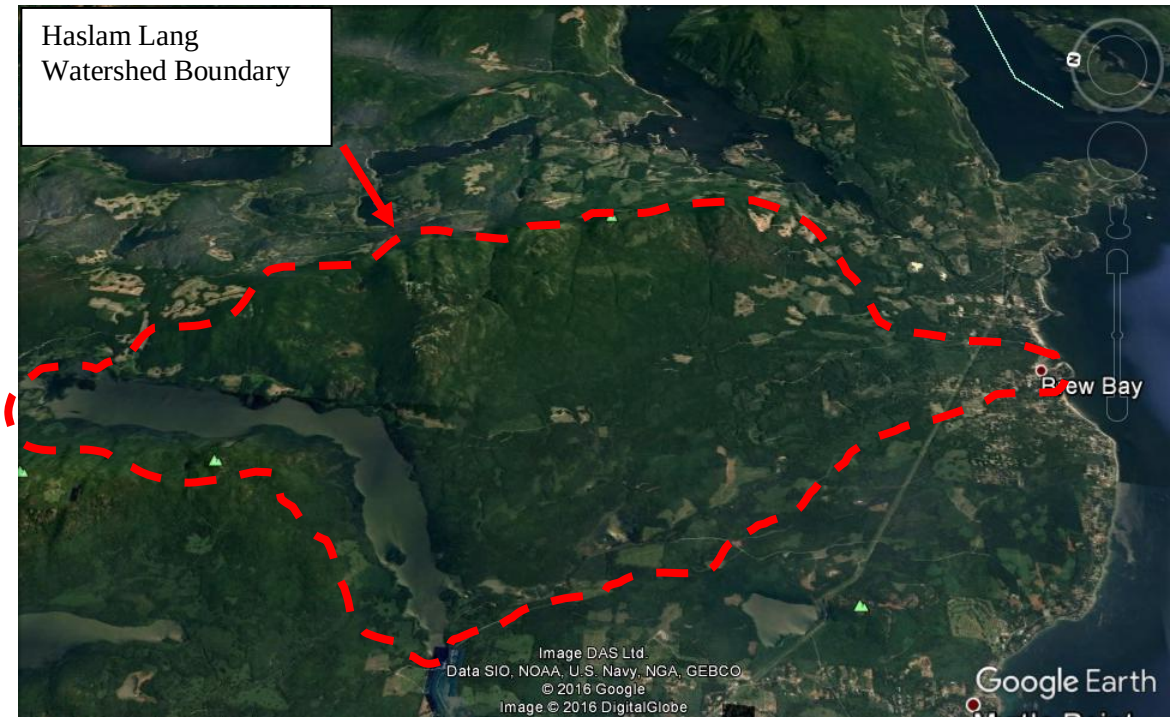
February 2018 Carson Land Resources Management Ltd.
1861 Lower Road, Roberts Creek, B.C. V0N 2W6
Ph 604 886 3282 Email: brianrobertcarson@gmail.com

Haslam Lake Lang Creek
Water Quality and Quantity Data
Results of Monitoring Program for 2017



Prepared for
Powell River Salmonid Enhancement Society
Funded by BC Timber Sales and
The Powell River Community Forest

February 2018

Submitted by

Brian Carson, P.Geo.

February 2018 Carson Land Resources Management Ltd.
1861 Lower Road, Roberts Creek, B.C. V0N 2W6
Ph 604 886 3282 Email: brianrobertcarson@gmail.com

Summary

British Columbia Timber Sales and the Powell River Community Forest continue to provide funds to the Powell River Salmonid Enhancement Society to support water quality monitoring throughout the Haslam Lang Community Watershed. This report reviews 2017 data collected (as well as selected historic data to demonstrate trends) and discusses results generated by the water quality monitoring program to date.

The automated data collection facility located at the Alex Dobler Salmon Centre (salmon sorting station) near the mouth of Lang Creek continues to record stage, rainfall, and water and air temperature (6 min intervals). These have been made available on line on a monthly basis by the Salmon Enhancement Society. Automated turbidity measurements were dropped some years ago because of poor performance of sensors and high cost in maintenance and the invariably questionable data generated. The problem of malfunctioning automatic turbidity meters is the rule rather than the exception. Automated turbidity meters should not be re-employed unless funding levels and technical commitment rise substantially.

Bi-monthly, on-site sampling conducted by Salmon Enhancement Society staff has continued at six strategic locations within the watershed throughout the 2017 season. This data has been evaluated taking into account all of the 1998 to 2017 data and provides an excellent historic record of variability of water quality parameters. Twenty years of data collection does not show any significant difference in previously established trends for in turbidity, pH, and EC or water temperature at six strategic locations within the watershed.

In addition to bi-monthly monitoring, continuous water temperature recorders have been employed in 2017 on Anderson Creek, Blackwater Creek and at the hatchery on upper Lang Creek. Some have failed after 5 years in service and new temperature sensors should be installed. The continuous stream temperature data is mostly of high quality and continued monitoring is essential if Licensees are anticipating changes to management within riparian management zones.

As there were no obvious changes to the stream channel beside the Alex Dobler Salmon Centre, repeat stage- discharge measurements were not conducted in 2017. The curves originally developed by Termuende Hydrology are still valid and can be found in the 2015 report.

The data collected continues to support the general conclusion that, although there have been considerable forestry operations throughout 2017, these did not have a measurable negative impact on water quality at either Haslam Lake drinking water intake (servicing Powell River City) or Lower Lang Creek[1] intake (serving Brew Bay water users group). The water temperature data collected along Anderson Creek shows no recognizable increase or decrease over the past 20 years in spite of accelerated harvesting activity in that sub-basin.

These conclusions provide the water purveyor with some assurance that the watershed is being well managed. However, the monitoring program does not address any localized water quality impact from sites not hydrologically connected to the intakes. Licensees should continue to manage their chart areas utilizing best management practices at all locations within the watershed to sustain ecological health.

[1] The Powell River Salmon Enhancement Society Alex Dobler Salmon Centre intake lies in the same stream reach as the Brew Bay Drinking Water Intake.

The tables and figures presented in this report represent just a small portion of the total data set collected under this monitoring program. All digital data is archived by the Powell River Salmonid Enhancement Society and is freely available to interested parties. This report will be made available on line at www.prsalmon.org

Acknowledgement

I would like to provide a tribute to Alex Dobler, formerly of the Salmon Enhancement Society. I had the honour of working with Alex over the last 20 years and I learned much of what I know about its streams from his gentle instruction. Alex not only had a feel for his salmon from egg through to adult, but he also had a feel for the whole watershed. He was greatly concerned about how it was being managed. Long before the monitoring program was initiated Alex would hound the city, forest licensees and recreationists to ensure they were treating the watershed with respect. He was a rough cut diamond in that he didn't mince his words. If he felt someone was behaving badly he said so. But he was almost always correct in his assessments and everyone knew it. His passing in 2017 will leave a huge gap professionally and personally that will be hard to fill.

Table of Contents

Figures

Tables

February 2018 Carson Land Resources Management Ltd.
1861 Lower Road, Roberts Creek, B.C. V0N 2W6
Ph 604 886 3282 Email: brianrobertcarson@gmail.com

I. INTRODUCTION

British Columbia Timber Sales and the Powell River Community Forest have provided ongoing support to the Powell River Salmon Enhancement Society in 2017 with funds to monitor water quality within the Haslam Lang Community Watershed. The purpose of water quality monitoring is to:

- Provide information for resource management planning and decision making at the community and regional level;
- Establish baseline levels in support of specific criteria/objectives development and attainment reporting;
- Provide information on the status, health, trends and uses of water resources; and
- Employ and train persons from local communities to foster interest and involvement in community watersheds.

This report presents a brief summary of the Water Quality data collected over the year. To a large degree it mirrors results of previous years.

