Bridge-Seton Water Use Plan

Lower Bridge River Aquatic Monitoring

Implementation Year 2

Reference: BRGMON-1

2013 Annual Data Report

Study Period: January 1, 2013 – December 31, 2013

Prepared by: Prepared for:

Coldstream Ecology, Ltd.
Box 2218
Lillooet B.C.
V0K 1V0
Tel: 250-256-0637

St'at'imc Eco-Resources
PO Box 1654
Lillooet, BC V0K 1V0

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July 31, 2014

Bridge-Seton Watershed

Lower Bridge River Aquatic Monitoring Program
2013 Annual Data Report

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1.0 ACKNOWLEDGEMENTS

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2.0 EXECUTIVE SUMMARY

Historically, the Bridge River Valley was a thriving, productive river valley that harbored a rich and abundant diversity of aquatic and terrestrial life. This diversity contributed vast benefits to local and regional culture, society and the environment. These benefits were partially the result of interconnectedness between the headwaters of the Bridge River and the confluence of the Fraser River. In 1948, the interconnectedness was broken by the building of Mission Dam, and in 1960 the system was fully fragmented by the finalization of Terzaghi Dam. Terzaghi dam blocked off all flow into the Lower Bridge River (LBR) between 1960 and 2000, converting approximately 4km of its uppermost reach from aquatic to semi-terrestrial habitat. During this time period, the St'at'imc First Nation and the Bridge River Band and others raised concerns about the lack of water released from Terzaghi Dam. To address these concerns, a long term monitoring program was designed that would test two main flow releases (Trials 1 and 2) against a zero-flow baseline scenario, which represented the previous 40 years. The zero flow was classified as a Pre-Trial baseline and data were collected from 1996-2000. Trial 1 was an annual water budget of 3 m^3s^{-1}, which was implemented between August 2000 and April 2011; Trial 2 is an annual water budget of 6 m^3s^{-1}, which was initiated in May 2011 and will be implemented for 4 years (until April, 2015).

Data from this monitoring program will be used to inform the management of the Lower Bridge River flow regime, and a future water use decision. Following the flow trials, St'át'imc Nation, the Bridge River Band, BC Hydro, regulatory agencies and other stakeholders will work together to determine a long-term flow release strategy for the LBR. A quantitative comparison of the two flow releases relative to the baseline will occur, with the optimal hydrograph being chosen in a synthesis assessment. This process is underway, and a decision will be made in early 2015. The existing LBR aquatic monitoring program is scheduled for an additional 6 years after the flow decision, however this is conditional on the outcome of an interim review following the water use decision and implementation of the flow release strategy. In order to inform any management decisions, a suite of biotic and abiotic aquatic indicators were chosen and are quantified within this report.

The main purpose of the program in 2013 was to continue monitoring the influence of the flow release from Terzaghi Dam on fish resources and the aquatic environment in the Lower Bridge River. Four monitoring activities were conducted as part of the monitoring program: 1) constant temperature and water stage recording; 2) water chemistry, aquatic invertebrate diversity and periphyton accrual during fall; 3) sampling to monitor juvenile salmonid growth; and 4) a fall standing stock assessment for evaluating fish distribution and calculating relative abundance indices. In addition, a rampdown monitoring component was integrated into the Lower Bridge River Aquatic Monitoring Program during the summer and fall seasons to identify an optimal strategy for ramping the river.

The main findings from 2013 are consistent with past years in the flow trial experiment. Broadly, the continual water release from Carpenter Reservoir has altered the physical habitat and associated ecological, social and cultural benefits. Relative to Pre-Trial (i.e., baseline) conditions, the seasonal temperature regime was modified, and the wetted area of the river was observed to be larger. Fall temperatures were distinctly warmer, and spring and summer temperatures were consistently cooler. Since the flow trial began, these effects were strongest in the upper reaches (i.e., Reaches 3 and 4) and observed less in Reach 2 due to the influence of the Yalakom River inflows, groundwater and the differing channel morphology. Water chemistry parameters for 2013 were similar to those reported in previous pink salmon spawning years (across the flow trials) and concentrations were within the water quality guidelines established by British Columbia.

Periphyton accrual gradually increased for all reaches through the middle of October and then stabilized across all reaches until the end of November. The algal species rock snot

(*Didymosphenia geminate*) was prevalent within the LBR; however periphyton biovolume estimates for this species were significantly lower than in 2012 across all reaches. Reach 4 data suggest periphyton accrual was slower to accumulate than in other reaches. Invertebrate data were confounded by variability; community diversity and abundance did not increase significantly over the Flow Trials. However it was clear that the Yalakom River had a strong influence on the aquatic productivity. Communities remain distinct upstream and downstream of the confluence, and benthic invertebrate biodiversity was greatest downstream of the Yalakom River.

The mean size of fish for each reach was analyzed during five different growth sessions. Size and growth inferences were confounded by variability. Fish density, relative abundance and spatial distribution derived from standing stock data followed similar patterns across the reaches in 2013 as during the previous flow trial years. Reach 4 had the highest biomass estimate for the twelfth consecutive year since the flow trials began. Reach 3 had a higher biomass estimate than Reach 2, but was lower than biomass estimates observed under baseline (no flow) conditions. Differences in 2013 data were apparent, however as total salmonid biomass decreased in Reach 4; Reach 3 estimates were similar to 2012; and Reach 2 estimates remained stable compared to other years in Trial 2, as well as Trial 1. Finally, chinook and coho biomass estimates show marked declines in Reaches 3 and 4 in 2013. Overall rainbow biomass proportions increased across the reaches.

The reasons for these observed parameter changes and the differences between flow trials are varied and uncertain. However, they are likely influenced by the changed thermal regime of the river, habitat alterations due to differing flow regimes, and nutrient inputs from pink salmon spawners. In addition, there are certainly other influences upon the aquatic ecosystem that are outside the scope of this monitoring program.

3.0 INTRODUCTION

The Bridge River, a tributary of the middle Fraser River, is an important fish bearing river in Southern Interior British Columbia. While it was used historically as a major food source, today it is used for a variety of purposes including hydroelectric power. Traditionally, fish comprised 60% of the local diet (Kennedy and Bouchard, 1992). However, the benefits to society from this fish resource extended much farther than just as a source of food. This fishery was also integral to a complex trading network where salmon and salmon oil were highly prized and considered the foundation of commerce in the region. The health and productivity of the Bridge River aquatic ecosystem contributed to the rich fish resource and culture in St'at'imc territory. Overall, this resource generated significant benefits towards the health and well-being of the St'at'imc Nation and trading partners.

In 1960, the Bridge River was fully impounded by Terzaghi Dam (formally called Mission Dam), which was built at the head of a long, narrow canyon approximately 40 km. upstream of the confluence with the Fraser River. This impoundment created Carpenter Reservoir, which serves as a water source for hyrdropower production in the Seton watershed, and fragmented the Bridge River, creating a controlled lower section called the Lower Bridge River. Initially, all flow was diverted to Seton Lake for hydroelectricity, with the exception of infrequent high-water spillover events. Consequently, 4kms of the river directly below the dam were dewatered for 40 years (1960-2000). Downstream of the dewatered reach, groundwater and tributary influence created a flow less than 1% of the historic mean annual discharge upstream of the Yalakom River (Longe and Higgins, 2002).

Concerns were raised and discussed over the lack of water flowing in the Lower Bridge River by the St'at'imc, federal and provincial regulatory agencies, and the public. After discussions in the 1980s, an agreement was reached to continuously release water to provide fish habitat downstream of Terzaghi Dam. An adaptive management approach was used to develop an environmental monitoring program. This program gathers empirical data to inform the flow management of the LBR, and aims to generate a a better understanding of the effects of the introduction of water from Carpenter Reservoir on the aquatic ecosystem productivity and the ecosystem services, or benefits which the river generates, below the dam. A 3.0 m^3s^{-1} interim water budget, based on a hydrograph that ranged from a minimum of 2 m^3s^{-1} to a maximum 5 m^3s^{-1} was initially allocated for in-stream flow releases into the Lower Bridge River (LBR). Water was released on August 1, 2000 and continued at this level from August 2000 until spring 2011. Prior to this release, data were collected from 1996-2000, to provide baseline information on the pre-release ecosystem and the ecological services the river provided, and to facilitate measuring and comparing the response of the aquatic environment to different flow trials. Currently, a second test flow of 6.0 m^3s^{-1} is being implemented from 2011-2014.

This report was prepared to demonstrate compliance with conditions of the Water Use Plan (WUP) Order to release water and monitor the environmental impacts of the flow trial on the aquatic ecosystem. It is also used to describe data collection methods and to present results from 2013 under the 6.0 m^3s^{-1} flow trial (Trial 2), with the water budget hydrograph ranging from 1.5 m^3s^{-1} to 15 m^3s^{-1} on a seasonal basis. Ultimately, these data will be used to inform the management of the LBR. The present implementation of this aquatic monitoring program is part of the Bridge-Seton Water Use Plan. St'át'imc Eco- Resources (SER), an incorporated company owned by the St'át'imc Chiefs Council, has been contracted by BC Hydro to undertake this work. Subsequently, Coldstream Ecology, Ltd. was subcontracted to implement the monitoring program. Detailed descriptions of past monitoring activities and results of past years can be found in McHugh and Soverel (2013), Bradford et al (2011), Riley et al. (1997, 1998), Higgins and Korman (2000), Longe and Higgins (2002), Sneep and Higgins (2003, 2004), and Sneep and Hall (2005 to 2010).

3.1 Management Questions

This ecological monitoring program utilizes an adaptive management framework to address uncertainties about the expected benefits of releasing water from Carpenter Reservoir downstream of Terzaghi Dam. This lack of certainty constitutes a major impediment for decision-making. The water use decision in May of 2015 will have significant implications for ecological resources and benefits derived from the Lower Bridge River, St'at'imc cultural values, and energy production. Consequently, the long-term monitoring program has been designed to provide defensible data defining the functional relationship between the magnitude of flow releases, and physical and biological responses in the Lower Bridge River channel. As identified in the Water Use Plan Terms of Reference for this monitoring program, four key management questions that directly describe the uncertainties are:

1) How does the in-stream flow regime alter the physical conditions in aquatic and riparian habitats of the Lower Bridge River ecosystem?

2) How do differences in physical conditions in aquatic habitat resulting from the in-stream flow regime influence community composition and productivity of primary and secondary producers in the Lower Bridge River?

3) How do changes in physical conditions and trophic productivity resulting from flow changes together influence the recruitment of fish populations in the Lower Bridge River?

4) What is the appropriate 'shape' of the descending limb of the 6 m^3s^{-1} hydrograph, particularly from 15 m^3s^{-1} to 3 m^3s^{-1}?

Juvenile salmonid biomass is used as a primary criterion for examination and study because it is a highly valued ecological component of the aquatic ecosystem. In addition, it integrates the effects of flow on trophic productivity and habitat conditions in the LBR. The monitoring program was designed to test the following hypotheses regarding the ecological benefits and the effects of flow on the fish populations in Lower Bridge River:

H_O: "High flow is better"

H_A: "Low flow is better"

The data provided in this annual data report summarize the 2013 program. These data are part of a larger dataset (i.e., 1996-2012) which will address management questions 1-3 (above) during synthesis report preparation in 2015. At the conclusion of this flow Trial, the synthesis report will inform the key WUP decision in 2015. The decision will surround the magnitude of the long term flow regime chosen (i.e., 0 vs. 3 vs. 6 m^3s^{-1}). The fourth question is being addressed by a ramp down monitoring component that was integrated into this WUP monitoring in 2012. Information collected from this component will inform the optimal “shape” of the hydrograph and assess the effectiveness of annual ramp down activities for protection of the LBR fish population from stranding effects.

