2023 Water Quality Monitoring Program Results

Haslam Lang Community Watershed

Project Number: 24-105
March 14, 2024

Client:
Powell River Salmon Society
5775 Ash Avenue
Powell River, BC V8A 4R3

Carlie Chan, M.Sc.
Statlu Environmental Consulting Ltd.
1-45950 Cheam Avenue
Chilliwack, BC V2P 1N6

www.statlu.ca

EARTH WATER LAND

SUMMARY

The Powell River Salmon Society (PRSS) has monitored water quality within the Haslam Lang Community Watershed since 1997. The watershed supplies drinking water to the City of Powell River and the community of Brew Bay. Haslam Lake, Lang Creek, and their tributaries provide important habitat for salmon species, and the PRSS operates a hatchery on Lang Creek. Maintaining water quality is important for providing clean drinking water and ensuring that salmon can spawn and rear.

PRSS retained Statlu Environmental Consulting Ltd. (Statlu) to analyze water quality data collected during the 2023 monitoring program and to compare the results with data from previous years. PRSS recorded water temperature, stage, turbidity, pH, and salinity twice per month at six locations within the watershed. The measurements were taken at Lang Creek near the Alex Dobler Salmon Centre, the outlet of Duck Lake, Anderson Creek, Blackwater Creek, Haslam Lake, and Slough Station, the weir at the outlet of Haslam Lake. The water quality monitoring program, which began in 1997, documents a long period within the watershed which is a valuable tool for establishing baseline conditions. This allows land managers to detect potential problems and implement solutions to maintain good water quality for fish and water users.

In general, 2023 was one of the driest years on record, and the second year of a multi-year drought, which began to end in autumn 2023. The watershed received 24% less precipitation in 2023 than the 30-year average from 1981 to 2010, with the first 8 months of the year receiving 41% less precipitation than normal and the last 4 months receiving 2% less precipitation. This resulted in relatively low stage and discharge measurements during the first part of the year, increasing towards the end of the year. The minimum Lang Creek stage measurements of 0.25 m were recorded on August 30 and September 15, and are the lowest measurements on record.

The maximum biweekly water sampling temperatures in 2023 were similar to 2022, with Duck Lake and Slough Station recording higher maximum temperatures than 2022, Blackwater Creek recording the same maximum temperature, and Haslam Lake, Lang Creek, and Anderson Creek recording cooler maximum temperatures. The 2023 maximum water temperature measured was 1.2°C less than the maximum biweekly water temperature recorded within the watershed in 2022

due to a less intense heat wave. The maximum water temperature from continuous measurements on Lang Creek in 2023 was 2.3°C cooler than the 2022 maximum.

Turbidity, pH, and salinity generally varied within the normal and acceptable range for 2023. The average turbidity measurements from all six stations were 2% to 51% higher than in 2022. The maximum turbidity on Lang Creek (10.2 NTU) is 83% higher than the 2022 bimonthly maximum of 5.6 NTU but is still much lower than high turbidity measurements recorded since 1997. All stations except for Duck Lake had higher maximum turbidity readings than in 2022, but only four readings were above 2 NTU. Average pH measurements were more acidic (lower values) than 2022 but remain within normal variability. Average and minimum salinity measurements were the same or lower than in 2022, with the exception of Blackwater Creek which had increased average salinity. This water quality data suggests that forest management strategies intended to protect water quality within the watershed remain successful.

CONTENTS

APPENDICES

1.0 INTRODUCTION

The Powell River Salmon Society (PRSS), with funding from the Powell River Community Forest (PRCF), British Columbia Timber Sales (BCTS), and Thichum Forest Products of the Tla'amin First Nation (Thichum), monitors streams and lakes within the Haslam Lang Community Watershed to identify how development and land use affect water quality and habitat. The watershed provides important habitat for several fish species, and the PRSS operates a hatchery on Lang Creek. The watershed provides drinking water to the city of Powell River and the community of Brew Bay.

As part of the ongoing water quality monitoring program, the PRSS retained Statlu Environmental Consulting Ltd. (Statlu) to analyze water quality data collected during 2023 and to compare the results with previous years of monitoring.

2.0 BACKGROUND

Land managers have prioritized sustainable development within the Haslam Lang Community Watershed for over two decades. Water quality monitoring within the watershed began in 1997 and a watershed management plan was implemented in 1999. Both initiatives aimed to study and maintain water quality to protect the communities and natural ecosystems that depend on the watershed.

The Haslam Lake and Lang Creek Integrated Watershed Management Plan (IWMP) and subsequent watershed assessments, most recently completed in 2020, have guided sustainable development within the watershed by identifying resources at risk and effectively managing public interests. Management planning, watershed assessments, stakeholder involvement, and implementation of best management practices have provided sound scientific and practical guidance for sustainable development in the watershed.

The water quality monitoring program provides important information to the watershed management plan process. The data analysis can identify short-term changes and long-term trends in water quality that can only be identified with active monitoring. If the monitoring identifies potential problems, the data can guide management strategies to reduce risks within the watershed

and to downstream resources. Land managers can use insights from these analyses to prioritize and respond to potential problems before they cause damage to watershed resources.

The monitoring program also ensures that water license operators meet sustainability requirements throughout the year. One requirement is to maintain a minimum flow greater than 15 ft^3/s (0.42 m^3/s) in Slough Creek downstream of the storage dam at all times of the year, and an increased discharge of 25 ft^3/s (0.71 m^3/s) during October and November to meet instream flow requirements for returning salmon runs. Maintaining the minimum flow requirements and good water quality is key for sustainable development within the watershed.

Four watershed assessments have been completed: the first in 1999 (Carson, 2000), the second in 2003 (Carson, 2003), and the third in 2015 (Carson Land Resource Management, 2015). Statlu completed the fourth and latest watershed assessment in 2020 (Statlu, 2020). Additionally, Carson (2010) assessed how PRCF operations affect water quality within the Powell River area, including areas within the PRCF but outside the community watershed. Statlu will conduct another watershed assessment of the Haslam Lang Watershed in 2024, with a final report expected by 2025.

3.0 METHODOLOGY

The water quality monitoring program includes biweekly measurements at six locations in the watershed, continuous water temperature monitoring at several locations, and continuous water temperature and discharge monitoring on Lang Creek at the Alex Dobler Salmon Centre. The biweekly measurements include stream stage, turbidity, pH, water temperature, and salinity. They are taken at Lang Creek near the Alex Dobler Salmon Centre, the outlet of Duck Lake, Blackwater Creek, Anderson Creek, Haslam Lake near the community water intake, and Haslam Lake at Slough Station (Figure 1 in Appendix 1). Continuous water temperature monitoring occurs in Duck Lake and in Lang, Anderson, and Blackwater Creeks. The data, along with general observations and photographs taken during the sampling, were sent to Statlu for analysis.

Statlu first compared monthly precipitation and temperature data recorded during 2023 to the latest average monthly data collected during the 30-year period from 1981 to 2010 (Environment Canada, 2024). Environment Canada has not yet published climate normal data conditions for the 1991 to 2020 interval for Powell River, but they are expected to be released by 2025. When those

data are made publicly available, they will provide a more accurate baseline against which to compare recently measured conditions. The data was recorded at the Powell River A climate station, located 130 m above mean sea level at the Powell River Airport, about 7 km southwest of Haslam Lake. The 30-year average of precipitation and temperature is referenced as normal climate conditions.

Statlu then prepared two graphs for each water quality variable measured during the biweekly sampling (water temperature, stage, turbidity, pH, and salinity). The data for all six sites within the watershed are plotted on each graph. The first graph shows how one of the water quality variables changed at each of the six locations during 2023. The second graph compares the data recorded during 2023 to data recorded from 1997 to present. The long-term graph shows how water quality within the watershed has changed over the history of monitoring and allows anomalous long-term trends to be identified.

Statlu compared the six water quality variables to the continuous hydrograph data recorded on Lang Creek at the Alex Dobler Salmon Centre. We extracted the daily maximum and minimum discharge (water volume) from the continuous stream flow data and compared those values to previous years. We plotted the stream flow data with daily precipitation data collected at the Powell River A climate station, located at Powell River airport. Precipitation data from the Powell River climate station replaces missing Powell River A data on November 10, 11, 13, and 14, 2023. The comparison of discharge to precipitation show how Lang Creek responds to short-term weather events. This also provides additional information about how the weather and climate affected water quality during the biweekly sampling and what may have occurred between sampling dates.

The PRSS used to collect precipitation data at the Alex Dobler Salmon Centre, but analysis of several years of data show that the Powell River A and Powell River climate station data closely match the means, range, and variability of the data collected in the watershed. Given the similarity between the climate data from the two locations, the Powell River data reasonably describes climactic conditions in the Lang Creek watershed. Accordingly, the PRSS decided to stop independently collecting climate data. This analysis uses data collected in Powell River (Environment Canada, 2024).

Statlu compared the continuous water temperature data recorded in Duck Lake and Lang, Anderson, and Blackwater Creeks to air temperature data recorded in Powell River. Statlu compared the daily water temperature data to the bimonthly water quality data recorded within the watershed.

The PRSS had several tidbit failures in 2023; however, there were enough redundant units in place to capture the necessary data. Tidbits are small water temperature data loggers, which continuously monitor temperature data in Anderson, Blackwater, and Lang Creeks, and in Duck Lake. Tidbit data for Duck Lake is missing for the first ten days of January.

4.0 OBSERVATIONS

The PRSS made field observations and took photographs within the watershed to record conditions that could influence the data. The photographs are shown in Appendix 2.

5.0 RESULTS

5.1 Precipitation and Air Temperature

I compared the total monthly precipitation and mean monthly air temperature, recorded at the Powell River A climate station during 2023, to the monthly 30-year averages (referred to as 'normal') recorded from 1981 to 2010 at the same location (Figure 2). As noted in Section 3, precipitation data from the Powell River climate station replaces missing Powell River A data on November 10, 11, 13, and 14, 2023.

The total precipitation recorded during 2023 was 911 mm, which is 12% less than the 1041 mm recorded in 2022, and 24% less than the 30-year average from 1981 to 2010 of 1206 mm per year (Environment Canada, 2024). April, October, and December had more precipitation than the 30-year average with 4%, 15%, and 10% increases relative to the long-term monthly averages, respectively. However, the rest of the year was drier than normal with January to March being 44% drier than the average, and May to September being 49% drier. The summer drought was widespread across the region and affected much of the coast, Vancouver Island, and the Interior Plateau. In particular, Vancouver Island and the Lower Mainland reached Stage 4 drought

conditions with some parts of Vancouver Island and the Sunshine Coast into Stage 5 drought for August and September 2023 (BC Government Drought Information Portal, 2024).