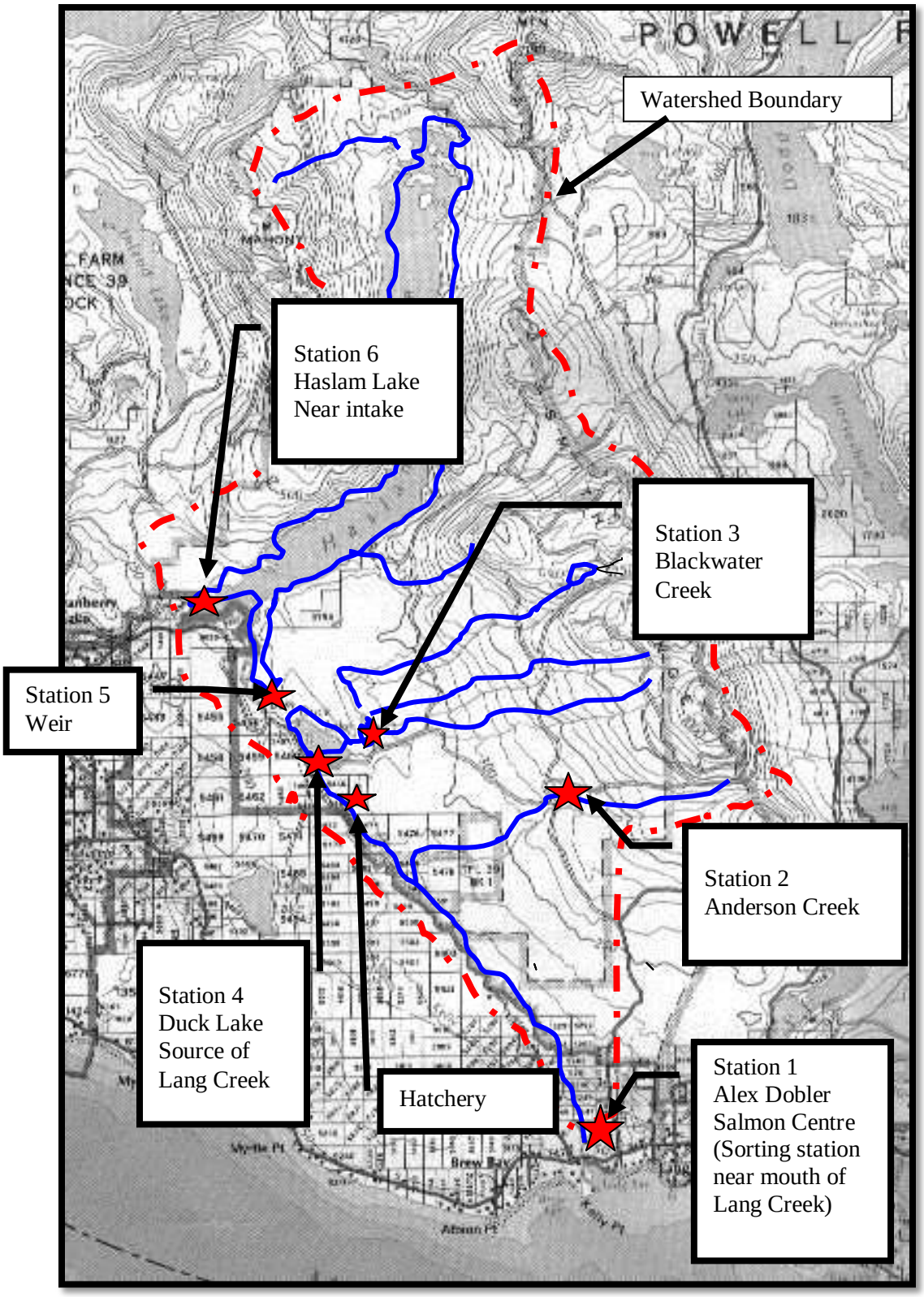
II. METHODOLOGY

The sites chosen for water sampling (as listed in Table 1) are similar to those developed in the original program and are located on the map on Figure 1.

Table 1. Schedule for Monitoring Sample sites

Station	Sampling Interval	Sampling For
Station 1 Alex Dobler Salmon Centre Provincial Identification Number E220912	Continuous Bi-monthly	Water temperature, stage, air temperature, and rainfall. Portable meter to check on continuous recorders.
Station 2 Anderson Creek Provincial Identification Number (4 km upstream of E220913)	Continuous Bi-monthly	Water temperature. Portable meter for turbidity, pH, specific conductivity, temperature and stage.
Station 3 Black Water Creek Provincial Identification Number E220914	Continuous Bi-monthly	Water temperature. Portable meter for turbidity, pH, specific conductivity, temperature and stage.
Station 4 Outlet of Duck Lake Provincial Identification Number E220915	Bi-monthly	Portable meter for turbidity, pH, specific conductivity, temperature, and lake level.
Station 5 Weir on Haslam Lake	Bimonthly	Water temperature.
Station 6 Haslam Lake (near intake)	Bi-monthly	Portable meter for turbidity, pH, specific conductivity, temperature and lake level.
Hatchery on Upper Lang Creek	Continuous	Water temperature

Figure 1. Location of Monitoring Stations within Haslam Lang Community Watershed



III. SAMPLING PROCEDURES

A. Analysis Using Portable Meters

Bi-monthly analysis of water temperature, pH, turbidity and salinity were conducted using portable meters. Before sampling, the meters were calibrated with standard solutions following directions supplied by the meter manufacturers.

B. Automated Samplers

Automated stage, water and air temperature and rainfall recorders make it possible to download stage and water quality data collected automatically at the Alex Dobler Salmon Centre directly from the PRSES website. Automatic temperature recorders are located at the Hatchery and on Anderson and Blackwater Creeks. They sample at 15 minute intervals and are downloaded either once or twice a year. While one of the recorders failed in 2017, it was replaced and all instruments are now up and running. Backup recorders are also in place.

IV. RESULTS AND DISCUSSION

Results and discussion of data collected during the course of the monitoring program are presented below. Some water temperature data was collected at 6 or 15 minute intervals, over the whole year. Some water temperature was also collected in spot samples bi-monthly. A small portion of the original digital data was used to develop the figures and tables shown in the report. Interested readers can find the whole database archived at the office of the Powell River Salmon Enhancement Society office.

A. Water Quality

1. Turbidity Measurements with Portable Meters

Turbidity events throughout the Haslam Lang Watershed are episodic and easily missed with spot sampling. However, given the technical difficulties of acquiring good continuous turbidity data, a sufficient number of spot recordings provide an indication of the range of turbidity events that can be expected at any given location. Now that we have more than 3,500 samples taken at 6 sites over 20 years[2] we are able to characterize water quality characteristics and trends with a considerable degree of accuracy.

Table 2 shows turbidity data collected in 2017 at 6 sites and flags those with a turbidity between 1 and 5 NTU[3] (blue) and >5 NTU[4] (red). Turbidities in excess of 1 NTU occurred 9 times out of 24 samples on lower Lang Creek (2 samples >5 NTU) whereas turbidies >1 NTU occurred only once at the outlet of Duck Lake. It is apparent that water quality at lower Lang Creek is not being impacted by all the drainages above Duck Lake. During the one event where Anderson Creek exceed 1 NTU, Lang Creek was already experiencing turbidity levels of over 7 NTU. Given the > 10 fold dillution of Anderson Creek upon flowing into Lang Creek, this means that the fine sediment contribution ofAnderon Creek was not significantly affecting water quality at the Brew

[2] With a two year gap (2006-2008)

[3] 1-5 NTU is still acceptable for drinking water provided disinfection is proven to be effective.

[4] >5 NTU initiates a boil water notice by Ministry of Health for run of river intakes.

Bay water intake. The only 2 turbidity events in excess of 5 NTU sampled in the watershed in 2017 were recorded on lower Lang Creek. Remembering that all samples are taken bi-monthly, more frequent and higher levels of turbidity will occasionally occur at all sample sites. These data gaps are unavoidable in the absence of a working automated turbidity recorder.

Table 2. Bi-monthly turbidity measurements at 5 stations over 2017

Date sampled	Anderson	Blackwater	Duck	Haslam	Lang
09/01/2017	0.29	0.54	0.31	4.74	0.47
25/01/2017	0.42	0.22	0.34	0.79	0.57
07/02/2017	0.29	0.33	0.48	0.38	0.51
21/02/2017	0.29	0.33	0.34	1.33	1.1
13/03/2017	0.63	1.16	0.4	3.57	0.85
28/03/2017	0.93	0.65	0.6	1.36	1.32
05/04/2017	0.58	1.24	0.61	2.6	1.89
24/04/2017	0.53	0.39	0.36	0.66	0.84
12/05/2017	1.94	1.4	0.8	0.73	7.21
29/05/2017	0.43	0.58	0.92	0.84	0.73
01/06/2017	0.59	1.17	0.71	0.77	0.78
15/06/2017	0.38	0.55	0.83	0.67	0.87
06/07/2017	0.37	0.66	0.73	0.63	1.16
25/07/2017	0.36	0.45	0.6	0.48	0.59
02/08/2017	0.3	0.43	0.53	0.56	0.69
15/08/2017	0.22	0.58	0.51	0.48	0.53
06/09/2017	0.27	0.67	0.53	2.74	0.57
18/09/2017	0.4	1.41	0.7	2.81	0.61
02/10/2017	0.3	0.71	0.83	0.36	1.09
25/10/2017	0.26	0.58	0.93	0.4	1.25
03/11/2017	0.31	0.85	0.78	0.73	1.28
16/11/2017	0.71	0.83	1.74	3.34	27.3
06/12/2017	0.46	0.28	0.42	0.47	1.01
21/12/2017	0.26	0.3	0.42	0.42	0.61

On Figure 2 spot turbidity measurements are provided for 2017. At all stations, turbidity events are most common between October and March and are usually associated with heavy precipitation, overland flow and an order of magnitude greater discharge than base flow. Turbidities rarely exceed 2 NTU for all sites between March and September. As in previous years, the samples collected at the Haslam Lake site were taken immediately adjacent to the intake along the shoreline. These periods of elevated turbidity were associated with wave action along an unprotected shoreline during times of high lake levels. There was also considerable ground disturbance in the immediate vicinity of the intake while some construction projects were underway at the pumping station this year. Based on data collected during Powell River's raw water sampling program, this surface generated turbidity appears to not be experienced at the level of the intake.