3.2 Objectives and Scope

The primary objectives of this monitoring program are twofold: 1) to reduce uncertainty regarding the effects of the flow release on the relative aquatic productivity of the ecosystem and these benefits; and 2) to design a summer and fall ramp down strategy that reduces the risk of fish stranding while meeting environmental objectives. Monitoring program activities in 2013 extended the historical monitoring dataset and focused on:

1) water temperature, dam discharge, and river stage;
2) water chemistry parameters, periphyton accrual and diversity, and the relative abundance and diversity of aquatic invertebrates during the fall series; and
3) growth, distribution, and relative abundance of juvenile salmonids, especially coho salmon (*Oncorhynchus kisutch*), chinook salmon (*O. tshawytscha*), steelhead and rainbow trout[1] (*O. mykiss*), within the study area;
4) summer and fall ramp down monitoring and salvage activities;
5) 1.5 m^3s^{-1} flow habitat surveys; and

[1] Throughout this report, juvenile O. mykiss are referred to as rainbow trout, although a large (but undefined) proportion of these fish in the LBR are anadromous steelhead.

6) Chinook life history and otolith pilot program implementation.

In future years, the scope will be guided by the outcome of the interim reviews in 2015.

3.3 Approach

The Lower Bridge River Aquatic Monitoring program has been implemented for nearly two decades (i.e. 1996-2013). As such, methodologies for each sampling component have been standardized to facilitate comparisons across flow trials. The methods and results are broken down into two distinct sections: the aquatic ecosystem monitoring components and the summer and fall ramp down surveys.

3.4 Study Area

The Bridge River lies within the St'at'imc Territory, in Southern Interior British Columbia. The Lower Bridge River is the section between the confluence of the Fraser River and Terzaghi Dam. It is divided into 4 reaches, which are defined in Table 1 and illustrated in a map in Figure 1. In 2013, like previous years, data collection focused in Reaches 2, 3, and 4, i.e., between the mouth of Camoo Creek and Terzaghi Dam (
Table 1). Water chemistry data were also collected at the surface of Carpenter Reservoir, Mission Creek, Yankee Creek, Russell Springs, Hell Creek, Michelmoon Creek, the Yalakom River, Antoine Creek, and Camoo Creek.

Table 1. Reach break designations and descriptions for the Lower Bridge River.

Reach	Boundary (Rkm) Downstream	Upstream	Description
1	0.0	20.0	Fraser River Confluence to Camoo Creek
2	20.0	25.5	Camoo Creek to Yalakom River confluence
3	25.5	36.8	Yalakom R. confluence to upper extent of groundwater in-flow
4	36.8	40.9	Upper extent of groundwater in-flow to Terzaghi Dam

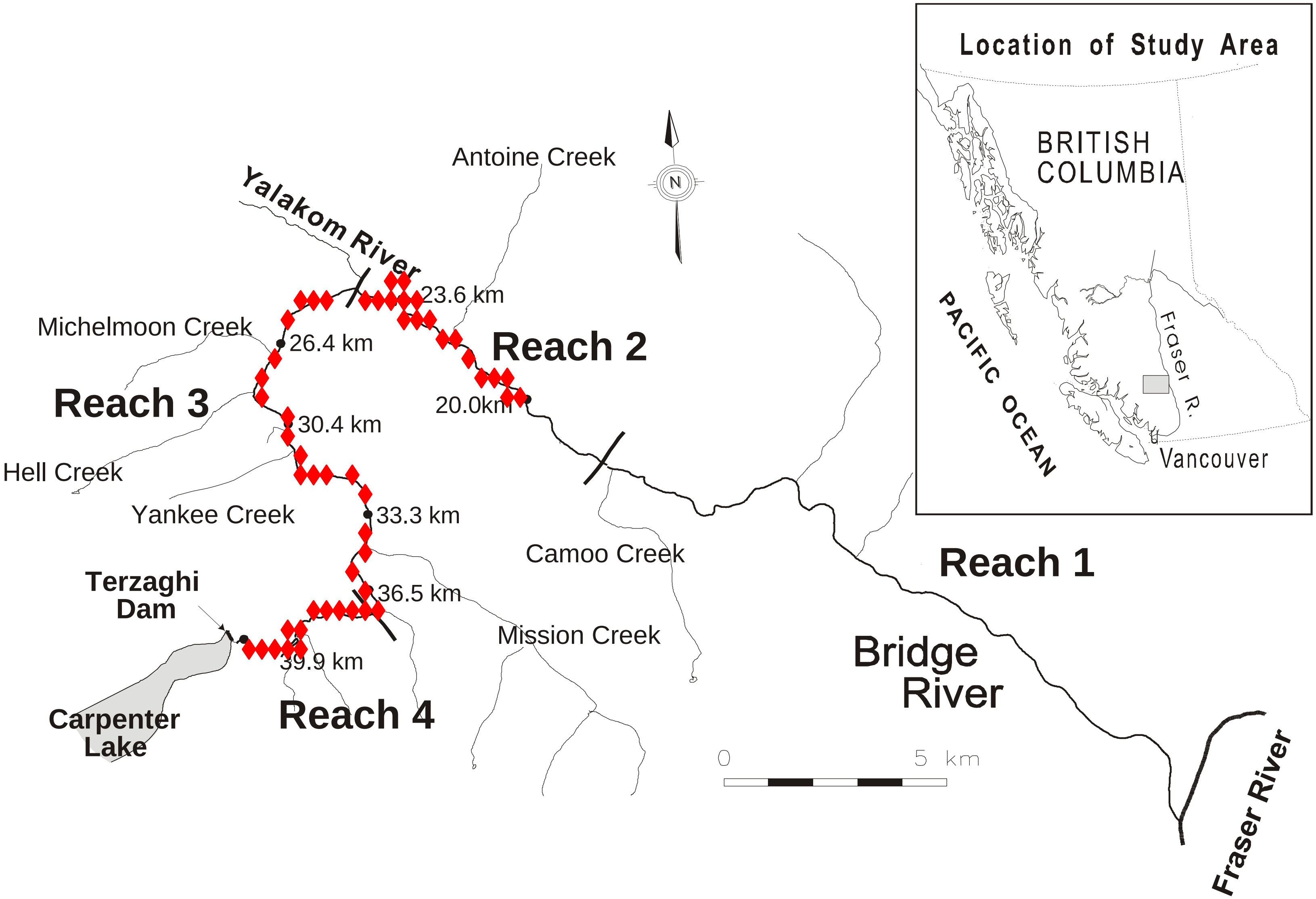


Figure 1. The Lower Bridge River Aquatic Monitoring Program study area, including reach breaks, index sample site locations (indicated by black dots), and the locations of tributaries between Terzaghi Dam and the Fraser River. The red diamonds indicate the approximate locations of the 50 fall standing stock assessment sites.

3.5 Study Period

Monitoring in 2013 occurred over nine sampling sessions in 2013. A general description of the activities and sampling timing are presented in Table 2.

Table 2. 2013 Sampling Schedule Timeline.

Sample Session	Sampling Dates	Activities
Spring	April 8; April 30 to May 2	Water sampling (metals); Electrofishing
Summer Fish Size Index and Ecology	8 to 11 July; 21 to 29 August	Electrofishing
Summer Rampdown	30, 31 July; 7 to 30 August	Rampdown surveys: fish salvage and staff stage, temperature and turbidity data collection; Electrofishing
Fall Stock Assessment	4 to 26 September	Depletion Sampling (electrofishing)
Early Fall	26 to 27 September	Deploying algae and bug samplers; Water sampling (metals)
Fall Rampdown	30 September; 2 October	Rampdown surveys: fish salvage and staff stage, temperature and turbidity data collection; Electrofishing
Fall	3 October to 15 November	Water sampling (nutrients), Discharge transects; low flow habitat surveys
Late Fall	12 November to 10 December	Electrofishing; Retrieving algae and bug samplers; Water sampling (nutrients); Logger downloads; Discharge transects
Early Winter	December 18; January 6	Logger Downloads, Discharge transects; Water sampling (metals)

4.0 METHODS

4.1 The Aquatic Monitoring Program

4.1.1 *Overview*

Monitoring methods and protocols employed in 2013 were nearly identical to those used in 2012. These methods and protocols originated from a general template of monitoring initiated at the start of the baseline flow monitoring phase in 1996 and have since undergone adaptations through the 3 m^3s^{-1} flow treatment (2000 to 2010) and 6 m^3s^{-1} flow treatment (2011 – present) as appropriate. Examples include adapting the flow release in response to early Chinook fry emergence and temperature pollution effects. The major data collection components of the LBR sampling design include:

- Water temperature
- River stage
- Flow release
- Water nutrient/chemistry
- Primary Productivity (periphyton)
- Secondary productivity (macroinvertebrate)
- Juvenile salmonid growth
- Fall standing stock
- Habitat surveys
- Ramp down and salvage surveys

The most thorough data collection occurred at the seven index sites located at 3 km. intervals along the LBR (Figure 1). At these site indices, all above bulleted parameters are measured with the exception of flow release, which is measured at Terzaghi Dam. In descending order from Terzaghi Dam, these include the following river kilometers: 39.9, 36.5, 33.3, 30.4, 26.4, 23.6, and 20.0. River kilometer (Rkm) 39.9 is a more recent index site where monitoring began at the start of Trial 1. Minimal data was collected in Reach 1 and includes Chinook life history and water sampling (metals). The timing and frequency of data collection were similar to historic LBR data collection within the program with a few exceptions. No high flow discharge transects or habitat surveys were conducted due to safety concerns, and photographs being taken for BRGMON-16 were discontinued. The methods used to collect water temperature, river stage, and flow release data are described below.

Water temperature was recorded at an hourly rate on every day of 2013 using data loggers manufactured by the Onset Computer Corporation (UTBI-001). These data loggers were located at the seven site index locations as well as an additional logger located at 100 meters upstream of the confluence of the LBR and the Yalakom River. Temperature loggers were anchored at locations and were submerged by river water. They were both checked and downloaded for data every 3 to 4 months to ensure data quality.

Relative river stage was recorded by PS9000 submersible pressure transducers (Instrumentation Northwest, Inc.) which were coupled with Lakewood 310-UL-16 data recorders. Data were collected at three Rkm locations: 20.0, 26.1, and 36.8. River stage was recorded every 15 minutes per day every day of the year. Loggers were regularly checked and downloaded by Via-Sat Data Systems to ensure data quality. In addition, discharge data were collected in December at two designated transect locations in Reach 3 and the bottom end of Reach 4. Water depth and velocity measurements were taken every 0.5 meters.

Data on flow release are measured and maintained by BC Hydro Power Records and were provided to Coldstream by BC Hydro. These data represent hourly discharge from the Lower Level Outlet (LLO) gates at Terzaghi Dam, every day of the year.