Southwest BC had a cool early spring and warm summer in 2023. Average air temperature was 1.2°C below normal in February to April, and 1.9°C above normal from May to August, before remaining similar to normal for September to November, and ending the year with December being 2.9°C above normal. The warmest month was July, with an average temperature of 19.0°C, which is 0.8°C less than the warmest average month in 2022 and 1.8°C more than the 30-year average warmest month temperatures of 17.2°C.

The Powell River A climate station recorded eight days above 30°C in 2023, which is the same as 2022. The maximum 2023 air temperature was 32.2°C on August 15, 1.4°C cooler than the 2022 maximum of 33.6°C, which occurred during the 5 consecutive days above 30°C in July 2022. During the 30-year average from 1981 to 2010, the Powell River A climate station recorded an average 1.6 days above 30°C per year. With eight days above 30°C in 2023 and 2022, that is a 400% increase from the 30-year average. It is likely that the average number of days above 30°C over the 1991 to 2020 climate interval will be shown to be more than 1.6 when that data is published. Neither 2022 nor 2023 reached as hot temperatures as occurred during the summer 2021 heat dome.

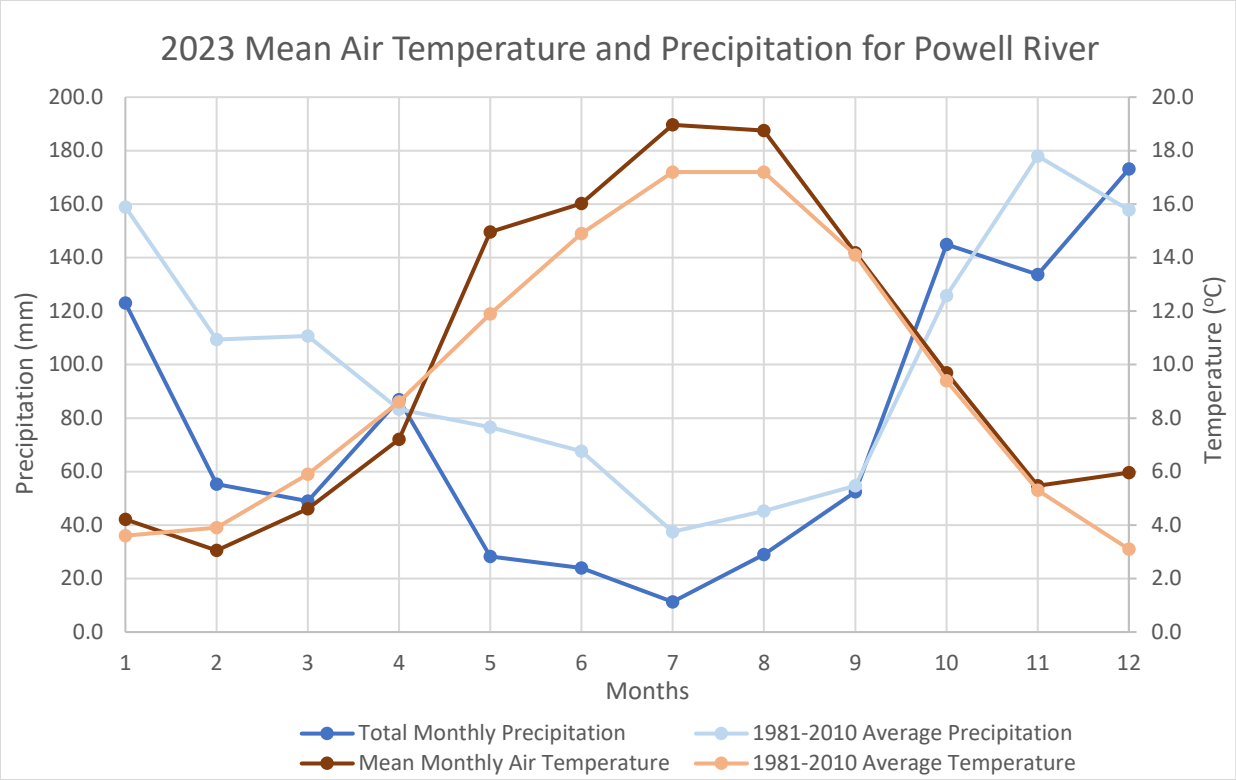


Figure 2: Mean air temperature (°C) and total monthly precipitation (mm) at the Powell River A climate station for 2023 compared to the 30-year average from 1981 to 2010. Precipitation data from the Powell River climate station replaces missing Powell River A data on November 10, 11, 13, and 14, 2023.

5.2 Water Temperature

Continuous water temperature monitoring at Lang, Anderson, and Blackwater Creeks, and in Duck Lake, show how water temperature responded to weather events (Figure 3). The continuous water temperature data is compared to air temperature data recorded at the Powell River A and Powell River climate stations (Environment Canada, 2024). The data show that water temperature spikes closely follow air temperature spikes. Lang Creek and Duck Lake have marginally larger temperature increases during summer than Anderson and Blackwater Creek. In spring, Lang Creek stays warmer than the minimum temperatures of the other creeks. In autumn, Duck Lake stays warmer than the minimum temperatures of the creeks. The maximum water temperatures occurred on August 16 and 17, with 24.2°C in Duck Lake, 21.8°C in Lang Creek, 18.6°C in Blackwater Creek, and 15.8°C in Anderson Creek. These high temperatures were recorded within

the two days following the warmest day measured at the Powell River A climate station in 2023. The maximum water temperature on Lang Creek in 2023 was 2.3°C less than the 2022 maximum.

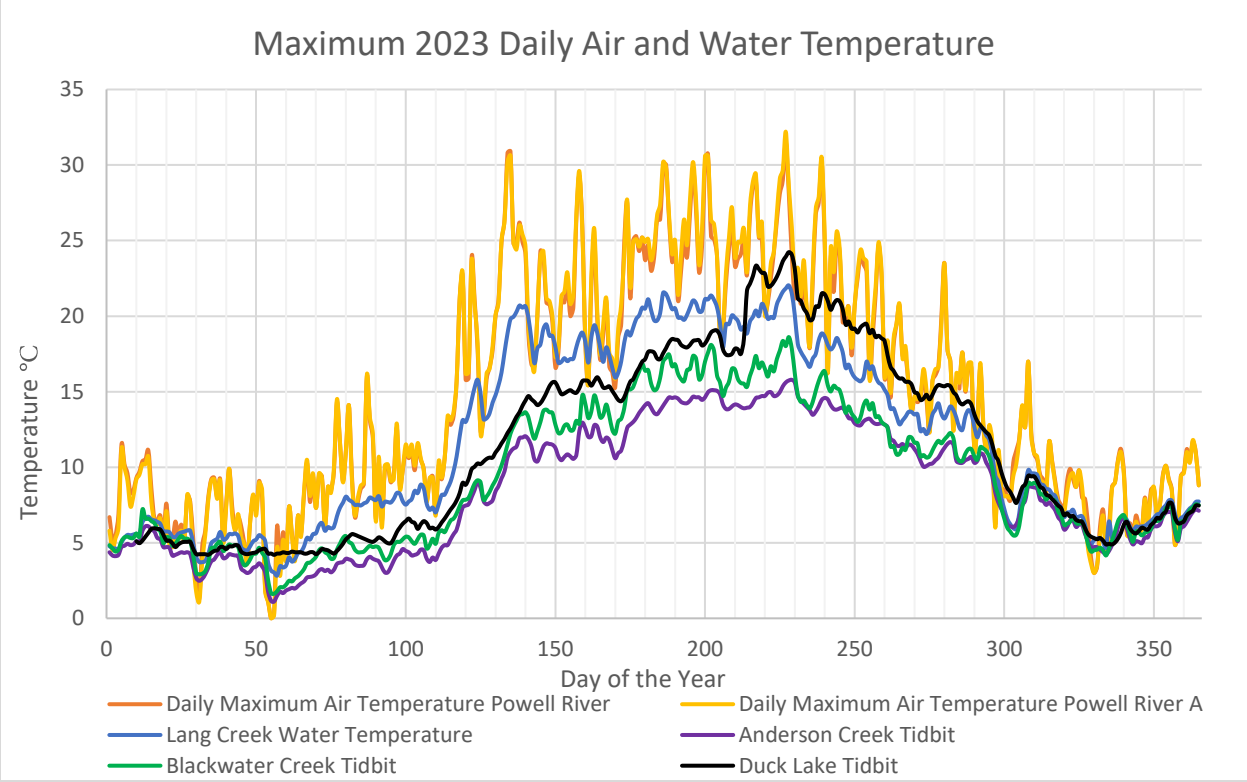


Figure 3: Comparison of maximum air temperature with maximum water temperatures in the watershed. Continuous water temperature data was recorded on Lang Creek at the Alex Dobler Salmon Centre. Air temperature data is from the Powell River and Powell River A climate stations (Environment Canada, 2024).

Bimonthly sampling throughout the watershed shows how temperatures at all six sites varied during the year. Average water temperatures within the watershed ranged from 7.9°C to 12.6°C, which is warmer than the 2022 averages from 7.5°C to 11.8°C. The temperatures are coldest during the winter and warmest during the summer (Figure 4). The maximum water temperatures recorded were 0.2°C to 2.6°C cooler than in 2022 at most sites, except for Duck Lake and the Sloughs, which were 0.6°C warmer and 0.5°C warmer, respectively, and Blackwater Creek which had the same maximum temperature as 2022. Duck Lake historically has the highest maximum water temperature within the watershed and this year had a maximum temperature of 24.1°C. The 2023 maximum is 0.6°C warmer than the maximum temperature recorded in Duck Lake in 2022 but is 1.2°C cooler than the maximum water temperature of 2021 which was recorded in Haslam

Lake. The maximum bimonthly water temperatures in 2023 remain within the normal variability recorded at the six sites from 1997 to present (Figure 5).

