 mg/L compared to 112.1 mg/L in 2014.

No Name Lake and Lower Quinsam Lake continue to record sulphate concentrations well below guideline levels, as expected. Conversely, sulphate concentrations in Long Lake are marginally below the guideline at all depths and have demonstrated a slight declining trend at depth in recent years (2013/14); this phenomenon is most likely attributed to the passive treatment system and consequent lower overall sulphate loading into Long Lake.

Hypolimnetic Dissolved Oxygen

Anoxic conditions in the hypolimnion can cause the lake bottom sediments to release iron, manganese, sulfides, and arsenic, all of which present potential toxicological impacts on aquatic receptors. This phenomenon typically occurs during the summer months as the dissolved oxygen (DO) supply in the hypolimnion is slowly consumed by microorganisms and chemical reactions as a result of lake stratification temperature and nutrient content. Accordingly, the water quality guideline for hypolimnetic DO is set at 3 mg/L minimum during June through August.

Long Lake and Lower Quinsam Lake exhibited anoxic conditions in the hypolimnion during the summer 2015 sampling event. These lakes are the deepest two with depths of approximately 20m and 18m for Long Lake and Lower Quinsam Lake, respectively. Therefore, less oxygen is able to reach the lower depths from surface mixing and stratification is more pronounced. Moreover, the lower DO at depth could be contributing to other chemical process (as described above) at the sediment/water interface (benthic zone).

6.1.2.2 Total and Dissolved Metals

Concentrations of most metals at all lake monitoring stations remained low throughout the spring, summer and fall periods. Elevated concentrations of total and dissolved iron, total manganese, and total zinc were observed at some stations and are discussed below.

Iron

Total and dissolved iron concentrations in all lakes followed a similar trend since 2013 with lower concentrations during spring and increasing concentrations during the summer and fall. No Name Lake and Long Lake recorded iron concentrations well below guideline levels. Once again Lower Quinsam Lake displayed the highest observed iron concentrations (both total and dissolved) that were more pronounced at depth and exceeded guidelines on multiple occasions during the summer and fall sampling events (both total and dissolved). Although Lower Quinsam Lake is not the deepest lake sampled, these elevated iron concentrations may be related to anoxic conditions and associated increase in iron solubility at the sediment/water interface.

During summer, total iron was elevated above WQG of 1.00 mg/L at surface on one occasion at MQL. The 1mb depth displayed increased concentrations during fall 2015 compared to 2013-2014 for both total and dissolved iron. One result of dissolved iron exceeded maximum WQG of 0.35 mg/L and two results for total iron exceeded maximum WQG of 1.00 mg/L. Appendix I, Tables (2 and 3) display the exceedances of WQG observed, while Appendix II, Graphs (76 & 77) display trending since 2013.

Manganese and Dissolved Oxygen

Total manganese (Mn-T) was elevated at depth above acute and chronic WQG guidelines of 0.8 mg/L and 0.7 mg/L, respectively in three out of the four lakes during the fall sampling period.

Total Mn in LL has been found in greatest concentrations at the 9 and 1mb depths where Mn-T is observed to be found in moderate to elevated concentrations since 2006 with increases continuing to be observed into fall of 2015. Long Lake displayed manganese concentrations elevated and at an all-time high during fall 2015.

The Ambient Water Quality Guidelines for Manganese[2] states:

> "*Mn is only slightly too moderately toxic to aquatic organisms in excessive amounts. It is present in almost all organisms and often ameliorates the hazard posed by other metals. Hence jurisdictions in the international arena have not disseminated for Mn guidelines to protect freshwater and marine life. Mn availability and, hence its toxicity in the aquatic environment can be influenced by many factors including water hardness."*

In deeper lakes, stratification may cause the development of anaerobic conditions in the bottom water zone and the dissolution of the iron and manganese from floor deposits. In 2009 Professor TJ Casey produce a paper titled: Iron and Manganese in Water Occurrence, Drinking Water Standards and Treatment Options through the Aquavarra Research LMT water engineering Papers (Paper 3)[3]:

> "*Iron and manganese are commonly found in groundwater and some surface water such as lakes that have a significant groundwater input. The existence of Fe-D and or Mn-T in groundwater generally infers prior anaerobic conditions with the result that the water is likely to be devoid of oxygen and may also have a high carbon dioxide (CO_2) concentration. As well as being associated with groundwater input the existence of Fe-D and Mn-T in some deep lakes and reservoirs, may be due to stratification, resulting in the development of anaerobic conditions in the bottom water zone and the dissolution of the iron and manganese from floor deposits*."

[2] Ministry of Environment.2013.Ambient Water Quality Guidelines for Manganese

3 Casey,T.J.2009.Iron and Manganese in Water Occurrence, Drinking Water Standards and Treatment Options through the Aquavarra Research LMT water engineering Papers. Paper 3.pp1.

Long Lake has historically been characterized as having very low dissolved oxygen (DO) with levels in September to October declining to below 4 mg/L at depths greater than 15 metres (Kangasniemi.1989)[4].

Norden 2006[5] reported that LL stratifies into hyerlimnion and hypolimnion sections in April and May and remains stratified until October through November. Appendix II Graph 58 displays historical dissolved oxygen (DO) vs total manganese reported at 1 metre from bottom samples since 2005. As depicted from Graph 58 there is an inverse relationship with DO and Mn-T. When DO levels drop Mn-T concentrations increase, this is observed during summer and fall when DO levels decline to below 3 mg/L.

The SLR[6] report suggests that these findings have potential implications for the means by which sediments and Contaminants of Potential Concern (COPC) are distributed in LL, and suggest that the deepest portion of the lake has the greatest potential to accumulate and retain those COPC's whose mobility in aquatic systems is affected by oxygen availability in overlying waters and sediments.

So it may be conceivable that manganese has a greater loading rate from parent material accelerated by the low DO at depth.

The regional geology of Long Lake as explained in the SLR suggests that LL is divided in half down the center by the Nanaimo group in the Southern half and the Northern half being the Island Plutonic Suite (IPS); which could have implications for different loading of arsenic from parent material or possibly manganese.