Figure 2. Haslam Lang Turbidity Data for 5 Sites in 2017

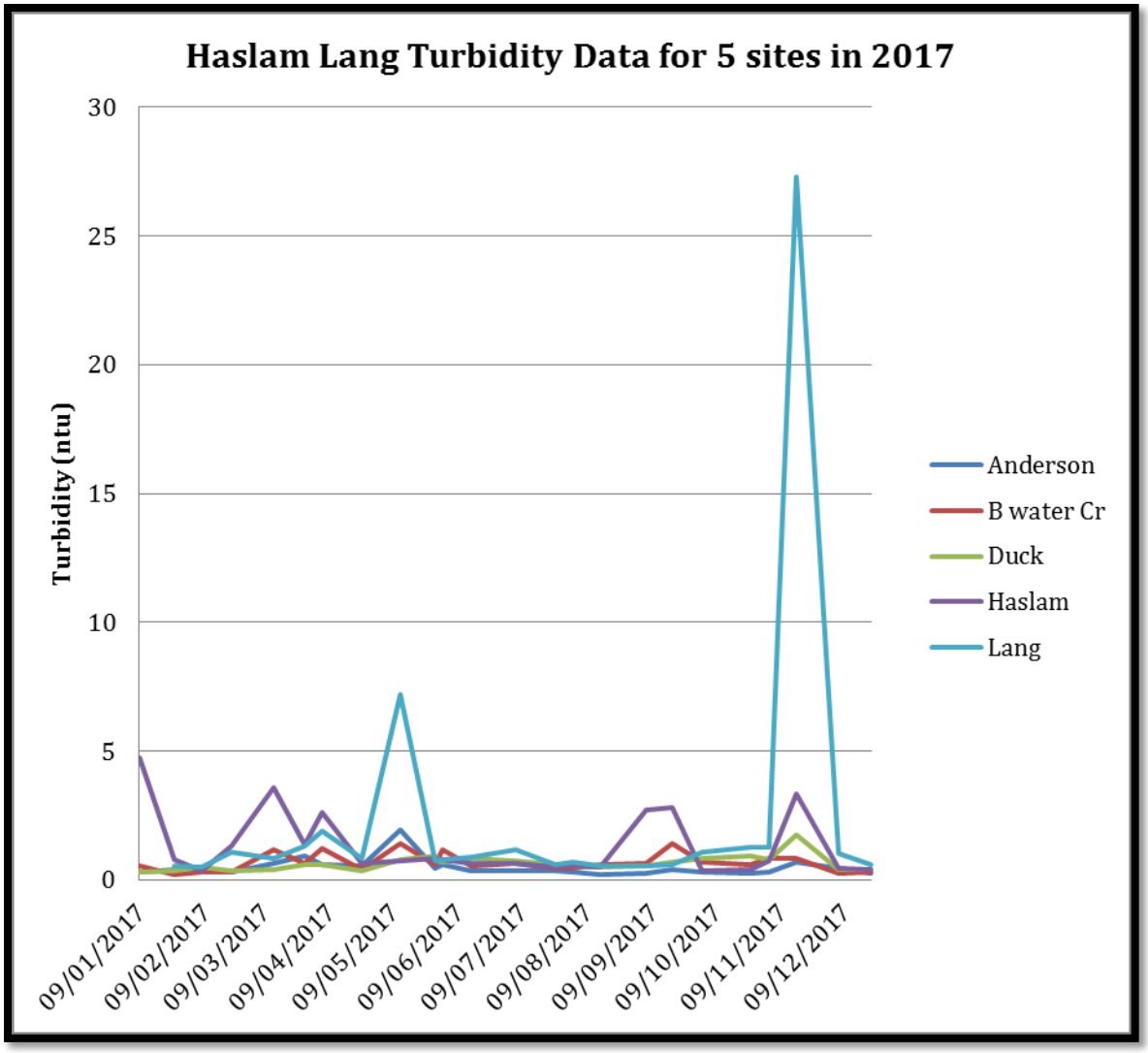
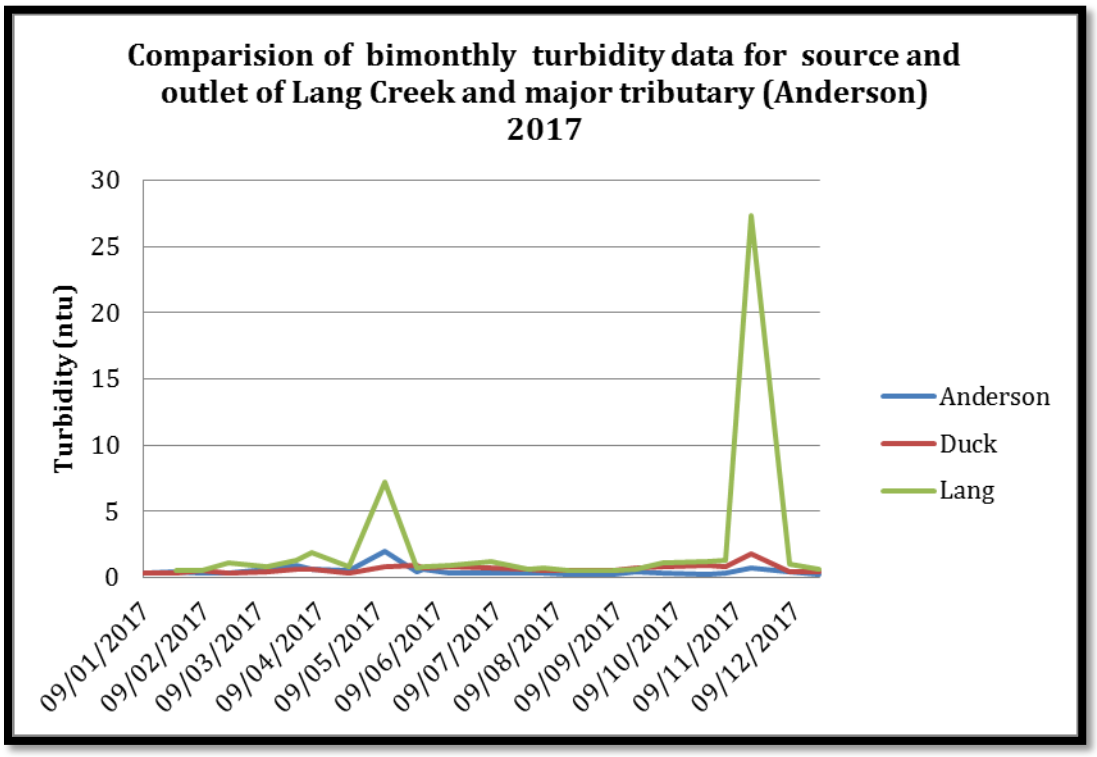


Figure 3 provides a closer look comparing spot bi-monthly turbidities on upper and lower Lang Creek and the major tributary flowing into lower Lang Creek. The figure confirms the recognized major additions of fine sediment being generated along the stream banks of Lang Creek, not from either the Duck Lake or Anderson Creek outlets. In 2017 the largest turbidity events that occurred on upper Lang (Duck Lake) and Anderson Creek could have accounted for only a small portion of the much greater magnitude and frequency of turbidity events experienced at the mouth of Lang Creek.

Figure 3. Comparison of Bi-monthly Turbidity Data for Source and Outlet of Lang Creek and Major Tributary (Anderson) 2017



These major differences between lower Lang Creek and Upper Lang Creek (Duck Lake outlet) and Anderson Creek are summarized in compiling all of the turbidity events that have been sampled under this monitoring program since between 1997 and 2016 (see Figure 4, Figure 5 and Figure 6 below). It is apparent that Lower Lang Creek has by far the highest proportion of higher turbidity samples. As explained this is a result of the Lang Creek river bed being incised into the finer textured glacial and glacial lacustrine deposits on its path between Duck Lake outlet and the mouth below the Alex Dobler Salmon Centre.

Figure 4. Lang Creek Mouth, Portion of 540 Samples in Given Turbidity Class (1997-2016)

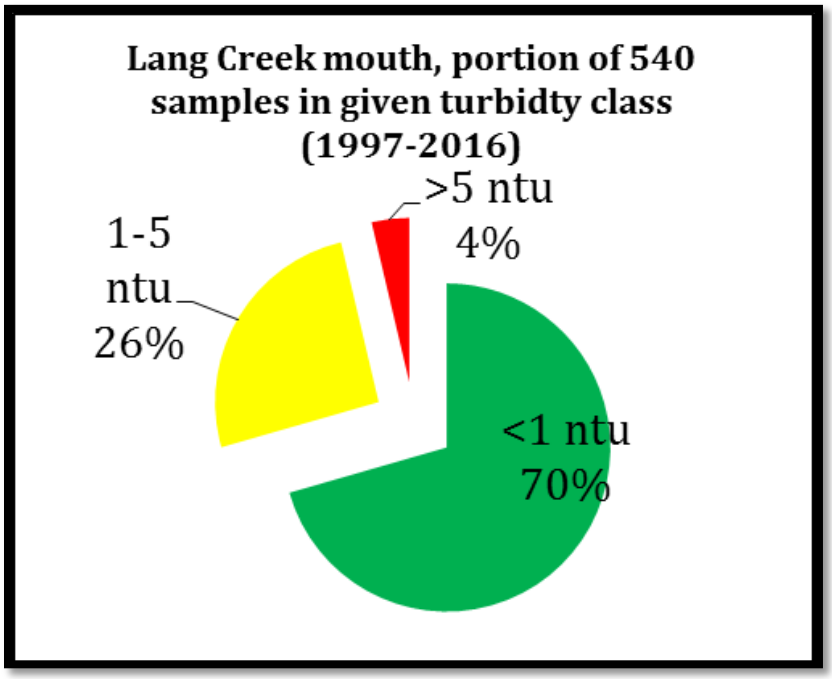


Figure 5. Duck Lake Outlet, Portion of 548 Samples in Given Turbidity Class (1997-2016)