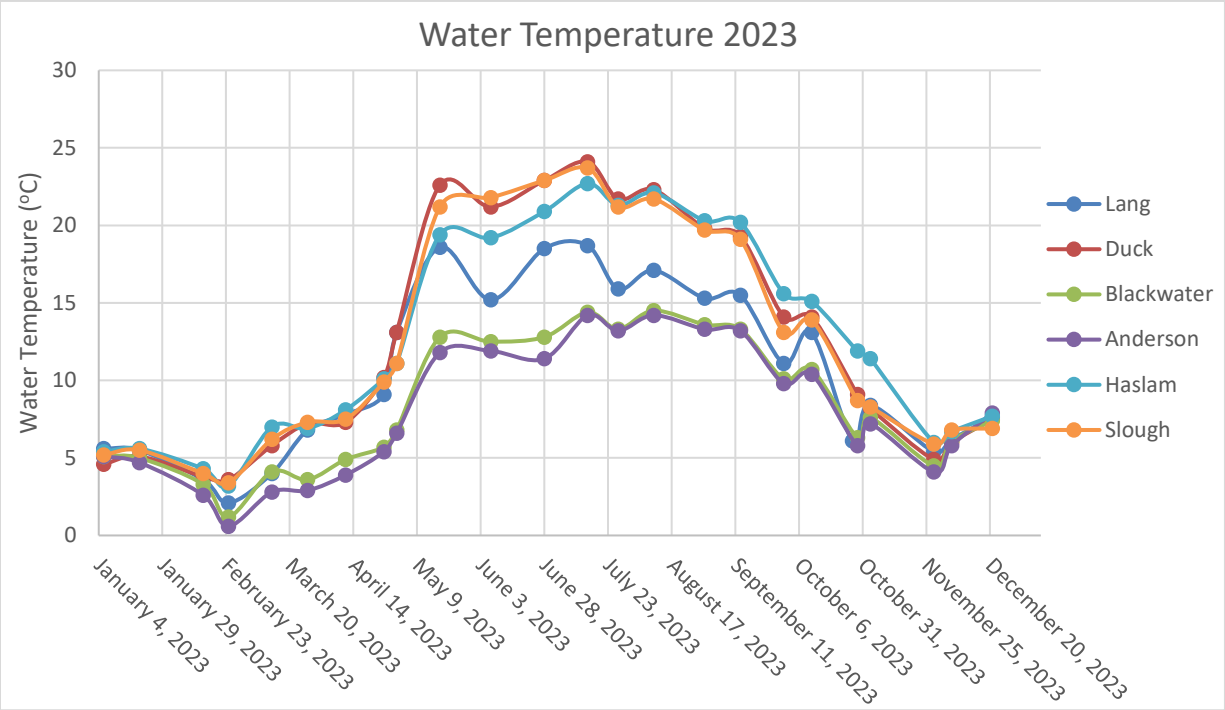


Figure 4: Water temperature measured at six sites within the Haslam Lang Community watershed.

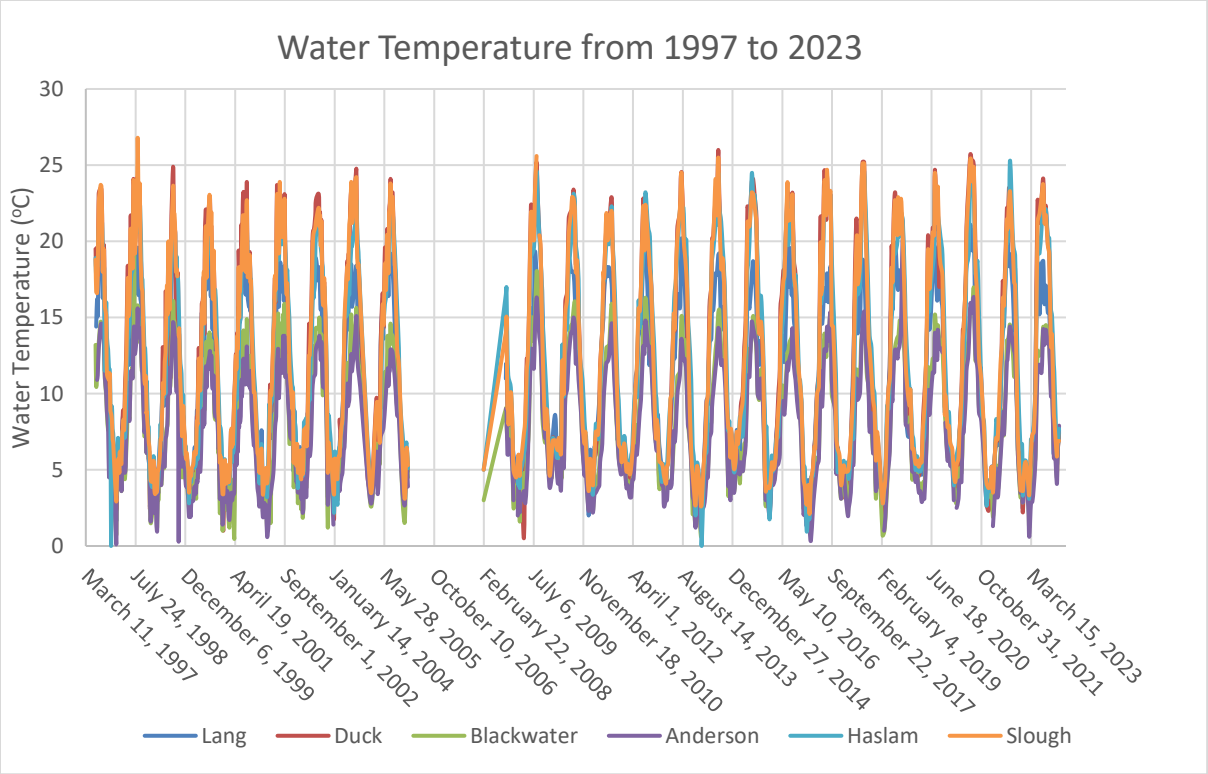


Figure 5: Water temperature at six sites within the Haslam Lang Community watershed between 1997 and present.

5.3 Stage and Hydrograph

Stage measurements record the height of the water surface relative to a known reference elevation (Figure 6). The stage data for Haslam Lake and Slough Station are plotted on a secondary axis as their stage reference points are geodetic elevations, which differ from the other four sampling locations. Despite having two different reference points, the stage data for all six sites shows similar water level variations within the watershed during 2023.

The stage measurements at all six sites started high, reached minimum levels in early fall, and then rose back to meet or exceed the water levels measured at the beginning of the year, in response to precipitation and temperature patterns (Figure 6). Most stage measurements in 2023 are similar to 2022 during the first few months of the year, lower in summer, and higher in the last few months. The average stage measurements range from 0.12 m lower to 0.03 m higher than the 2022 measurements. The average stage was lower at Lang Creek, Haslam Lake, and Slough Station, and higher in Duck Lake, Anderson, and Blackwater Creek. The minimum stage measurements in 2023 on all creeks range from 0.02 m higher to 0.15 m lower than in 2022. Duck Lake recorded higher minimum stage measurements, while all the other stations recorded lower minimum stage measurements. The minimum stage measurements on Lang Creek were 0.25 m, recorded twice, on August 30 and again on September 13. These measurements tied the lowest stage measurements on record, which were reached once before on August 15, 2017 (Figure 7). The stage measurements overall remained just within the range of previous measurements in the watershed.

The increased precipitation at the end of the year resulted in high stage measurements in December. The maximum stage was up to 0.33 m higher than in 2022, but all measurements are similar to the normal range of values recorded since 1997 (Figure 7). The biweekly measurements did not capture the maximum Lang Creek discharge on January 13 (Figure 8) but did capture high stage on April 11 which occurred after several days of rain and high discharge.

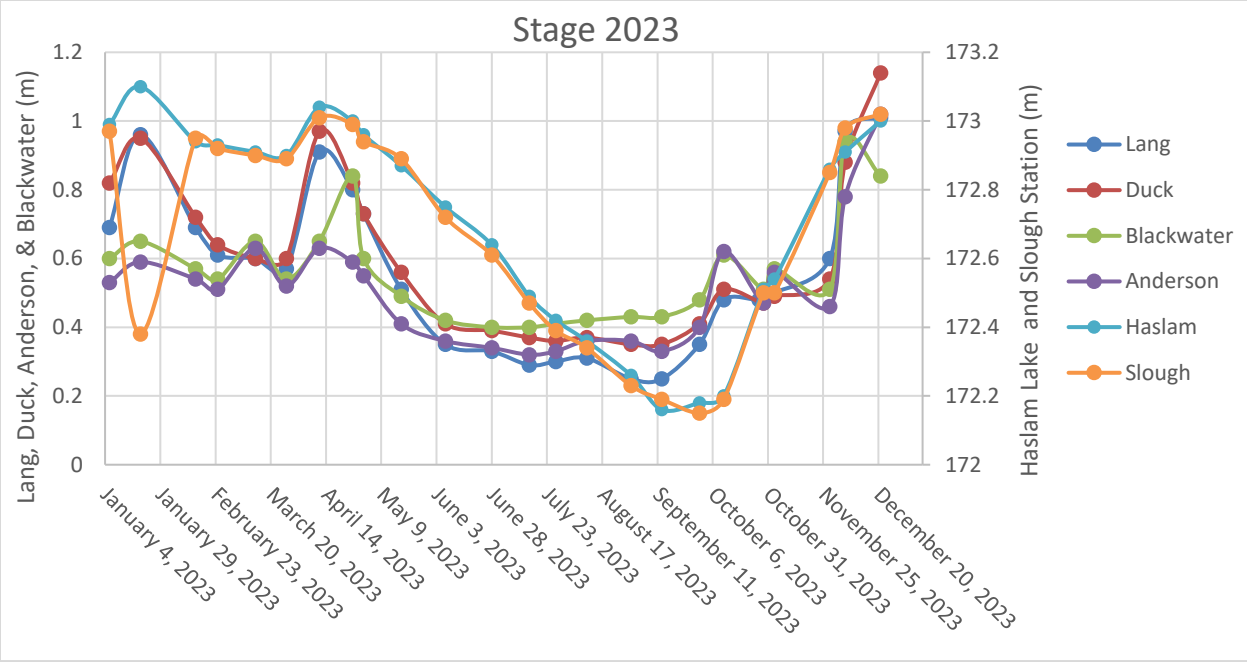


Figure 6: Stage level at six sites within the community watershed during 2023. Stage measurements for Haslam Lake and Slough Station are graphed on the secondary (right) axis.