4.1.2 *Water Chemistry and Nutrients*

Water chemistry and nutrient data collection occurred in the early fall session on October 21 and 10 December for the late fall session. During the early fall period, water samples were taken from all site index locations, Carpenter Reservoir, and the following LBR tributaries: Antoine Creek, Camoo Creek, Hell Creek, Michelmoon Creek, Mission Creek, Russell

Springs, Yalakom River, and Yankee Creek (refer to Figure 1). The late fall session omitted three index sites (Rkms 26.4, 23.6, and 20.0) due to frozen conditions. These water samples were submitted to ALS Environmental and analyzed for the following nutrient levels: NH_4, NO_2/NO_3, Soluble Reactive Phosphorus, Total Dissolved Phosphorous, turbidity, and Total Phosphorus; the chemical parameters included total alkalinity and pH. Methods used for the field sampling and laboratory techniques are explained in further detail within Riley et al. (1997). Supplemental water quality data were measured at each site using a WTW handheld field meter and these included conductivity, pH, and spot water temperature.

4.1.3 *Primary and Secondary Productivity Sampling*

Abundance, when discussed in this report relates to the overall number or count of individuals within a given population. Diversity is defined as the number of species, genus, or family within a defined group. The definition of productivity is the rate of generation of biomass in an ecosystem. Primary productivity was monitored using periphyton accrual as the main parameter. Macroinvertebrate abundance and diversity were monitored as the main indicators of secondary productivity. At each of the seven index site locations, both periphyton and macroinvertebrate data were collected at three replicate subplot locations spaced approximately 20 meters apart. At each replicate subplot, a depth and velocity measurement was taken using a top-set wading rod and velocity meter manufactured by Swoffer Instruments, Inc. The data was collected to assist in the characterization of inter-annual variations of primary and secondary productivity.

The medium used to accrue periphyton consisted of a 30 x 30 x 1 cm cell Styrofoam sheet that was rubber banded to a plywood backing which was bolted to a 30 x 30 x 10 cm concrete block. At each site index, periphyton accrual samplers were placed at each replicate in areas relatively similar in water depth and velocity. Periphyton accrual data were collected approximately every week at all the replicate subplots and for all seven site index locations between September 27 and November 25, 2013. Each weekly sample involved the removal of a core of Styrofoam using the open end of a 7-dram plastic vial (8.5 cm^2 core area). These samples were then sent to ALS Environmental for measurement of Chlorophyll a concentration. At the end of the fall series, an additional Styrofoam core was extracted and sent to Limnotek so that species composition and cell counts per unit could be measured. More detailed methods regarding LBR specific field techniques for periphyton accrual methods can be found in McHugh and Soverel (2013).

The medium used to measure macro-invertebrate abundance and diversity included a standardized metal basket filled with river gravel and substrate collected at each site. These prepared baskets were placed at similar water depths and velocities at each of the site locations and proximal to the periphyton accrual samplers. The baskets were left undisturbed for the duration of the eight week fall sampling series at which point they were carefully lifted out of the water and placed into buckets. The contained substrates were carefully removed from the baskets and were hand scrubbed in order to remove all attached material. This material was filtered through a mesh sieve (Nitex), and placed into a sample jar that contained 10% formalin solution. As was done in previous years, the samples were sent to Mike Stamford at Stamford Environmental to be sorted, identified to family, and enumerated.

4.1.4 *Sampling for Juvenile Salmonid Growth Data*

In 2013, juvenile salmonids were collected for growth data at each index site five times (i.e., May, July, August, September and November) in order to characterize temporal and spatial patterns of fish growth. The intent of this sampling was to collect a target of approximately 30 salmonids within each age/species class; as this was the target number utilized in previous studies. Live fish were collected using a backpack electroshock approach whereby fish were anaesthetized, identified to species, forklength (nearest millimeter) measurements taken and weights (to the nearest .1 gram) recorded. Following a brief recovery from the anesthetic, all fish were released very close to their initial collection area.

4.1.5 *Fall Standing Stock Assessment*

The objective of the fall standing stock assessment is to estimate the abundance and distribution of juvenile chinook salmon, coho salmon, and rainbow trout in Reaches 2, 3, and 4. Unlike the fish growth sampling, the standing stock assessment has a much larger geographic scope, spanning 50 sites along the LBR. The fall stock assessment was conducted during a 3 m^3s^{-1}discharge. The timeframe and flow magnitude during this sampling period is the same as in Trials 1 and 2 (Figure 2).

Upon arrival at each site, the standing stock survey area was enclosed with three ¼-inch mesh stop nets in size ranging from 50 to 150 m^2. Perpendicular to the bank, two shorter panels were used as stop nets upstream and downstream of the bank while a longer net was used parallel to the bank. Stop nets were attached to bipods and anchored to the bottom so that they were fixed during sampling. As crews changed over the years and the river changed, net placement deviated slightly between surveys and was dependent on site habitat and site conditions at the time of sampling. Any such deviations were minimized to reduce sampling bias.

A four-pass depletion method using electrofishers was executed within the netted enclosure by using a 400 volts DC. Live fish were anaesthetized, identified to species, forklength (nearest millimeter) measurements taken, and weights (nearest .1 gram) recorded. Fish were kept in a live basket in the stream until the sampling was complete and fish were then released near the original electroshock location.

Upon completion of the electroshocking, physical (abiotic) data of the site was measured and recorded. Length measurements of the netted enclosure were recorded and included offshore, mid, and inshore; followed by three width measurements which included upstream, mid, and downstream. The length and width measurements were taken in order to calculate the area sampled. After the net enclosure was removed, water depth and flow velocity was recorded via three transects at upstream, mid, and downstream locations. At each transect, five depths and five velocities were measured at equidistant intervals from bank to the offshore extent of the sampled area. Water velocity was measured with a Swoffer™ current meter at a depth of 0.6 m. Maximum depth and velocity were also noted at each site.

Supplementary site data included sampling effort (Electrofishing seconds), date, dominant habitat type, D90 (grain size of 90th percentile expressed in millimeters), substrate composition, and mean particle size.

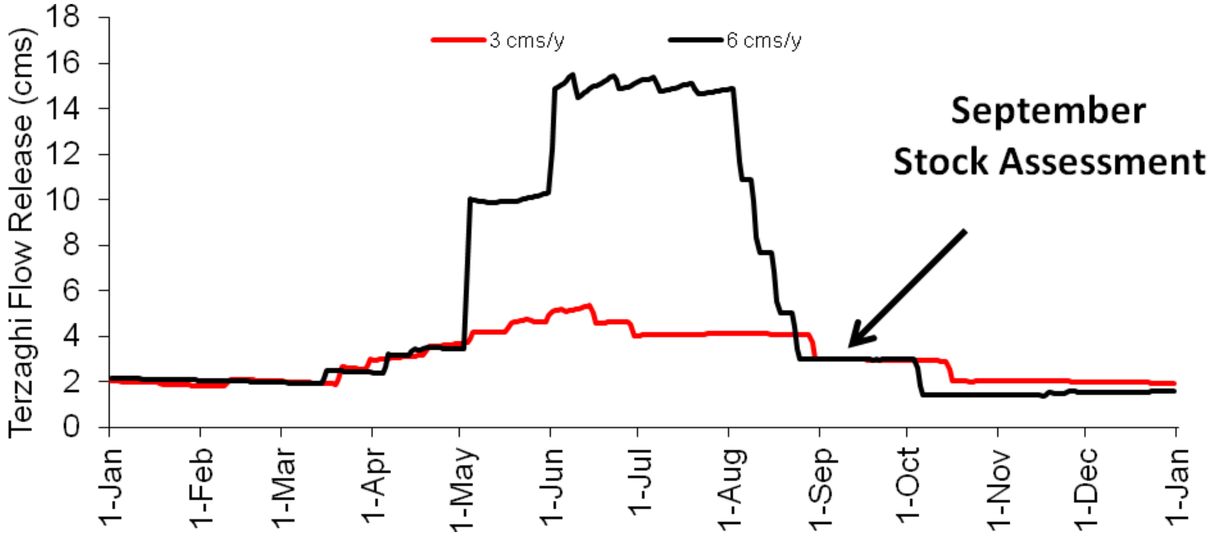


Figure 2. Lower Bridge River hydrographs at the 3 m^3s^{-1} and the current 6 m^3s^{-1} water budgets. Arrow indicates the timing of the annual fall standing stock assessment sampling.

4.1.6 *Chinook Life History*

Since the inception of the flow trial, juvenile chinook salmon abundance has demonstrated a downward trend. It is believed that a contributing factor is likely to be the affect of introduced water from Carpenter Reservoir. The reservoir's hypolimnetic release has created warmer water temperatures during the fall spawning and early egg incubation periods relative to pre-Trial temperatures, particularly in the upper reaches (Reaches 3 and 4) of the Lower Bridge River (see Figure 8 and Figure 9). Consequently, increased temperatures have been shown to lead to accelerated egg development, which has been shown to lead to early emergence in juvenile chinook (Angilletta et al 2008; Geist et al 2006; Olden and Neiman 2010). Early egg development and premature fry emergence, (relative to the pre-flow release incubation period), was observed during several of the Trial 1 years (Sneep and Hall, 2010). Uncertainty remains in how the temperature regime and accelerated incubation has directly affected chinook fry. Two studies observed that Juvenile chinook fry in the LBR have diverse life-histories and adapt their behavior in response to varied environmental conditions. Bradford and Higgins (2001) showed that decisions made by individual juvenile chinook in the LBR affect foraging patterns, and these choices affect trade-offs that are made between energy acquisition and safety (e.g. predator avoidance) for individual fish. According to Bradford and Taylor (1997), juvenile chinook display differing life history patterns as reflected by seasonal movements and dispersal patterns.

To reduce uncertainty regarding how the flow release and temperature regime affects juvenile chinook, a pilot program specifically focusing on these knowledge gaps was implemented in 2013. Otoliths have been shown to help solve this problem by linking otolith elemental signatures with water chemistry (Wells et al 2003; Clark et al 2007b; Shrimpton et al 2009). The pilot program data from 2013 were used to evaluate the efficacy of the otolith microchemistry technique in the LBR and to better understand how the flow release schedule impacts early life-history and dispersal information for juvenile chinook salmon.

Life-history patterns of 40 juvenile chinook salmon were collected during spring and fall sampling sessions. Otoliths were extracted and LA-ICPMS, a methodology to analyze the composition of very small carbonate samples such as fish otoliths, was conducted at the School of Earth and Ocean Sciences, University of Victoria, using the UP-213 Laser Ablation System (New Wave Research) attached to an X Series II ICP-MS (Thermo Electron Corporation) on the samples. Plasma Lab (version 2.5.3.280, Thermo Electron 2003) software was used for data collection and reduction, and a relationship between water elemental signatures and otolith microchemistry was determined by linear regression and an incorporation coefficient (Clark et. al 2014).

Water chemistry stability was assessed and a combination of otolith chemistry plots were examined. Dissolved trace metal chemistry data were collected in 2013. Water samples for dissolved Sr (mg/L), Ba (mg/L), Mg (mg/L), and Mn (mg/L) were obtained and submitted to ALS Environmental and analyzed using CRC ICPMS (inductively coupled plasma mass spectrometry) methods. To determine the variation of chemical signatures in the LBR and Fraser River, duplicate water samples were collected seasonally in spring, fall and winter (i.e., April 8, September 27, January 6). Samples were taken from the LBR main-stem from five site index locations (Rkms 20.0, 26.4, 30.4, 33.3, and 39.9), downstream of the confluence with the Yalakom River and Applespring Creek in Reaches 2 and 1 respectively, and in the Fraser River just downstream from the Bridge River confluence. Protocol for obtaining water samples followed methods outlined by Shiller (2003) for sampling dissolved elements in remote locations, with some minor modifications as recommended by Clarke et al. (2007b). Analyzed data were then sent to Adrian Clark for inclusion in chinook life-history analysis.