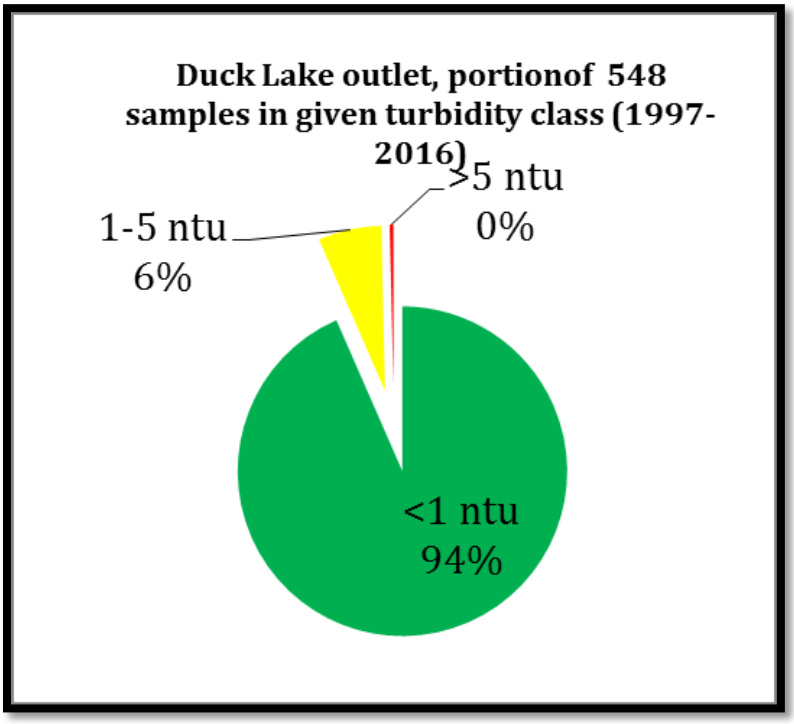
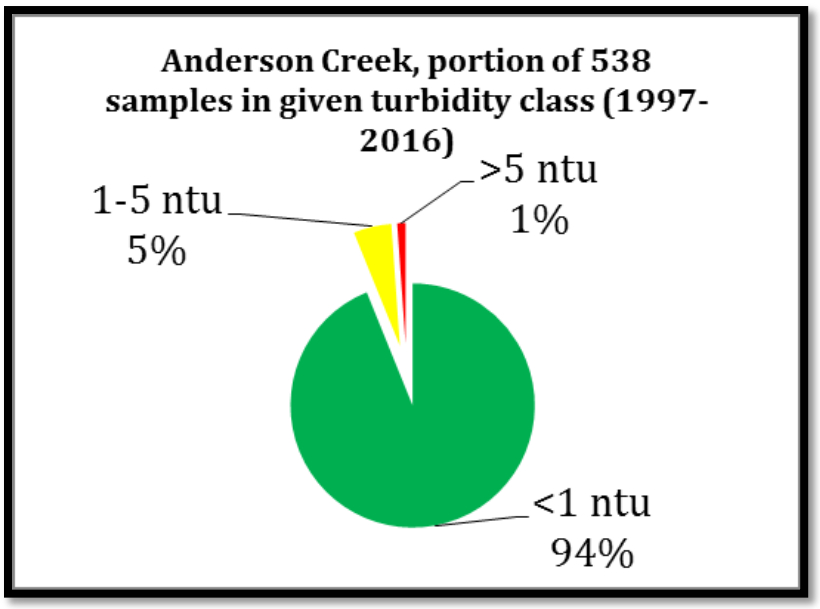


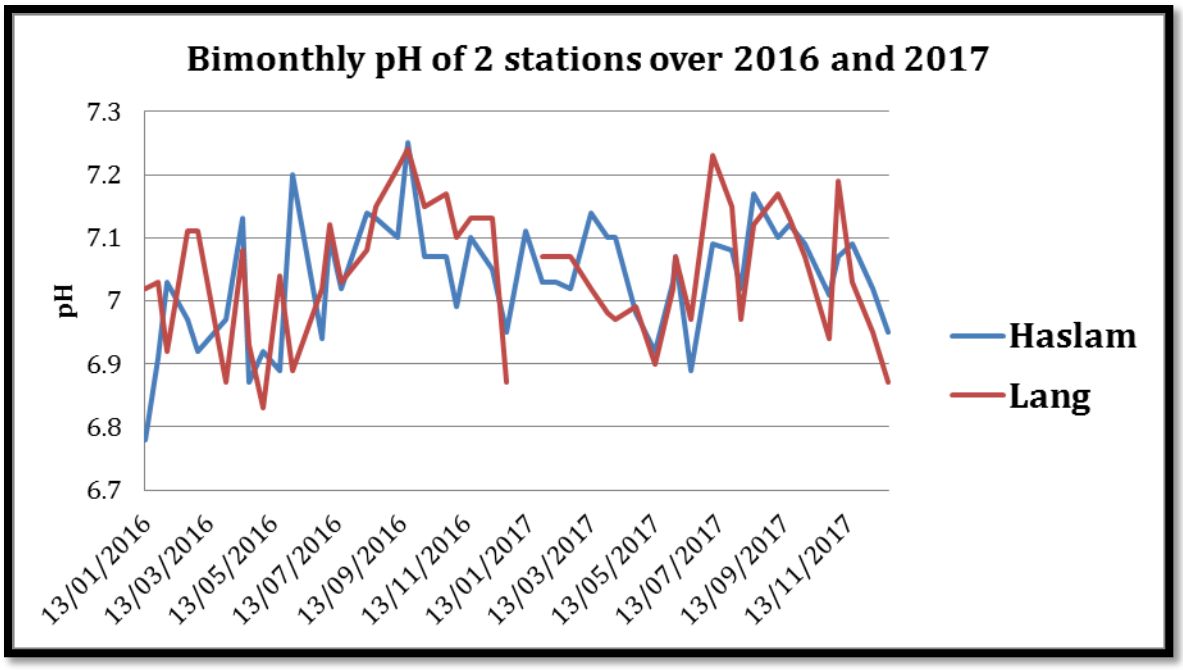
Figure 6. Anderson Creek, Portion of 538 Samples in Given Turbidity Class (1997-2016)



2. pH with Portable Meters

Figure 7 shows the variability of pH over 2016 and 2017 for the two sampling stations nearest the Brew Bay Intake at the mouth of Lang Creek and the Powell River City intake at the head of Haslam Lake. The pH is found to be near neutral for most recorded measurements and is acceptable for drinking water untreated. (Average over all years is 7.0 for Haslam Lake and 6.8 for Lang Creek). All other factors being equal, pHs tend to be slightly higher in the summer months and slightly lower in winter and spring when groundwater (and basic salts) makes up a smaller portion of the discharge.

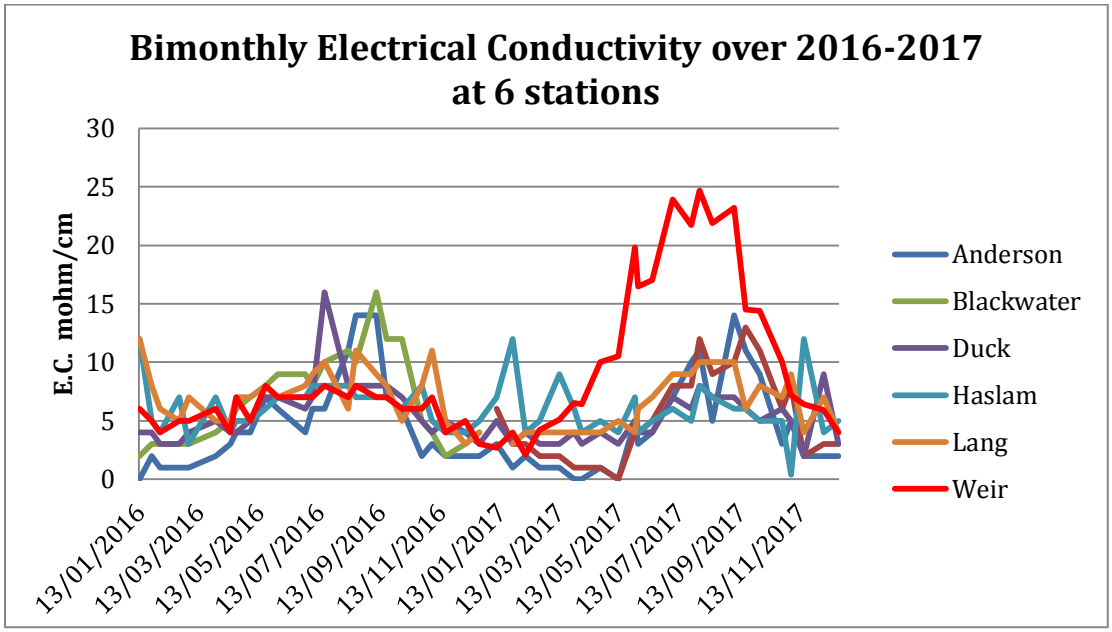
Figure 7. Bi-monthly pH of Haslam and Lang Stations over 2016 and 2017



3. Electrical Conductivity

In all sampling to date (see Figure 8), the data indicates extremely low electrical conductivity meaning that dissolved salts are available in only very low concentrations throughout the watershed. An unusual anomaly (albeit not a health risk) was noted in the data whereby over the summer at the weir, E.C.s were significantly higher than all other stations. No adequate reason could be entertained except some disturbance must have occurred along the Haslam Slough.

Figure 8. Bi-monthly Electrical Conductivity over 2016-2017 at 6 Stations



B. Water Temperature Monitoring Results

1. Bi-monthly Manual Collection from 6 Sites within the Watershed

Figure 9 shows the bi-monthly water temperature taken at 6 sites between 1997 and 2017. Focusing on the last three years of data for 3 stations (Figure 10) the highest summer temperatures of (>24 ^{o} C) are recorded at the surface of Duck lake, (also the Haslam and Slough Station,) the lowest summer temperatures from small streams under forest cover are recorded at Anderson (and Blackwater Creek) and intermediate summer temperatures recorded on streams where warmer lake water is cooled as it flows through forested riparian zone (Lang).