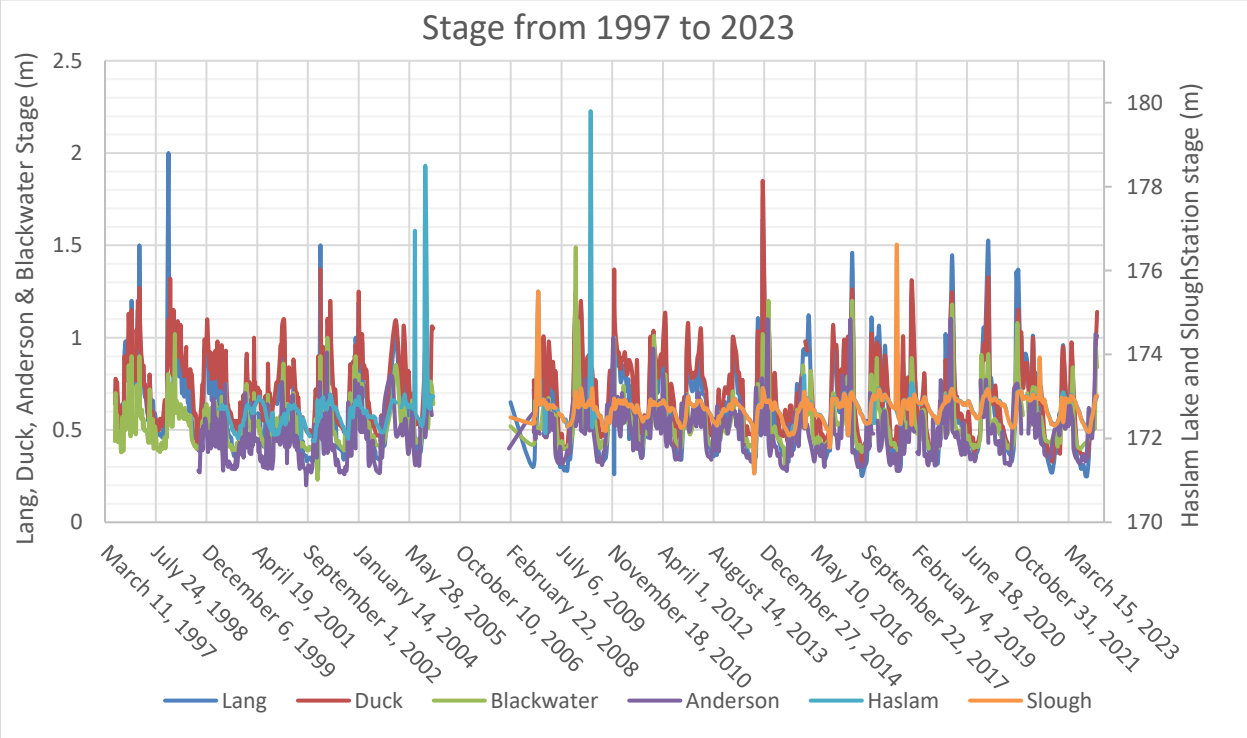


Figure 7: Stage discharge at six sites within the community watershed between 1997 and present. The stage for Haslam Lake and Slough Station is graphed on the secondary (right) axis.

Continuous data recording in Lang Creek measured discharge rates throughout 2023 (Figure 8). The maximum peak discharge in Lang Creek was recorded on January 13 at 30.6 m^3/s. The lowest discharge was on September 12 at 0.219 m^3/s. The average discharge through 2023 was 3.71 m^3/s and the median discharge was 2.63 m^3/s. The 2023 maximum, minimum, and average discharge values are less than those recorded in 2022 (Table 1, Figure 9). The maximum discharge is 20% lower, the minimum discharge is 22% lower, and the average discharge is 6% lower than the 2022 values. The median discharge of 2023 is 19% higher than the 2022 median. The 2023 average and minimum discharges are the lowest observed in the last 5 years (Table 1, Figures 7 and 9).

Haslam Lake was below the level of the outlet weir from about May 20 to about September 30, resulting in consistently low flow in Lang Creek. Several rainstorms beginning around day 273 (September 30) gradually raised the level of Haslam Lake, overtopped the weir, and allowed water to raise the level of Lang Creek. After this date, smaller single day rain events in October, November, and December resulted in discharge spikes because Haslam Lake's weir was no longer suppressing downstream peak flows.

Table 1: Yearly discharge rates of Lang Creek from 2019 to 2023.

Year	Maximum (m^3/s)	Average (m^3/s)	Median (m^3/s)	Minimum (m^3/s)
2019	23.3	3.77	2.38	0.472
2020	59.1	6.07	2.70	0.722
2021	70.1	7.56	4.14	0.490
2022	38.1	3.94	2.18	0.282
2023	**30.6**	**3.71**	**2.58**	**0.219**

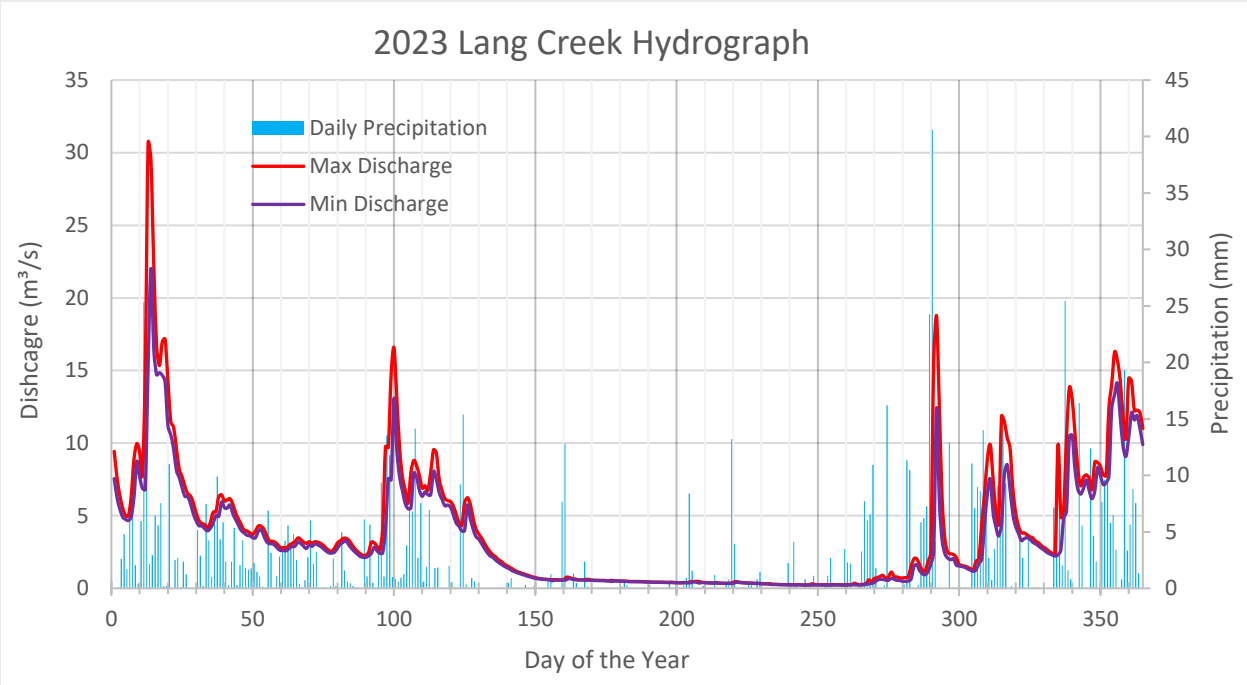


Figure 8: 2023 Hydrograph for Lang Creek. The minimum and maximum daily discharge (m³/s) for Lang Creek is plotted against the total daily precipitation (mm) recorded at the Powell River A climate station. Precipitation data from the Powell River climate station replaces missing Powell River A data on November 10, 11, 13, and 14, 2023.

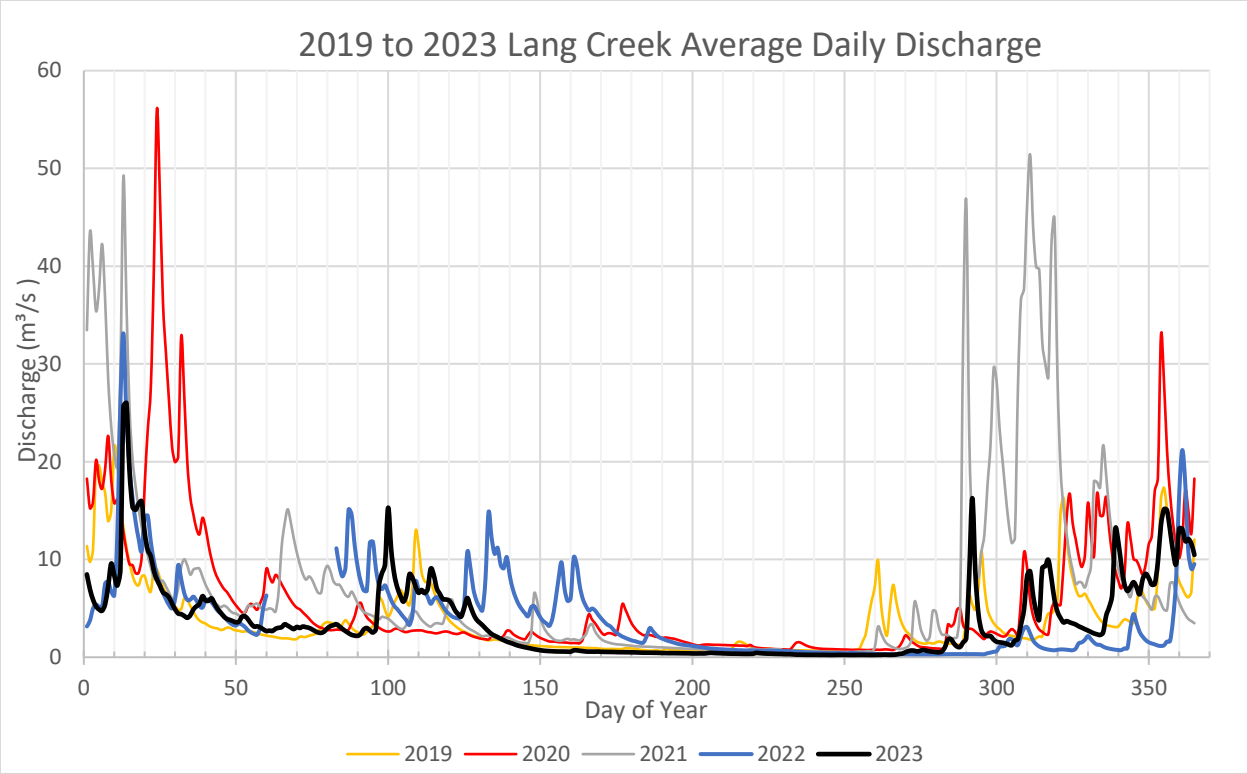


Figure 9: Average daily discharge data for Lang Creek comparing 2019 to 2023 data.

5.4 Turbidity

The bimonthly turbidity measurements in 2023 were between approximately 0.26 NTU and 10.2 NTU, with average readings between 0.58 NTU and 1.52 NTU (Figure 10). The highest turbidity reading occurred on December 5 on Lang Creek. Other elevated readings occurred on January 6 at Haslam Lake and on September 13 and October 11 at Lang Creek. All other turbidity readings were below 2 NTU.