4.2 Flow Rampdown Surveys

4.2.1 *Overview*

The focus area of the LBR flow rampdown occurs between Terzaghi Dam and the confluence of the Yalakom River, a river length of 16 km. Index site 23.6 was identified as an additional sensitive spot with regards to potential fish stranding and was monitored periodically throughout the rampdown less intensively. At the start of each rampdown day, a preliminary baseline reconnaissance of the entire 16 km was conducted. The physical progress of the flow reduction was monitored with stage gauges, and close attention was paid to those areas with historically high fish stranding potential.

Once reconnaissance was complete and areas with potential risk identified, salvage crews were dispatched to those areas. Upon arrival, these crews documented the physical attribute characteristics of the area; and if necessary, crews begin fish salvage. At the start of the work day, fish salvage efforts started closest to Terzaghi dam and highest priority was given to the following river habitats: side-channels, low gradient edge habitats, and ‘potholes’ from historic and current gold mining endeavors.

4.2.2 *Communications*

In order to mitigate rampdown operations it was critical that field personnel at various locations along the river were able to communicate promptly with BC Hydro electricians at Terzaghi Dam. Field personnel provided the on-the-ground feedback to the BC Hydro electricians so field personnel could adjust the timing and magnitude of gate changes at Terzaghi Dam.

At the beginning of each rampdown day, all involved parties congregated at a safety tailboard meeting. There all personnel discussed the objective, plans, and logistics for that day. After crews are dispersed, two-way radio communications were used with line-of-site radios tuned to BC Hydro's simplex channel (F1) and outside of line-of-site the duplex channel (F2 – Bridge River repeater) were used. Periodic check-ins occurred via radio communication.

4.2.3 *Terzaghi Flow Release and River Stage*

Hourly flow release data were provided by BC Hydro and are determined from the water surface elevation of flows over the top of the weir at the end of the LLO gate. Scaling factors were used to transform the water surface elevation readings into flow release data.
River stage was a critical factor during the rampdown because it triggers timing and focus of fish salvage operations downstream. River stage was recorded electronically every fifteen minutes using PS9000 submersible pressure transducers (Instrumentation Northwest, Inc.) coupled to Lakewood 310-UL-16 data recorders. Two staff gauges were permanent (Rkms 36.8 and 33.3) while two were temporary (Rkms 40.9 and 25.0). The electronic stage loggers were maintained by Via-Sat Data Systems Inc. of Burnaby, BC. During the rampdown surveys, rampdown staff also recorded river stage on a manual basis.

4.2.4 *Water Temperature and Turbidity*

Significant fluctuations in temperature and/or turbidity can impact ecological processes as well as have detrimental effects on salmonids. During the rampdown surveys water temperature and turbidity were recorded to measure the amount of change that occurred before, during, and after the steps of the rampdown. Hourly water temperature was recorded electronically by permanent loggers located at Rkms: 39.9, 36.5, 33.3, 30.4, and 26.4. Periodic manual readings of temperature were also recorded using handheld meters by rampdown staff.

In order to collect water turbidity, staff collected water samples just below the plunge pool at the start and end of each rampdown day. A clean sample bottle was used for each sample, rinsed three times with river water, and finally plunged under the surface until full. All turbidity samples were measured using a turbidimeter and the results reported as Nephelometric Turbidity Units (NTUs).

4.2.5 *Fish Salvage*

When crews arrived to an identified fish salvage site, physical habitat attribute information were recorded as notes. These notes include:

- Date, time, full names of crew members, operational changes being assessed
- General site description (i.e. reach #, river km, bank location, proximity to landmarks, etc.)
- NAD 1983 UTM Zone 10 North coordinates
- Estimated dewatering time for the site
- Additional Comments

Crews also assessed the overall abundance of fish present and size of habitat that would likely dewater. A strategy for moving fish out of the affected area and back into the main river was determined. Captured fish were categorized into the following:

- Incidental - fish habitats that were not yet isolated, and fish still had the opportunity to move to deeper areas on their own;
- Isolated – fish in wetted areas that were isolated from the main flow of the river (i.e. strand pools)
- Stranded – fish that were found in habitats that had completely dewatered, but were still alive when salvaged;
- Mortality – fish that were found dead in habitats that were isolated or completely dewatered.

Fish that were herded from shallow water into the main channel were considered ‘incidental’. When sites were completely isolated from the main channel and fish could not be captured in an incidental manner, they were captured by hand, dipnet, and backpack electrofishing. Minimal handling and low electroshocker settings were maintained in order to minimally disturb fish. All captured fish were counted and identified to species before returning them back to the main channel. A subset of the captured fish were measured to forklength (to the nearest mm). All fish data were recorded on data sheets developed in 2013.

5.0 AQUATIC MONITORING RESULTS

5.1 Physical Conditions

5.1.1 *River Stage*

Relative stage data in 2013 were recorded at three index sites (Rkm 20.0, 26.1, and 36.8) along with LLO flow release which are presented in Figure 3.

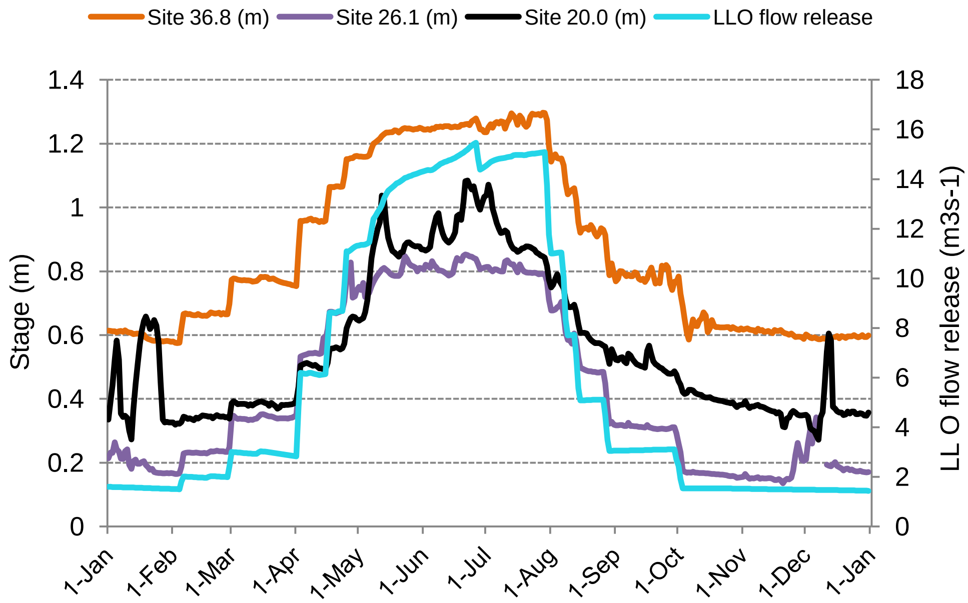


Figure 3. Mean daily river stage levels at three locations on the Lower Bridge River and mean daily flow releases from the LLO (lower level outlet) gate at Terzaghi Dam during 2013 (2° axis).

As shown in Figure 2, under the target Trial 2 hydrograph (i.e., 6 m^3s^{-1} MAD), target seasonal flows range from a spring and summer peak of approximately 15 m^3s^{-1} to a fall and winter low of approximately 1.5 m^3s^{-1}. In 2013, ramp-up from the initial 3 m^3s^{-1} began on 1 April and progressed until mid-June with the highest flow being maintained until fall rampdown which started on 30 July. Through the month of August, LLO flow release was ramped down from 15 m^3s^{-1} to 3 m^3s^{-1} ,which occurred over multiple weeks in order to reduce the magnitude of this significant change in flow. Consequently, water reduction was gradual and increased the success of fish salvage, while decreasing mortality and stranding throughout the rampdown. In October, the LBR was further ramped down from 3 m^3s^{-1} to 1.5 m^3s^{-1} over a period of two days. Trial 2 fall flow release was reduced so as to minimize the effect of the hypolimnetic water in the upper reaches of the river during the fall spawning and early incubation periods. The intent was to mitigate the effects of the flow release and consequent warmer temperatures on the emergence timing of chinook alevins that had been observed under Trial 1. Figure 4 presents the 2011, 2012 and 2013 mean daily flow releases.

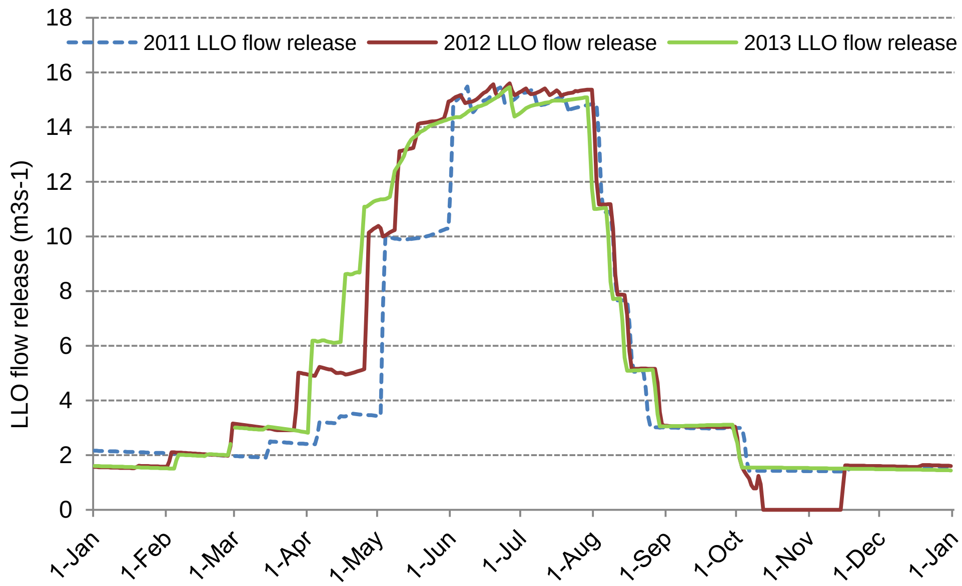


Figure 4. Mean daily flow releases from the LLO (lower level outlet) gate at Terzaghi Dam during 2011, 2012, and 2013.

5.1.2 *Water Temperature*

Annual mean daily water temperatures for Reaches 2, 3 and 4 of the Lower Bridge River for 2013 are presented in Figure 5 and Figure 6. Figure 5 depicts mean daily temperatures for Reaches 2, 3 and 4 and the Yalakom River for 2013. Figure 6 depicts temperatures covering (A) the entire twelve month period; (B) the fall spawning and early incubation period and (C) the winter and early spring period. Figure 7 presents data showing minimum and maximum daily water temperatures in each reach during the fall spawning and early incubation period.

Seasonal temperature trends for 2013 in Reaches 2 - 4 of the Lower Bridge River were similar to those observed throughout Trial 2, (McHugh and Soverel 2013; Sneep and Hall 2010). In general, temperatures in Reaches 3 and 4 appear to be warmer in the fall and cooler in the early spring and late summer, as compared to the pre-Trial thermal regime (Figure 8B,C). Water temperatures in Reach 4 reflected the principal influence of the hypolimnetic flow from the reservoir (Figure 8C). The hypolimnetic effects of the Trials were not as markedly evident in Reach 2; likely moderated by the influence of the unregulated Yalakom River (Figure 5, Figure 8A).