Figure 9. Bi-monthly Water Temperature at 6 Stations in Haslam Lang Watershed

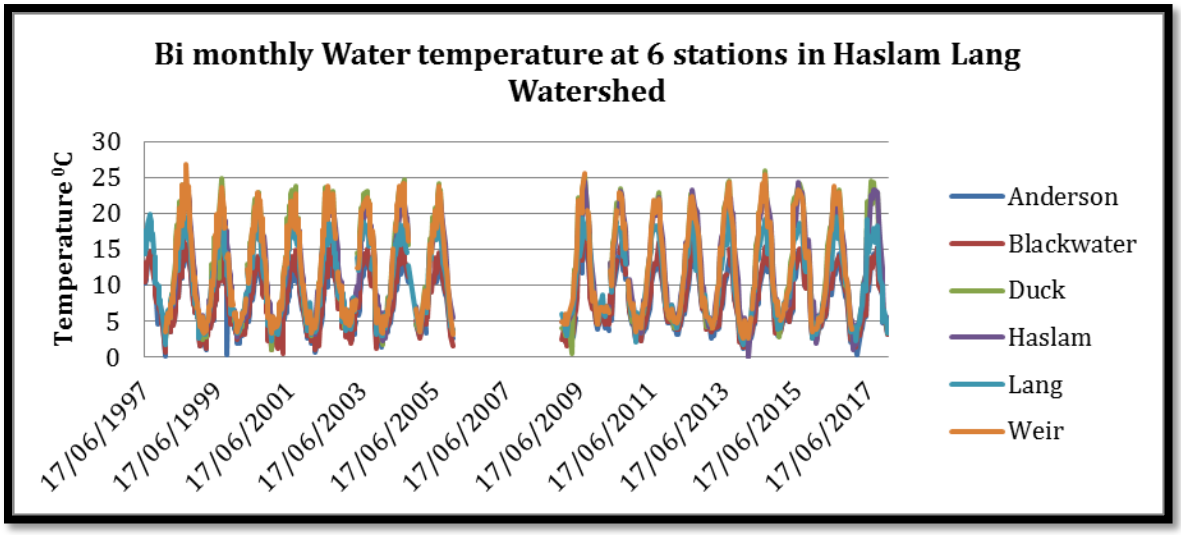


Figure 10. Comparison of Water Temperature Variation over the Year at Anderson, Duck and Lang Stations (2015-2017)

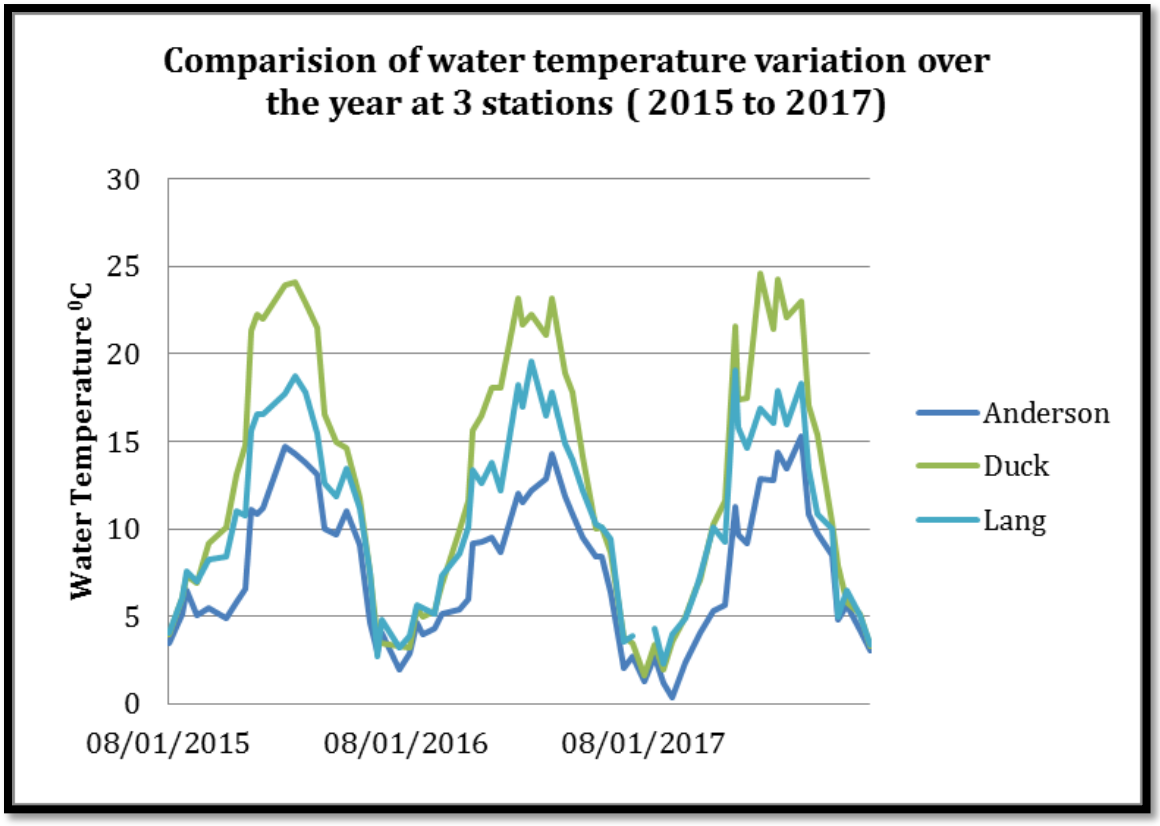
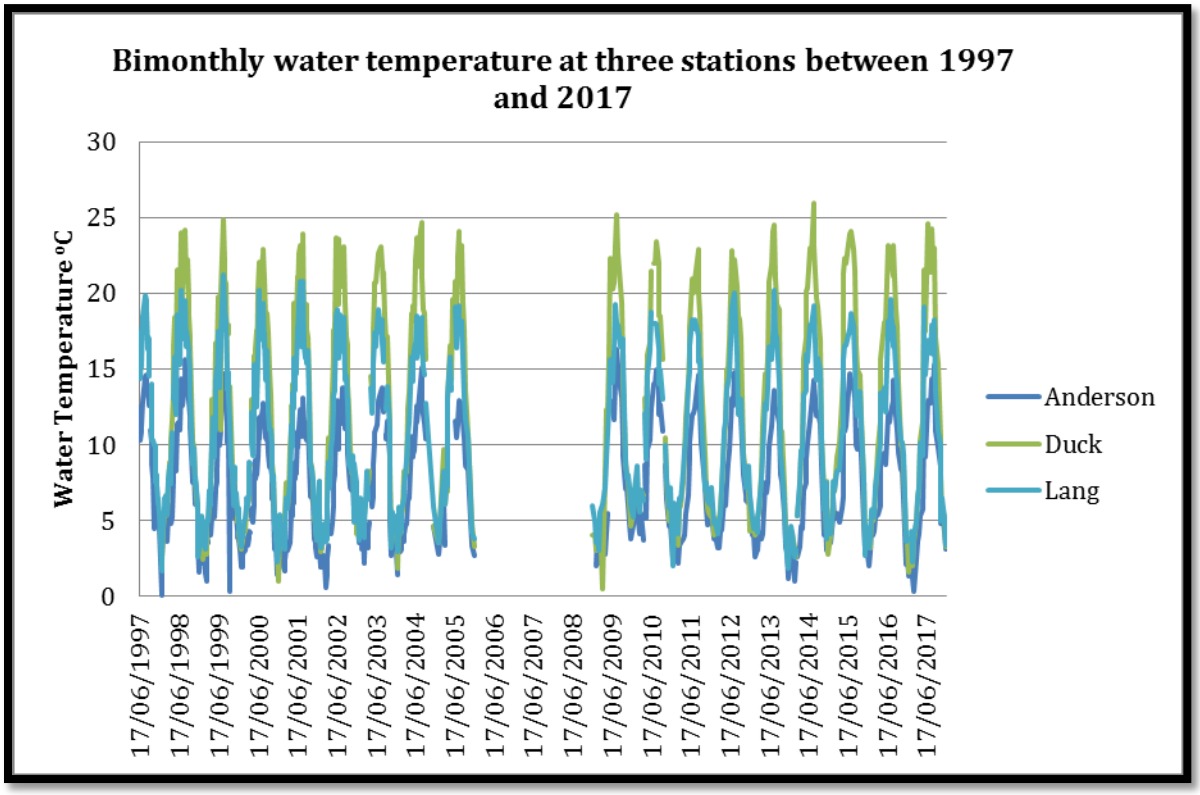


Figure 11 shows data collected over the last 20 years depicting water temperatures to be remarkably consistent. The data on Anderson Creek is of particular interest because it shows no tendency to warmer temperatures in spite of considerable harvesting taking place in that watershed in the last 10 years. This suggests that present cautionary management within and adjacent to riparian areas has been effective.

Figure 11. Bi-monthly Water Temperature at Anderson, Duck and Lang Stations Between 1997 and 2017.



The complete daily air and max- min water temperature for 2017 is presented on Figure 12. Average summer daily air temperatures reach 20 degrees while average winter daily air temperatures can drop as low as minus 5 degrees. A maximum of a three degree fluctuation can occur between low and high temperatures in the summer while temperature differences over the day are much more muted in winter.