As an increase in Mn-T was observed throughout all lakes at depth this may only be attributed to low DO observed during fall sampling as there was limited mixing and turnover occurring during the fall sampling event.

NNL also displayed an increase at 9 metre and 1mb depths during fall. An increasing trend was observed at depth for 1mb samples in NNL compared to previous data.

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[4] Kangasniemi, B.J.1989.Campbell River Area Middle Quinsam Lake Sub-Basin Water Quality Assessment and Objectives. Ministry of Environment, Lands and Parks. Summary.pp2.

[5] Nordin, R.N.2006.An Evaluation of the sediment quality and invertebrate benthic communities of Long and Middle Quinsam Lakes with regards to local coal mining activity. pp2.

[6] Coady.M, Ott.C.2015. SLR Report. pp 4-5.

MQL 1mb depth exhibited elevated concentrations above acute and chronic guidelines during fall. Comparably, LQL 1mb depth also exhibited elevated concentrations above acute guidelines. Total manganese does not appear to be mine related as concentrations at most discharge locations remains low; however, trending in the receiving environment is an important factor when considering potential aquatic effects and will therefore be monitored in subsequent years.

The hypolimnetic DO is a Water Quality Object developed for the Middle Quinsam Lake Sub-basin and is therefore applied to MQL and LL in the hypolimnion zone. The hypolimnion is the dense, colder bottom layer of water in a thermally-stratified lake. It is the layer that lies below the thermocline. Typically the hypolimnion is the coldest layer of a lake in summer, and the warmest layer during winter. This objective requires that DO be at a minimum of 3 mg/L during June through August.

Hypolimnetic DO in Long Lake was observed to be below 3 mg/L during the summer 5 in 30 sampling events and continued to decline into the fall. These were the lowest levels ever recorded for Long Lake as displayed in Appendix II, Graph (58).

During the fall sampling event all lakes displayed lower DO levels at depth. With all but NNL displaying concentrations lower than 1 mg/L at 1mb. Interestingly, the concentrations of Mn-T were elevated during these events as well as iron at LQL.

Appendix I, Tables (2 and 3) display the exceedances of WQG observed, while Appendix II, Graphs (47, 48, 58, 61, 62, 73, 74, 85 & 86) display trending of the average and maximum concentrations of manganese in each lake since 2013.

Zinc

Zinc is normally found in lower concentrations but was occasionally found in elevated concentrations in the lakes. Total zinc concentrations exceeded guideline levels during spring at surface in NNL, LQL and at depth (1mb) in MQL. This parameter has been naturally elevated in background samples with exceedances observed upstream. These exceedances are associated with runoff and flushing events in the surrounding environment. Upstream monitoring locations not influenced from mining have recorded high levels of total zinc in the past.

Arsenic

Arsenic has become a parameter of interest in the Quinsam watershed and is therefore included in this discussion. However, results for the 2015 lake sampling program demonstrate that concentrations of arsenic remain well below guideline levels and, consequently, are not of concern. The only lake exhibiting elevated arsenic was LQL at 1mb sample on one occasion during fall sampling. The Iron River was observed to have elevated concentrations of arsenic during summer sampling which may have contributed to this exceedance.

Long Lake arsenic concentrations, which have historically been a focal point for discussion around potential toxicity, remained an order of magnitude below the water quality guideline again this monitoring year.

6.1.3 *Biological Monitoring: Lakes*

Biological monitoring is included at the lakes to gain an understanding of phytoplankton and zooplankton communities along with their relative abundances. Trends observed in plankton populations can give an indication of lake health and may indicate if lake ecology is changing due to mine related practices.

During the 2015/16 report period, chlorophyll “A”, phytoplankton and zooplankton were sampled once per 5 in 30 sampling event at each lake. Chlorophyll “A” and phytoplankton samples are obtained at 1 metre as a grab sample while zooplankton are collected using a 10 metre vertical tow to surface with a zooplankton net.

6.1.3.1 Phytoplankton and Chlorophyll “A”

Phytoplankton are single celled microorganisms that reside in most productive water bodies and are found near the surface where adequate sunlight penetrates. As phototrophs, phytoplankton have the ability to convert sunlight, CO_2 and water into usable energy. Phototrophs are primary producers in lake ecosystems and are the foundation for the aquatic food web. Phytoplankton can be divided into two classes; algae and cyanobacteria. These two classes have the common ability of photosynthesis, but have different physical structures. Regardless of their taxonomy, all phytoplankton contain at least one form of chlorophyll (chlorophyll “A”) and thus can conduct photosynthesis for energy. Chlorophyll is a color pigment found in plants, algae and phytoplankton. This molecule is used in photosynthesis as a photoreceptor, absorbing light energy emitted from the sun. Chlorophyll makes plants and algae appear green because it reflects a range green wavelengths found in sunlight, while absorbing strongly in the blue and red colour ranges.

Chlorophyll “A” concentrations found from sampling can indicate how abundant the overall community is and productivity for the water body. The Chlorophyll “A” and the phaeopigment concentrations provide a useful measurement when determining phytoplankton blooms. Spring and mid-summer blooms are common in lakes due to the spring and summer “turning” that redistributes nutrients that normally accumulate in the benthic zone.

The chlorophyll “A” concentrations (composed of one sample per season) were found to peak and dip during different times and do not correlate directly to total phosphorus concentrations. This may be a result of limited sample numbers and uneven distribution across the lake. Further monitoring will provide supplementary information and addition interpretation of the data.