Diurnal temperature variation, i.e., daily minimum and maximum temperatures are presented in Figure 7. The range between minimum and maximum temperatures varies by reach according to the extent of tributary and groundwater input, as well as ambient air influence. Water temperatures fluctuated less seasonally, and showed muted diurnal variation in Reach 4 (Figure 7C). Reaches 2 and 3 have similar peaks and troughs over the fall spawning period (Figure 6). Reach 3 has a wider range of daily temperature fluctuations than Reach 2 (Figure 6). This is likely the case in Reach 3 and not in Reach 2 due to a different volume to surface area ratio, resulting in Reach 3 being more susceptible to influences from ambient air. While the temperature variation may not be muted, the minimum and maximum temperatures are still altered and influenced by the hypolimnetic flow. For example, on September 26, the temperature minimum in Reach 3 was 9.5C, whereas in Reach 2 it was 7.2C (Figure 7). For the fall spawning period, Reach 3 minimum temperatures remain consistently elevated as compared to Reach 2.

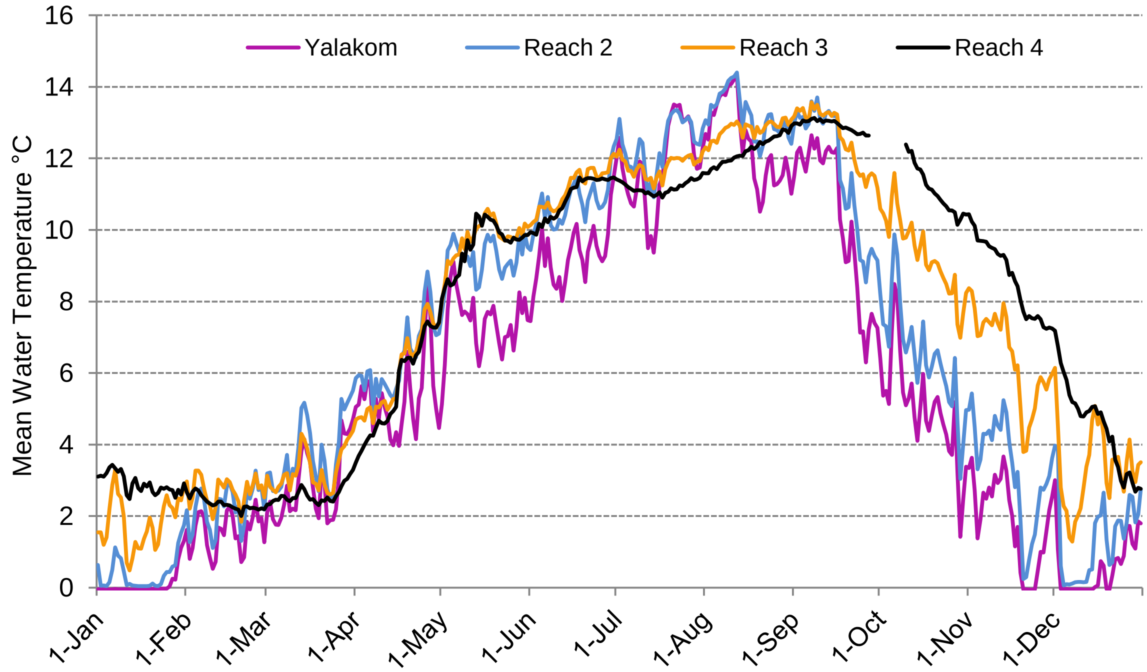


Figure 5. Yalakom River, Reach 2, Reach 3, and Reach 4 mean daily temperatures in the LBR between 1 January and 31 December, 2013.

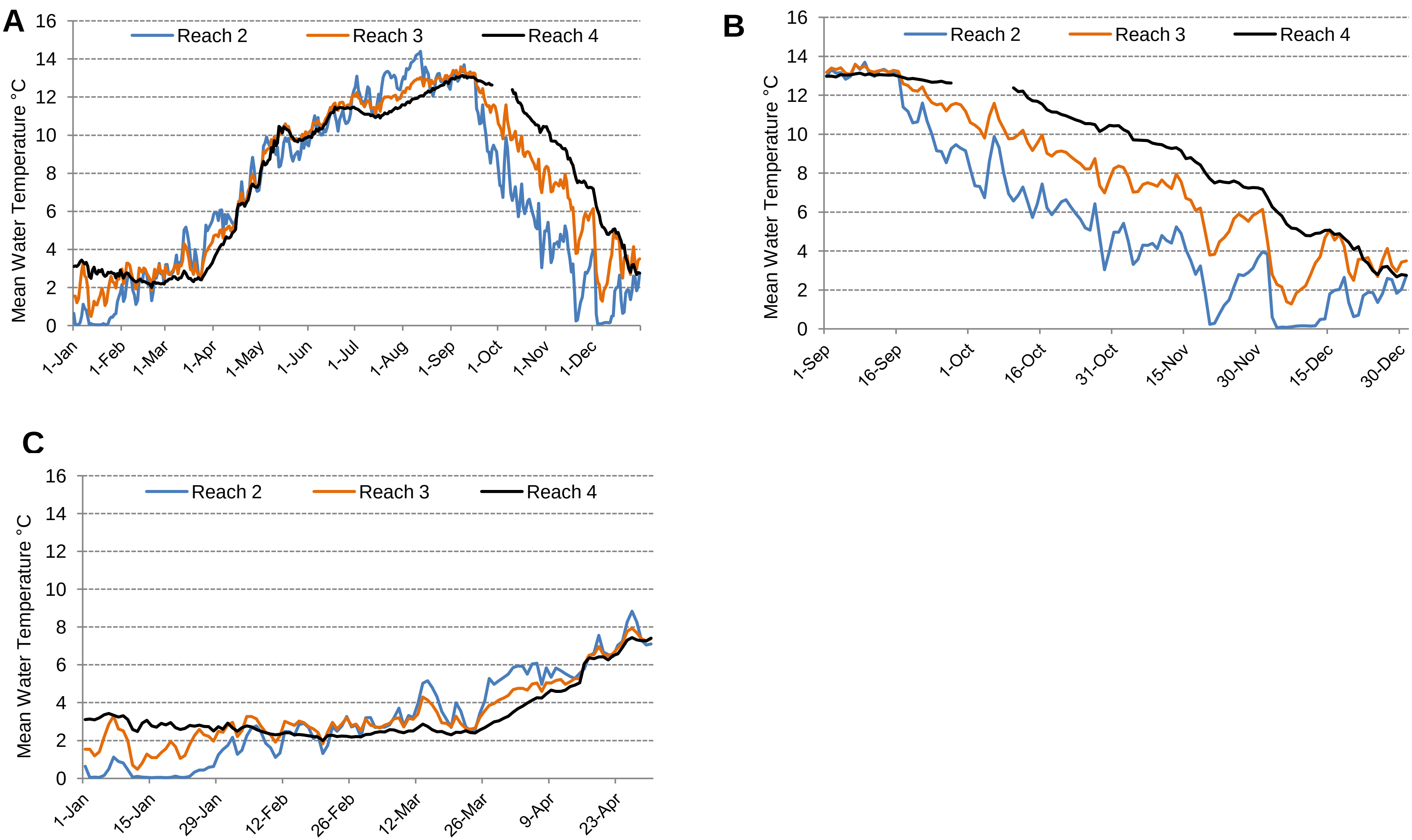


Figure 6. (A) Mean daily water temperatures recorded in the Lower Bridge River, 1 January to 31 December 2013.(B) Mean daily temperatures for Reaches 2, 3, and 4 covering the fall spawning period, 1 September – 31 December, 2013, and (C) Mean daily temperatures for Reaches 2, 3, and 4 covering the winter period.

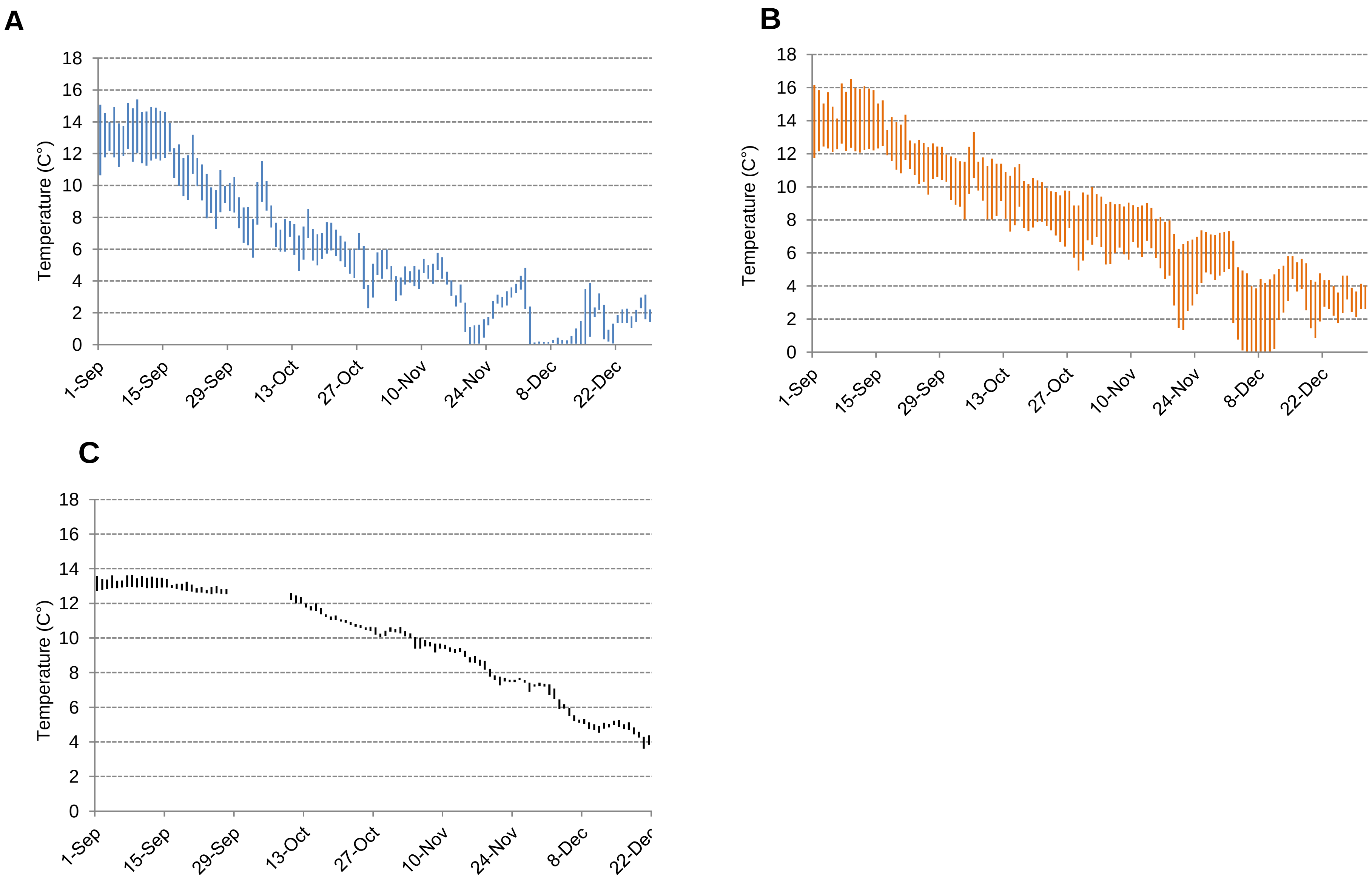


Figure 7. A – C. Diurnal temperature variation: minimum and maximum daily water temperatures (C°) for Reach 2 (A), Reach 3 (B), and Reach 4 (C).