Figure 12. Water and Air Temperature at Alex Dobler Salmon Centre (Daily Data over 2017)

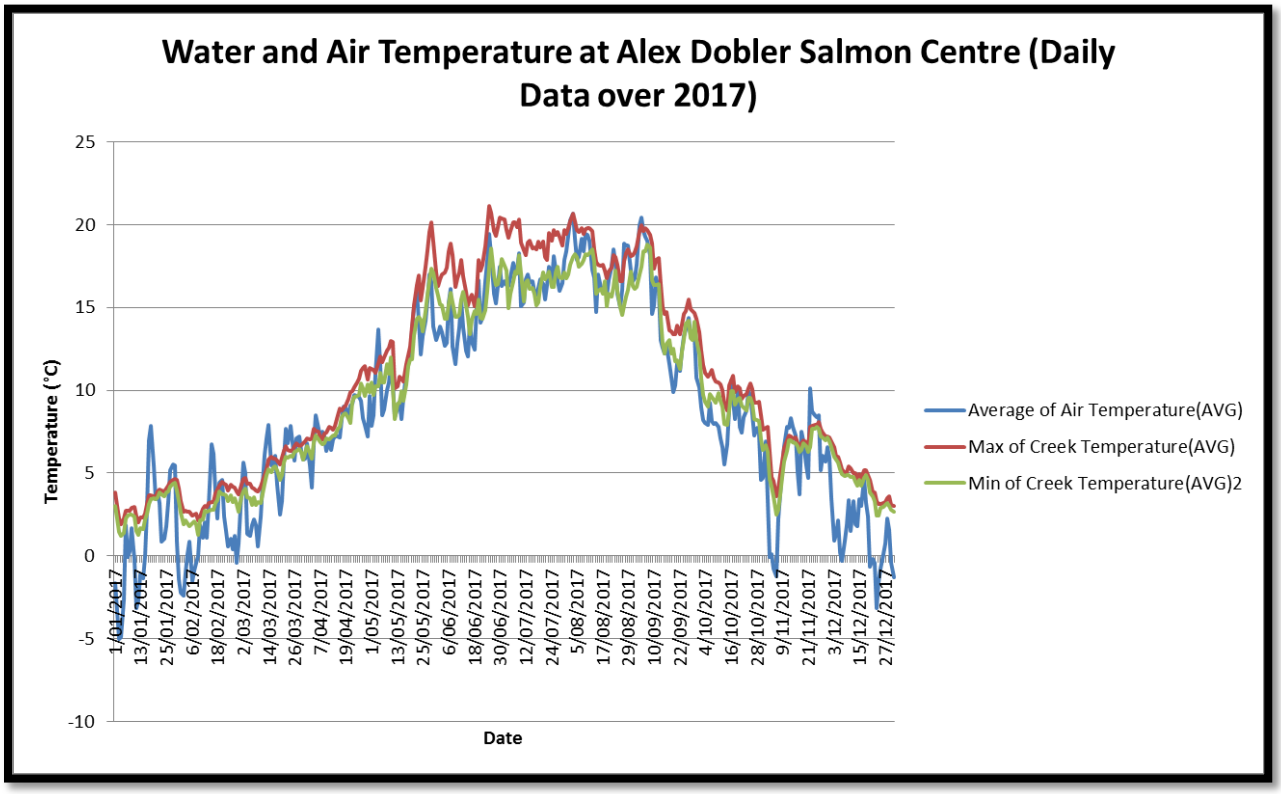
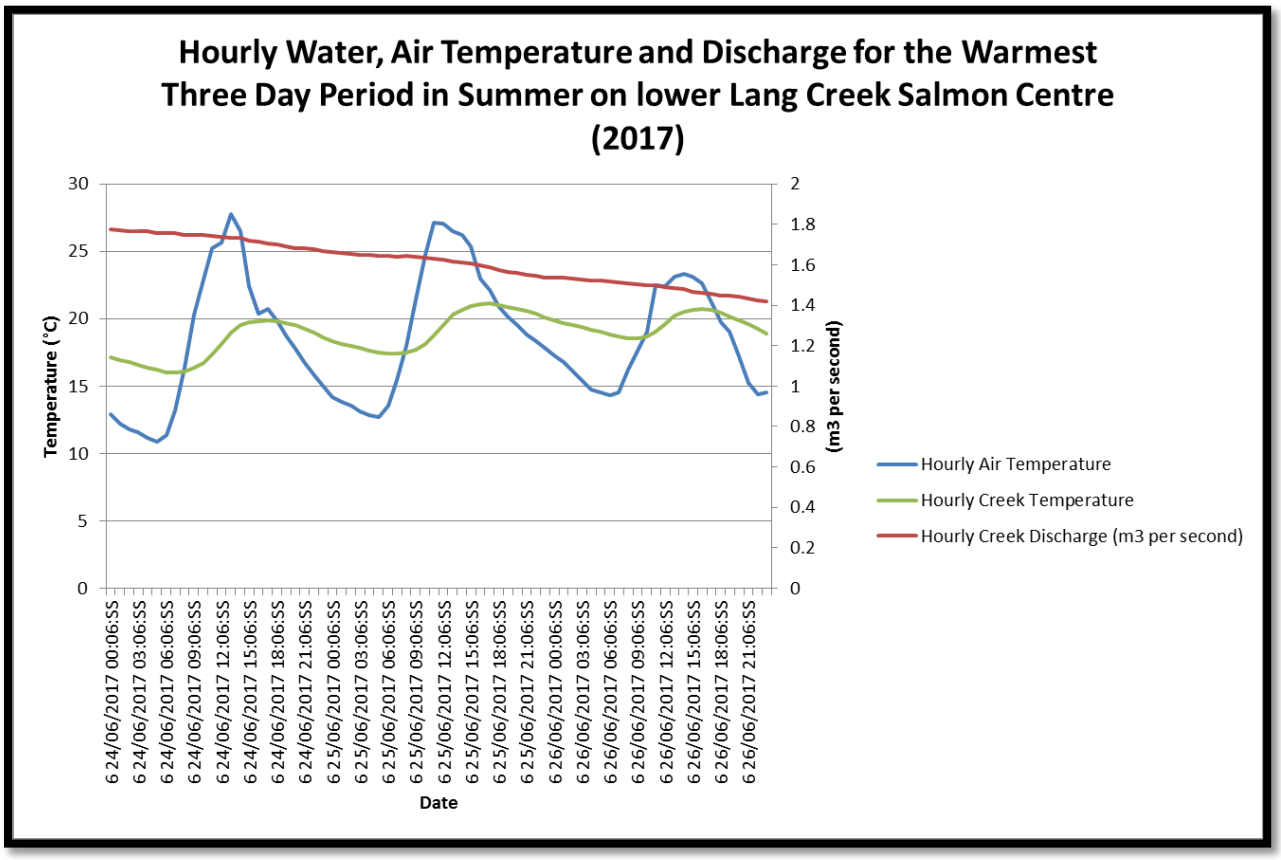


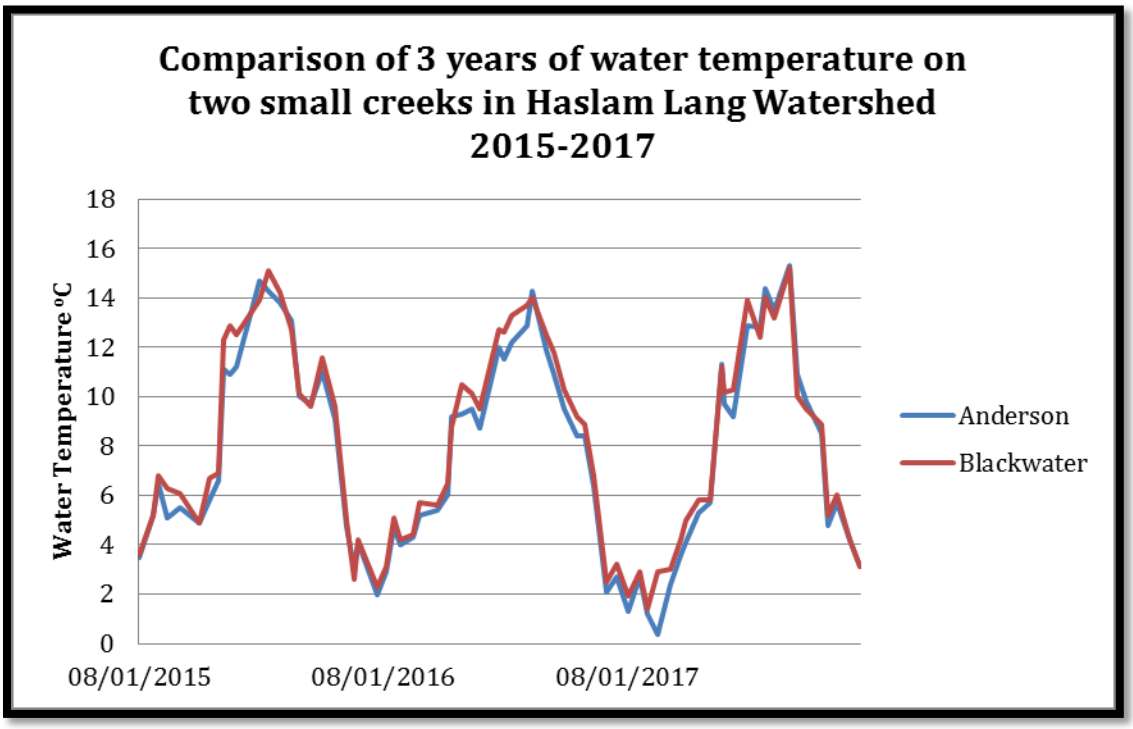
Figure 13 provides hourly water and air temperature data collected at the Alex Dobler Salmon Centre on lower Lang Creek over a three day period. Air temperature ranged from 11 ^{o} C to 28 ^{o} C over that period with a maximum fluctuation of 17 ^{o}C daily. Water temperatures ranged from 16 ^{o} C to 21^{o} C with a maximum daily fluctuation of 3.5 ^{o}C. Discharge of the creek dropped from 1.8 m^3 to 1.4 m^3 over the same period. The lag time between maximum heat of day (1 P.M.) and maximum water temperature (5 P.M) is illustrated here. Data such as these will be instrumental when addressing riparian zone buffers and leave strips.