The turbidity levels in 2023 are generally higher than in 2022. The maximum turbidity on Lang Creek (10.2 NTU) is 83% higher than the 2022 bimonthly maximum of 5.6 NTU. The average turbidity measurements from all six stations were 2% to 51% higher than in 2022. The maximum turbidity readings at Anderson Creek and Haslam Lake were 92% and 71% higher than 2022, respectively.

Turbidity data from 1997 to present shows low average turbidity with episodic spikes through the years (Figure 11). The 2023 data shows that average turbidity levels within the watershed are normal and that maximum turbidity levels are well below other turbidity spikes in previous years.

It is possible that the slightly higher turbidity levels in 2023 result from the drought, for two reasons. Firstly, because it had been so dry for so long, there was a greater amount of dust and less vegetation to retain sediment. Secondly, because low flows remained lower for longer, the normal, or slightly increased, amount of fine sediment was concentrated by the low water, resulting in a slightly increased of suspended sediment per unit volume of water at low water levels, and increased availability of fine sediment to transport during the first spikes in discharge as the drought ended in September and October.

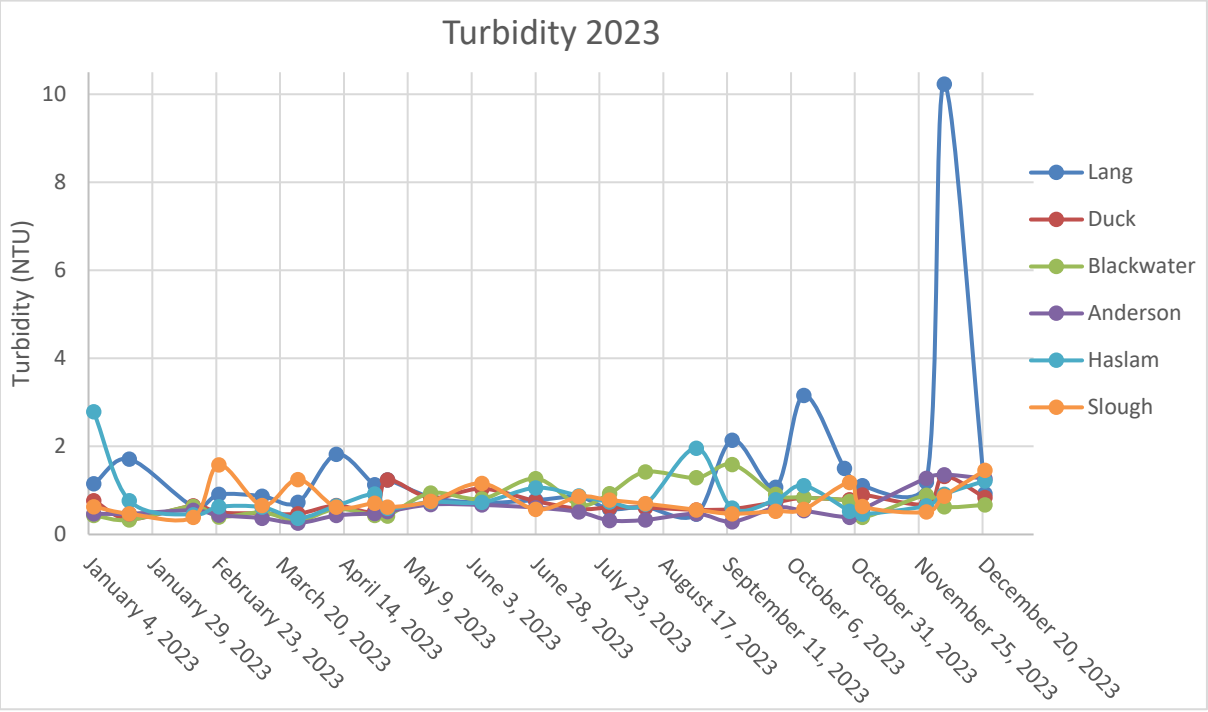


Figure 10: Turbidity measurements through 2023 at six sites within the Haslam Lang Community watershed.

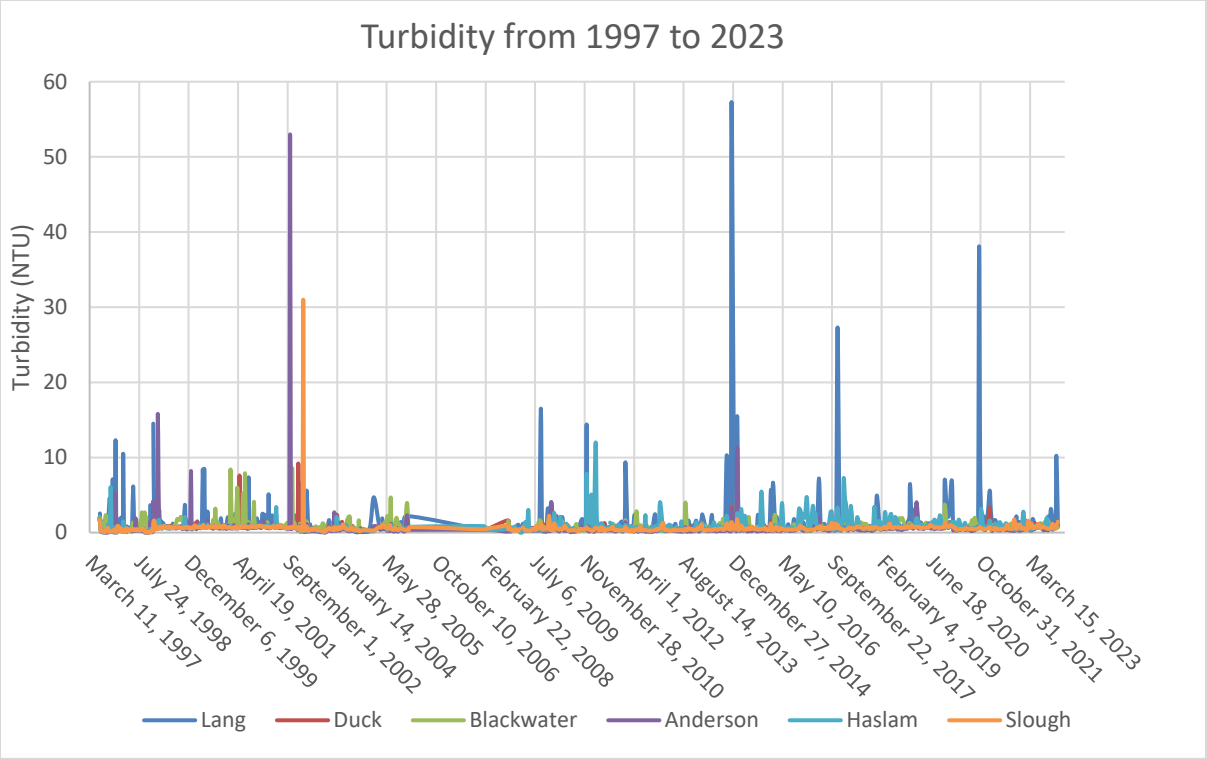


Figure 11: Turbidity at six sites within the Haslam Lang Community watershed between 1997 and present.

5.5 pH

The pH ranged between 6.3 and 7.6 within the watershed during 2023 (Figure 12). Overall, pH varies with a level trend during the year with some lower pH measurements early in the year. Average pH measurements at all sites were lower (more acidic) than recorded in 2022. The 2023 averages were between 6.9 and 7.0, slightly less (more acidic) than the 2022 pH averages of 7.0 to 7.1. Maximum (basic) pH measurements of 7.4 to 7.6 occurred in Haslam Lake, Slough Station, and Anderson Creek on October 11. These readings are 0.1 to 0.4 (1% to 6%) more than the maximum pH recorded in 2022. The minimum pH measurements of 6.3 on Haslam Lake and 6.4 at Slough Station occurred on January 6. These readings are up to 5% less than the 2022 minimums recorded at these locations.

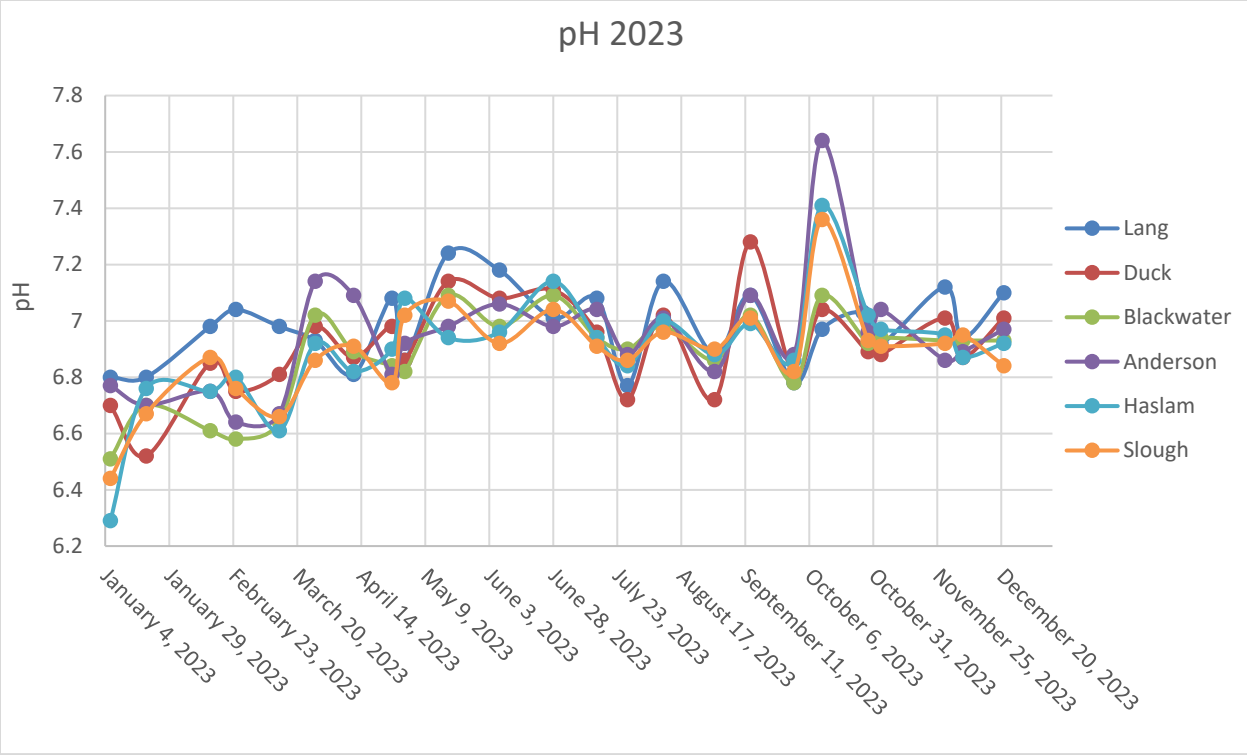


Figure 12: pH at six sites within the Haslam Lang Community watershed.