Figures 8, 9 and 10 present temperature trends across the entire flow experiment. Daily mean temperature trends during pre-trial, Trials 1 and 2 are presented in Figure 8 (A-C). Graphs (A-C) depict annual temperatures for Reaches 2 (A), 3 (B) and 4 (C). Figure 9 depicts the fall spawning period throughout the Flow Trial experiment. Water temperatures during the fall spawning season were generally warmer under Trial 1 relative to pre-Trial conditions (Figure 6; Sneep and Hall 2011). Using adaptive management, to partially mitigate and not further exacerbate these effects, the fall and winter flow magnitude was reduced for Trial 2 from 2 m^3s^{-1} to 1.5 m^3s^{-1}.

Temperature trends during the fall period across the Flow Trials are presented in Figure 9. Trial 2 had a lower fall flow release than Trial 1. In early October the release drops to a low of 1.5 m^3s^{-1}, compared to a low flow in Trial 1 of approximately 2 m^3s^{-1}. Consequently, an initial slight cooling effect of water temperatures appears to have been achieved modestly in Reaches 2, 3 and 4 (Figure 8) immediately after the rampdown event. In Reach 3, the temperatures in 2013 and the other Trial 2 years appear to be slightly lower than average temperatures in Trial 1 through the fall period. While changes were observed and temperature decreased, the effects on the overall thermal regime were minimal. Flows in Reach 4 and most of Reach 3 are still dominated by the hypolimnetic release, and temperatures were therefore still elevated above the pre-flow background. These results were expected by the technical committee. The 6 m^3s^{-1} hydrograph needed to strike a balance between meeting the annual water budget, without further exacerbating the temperature effect on chinook incubation timing and emergence, which had been observed under the 3 m^3s^{-1} hydrograph.

Figure 10 depicts winter and early spring temperatures. It appears that pre-Trial temperatures rose much earlier in the spring than water temperature in Trials 1 and 2. Slightly cooler spring and early summer temperatures are generally part of typical altered thermal regimes under large dams across North America and the world.

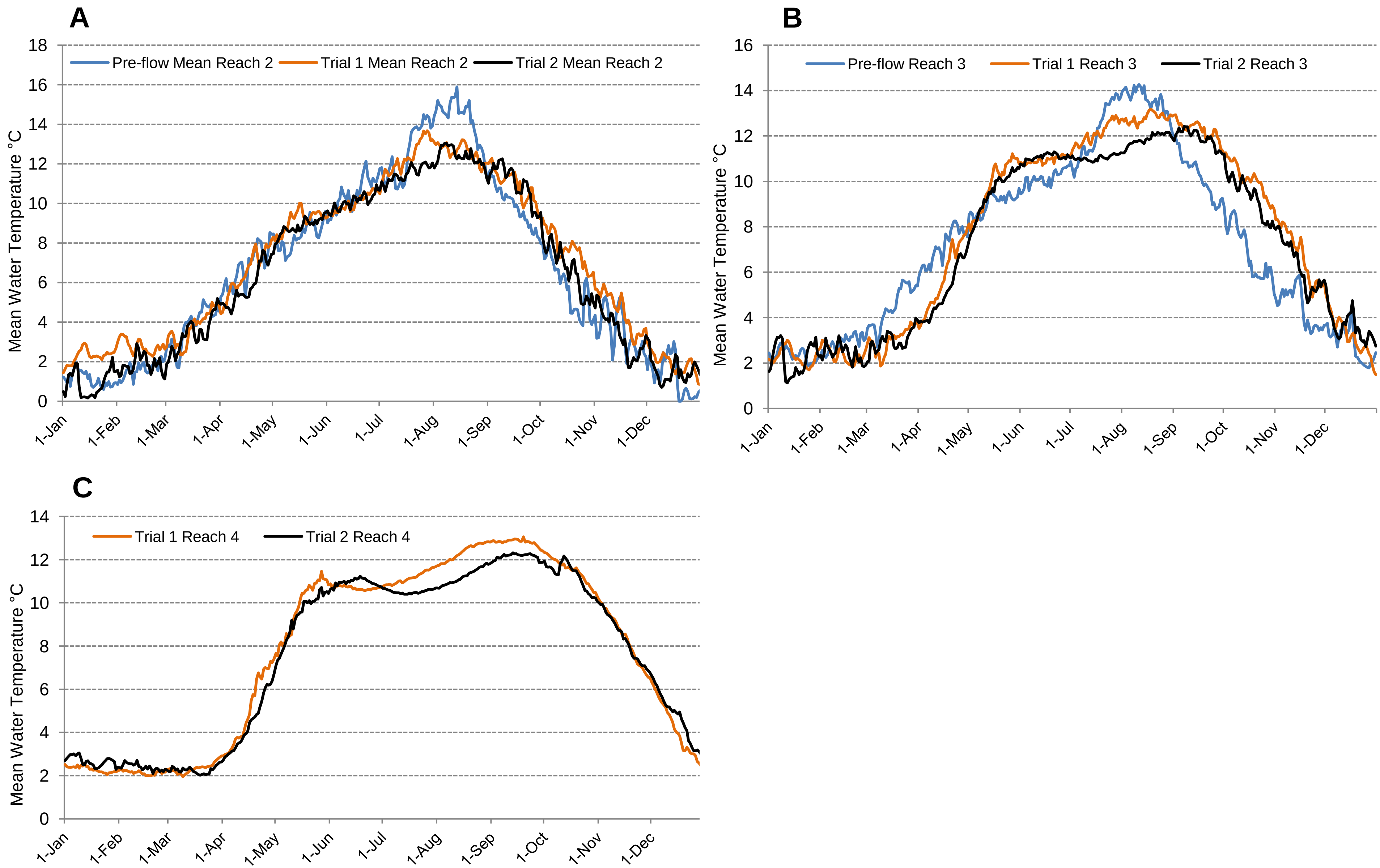


Figure 8. A – C. Reach 2 (A), Reach 3 (B), and Reach 4 (C) comparisons of annual daily mean temperatures of the Pre-flow, Trial 1, and Trial 2 flow treatments, 1 January – 31 December, 2013.

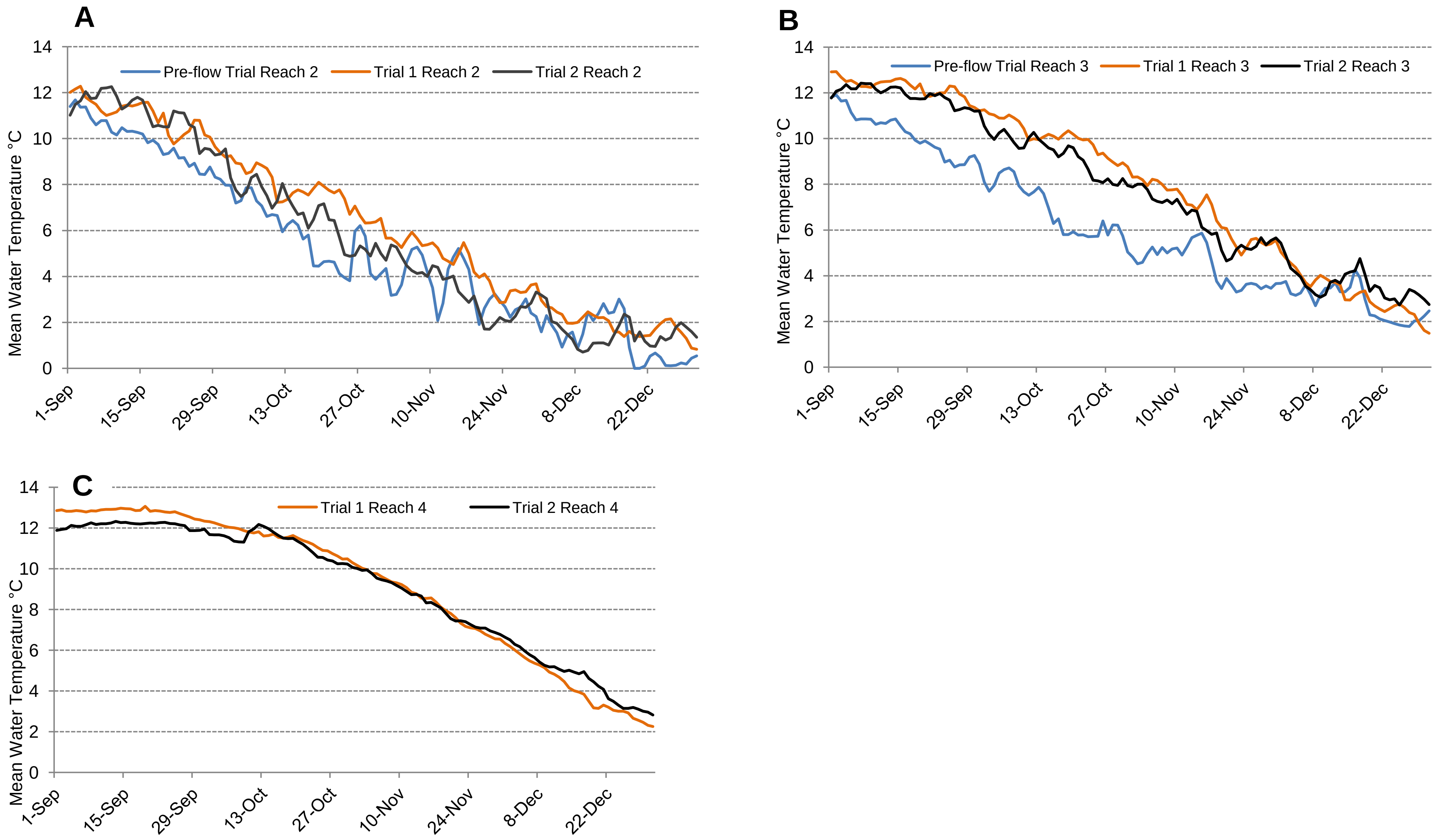


Figure 9. A – C. Reach 2 (A), Reach 3 (B), and Reach 4 (C) comparisons of daily mean temperatures of the Pre-flow, Trial 1, and Trial 2 flow treatments during the fall spawning period, 1 September – 31 December, 2013.