Table 7: Chlorophyll "A" Concentrations at 1 Metre- 2015

Chlorophyll “A” Concentrations at 1 Metre				
	No Name Lake	Long Lake	Middle Quinsam Lake	Lower Quinsam Lake
Spring 2013	1.12 µg/L	1.20 µg/L	1.29 µg/L	0.91 µg/L
Summer 2013	0.50 µg/L	0.50 µg/L	1.09 µg/L	0.82 µg/L
Fall 2013	0.50 µg/L	1.19 µg/L	1.09 µg/L	
Spring 2014	2.46 µg/L	2.11 µg/L	1.59 µg/L	1.32 µg/L
Summer 2014	1.84 µg/L	1.00 µg/L	0.96 µg/L	0.86 µg/L
Fall 2014	1.56 µg/L	1.68 µg/L	2.04 µg/L	2.67 µg/L
Spring 2015	0.59 µg/L	1.41 µg/L	0.87 µg/L	2.68 µg/L
Summer 2015	0.96 µg/L	0.58 µg/L	1.06 µg/L	0.98 µg/L
Fall 2015	1.25 µg/L	1.17 µg/L	1.16 µg/L	1.62 µg/L

6.1.3.2 Counts and Identification

Permit requirements were amended for 2014 to include surface water sampling (1.0m depth) three times a year (spring, late summer, fall overturn). Four lakes are now sampled: Long, Middle Quinsam, No Name and Lower Quinsam lakes. From 1994 through 2012, the requirement was for sampling at 1, 4 and 9 m in April through September for Long Lake and Middle Quinsam Lake, with No Name Lake added to the program in June 2012 and Lower Quinsam Lake added in 2013. Samples are submitted to Stantec Consulting Ltd. for phytoplankton taxonomic analysis, as part of ongoing monitoring requirements of the Ministry of Environment. Some months, an additional sample is taken as a field replicate for Quality Assurance/Quality Control (QA/QC).

The following is a summary of the Stantec phytoplankton reports that are presented in Appendix IV.

Table 8: Phytoplankton Abundance (cells/mL) in Quinsam Lake System, 2015

Phytoplankton Abundance (cells/mL) in Quinsam Lake System, 2015					
Lake	**Season**	**Total Count**	**< 5 µm (1000X)**	**5 to 25 µm (400X)**	**> 25 µm (100X)**
Long	Spring	3,700	3,300	400	15
Middle Quinsam		1,600	1,300	300	2.4
No Name		1,200	870	350	1.1
Lower Quinsam		2,200	1,800	350	28
Long	Summer	1,300	1,030	260	6.6
Middle Quinsam		2,900	1,060	1,850	2.8
No Name		880	610	260	6.6
Lower Quinsam		3,200	580	2,630	3.3
Long	Fall	2,100	1,800	230	14.6
Middle Quinsam		1,150	920	230	0.3
No Name		1,350	1,000	300	4.3
Lower Quinsam		1,500	1,100	330	71

The most abundant phytoplankton in each lake throughout the year was the very small (<5 µm) chryso flagellates (*Ochromonas spp. and Chromulina spp*.). Although these ultra-nanoplankton species were very abundant numerically, they usually contribute little to algale biomass. These two species were the most abundant in 2013 and 2014 and continue to display similar numbers in population density in 2014. These chryso flagellates are common in most water bodies and often dominate phytoplankton populations.

During the spring 5 in 30 sampling regime, total abundance was highest in Long Lake (3,700 cells/mL), intermediate in Lower Quinsam Lake (2,200 and 2,300 cells/mL for the duplicates), and lowest in Middle Quinsam Lake (1,600 cells/mL) and No Name Lake (1,200 cells/mL). In Long Lake and Lower Quinsam Lake, the larger *Ochromonas* spp. (chrysophyte) was predominant and *Rhodomonas minuta* (cryptophyte) and *Dinobryon* spp. (chrysophyte) were common. In No Name Lake, *Rhodomonas minuta* was predominant and *Ochromonas* spp. And *Oocystis* sp. (green alga) was common. In Middle Quinsam Lake, *Ochromonas* spp. Were predominant and no other species were common.

During the summer, total abundance was highest in Lower Quinsam Lake (3,200 cells/mL), intermediate in Lower Quinsam Lake (2,900 cells/mL), and Long Lake (1,300 cells/mL) and lowest in No Name Lake (880 cells/mL). In Long Lake the larger *Ochromonas* spp. (chrysophyte) were common, and in No Name Lake *Rhodomonas* sp. was common. In Middle and Lower Quinsam lakes, the colonial green alga *Dictyosphaerium* sp. was predominant and the very small (≤5 μm) *chrysoflagellates (Ochromonas* spp. and *Chromulina* spp.) were common.

During the summer, total abundance was highest in Long Lake (2,100 cells/mL), intermediate in Lower Quinsam Lake (1,500 cells/mL), and No Name Lake (1,350 cells/mL) and lowest in Middle Quinsam Lake (1,150 cells/mL). In Long Lake, larger *Ochromonas* spp. was predominant and the green algae *Nephrocytium* sp., *cryptophytes Rhodomonas minuta*, and diatom *Asterionella formosa* were common. In Middle Quinsam Lake, the colonial *chrysophyte Chrysostephanosphaerella* and larger *Ochromonas* spp. were predominant. In No Name Lake and No Name Lake replicate, *Ochromonas* spp. and *Rhodomonas minuta* were predominant and diatom *Melosira italica* and *cryptophyte Cryptomonas* spp. were common. In Lower Quinsam Lake, the larger *chrysophyate Ochromonas* spp. was predominant and *Cryptomonas* spp. were common.

The results of the phytoplankton counts and identification analyses at the center of all lakes are presented in Appendix IV while chlorophyll “A” analyses are displayed in Appendix I, Tables (32-79).

6.1.3.3 *Taxa and Abundance of Zooplankton Samples*

Fraser Environmental Services of Burnaby B.C. was contracted to perform zooplankton counts and identification of species. One 10m vertical tow sample was collected at each lake during each 5 in 30 set. The samples were preserved with ethanol and sent to Fraser Environmental Services for analyses. The results of the analysis are displayed in Appendix I, Tables (168-170).

There is a high variance between species composition and abundance in each lake due to the diversity in water chemistry and environment suited for each species. It is also important to note that total abundance of zooplankton species is diverse across each lake. The larger lakes are typically diatom dominated, and exhibit predictable seasonal dynamics. The small coastal lakes have zooplankton and phytoplankton communities that appear to be much more diverse in community than the larger well studied lakes and reservoirs such as Buttle and Cowichan Lakes (MoE, 1995). Challenges associated with the interpretation are attributed to the high degree of diversity and variability in each of these lakes. In an assessment of a ten year record of phytoplankton and zooplankton in six small lakes in B.C. performed by the Ministry of Environment (MoE); the MoE suggested that in order to properly interpret the phytoplankton and zooplankton data the variability in population must first be quantified, so that it can be predicted on a year to year basis. At this time, Quinsam has performed three full years of sampling at each lake, one event per season. The zooplankton community is not as diverse as the phytoplankton but comparable as there is much variation in the populations from season to season and lake to lake. Some taxa that are present during spring are not present during summer or fall in the lakes.