Figure 13. Hourly Water, Air Temperature and Discharge for the Warmest Three Day Period in Summer on lower Lang Creek Salmon Centre (2017)



Using the bi-monthly water temperature data from the two forested tributary streams sampled within the watershed (Figure 14) we see a close mirroring of annual variation of water temperature throughout the year. This suggests that similar temperature regimes might be expected on other similar forest streams in the watershed.

Figure 14. Comparison of 3 Years of Water Temperature on 2 Small Creeks in Haslam Watershed 2015-2017



C. Water Quantity and Timing of Flows

1. Precipitation

On Figure 15 monthly total precipitation is provided as collected at the Alex Dobler Salmon Centre on Lower Lang Creek. Figure 16 shows daily precipitation. Total annual precipitation for 2017 was 1312 mm which is somewhat higher than average (1000 mm).

Figure 15. Monthly Rain 2017

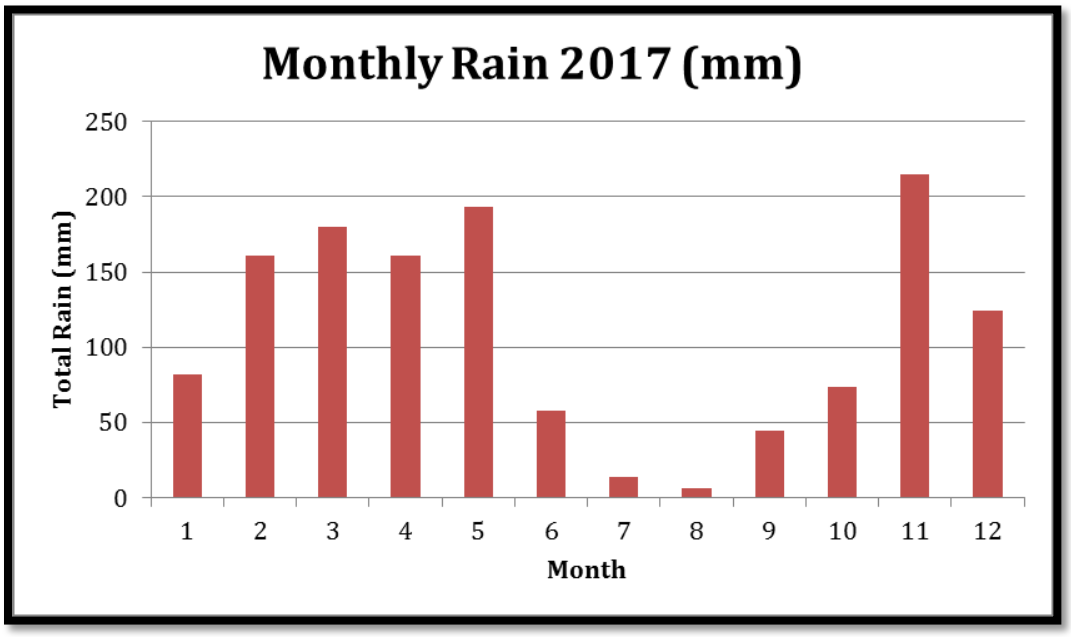
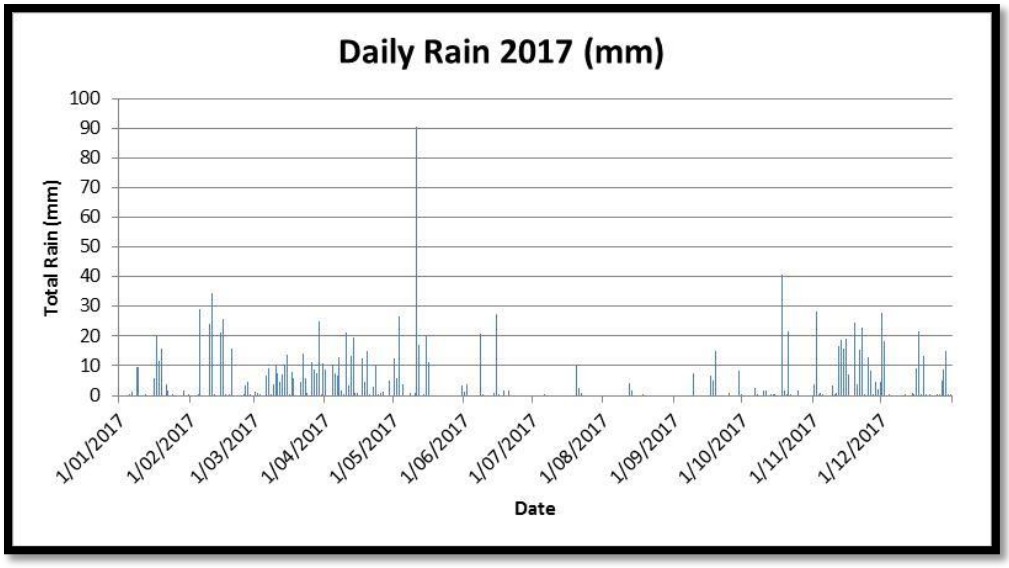


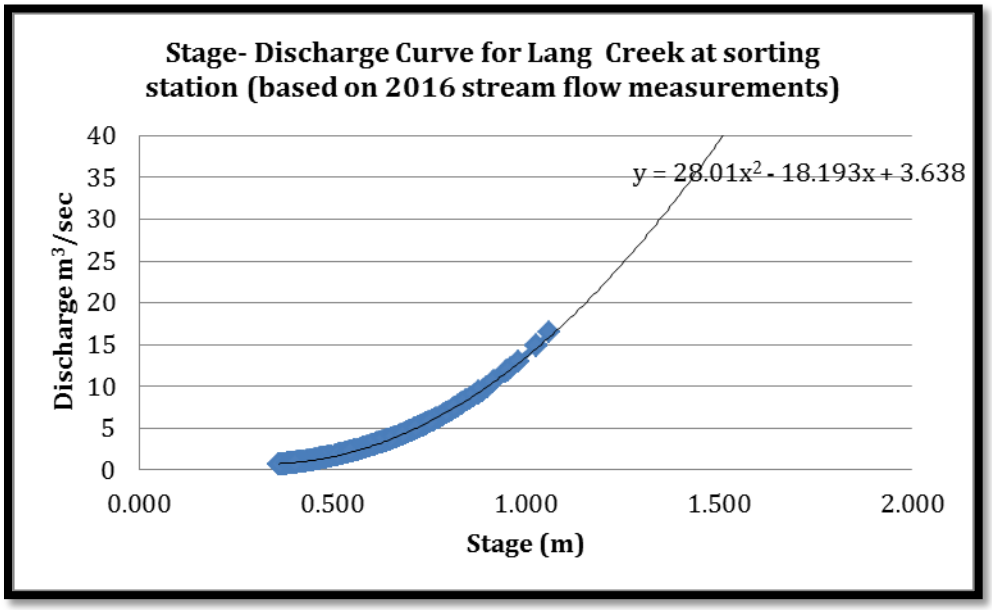
Figure 16. Daily Rain 2017



2. Stream Discharge

On Figure 17 the 2015 stage discharge curve is presented. Low discharge flows were measured this summer to ensure the calculated discharges accurately reflect the actual discharge of Lang Creek. As there were no measurable changes to the banks inundated by higher stage levels, higher discharge levels were not included in the calibration transects.

Figure 17. Stage Discharge Curve for lower Lang Creek at the Alex Dobler Salmon Centre (Based on 2016 Stream Flow Meausurements)



On Figure 18 the Lang Creek hydrograph for 2017 data is presented. Daily changes in discharge of more than 100% are commonly recorded during winter storms. Peak flow of Lang Creek was recorded at 55 m^3/sec which surprisingly occurred in April this year. As has been discussed in previous reports, Haslam and Duck lake system create a major hydrological and water quality buffer for the majority of the watershed. Anderson Creek, being un-buffered, is a major storm water contributor during peak flows on lower Lang Creek particularly in the post summer period when Haslam Lake is recharging and the weir spillway has not yet breached. The data at which the weir breaches generally occurs in mid November.