Variations in pH for the recorded history for all sites are shown in Figure 13. The pH values over the last three years show slightly more variability than between 2016 and 2021, where the pH generally varied between 6.7 and 7.3 (with the exception of one low pH spike in 2019). Despite the increased variability, pH range over the last three years remains within normal variability and is much less than pH variation recorded from 1997 to 2013.

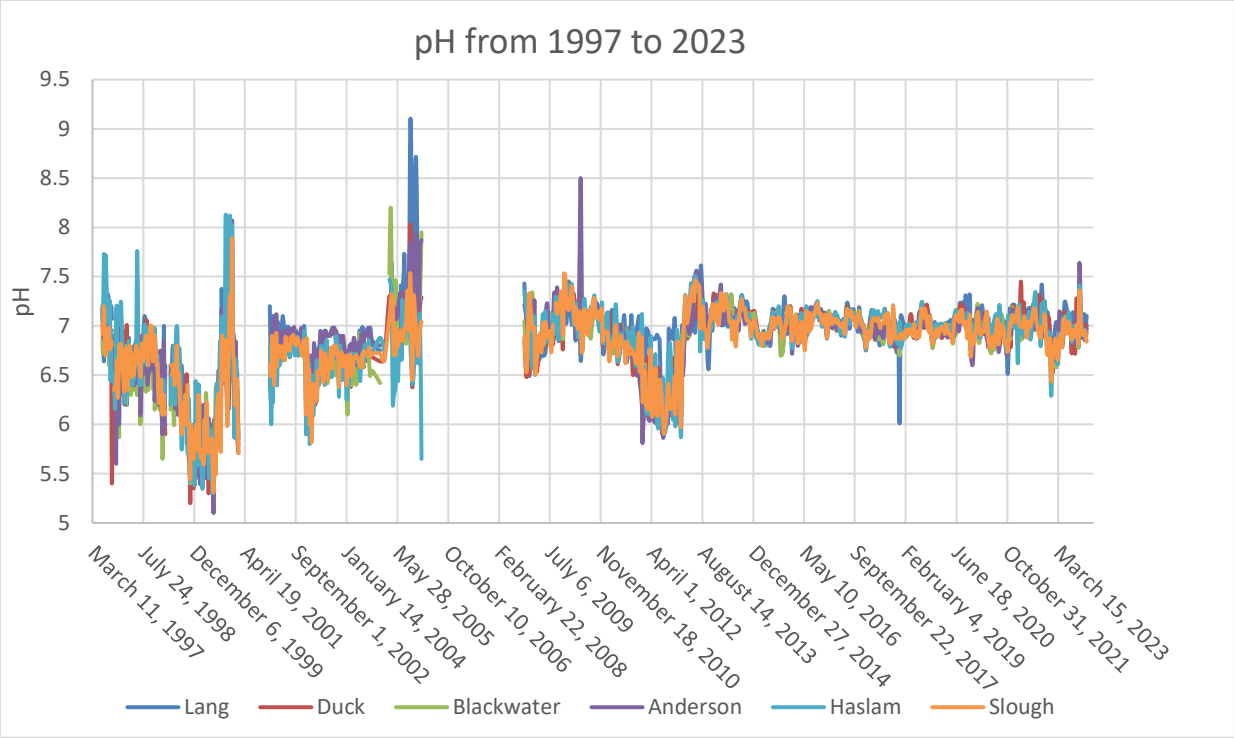


Figure 13: pH at six sites within the Haslam Lang Community watershed between 1997 and 2022.

5.6 Salinity

Salinity varied from about 0 ppm to 19 ppm at the six sites during 2023 (Figure 14). Average 2023 salinity ranged from 7 ppm to 9 ppm, which is less than the 2022 averages between 7 ppm and 11 ppm. The average salinity in Blackwater Creek was 22% more than in 2022. The other five stations recorded the same to 16% lower average salinities than in 2022. The smallest changes occurred in Lang and Anderson Creeks, where average salinity was 1% and 0% less than in 2022, respectively.

The maximum 2023 salinity measurement occurred on September 13 on Anderson Creek at 19 ppm. On the same day, Blackwater Creek recorded the station's maximum salinity reading at 18 ppm. Lang Creek also had 18 ppm salinity recorded on November 28. Overall, the maximum salinity readings ranged from a 14% decrease at Haslam Creek to a 46% increase at Anderson Creek in comparison to the measurements taken in 2022.

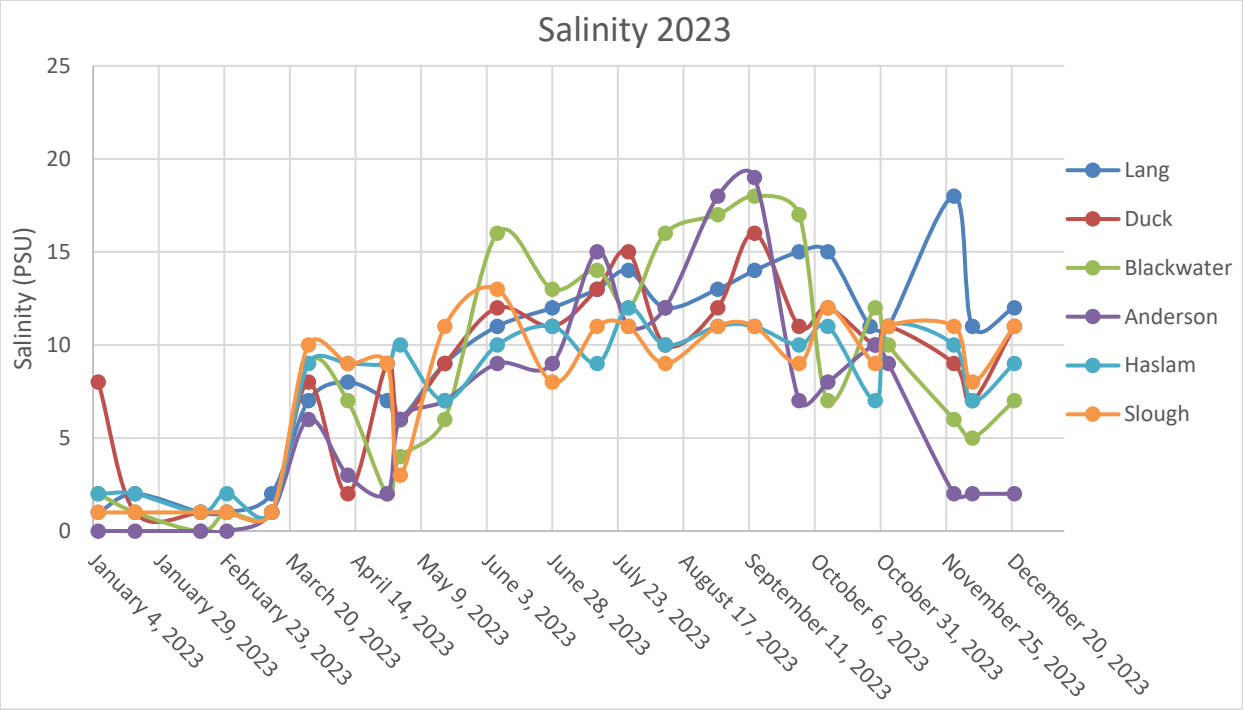


Figure 14: Salinity at six sites within the Haslam Lang Community watershed.

Duck Lake, Blackwater and Anderson Creeks have variable salinity, that on average, increase from winter to summer and decreases from summer back to winter. Haslam Lake, Lang Creek, and the Slough Station have low salinity readings early in the year, before increasing and remaining around 10 ppm to 12 ppm on average.

Salinity data from 1997 to present are graphed on Figure 15 with a gap between 2006 and 2008 when no monitoring occurred. Salinity data recorded from 1997 to 2006 are greater than salinity data recorded from 2008 to 2019. The abrupt decrease in salinity could result from equipment or measuring differences between the two periods. From 2009 to 2018, the salinity data for all six creeks varies from 0 ppm to 16 ppm and has average values between 4 ppm and 6 ppm. Salinity values started to increase at the end of 2018, and they continued to increase through 2019. The PRSS purchased a new salinity probe in 2020. It recorded similar, but slightly lower salinity levels in 2020 and again in 2021 and 2022. Despite the low salinity recorded at the beginning of 2023, average salinity levels are similar to 2022 and remain within normal salinity levels for the watershed.

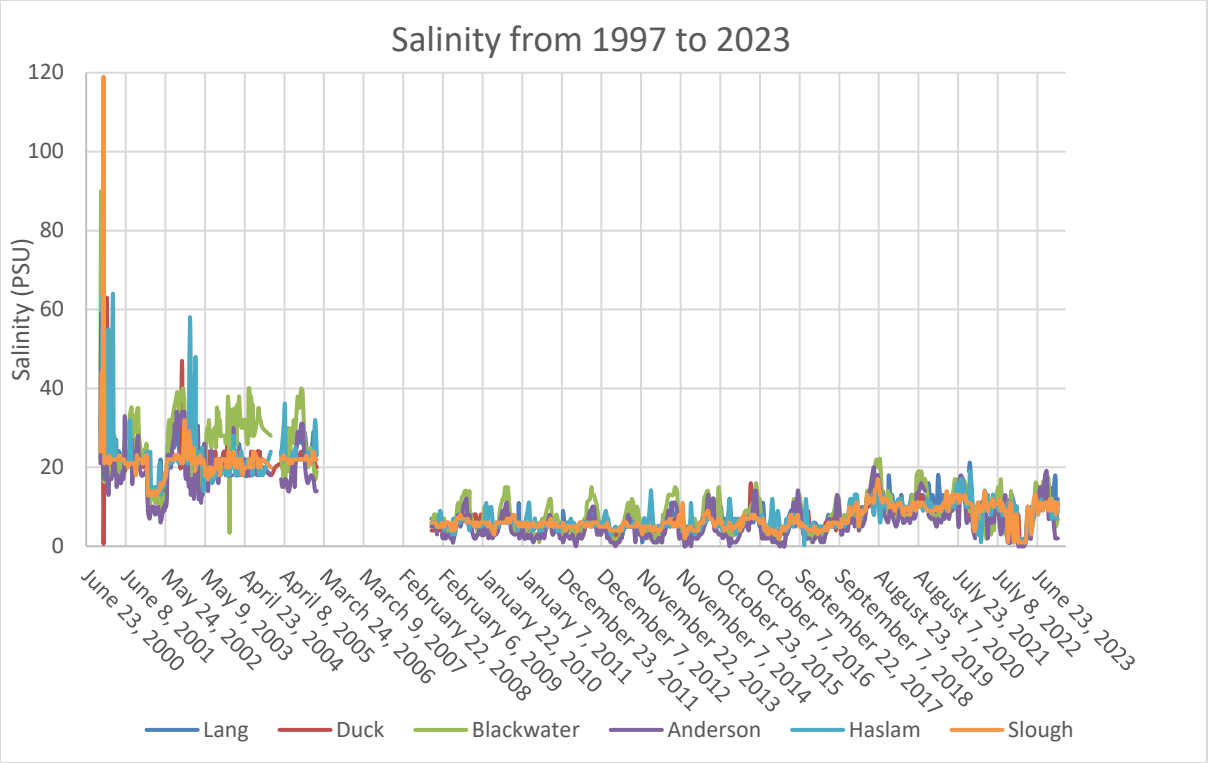


Figure 15: Salinity at six sites within the Haslam Lang Community watershed between 2009 and present.