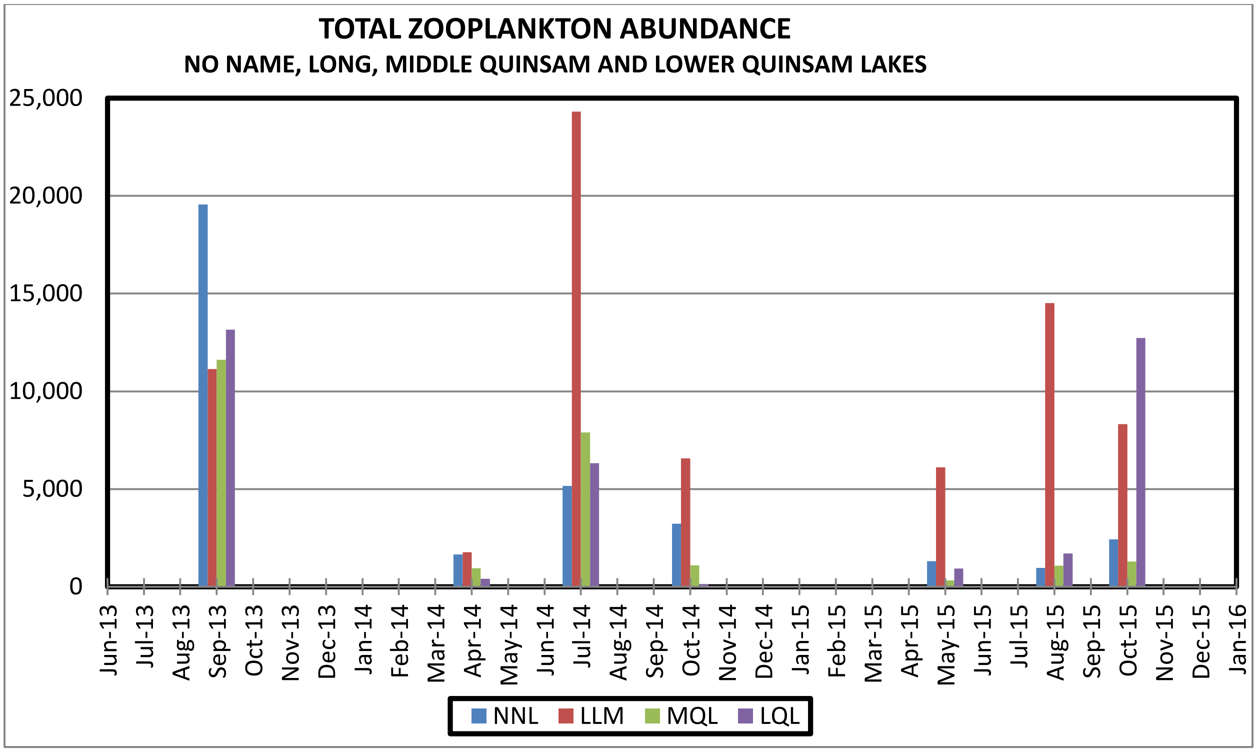

Figure 13: Total Zooplankton Abundance in NNL, LL, MQL and LQL

In 2015, all lakes had a considerable diversity in zooplankton species composition. Long Lake displayed the greatest total abundance during spring and summer while Lower Quinsam Lake displayed the most in the fall. No Name Lake and Middle Quinsam Lake generally displayed the lowest count of species abundance which has been observed in since 2013. Figure 13 displays total abundances from the last 3 monitoring years in the 4 lakes sampled. Future monitoring will build on the current dataset to gain a better understanding of any notable trends and overall lake health.

Like phytoplankton results, three sampling events in a year can give an idea of the abundance of zooplankton however; it cannot give complete confidence fully representing the lake community. In addition, these samples are obtained at one discreet location in each lake and may not fully represent the communities found within the entire waterbody as populations tend to reside and drift different locations irregularly.

The following charts display the main 4 orders of zooplankton counted and identified in the last 3 monitoring years.