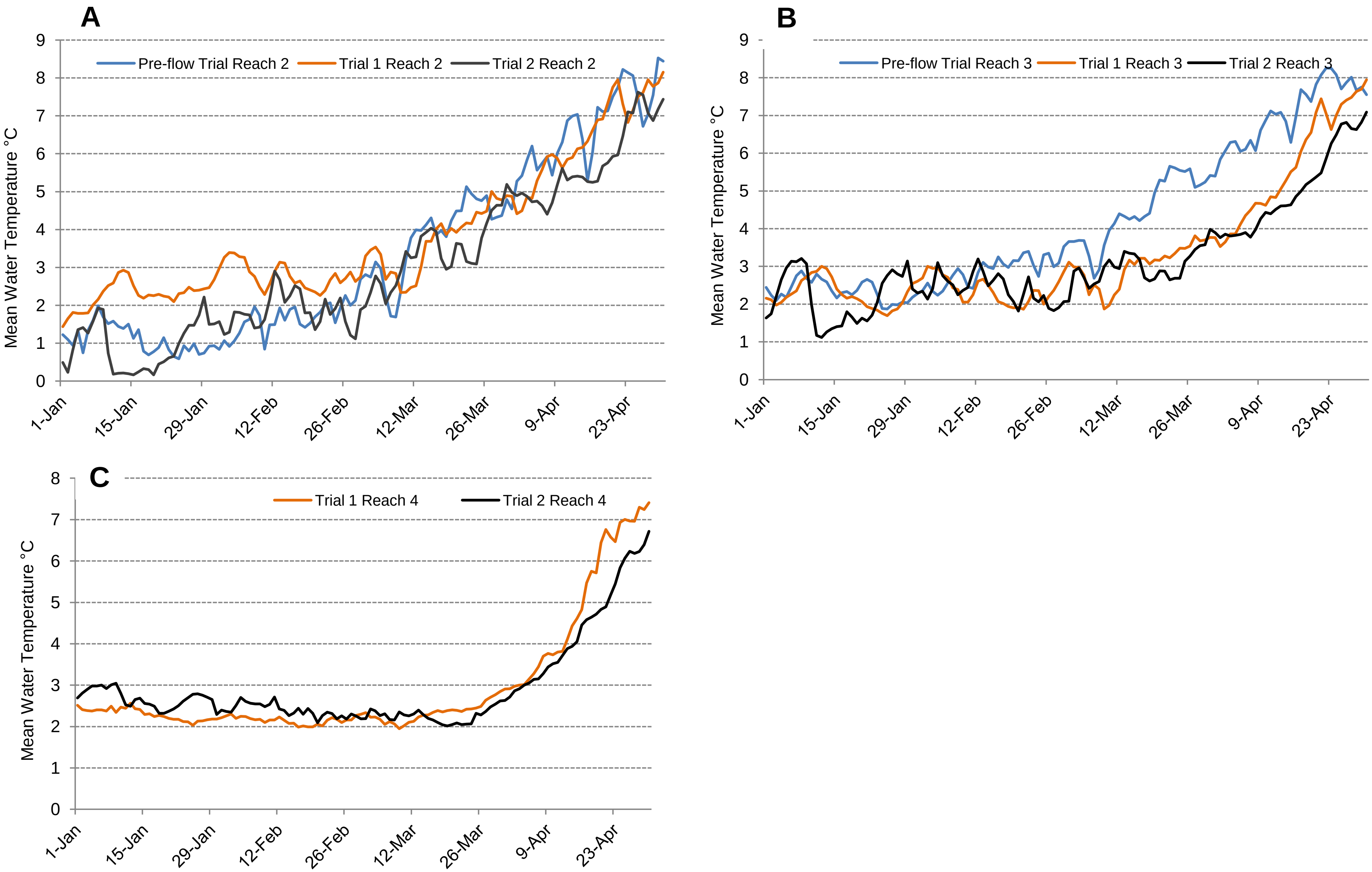


Figure 10. A – C. Reaches 2 (A), Reach 3 (B), and Reach 4 (C) comparisons of daily mean temperatures of the Pre-flow, Trial 1, and Trial 2 flow treatments during the winter period, 1 January to 30 April, 2013.

5.1.3 *Water Chemistry*

Water chemistry samples were collected from the LBR, Carpenter Reservoir, and tributaries within the study area during October and early December 2013. The water chemistry parameters observed in 2013, (i.e., alkalinity levels, concentrations of nitrates and nitrites, and pH) were similar to those reported in previous pink salmon spawning years. All levels of parameters measured were within the normal range for freshwater streams in British Columbia and the water quality guidelines. The Lower Bridge River is a moderately alkaline environment. The levels of pH in the main stem remained in the optimal category for most organisms and ranged from 7.41 to 8.15. Tributary levels ranged from 8.08 to 8.38. Alkalinity appears to have dropped from 2011 levels, but water remains very hard. Carpenter Reservoir measurements ranged from 7.41 to 7.72. Concentrations of nitrates and phosphates levels are within drinking water standards and have remained relatively stable since the flow trials began. As such, these differences cannot be easily distinguished from natural variations between years using descriptive graphical comparison.

5.1.4 *Habitat Attributes*

Habitat attributes for Reaches 3 and 4 were measured from October through early November of 2013 during the 1.5 m^3s^{-1} flow (Table 3). Various attributes were measured in the field; however, the data summary portrays the information related only to the area, i.e., length and width of aquatic riverine habitat attributes Figure 11, A – D presents total habitat area by habitat type (i.e., riffle, run, pool, side-channel, cascade, etc.) in Reach 3 (A) and Reach 4 (B); and relative proportions of habitat types in Reach 3 (C) and Reach 4 (D). Both total habitat area and proportion of habitat area by type show very similar patterns in area to that collected under the $3m^3s^{-1}$ flow (Table 3).

Table 3. Area (100 m^2) of habitat type by flow release levels through study years 1996 -2013.

Reach	Habitat Type	0 cms	0 cms	1.5 cms	3 cms	4 cms	5 cms	8 cms
4	Run	-	-	140	149	145	83	141
	Riffle	-	-	247	310	489	363	346
	Pool	-	-	190	223	120	222	260
	Cascade	-	-		-	-	55	61
	Rapid	-	-		-	-	-	-
	SC	-	-	41	37	37	55	72
Reach 4 Subtotal		-	-	618	718	792	778	880
3	Run	618	581	630	543	818	730	838
	Riffle	1,004	1,211	1,296	1,569	1,186	1,449	1,297
	Pool	52	54	176	183	71	174	124
	Cascade	89	93	-	23	30	436	474
	Rapid	-	-	-	-	-	6	8
	SC	-	-	39	2	2	45	48
Reach 3 Subtotal		1,763	1,939	2,141	2,319	2,107	2,839	2,789
2	Run	541	208	-	605	555	580	-
	Riffle	1,093	1,581	-	917	1,288	591	-
	Pool	18	18	-	12	6	15	-
	Cascade	87	105	-	254	76	482	-
	Rapid	-	-	-	-	-	419	-
	SC	71	71	-	87	87	124	-
Reach 2 Subtotal		1,809	1,983	-	1,876	2,013	2,211	-

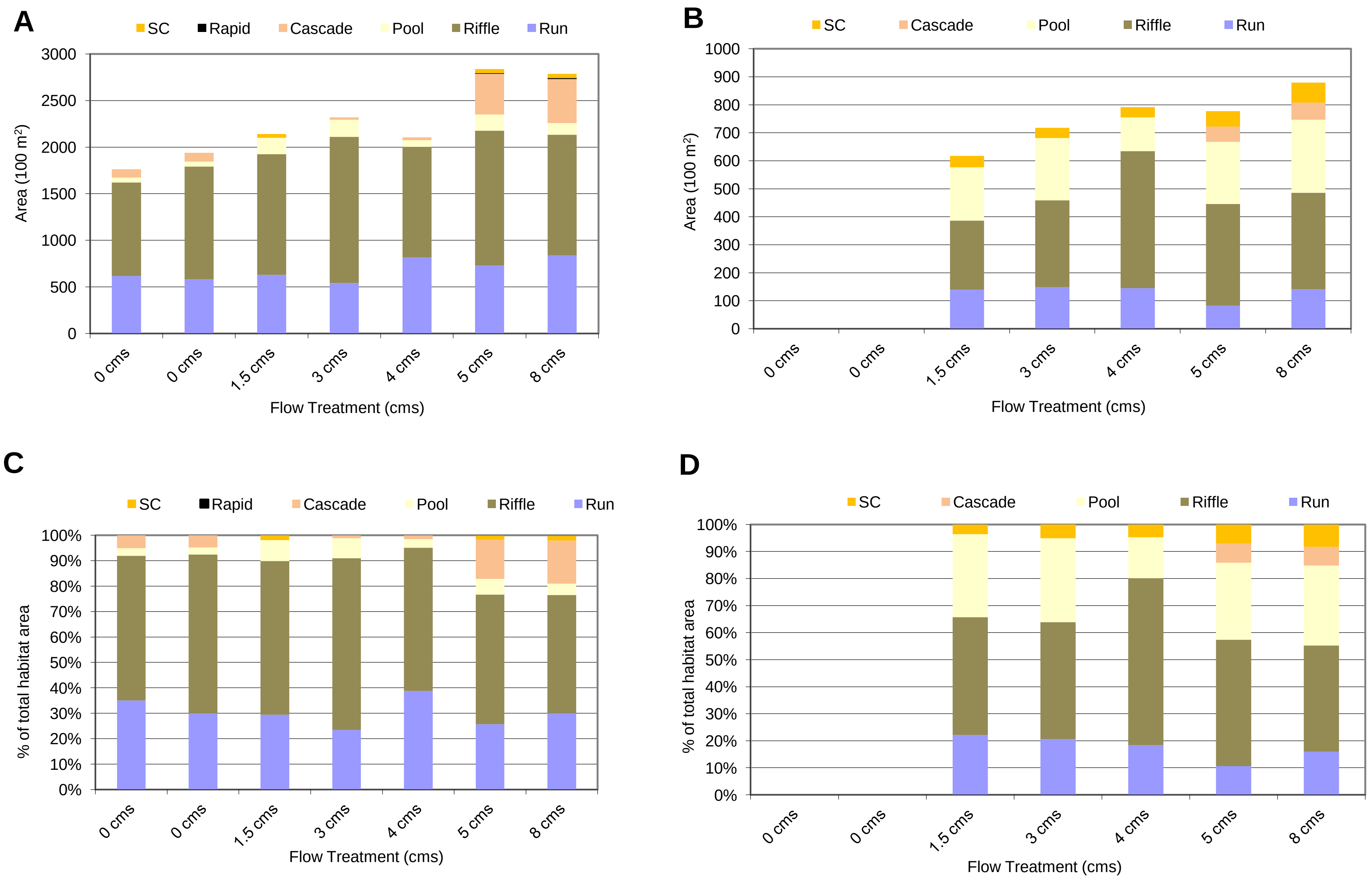


Figure 11. A – D. (A) Total habitat area by type in Reach 3, (B) Total fish habitat area by type in Reach 4, (C) Relative (%) area by type in Reach 3, (D) Relative (%) habitat by type in Reach 4.

5.2 Periphyton and Macroinvertebrates

5.2.1 *Periphyton*

Periphyton accrual rates (measured as cumulative concentration of Cholorphyll a) were lowest throughout the sampling period in Reach 4 (Figure 12). Reaches 2 and 3 showed relatively similar accrual over the sampling series. Mean cholorphyll a levels in Reach 3 peaked in week four (appx. October 17), followed by a slight decline, and then a relatively slow increase throughout the rest of the series. Reach 2 followed a comparable trend to Reach 3; however this mean reached its highest level during the last week of the field series. Reach 4 showed similar accrual patterns as the other reaches but with overall lower levels of accrual as compared to Reaches 2 and 3.

Mean periphyton biovolume (Figure 13) and total mean periphyton cell counts (Figure 14) were both higher in Reach 3 than in Reaches 2 and 4 throughout the sampling period. Reach 4 had a slightly higher mean biovolume count than Reach 2, while periphyton density was higher in Reach 2 than Reach 4. At the site level, index site 36.8 had the highest periphyton biovolume and density of any index site across most weeks. This site has an influx of groundwater, which may contribute to a unique microhabitat environment and could explain the increased biovolume and density observed.