6.0 DISCUSSION

Climate, weather, and land use affect water quality within the Haslam-Lang community watershed. Precipitation controls the volume and timing of water that enters the watershed, which determines how much erosive power streams have and the proportion of stream flow composed by runoff and groundwater. Variances of these properties control the physical and chemical characteristics of the stream such as temperature, discharge, turbidity, pH, and salinity. Land use within the watershed affects the amount of dust and sediment on road surfaces and the amount of potential contaminants within the watershed. Forest harvesting can affect runoff and forest cover near streams, which influences discharge and water temperature. This section compares water quality measurements within the watershed to identify trends between variables and understand how the hydrology of the Haslam Lang Community watershed may vary over time.

Maintaining suitable water temperature is important for maintaining healthy habitat within the watershed, as increasing water temperature results in lower water oxygen levels, which can kill

aquatic organisms. Water temperatures are closely related to air temperature. The 2023 monthly average air temperatures in Powell River were 0.8°C to 1.3°C below normal from February to April, and up to 3.1°C above normal from May to August and in December. The warmest 2023 Lang Creek water temperature was 2.1°C less than in 2022. Bimonthly sampling also recorded cooler maximum water temperatures in 2023 than in 2022 at Anderson Creek and Haslam Lake. Duck Lake and Slough Station recorded higher maximum water temperatures and Blackwater Creek recorded the same maximum temperature in 2023 as in 2022. The relatively similar water temperatures recorded between 2022 and 2023 might result from the lack of extreme weather events within both years.

Continuous water temperature monitoring in Duck Lake and in Lang, Anderson, and Blackwater Creeks show how water temperature varies in the watershed. The highest water temperatures occur on Duck Lake and Lang Creek, while Anderson and Blackwater creeks are much cooler. The larger surface area of Duck Lake and Lang Creek, along with the north-south orientation of Lang Creek, likely allow more solar heating than in Anderson and Blackwater Creeks, which flow roughly east-west and are shaded by forest. Additionally, the storage time of water in Duck Lake allows more solar heating than the flowing water in Anderson and Blackwater Creeks.

The 30-year average from 1981 to 2010 recorded 1.6 days above 30°C in Powell River. The last two years in 2022 and 2023 recorded 8 days above 30°C, a 400% percent increase (5 times greater) as compared to the climate normal interval. The most recent climate normal interval from 1991 to 2020 remains unpublished. We expect the 1991 to 2020 interval will have more annual days above 30°C than from 1981 to 2010. Despite the increased number of warmer days, water temperatures within the watershed remain within normal values recorded since 1997 and are even lower than some years between 1997 and 2013. The suitable water temperatures may be helped by effective land management strategies related to riparian retention that help maintain water temperature during the heat waves.

Precipitation and temperature control runoff, groundwater, evaporation, and the intensity of floods and droughts. April, October, and December had higher than precipitation than the 30-year average with 4%, 15%, and 10% increases, respectively. However, the rest of the year was drier than normal with January to March being 44% drier than the average, and May to September being 49%

drier. Vancouver Island and the Lower Mainland reached Stage 4 drought conditions with some parts of Vancouver Island and the Sunshine Coast into Stage 5 drought for August and September 2023. This resulted in lower stage measurements early in the year, relative to the past 25 years of record, which may also be a result of the drier than normal fall in 2022. Stage measurements were low at all sites throughout the summer months of 2023 and increased towards the end of the year with the increased precipitation that fell in October. In 2023, Lang Creek had the longest duration of low flow measurements with 137 days of flow below a reference discharge of 1 m^3/s. The second longest low flow period was measured in 2022 with 117 days of flow below the same reference discharge. 2021, 2020, and 2019 each had 73 days, 46 days, and 86 days below 1 m^3/s, respectively.

Peak flow in Lang Creek in 2023 occurred in January, two days after a day of heavy precipitation. Temperatures in Powell River in November and December 2022 were 52% lower than normal and some precipitation fell as snow in late December. This peak flow may have been the result of the increased January 2023 temperatures and heavy rainfall potentially falling on a melting snowpack. Other rainstorms with similar or higher intensity occurred during the fall and winter of 2023 but did not cause peak discharges as large as in January. As groundwater levels decreased into February, as indicated by lower stage measurements in the creeks, the infiltration capacity of the land increased and reduced runoff and floods from similar rainstorms later in spring. Similarly, the higher intensity rainstorm events in the fall occurred following a drier than normal summer, and the lower groundwater levels likely reduced peak discharge. October 18 received the highest amount of rain in a single day in 2023; however, the discharge measured on Lang Creek does not exceed the discharge observed following a smaller rainstorm in January. This is likely due to both soil moisture levels being depleted after the drought, the water level in Haslam Lake being lower than the weir during the drier summer months, and the reservoir being refilled with the increased precipitation throughout the fall and therefore not providing it transported as streamflow down Lang Creek.

Following April, precipitation was 49% less than normal from May to September, and resulted in annual precipitation that was 24% less than normal. This period was also 1.5°C warmer than normal, resulting in higher evaporation along with minimal precipitation. This resulted in a minimum discharge in Lang Creek of 0.219 m^3/s on September 12, which was 22% lower than the

2022 minimum, and was the lowest minimum discharge recorded during the last five years. This minimum flow occurred despite the summer drought being less extreme than the 2022 drought. For comparison, the driest three-month period in 2022 was from July to September and received only 40 mm of rain, whereas in 2023, the driest three-month period from May to July received almost 64 mm of rain, a 60% increase. Following the dry period, precipitation increased, though was still 5% drier than normal for the last five months of the year.

Similar to discharge, the minimum stage measurements at most sites within the watershed were lower in 2023 than in 2022. The minimum stage and discharge in Lang Creek occurred one month earlier in 2023 than in 2022. This measurement was the lowest on record, being reached only once before in 2017. The average stage measurements were slightly higher in 2023, as compared to the previous year, at Duck Lake, Blackwater Creek, and Anderson Creek. However, at Haslam Lake, Slough Station, and Lang Creek, average stage measurements were lower than in 2022.

The minimum flow downstream of the dam that is required by the monitoring program was not met during the drier months of 2022 or 2023. In 2022, the minimum stage measurements at Haslam Lake and Slough Station were slightly higher than 2021; however, the required flow was achieved in 2021 and not in 2022. This might suggest that more water could have been released from Haslam Lake to help maintain minimum flow in Lang Creek in 2022. This year, the minimum required flow was not met, but the minimum stage measurement at Haslam Lake and Slough Station were the lowest recorded in the last five years. That is, it is likely that it was not possible to release enough water to meet the discharge requirements because Haslam Lake was too low to do so.

Although low flows in Lang Creek were lower than the required minimum flow requirements, PRSS has not requested additional flow during the warmer months as they are concerned that the additional water from the warm lakes would warm all of Lang Creek and create an unfavourable environment for returning salmon and juvenile salmon in the system. Allowing discharges in Lang Creek to be lower than the required low flow through the weir during high temperature events results in Blackwater and Anderson Creeks contributing higher relative inputs of cooler water to lower Lang Creek. This keeps Lang Creek downstream of these two tributaries more hospitable during the spawning period and encourages salmonids in the system to preferentially move into

these colder water tributaries to offset warm temperatures in the main creek. The Lang Creek discharge data shows little variability between about May 20 (Day 140) and October 19 (Day 292) suggesting that water levels in Haslam Lake fell below the elevation of the weir that controls water flow into Lang Creek. Water levels likely overtopped the weir after several rainstorms in early October, and all subsequent spikes represent the full drainage area of the watershed.

The turbidity levels in 2023 were generally higher than in 2022. The turbidity spikes in most creeks are associated with elevated stage and discharge readings. The highest turbidity reading on Lang Creek occurred in early December, one day after the second highest precipitation event of the year. However, since this spike in turbidity is only observed at the Lang Creek station, which is downstream from the other stations, it is likely that the high turbidity is due to a local disturbance such as a tree falling into the channel or a small bank failure upstream. The bimonthly measurements in January fell one week before and after the peak discharge rate that occurred in January. Turbidity was slightly elevated in the reading that followed the event, but likely did not capture the full extent of the turbidity spike that could have resulted from the high flows. Similarly, the turbidity measurement following the highest rainfall event of the year, occurring October 18, was taken nine days after the event, and therefore, any elevated turbidity is not well captured in the data. During the summer months, the absence of large rainstorms maintained low turbidity levels within the watershed in many creeks, until Haslam Lake overtopped the weir and resulted in higher stream flow and higher turbidity in Lang Creek.

Salinity and pH levels are related to the ratio of groundwater to surface runoff comprising stream flow. Groundwater contains dissolved solids that increase pH and salinity while rainstorms can capture air pollution that decreases pH and dilutes salinity. Past salinity and pH measurements are generally greater during the dry season when groundwater comprises a greater portion of stream flow, and lower during the wet season when precipitation runoff is greater. The 2023 salinity and pH measurements are low at the beginning of the year and begin to increase in March. At the end of the year, precipitation and streamflow increase but pH stays relatively high. Salinity decreases at the end of the year in Duck Lake, Blackwater Creek, and Anderson Creek but stays elevated at Lang Creek, Haslam Lake, and Slough Station. Most of the high salinity and pH measurements occurred from May to October, when groundwater predominantly contributed to streamflow.

Interestingly, the salinity in the first three months of 2023 is very low despite the drier than normal late 2022 and early 2023. This could be due to the extended drought in summer and fall 2022 that would have lowered the water table over several months. As the drought ended in late 2022, the majority of the precipitation would have infiltrated the vadose zone and moved as subsurface flow into the channels while also recharging the groundwater. The salinity is very low for the first few months of 2023 as the streamflow in Lang Creek consists almost entirely of precipitation-sourced water with little contribution from groundwater. Beginning in March, the salinity increases, signifying the rise of the water table and the contribution of groundwater to the channel.