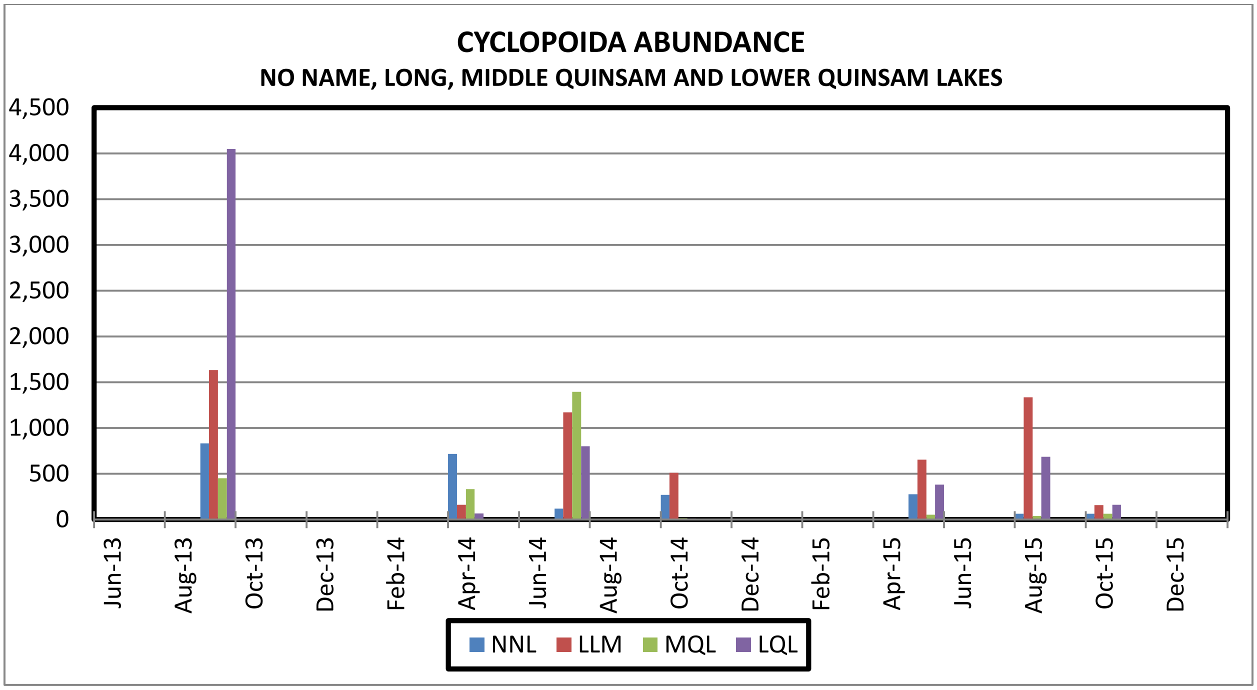

Figure 14: Cyclopodia Abundance in NNL, LL, MQL and LQL

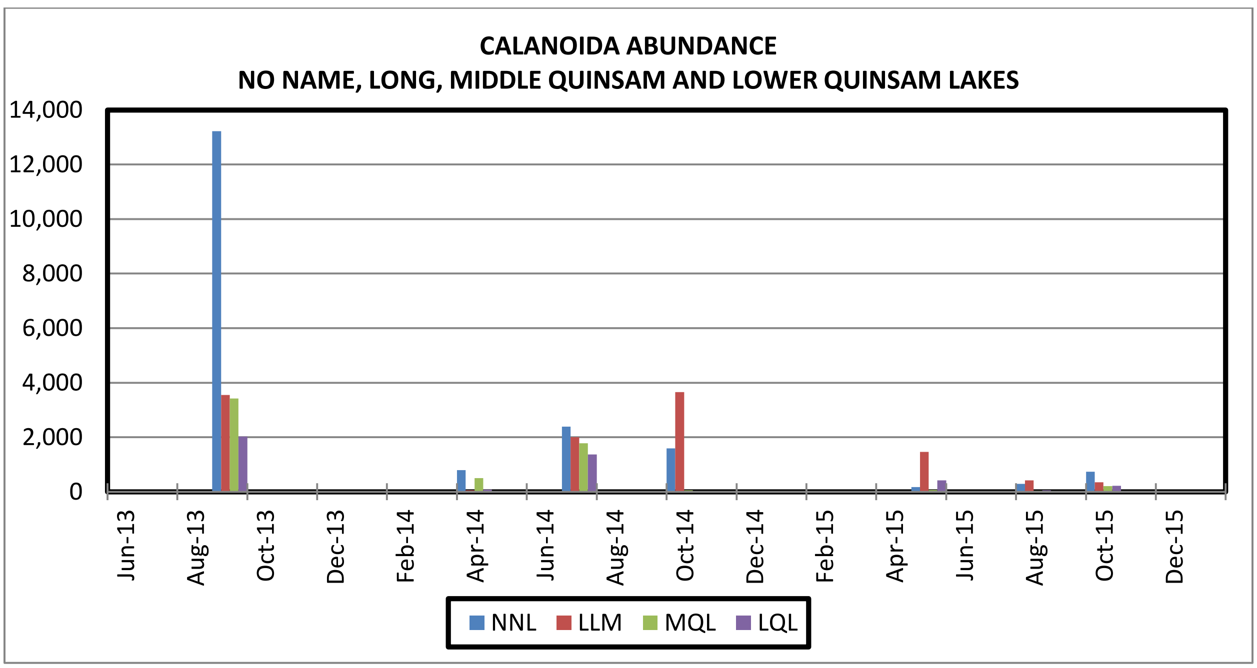

Figure 15: Calanoidia Abundance in NNL, LL, MQL and LQL

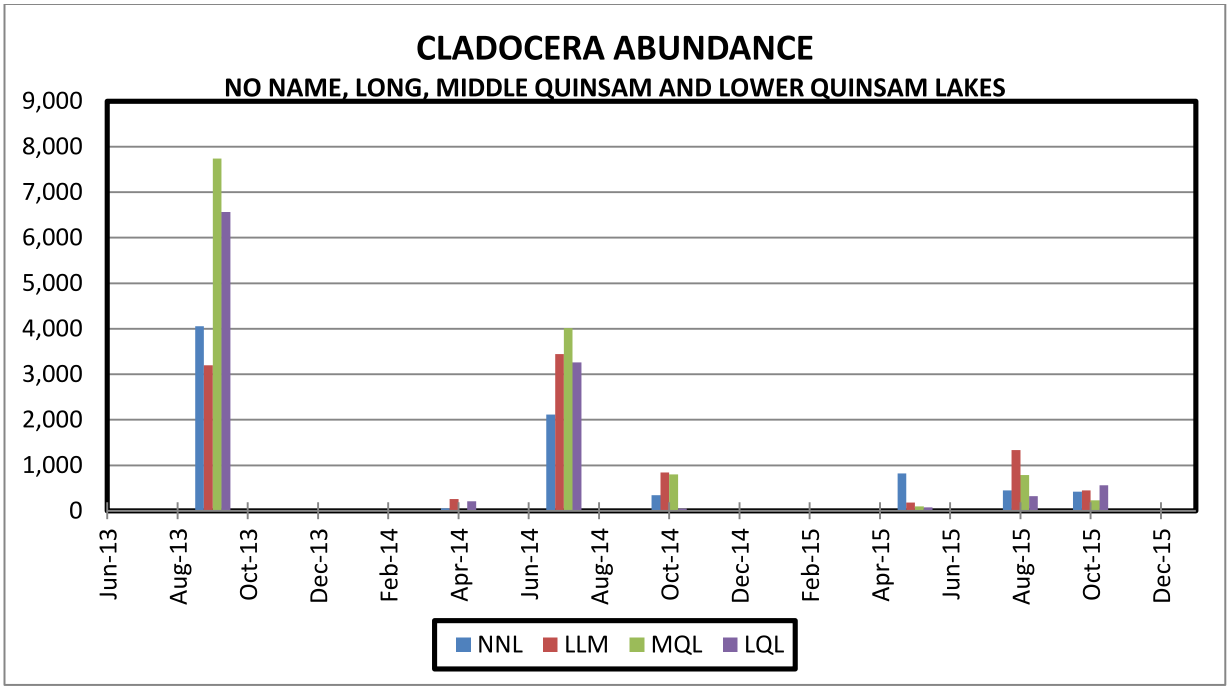

Figure 16: Cladocera Abundance in NNL, LL, MQL and LQL

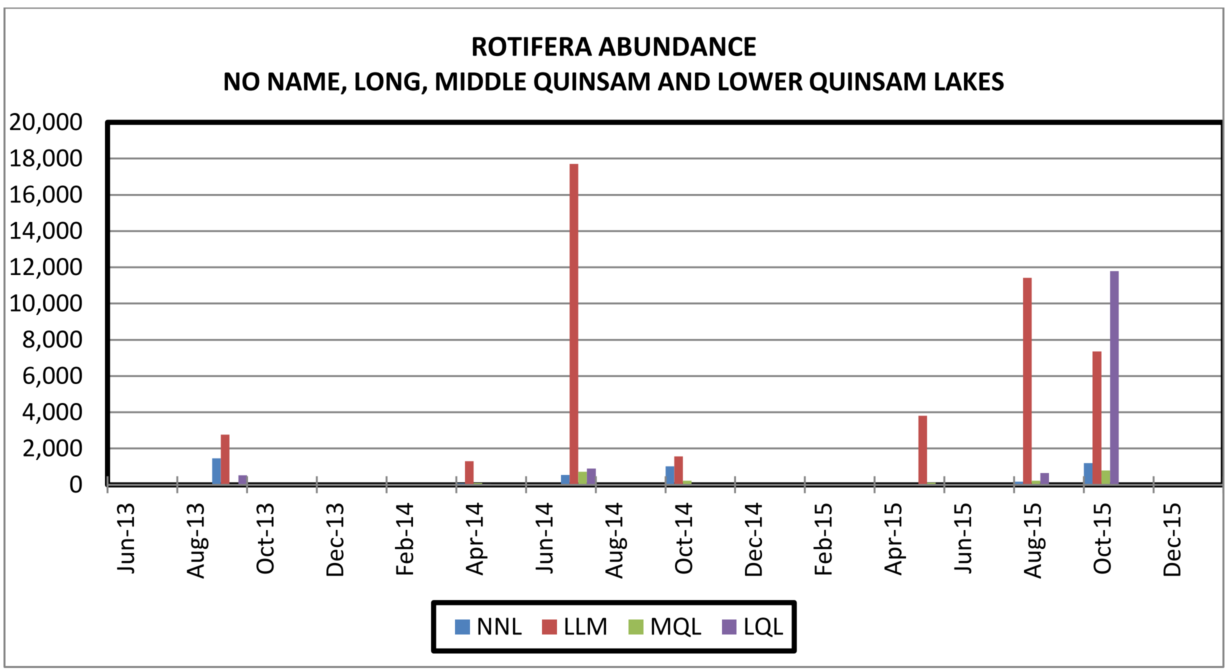

Figure 17: Rotifera Abundance in NNL, LL, MQL and LQL

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6.2 River and Stream Stations

6.2.1 *Middle Quinsam Lake Inflow (WA) and Outflow (WB)*

Comparing Middle Quinsam Lake's inlet (WA) and outlet (WB) offers an opportunity to assess the possible effects from anthropogenic sources on Middle Quinsam Lake water quality. Furthermore, water quality results from WA are considered "baseline" for the Middle Quinsam sub-basin receiving environment stations as it is situated upstream of any mine discharge. Data obtained from station WB (outlet of Middle Quinsam Lake) provides information on lake water quality after the addition of various inputs including: shallow and deep groundwater, Long Lake Outlet (LLO), mine related discharge from SP4, and other anthropogenic sources (e.g. logging). Water quality data for stations WA and WB are presented in Appendix I. Tables 79 through 84 include a comparison to water quality objectives (WQO) and water quality guidelines (WQG) and Tables 163 and 173 displays the summary statistics for the last six years. Appendix II, Graph (104) displays Middle Quinsam Lake's daily inflow obtained from the hydrometric station at WA and Graph (105) compares WB's discharge with precipitation. Appendix II, Graphs (91-100) display the parameters of interest in the Quinsam Sub-basin.