Figure 18. Hydrograph for lower Lang Creek at the Alex Dobler Salmon Centre 2017

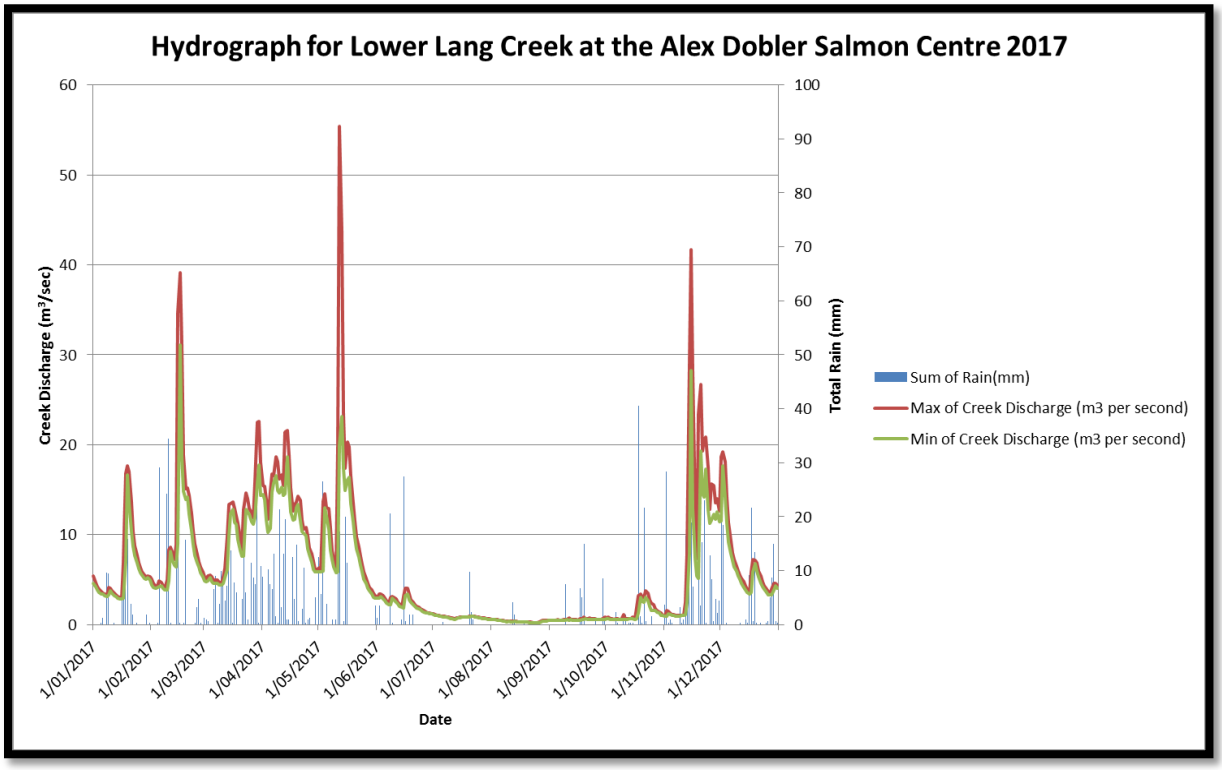


Figure 19 and Figure 20 provide a close up view of daily rainfall and discharge of Lower Lang Creek for 2017 (August and November). Figure 19 data clearly indicates the pause in discharge in early November as Haslam Lake is being recharged, when the heavy rain event in early November had virtually no effect on stream discharge. In Figure 20 we see that even substantial rainfalls after period of long drought will have no effect on discharge as all water is being used to recharge the soil before runoff can occur.

Figure 19. Lang Creek Hydrograph for November; Wettest Month (214.6 mm)

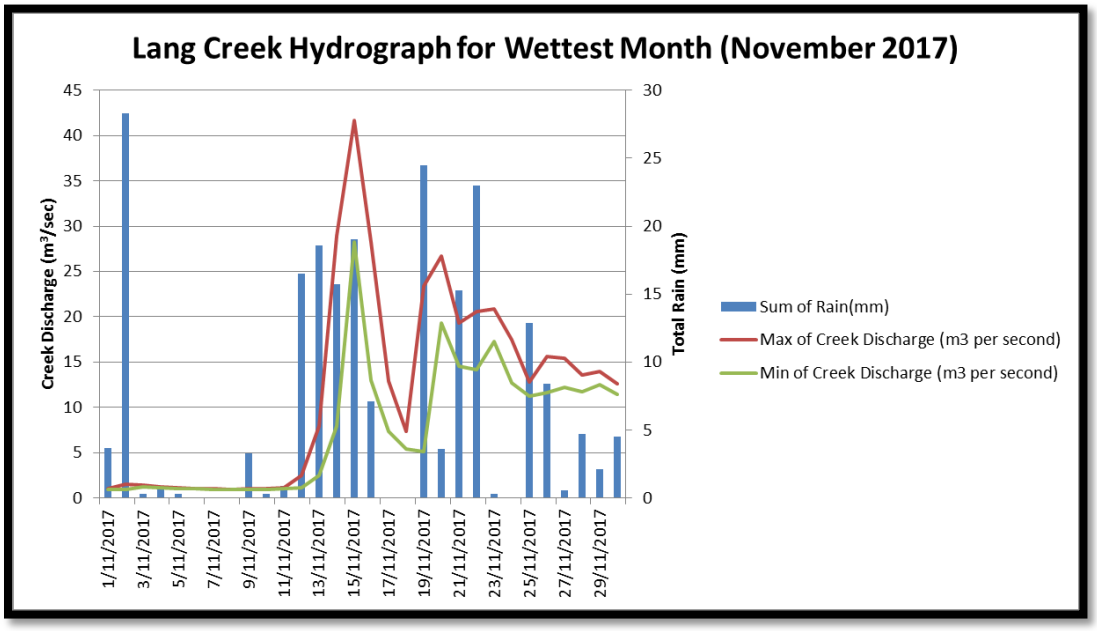
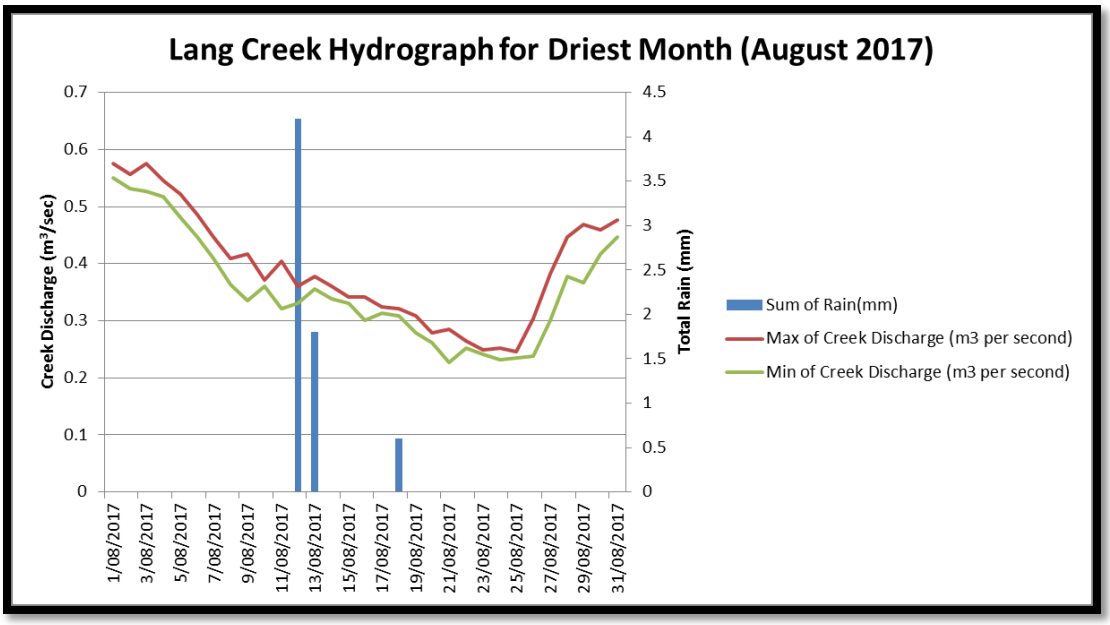


Figure 20. Lang Creek Hydrograph for August; Driest Month (6 mm)



V. CONCLUSIONS AND RECOMMENDATIONS

The majority of the 2017 data collected by the Salmon Enhancement Society shows no significant changes from 2016 or any of the previous 20 years when water quality data has been collected. The sampling program continues to support the general conclusion that neither water quantity nor quality at either drinking water intake has been adversely impacted by present forest harvesting operations. Ongoing evaluation of historic data collected over the last 20 years within the Haslam drainage indicates that the watershed is capable of supplying raw water of sufficient quantity and good quality at the Haslam Lake Intake.

The Brew Bay Water Users Group and the Powell River Salmon Enhancement Society, holding the two water licenses on lower Lang Creek, continue to deal with the periodic natural turbidity events that characterize that reach of the river. It is now well documented that these turbidity pulses on Lang Creek are unrelated to any forestry triggered disturbances upstream but are tied to the fine silty lacustrine deposits along the length of Lang Creek Channel.

All water users are dependent on the weir for summer storage on Haslam Lake and maintaining summer low flow on Lang Creek. Forestry activities are having no measurable effect on water quantity or timing of flow on Lang Creek. Careful management of Haslam Lake level via the Powell River city's slough weir is crucial for maintaining adequate water flow at the Brew Bay intake and the Alex Dobler Salmon Centre during late summer and early autumn.

While the sampled sites have shown no degradation in either water quality or quantity or timing of flows associated with the intakes, it is still important to ensure that all industrial and recreation activities within the watershed are conducted with care to protect all creeks and water bodies regardless of their impact on the intakes. This is especially important for the fish populations that are found on small tributaries throughout the whole watershed.

Because of the high water temperatures within the channel of lower Lang Creek, the small, relatively cold tributary streams flowing from the north between Anderson Creek and the mouth of Lang Creek continue to be important for fish fry to escape the main channel heat. Maintaining the present temperature and regime on these creeks is essential.

General water chemistry analysis (pH, TTS, turbidity, CaCO3 equivalent, TOC, colour, N, P, total metals and fecal coliform) is recommended for summer low flow and peak autumn flow to document any changes that might have occurred since last analysis was completed in 2010.