The elevated salinity and pH throughout the year could result from the lower-than-normal precipitation that was recorded in 2023. Precipitation can both increase and decrease pH and salinity results. When the ground is saturated, precipitation runs directly into streams, both diluting groundwater and potentially adding contaminants, thereby decreasing pH and salinity. At lower precipitation rates or immediately after dry conditions, precipitation can recharge ground water levels and increase the outflow of older ground water entering streams, thereby increasing salinity and pH. Additionally, periods of below average precipitation could have resulted in each rainstorm delivering pulses of water of varying quality to the creeks, resulting in larger decreases and variable data. Overall, both pH and salinity varied within a larger range in 2023 than in 2022 but are within the normal variability recorded from 1997 to present. The data suggests that management practices within watershed have been effective at maintaining water quality.

The 2019 and 2020 water quality reports by Statlu identified that salinity increased from 2018 to 2019 and remained elevated from 2019 to 2020. The PRSS purchased a new salinity probe for the 2021 monitoring program to ensure that the increased salinity measurements were not caused by equipment error. The measured salinity in 2021 was about 10% lower than in 2020 but remained greater than values recorded in early 2018. The salinity measurements in 2023 are similar to the previous two years which have used the new salinity probe. If the increased salinity resulted from equipment error, the salinity would have abruptly returned to early 2018 levels after the probe was replaced. The gradual increase and then decrease of salinity since 2018 indicates the trend is real and not a result of equipment error.

The 2023 data shows that water quality remains within acceptable levels within the watershed. The relatively low levels of turbidity and salinity, along with stable pH values, suggest that watershed management practices have been effective in limiting sediment production and reducing the volume of water that transports sediment and contaminants from roads and ditches directly into streams.

The PRSS has noted that the sloughs are popular recreation areas and garbage can be left near the water. Water sampling for general chemistry parameters such as fecal coliform, total metals, and $CaCO_3$ equivalent were last completed in 2010 (Carson, 2017). Additional data collection of these parameters could quantify how human activity affects water quality and would be useful to maintain a robust baseline monitoring program.

7.0 CONCLUSION

The Powell River Salmon Society (PRSS) has monitored water quality within the Haslam Lang Community Watershed since 1997. The watershed supplies drinking water to the City of Powell River and the community of Brew Bay. It provides important habitat for salmon species, and the PRSS operates a hatchery on Lang Creek. Maintaining water quality is important for providing healthy drinking water and maintaining clean salmon habitat.

PRSS retained Statlu Environmental Consulting Ltd. (Statlu) to analyze water quality data collected during the 2023 monitoring program and to compare the results with data from previous years. PRSS recorded water temperature, creek stage, turbidity, pH, and salinity twice per month at six locations within the watershed. The measurements were taken at Lang Creek near the Alex Dobler Salmon Centre, the outlet of Duck Lake, Anderson Creek, Blackwater Creek, Haslam Lake, and the weir at the outlet of Haslam Lake named Slough Station. The water quality monitoring program, which began in 1997, documents a long period within the watershed which is a valuable tool for establishing baseline conditions. This allows land managers to detect potential problems and implement solutions to maintain good water quality for fish and water users.

The watershed received 24% less precipitation in 2023 than the 30-year average from 1981 to 2010, with the first 8 months of the year receiving 41% less precipitation than normal and the last 4 months receiving 2% less precipitation. This resulted in relatively low stage and discharge

measurements during the first part of the year, and higher measurements towards the end of the year. The minimum Lang Creek stage measurements of 0.25 m were recorded on August 30 and September 15, and were the lowest measurements on record.

The maximum biweekly water sampling temperatures in 2023 were similar to 2022, with Duck Lake and Slough Station recording higher maximum temperatures than 2022, Blackwater Creek recording the same maximum temperature, and Haslam Lake, Lang Creek, and Anderson Creek recording cooler maximum temperatures. The 2023 maximum water temperature measured was 1.2°C less than the maximum biweekly water temperature recorded within the watershed in 2022 due to a less intense heat wave. The maximum water temperature from continuous measurements on Lang Creek in 2023 was 2.3°C cooler than the 2022 maximum.

Turbidity, pH, and salinity generally varied within the normal and acceptable range for 2023. The average turbidity measurements from all six stations were 2% to 51% higher than in 2022. The maximum turbidity on Lang Creek (10.2 NTU) is 83% higher than the 2022 bimonthly maximum of 5.6 NTU but is still much lower than high turbidity measurements recorded since 1997. All stations except for Duck Lake had higher maximum turbidity readings than in 2022, but only four readings were above 2 NTU. Average pH measurements were more acidic (lower values) than 2022 but remain within normal variability. Average and minimum salinity measurements were the same or lower than in 2022, with the exception of Blackwater Creek which had increased average salinity. This water quality data suggests that forest management strategies intended to protect water quality within the watershed remain successful.

8.0 LIMITATIONS

The recommendations provided in this report are based on observations made by Statlu and are supported by information Statlu gathered. Observations are inherently imprecise. Conditions other than those indicated above may exist on the site. If such conditions are observed or if additional information becomes available, Statlu should be contacted so that this report may be reviewed and amended accordingly.

This report was prepared considering circumstances applying specifically to Powell River Salmon Society and the forestry organizations which provide funding for the water quality sampling. It is intended only for internal use by the client for the purposes for which it was commissioned and for use by government agencies regulating the specific activities to which it pertains. It is not reasonable for other parties to rely on the observations or conclusions contained herein.

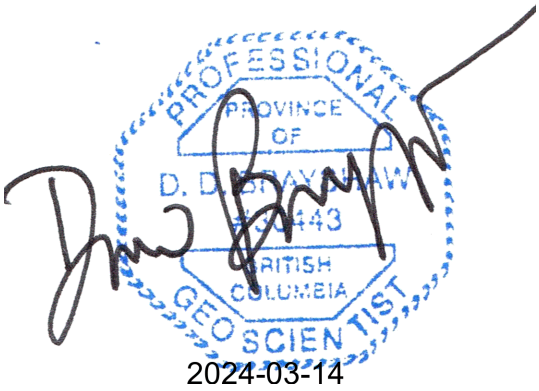
Statlu prepared the report in a manner consistent with current provincial standards and on par or better than the level of care normally exercised by Professional Geoscientists and Professional Agrologists currently practicing in the area under similar conditions and budgetary constraints. Statlu offers no other warranties, either expressed or implied.

9.0 CLOSURE

Please contact me should you have any questions or if you require further clarification.

Yours truly,

Statlu Environmental Consulting Ltd.



Prepared by:
Carlie Chan, M.Sc.
Junior Geomorphologist
CC/DB/js

Reviewed by:
Drew Brayshaw, Ph.D., P.Geo.
Senior Hydrologist and Geoscientist

Permit to Practice: 1000170

REFERENCES

BC Ministry of Environment and BC Ministry of Forests, 2001. Coastal Watershed Assessment Procedure Guidebook. Second Edition, version 2.1.

BC Drought Information Portal https://governmentofbc.maps.arcgis.com/apps/MapSeries/index.html?appid=838d533d8062411c820eef50b08f7ebc accessed March 1, 2024

Burn, D.H., P.H. Whitfield, and M. Sharif, 2016. Identification of changes in floods and flood regimes in Canada using a peaks over threshold approach.

Carson, B. 2000. Watershed Assessment of Lang Creek Community Watershed, Powell River, B.C. Unpublished technical report prepared for the Watershed Advisory Committee by Carson Land Resources Management Ltd.

Carson, B. 2003. Watershed Assessment of Haslam Lake Lang Creek Community Watershed, Powell River, B.C. Unpublished technical report prepared for the Weyerhaeuser Company Ltd., Wester Forest Products Ltd., and B.C. Timber Sales.

Carson, B. 2010. Assessment of Water Quality Impacts of the Powell River Community Forest Operations within the Powell River area. Submitted to: Results Based Forest Management Ltd. Representing the Powell River Community Forest.

Carson, B. 2018. Haslam Lake Lang Creek - Water Quality and Quantity Data - Results of Monitoring Program for 2017. Unpublished technical report prepared for the Powell River Salmonid Enhancment Society.

Carson Land Resources Management Ltd, 2015. Haslam Lang Community Watershed – Coastal Watershed Assessment Procedure (CWAP) 2015 update. Unpublished technical report prepaored for Results Based Forestry Management Co. Ltd.

Environment Canada. 2024. Daily Data Report for Powell River A 2024. https://climate.weather.gc.ca/climate_data/daily_data_e.html?hlyRange=1982-03-23%7C2013-12-12&dlyRange=1954-01-01%7C2024-02-26&mlyRange=1954-01-01%7C2007-02-01&StationID=327&Prov=BC&urlExtension=_e.html&searchType=stnName&optLimit=yearRange&StartYear=1840&EndYear=2024&selRowPerPage=25&Line=1&searchMethod=contains&txtStationName=POWELL+RIVER+A&timeframe=2&Day=27&Year=2023&Month=1#

Integrated Watershed Management Plan (IWMP) Committee. 1999. Haslam Lake and Lang Creek Integrated Watershed Management Plan. Powell River.

Statlu Environmental Consulting Ltd., 2020. Watershed Assessment – Haslam Lake and Lang Creek, Haslam Lang Community Watershed. Statlu Project #17-183.

Statlu Environmental Consulting Ltd., 2020. Water Quality Report for 2019, Haslam Lang Community Watershed. Statlu Project #20-103

Statlu Environmental Consulting Ltd., 2019. Waters Quality Report for 2018, Haslam Lang Community Watershed. Statlu Project #19-110

Wang T., A. Hamann, D. Spittlehouse, and C. Carroll. 2016. Locally Downscaled and Spatially Customizable Climate Data for Historical and Future Periods for North America. PLoS ONE 11(6): e0156720. doi:10.1371/journal.pone.0156720. http://www.climatewna.com/help/ClimateBC/Help.html

statlu
ENVIRONMENTAL CONSULTING

Figure 1: Monitoring Stations within Haslam Lang Community Watershed

1:100,000

Client: PRSS
Date Saved: Mar 24, 2023
Project Number: 23-106

APPENDIX 2: PHOTOS

Photo 1: Lower Lang Creek with woody debris and a leaning alder on the steep sidewall.

Photo 2: Fine sediment and clean water in a low-gradient reach of Blackwater Creek.

Photo 3: The Alex Dobler Salmon Centre counting fence on Lower Lang Creek.