TSS results at WA and WB remained mostly below detection limits (<4.0 mg/L) throughout the year as displayed in tables 79 through 84. This level is consistent with previous reporting years and is expected to continue as there are no major operational changes in this system. It is important to note that samples for WB are collected below the Coal Main road crossing on the Quinsam River; therefore, TSS results exemplify the efforts made in reducing sediment and erosion at this location.

The pH values are very similar at both stations WA to WB. During this reporting period, pH values at WA and WB remained weakly alkaline and within WQG specifications of 6.5-9.0; pH values averaged 8.0 and 7.9 for WA and WB, respectively.

As shown in Graph 92, sulphate concentrations in WB are higher than WA reflecting mine related influences in Middle Quinsam Lake. Throughout this reporting period, both stations remain below WQG levels with sulphate concentrations averaging 1.07 mg/L for WA while WB sulphate concentrations averaged 34.6 mg/L.

A comparison of the two stations demonstrates that total metals increase from WA to WB likely attributed to mine related discharge. All total and dissolved metals remained below WQG levels with a similar concentration as previous years. One sample was missed at WA when the incorrect location was sampled resulting in an incomplete 5 in 30 sampling event for the summer low flow. When reviewing annual averages over the past six years, total manganese was observed to increase this year as displayed in Appendix 1, Table (173).

The maximum VIO for total phosphorous in streams from May through September is 0.01 mg/L. This threshold was exceeded at WB during one sampling event resulting reported at 0.1020 mg/L. Total phosphorus continues to be monitored in 2016-17. Appendix I, Table (117) displays nutrient sampling performed during 2015.

6.2.2 *No Name Outlet (NNO) and Long Lake Outlet (LLO)*

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

As shown in tables 85 through 87, 5 in 30 averaged concentrations of total suspended solids (TSS) for LLO remained ≤ 4 mg/L. NNO was not discharging throughout the summer low flow period and TSS remained below ≤ 4 mg/L.

Both LLO and NNO have similar trends in pH, displaying pH highs during the summer and early fall months and pH lows during the winter months. During the 2015/16 reporting period, pH values at LLO averaged 7.7 while field pH values at NNO averaged 7.8; no WQG exceedances were noted throughout 15 sampling events.

At NNO, concentrations of sulphate averaged 1.80 mg/L; very similar to the previous year's average of 2.07 mg/L. Concentrations at LLO are higher than that of NNO as a result of the sources described above. The average sulphate concentration for the reporting year was 66.2 mg/L with no events exceeding the WQG. It is noted that concentrations of dissolved sulphate at LLO depict an increasing trend in the past three years as displayed in the annual averages Appendix I, Tables (164).

Appendix I, Table (129) displays rolling average values from the weekly sulphate samples obtained; this average is the most appropriate concentration to compare to the WQG.

Most other total and dissolved metals were under WQG levels while many remained below laboratory detection limits. However, total nickel exceeded the WQG (0.025 mg/L) at LLO during 1/5 spring sampling event with a result of 0.0412 mg/L. This exceedance may be considered an outlier as nickel was not elevated at other point sources (i.e. LLE).

Water quality data for stations LLO and NNO are presented in Appendix I, Tables (85 to 90 and 163, 174) with comparison to WQO and WQG's. Appendix II, Graph 108 compares discharge with precipitation at Long Lake Outlet.

6.2.3 *Stream 1 – 7S and Lower Wetland Outlet*

The headwaters of Stream 1 are formed by the discharge of 7SSD and combine with Stream 2 above sampling location 7S. Downstream of station 7S, Stream 1 enters the Lower Wetland prior to combining with the Quinsam River. Given the aquatic values (fish habitat) in this area, the 7S station has been defined as the receiving environment and is therefore used to evaluate the influence that the 7-South operations have on aquatic receptors. The Lower Wetland Outlet station monitors the cumulative water quality in Stream 1 to understand overall Quinsam River contribution.

Sulphate levels at 7S averaged well below the WQG of 128 mg/L with a concentration of 4.28 mg/L. This low concentration is a direct result of diligent control during sedimentation pond discharge (to ensure a favorable dilution ratio) coupled with water management measures employed at 7-South operations.

For this reporting period the majority of total and dissolved metals remained below WQG levels. Total copper was elevated above the WQG (0.002 mg/L) during late December resulting in 0.165 mg/L. This exceedance is an isolated event and most likely attributed to natural conditions or is an outlier. Total copper is not typically elevated in the receiving environment or found in high concentrations of mine discharge.

Downstream station Lower Wetland Outlet (LWO) continued to demonstrate elevated concentrations of metals with exceedances occurring for total and dissolved iron, total copper and dissolved aluminum. The results are consistent with previous measurements and is attributed to natural causes. This sampling location was dry during the summer low flow period. The metal source appears to be localized and below monitoring station 7S as concentrations remained low at 7S throughout the reporting period.

All other parameters were below WQG levels; results for 7S are displayed in Appendix I, Tables (2, 3, 24-26 and 152) and Appendix II, Graphs (21-22 & 26- 31 & 110).

6.2.4 *Quinsam River Downstream Site 1 (QRDS1) & 7-South Quinsam River (7SQR)*

QRDS1 is located approximately 2 km downstream from the MQL outlet (sampling station WB) and above any input associated with 7-South operation. The 7-South Quinsam River (7SQR) monitoring station is located on the Quinsam River downstream of QRDS1 and is used to evaluate the influence of 7-South mine related discharge to the Quinsam River.

The incremental loading associated with discharge from 7-South operation was observed to be negligible throughout this monitoring period. General parameters were closely aligned for both stations with TSS values recorded below detection limits throughout the monitoring period.

Sulphate concentrations were consistent between the two stations and remained well below the WQG of 128mg/L. For example, the fall 2015 sampling program resulted in average sulphate concentrations of 29 mg/L and 31mg/L at QRDS1 and 7SQR, respectively.

Total and dissolved metals presented a similar trend with all parameters of interest remaining similar between each site. 7SQR demonstrates a slightly higher concentration of metals than QRDS1. There were no exceedances of WQG this monitoring year.

The maximum VIO for total phosphorous was exceeded at 7SQR during one sampling event resulting in 0.0103 mg/L concurrent to WB's exceedance on August 17, 2015.. Appendix I, Table (117) displays nutrient sampling performed during 2015.

Appendix I, Tables (91 -93 & 97 to100 & 165 to 175) and Appendix II, Graphs (91 - 100) display relevant parameters of interest for these stations.

6.2.5 *Iron River*

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

As part of the 7-South Area 5 permit application, baseline water quality was collected on the Iron River to gain an understanding of existing water quality. There were 10 monitoring stations established on the river to best identify hydrogeologic interactions and their respective influences on water quality. Additionally, 6 tributaries were monitored to identify incremental loading.

One year of monthly baseline samples were obtained at all sites to maximize interpretation of seasonal variations and trending on the Iron River. Post-baseline monitoring consists of 5 in 30 and monthly sampling at sites three sites on the Iron River (IR1, IR6 & IR8) and one downstream of the tributary of the Quinsam River and Iron River (IRQR).

Most general parameters (e.g. TSS, sulphate) were observed to be in low concentration across all four sites and remained well below WQG. Of note, hardness exhibits seasonal variability with both spring and fall (higher flow) periods remaining soft while summer (low flow) levels increased. As such, variations at IR1 (upstream of mining operations) have been used to calculate the water quality guidelines for those parameters with a hardness dependency for this annual report.

Once again dissolved aluminum and total arsenic were determined to be the two primary parameters of interest in the Iron River. Both parameters exceeded the water quality guideline during multiple sampling events at both IR6 and IR8; on one occasion D-Al exceeded at IR1 during winter.

An inverse relationship has been established between these two parameters as dissolved aluminum is elevated during periods of higher flow while total arsenic is elevated at times of low flow. For example, arsenic exceeded the WQG at both IR6 and IR8 during the summer 2015 sampling program in most sampling events; while dissolved aluminum remained below guideline levels during summer but displayed elevated concentrations above the chronic and acute guidelines during fall through winter. This relationship is presented in Appendix II, Graphs 101 and 103.

Total zinc exceeded the WQG on one occasion at IR6 during a monthly sampling event in June 2015, resulting in 0.0571 mg/L and on one sampling event downstream of the confluence of the Iron River and the Quinsam River at IRQR during February 2015 resulting in 0.048 mg/L. As stated previously zinc is elevated naturally throughout the receiving environment and appears to be attributed to runoff or groundwater inputs.

All other parameters of interest (from the Iron River) were below their respective guideline levels at IR1, IR6 and IR8. Furthermore, besides the one zinc exceedance all WQG parameters were observed below guidelines at station IRQR throughout the reporting period; therefore, mixing of the Quinsam and Iron River(s) continues to result in sufficient dilution to reduce total arsenic and dissolved aluminum.

Appendix I, Tables (101 -116) and Appendix II, Graphs (101 to 103) display relevant data for all Iron River stations graphed against flow.

7.0 Conclusion

Water quality in the Middle Quinsam Sub-Basin remained consistent with previous years and is considered to be in good condition. The majority of parameters of concern were below Provincial guideline and objective levels indicating minimal health risk to sensitive aquatic receptors. For example, sulphate concentrations were recorded below its respective guideline during all sampling events in all lakes; this trend signifies water management features and controls at the mine site are effective.

This year Quinsam experienced two permit limit exceedances for TSS; one in the North and one in the South and 5 events at 7SSD where pH was slightly more alkaline than the 7-South permit limit of 8.0. However, the levels recorded were not detectable at downstream monitoring stations and, therefore, not considered detrimental to the receiving environment. Nevertheless, remedial measures were developed and implemented to mitigate future occurrences and ensure compliance with effluent permit conditions. These include:

- Improving water management structures
- Ensuring decant risers are free of macrophyte growth
- Ensuring automated samplers, suction lines and bottles are cleaned regularly
- Installing a pumping system operated on floats and powered by a generator at 7-South
- Frequent site inspections
- Reduced pumping and discharging

These efforts have resulted in minimal permit limit excursions throughout out 2015-16 monitoring year.

Parameters of interest and those displaying elevated concentrations in the lakes include total and dissolved iron & total manganese, both of which are associated with low dissolved oxygen concentrations. Total and dissolved iron concentrations were elevated during summer and fall sampling at 1 metre from bottom samples on Lower Quinsam Lake. Middle Quinsam Lake was observed to have elevated total and dissolved iron during fall at 1 metre from bottom. Total manganese was elevated at depth in all three lakes (LLM, MQL and LQL) during fall.

The relationship between low DO and elevated manganese in Long Lake 1 metre from bottom sample has been demonstrated in Appendix II, Graph (58). This pattern of elevated manganese at depth 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.

When surface water quality emanating from the South Water Management System is examined there does not appear to be a correlation between mine related discharge and Long Lake manganese concentrations. For example, total manganese concentrations at monitoring station LLE remained well below guideline levels with an average concentration of 0.107 mg/L for the reporting year (Although, it is questionable if discharge at LLE actually impacts the LLM sampling location). However, manganese concentrations (dissolved fraction) in the historical mining zones (e.g. 2-South and 4-South) within close proximity to Long Lake are observed to be elevated and may be influencing water column concentrations through both shallow and deep groundwater. Reclamation efforts were initiated in March at the 4-South Pad and have continued into the 2016-2017 monitoring year. This has entailed:

- Trenching and lining a new ditch so collected surface water does not drain through the pad
- Removing the remaining coal and other material on the pad
- Backfilling / recontouring high wall and place cover soil
- Filling in the portals
- Seeding / tree planting

Reclamation efforts are now underway at the 2-South and 3-South areas which include:

- Backfilling / recontouring high wall and placement cover soil
- Seeding/ tree planting
- Filling in the 1-South Sump & recontouring and placing cover soil

Quinsam anticipates that the efforts invested into these reclamation projects will continue to contribute to improving water quality in Long Lake.

Total zinc was observed to be above the water quality guideline in the receiving environment yet not considered to be mine related. The exceedances occurred during spring at two sampling events on surface in No Name Lake, and one sampling event at surface on Lower Quinsam Lake and at depth in Middle Quinsam Lake. IRQR experienced one elevated zinc concentration during winter.

When considering the potential toxicological effects of such an exceedance it is important to consider the bioavailable form of the parameter; in this case, the dissolved fraction was below detection limits for each sample/station. Therefore, the risk to sensitive aquatic receptors associated with these exceedances is deemed to be very low. The cause of this pronounced increase is unknown at this time and Quinsam will carefully examine monitoring data from future programs to identify any potential local sources.

Field pH at depth in the lakes has exceeded lower water quality guidelines of 6.0 in all lakes on occasion throughout 2015-2016. However, the only lake where there is concern is No Name Lake as the slightly acidic conditions are prevalent year over year and not associated with depth. Monitoring of this lake has only occurred since 2012. It may be naturally occurring due to the location and depth of No Name Lake. This will continue to be monitored in the future.

The Iron River was added to the receiving environment monitoring program during the 2014/2015 monitoring period as a result of the 7-South Area 5 mine approval. This development has been postponed until the demand for thermal coal increases. This system experiences naturally elevated concentrations (above water quality guidelines) of aluminum and arsenic; 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. These parameters have continued to be observed throughout 2015-16 monitoring in this system. The main intention is to develop water quality objectives reflective of baseline conditions.

Quinsam Coal will continue to focus on site wide water management with a target of mitigating parameter 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 reducing concentrations of certain parameters (e.g. sulphate). This trend is expected to persist and will be highlighted by future monitoring programs.