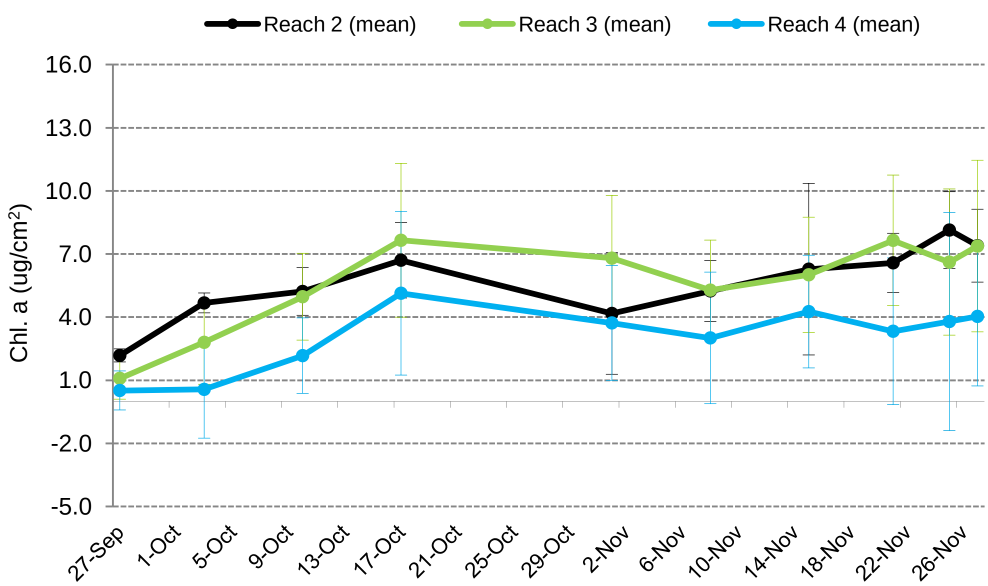


Figure 12. Mean periphyton accrual (measured as Chlorophyll a) on artificial substrates in the Lower Bridge River, during the fall series sampling in 2013. Each point represents an average accrual for all stations within a reach; bars represent +/- 1 standard dev.

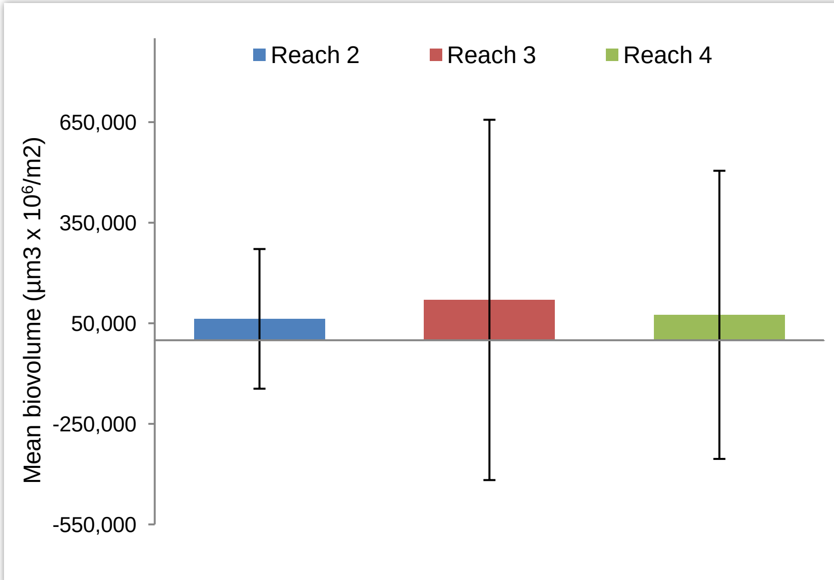


Figure 13. Mean and standard deviation for periphyton biovolume for Reaches 2, 3, and 4 in the Lower Bridge River.

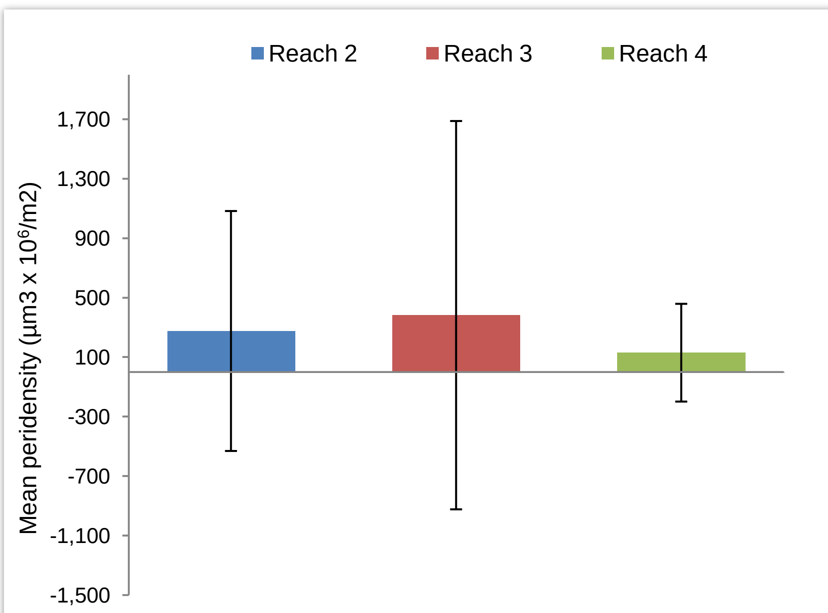


Figure 14. Mean and standard deviations for periphyton peridensity for Reaches 2, 3, and 4 in the Lower Bridge River.

5.2.2 *Macroinvertebrates*

Abundance and diversity were the primary metrics used to assess benthic invertebrate health. For 2013, as in years past, abundance of benthic invertebrates was variable and not significantly different among sites (ANOVA; p=0.15; Stamford and Vidmanic, 2014). Community groups followed similar patterns in 2013 as have been observed from 2008 – 2011 (exclusive of 2011, as these data were archived). They were distinct and consistent upstream and downstream of the Yalakom River confluence for years in Trials 1 (2008-2010), and 2 (2012, 2013). Biodiversity was higher downstream of the Yalakom River. Total taxa biodiversity among sites appear to have stronger correlation with longitudinal changes than total mean taxa abundance (Stamford and Vidmanic 2013; 2014; McHugh and Soverel 2013). For example, longer lived stonefly taxa (one to three year life cycles) only occur downstream of the Yalakom River confluence, while only short lived taxa occur in the upper reaches closer to the dam. Figure 15 describes the total mean abundance per taxa for the index sites. Figure 16 shows the total biodiversity of taxa in 2013. Both figures illustrate how taxa abundance and biodiversity followed an increasing trend from upstream to downstream. Stamford and Vidmanic (2014) found taxa biodiversity was significantly lower upstream in sites 36.5 and 39.9 (p<0.0001) for 2013; taxa assemblage diversity furthest downstream was higher during all study years; and diversity across index sites was highest in 2012 (Figure 17). These data suggest that flow release between Trials 1 and 2 has not overwhelmed the driving influence on invertebrate biodiversity in Reaches 2, 3 and 4 in the LBR (Stamford and Vidmanic 2014). In other words, invertebrates are not being primarily influenced by flow, or flow alone. Distribution and abundance of benthic invertebrates were analyzed by Stamford Environmental. This report is available upon request from St'at'imc Eco-Resources and BC Hydro (Stamford and Vidmanic draft report 2014).

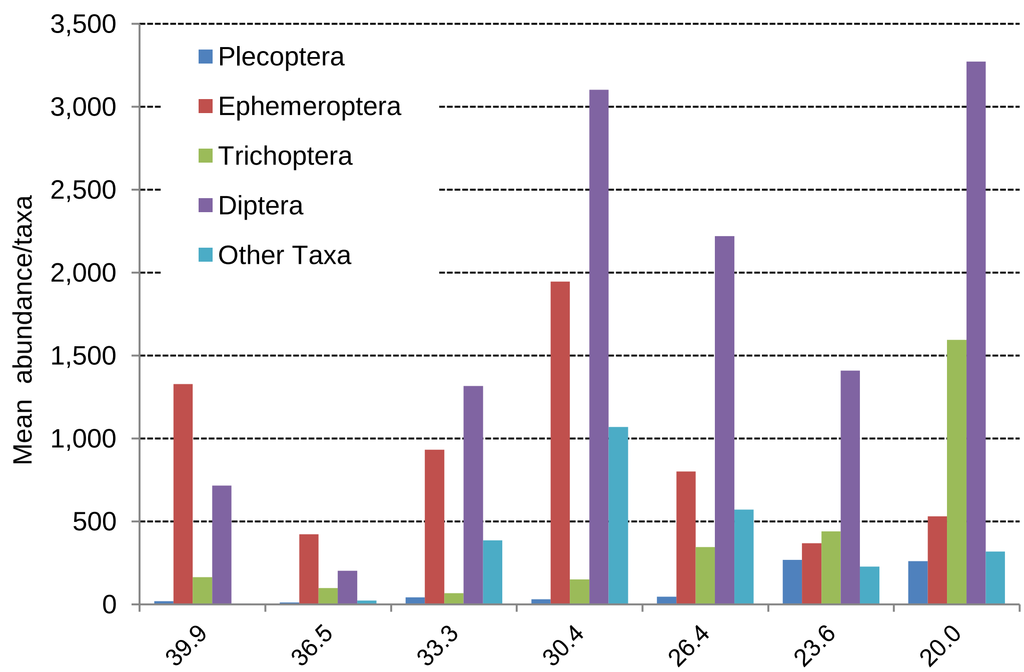


Figure 15. Macroinvertebrate mean abundance per taxa for 2013 at site index locations 39.9, 36.5, 33.3, 30.4, 26.4, 23.6, and 20.

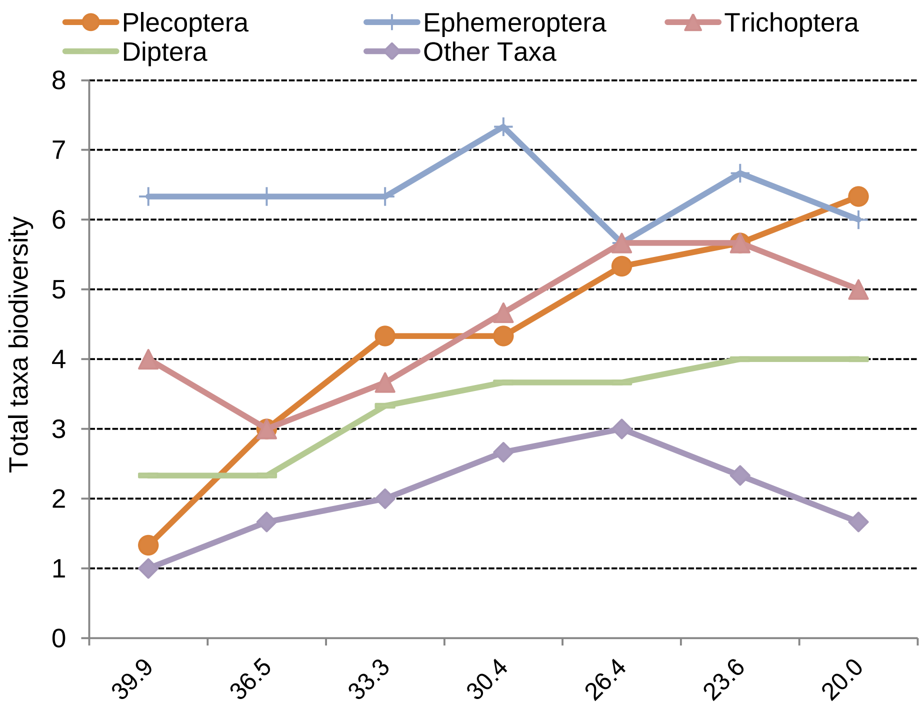


Figure 16. Mean taxa biodiversity for 2013 at site index locations 39.9, 36.5, 33.3, 30.4, 26.4, 23.6, and 20.

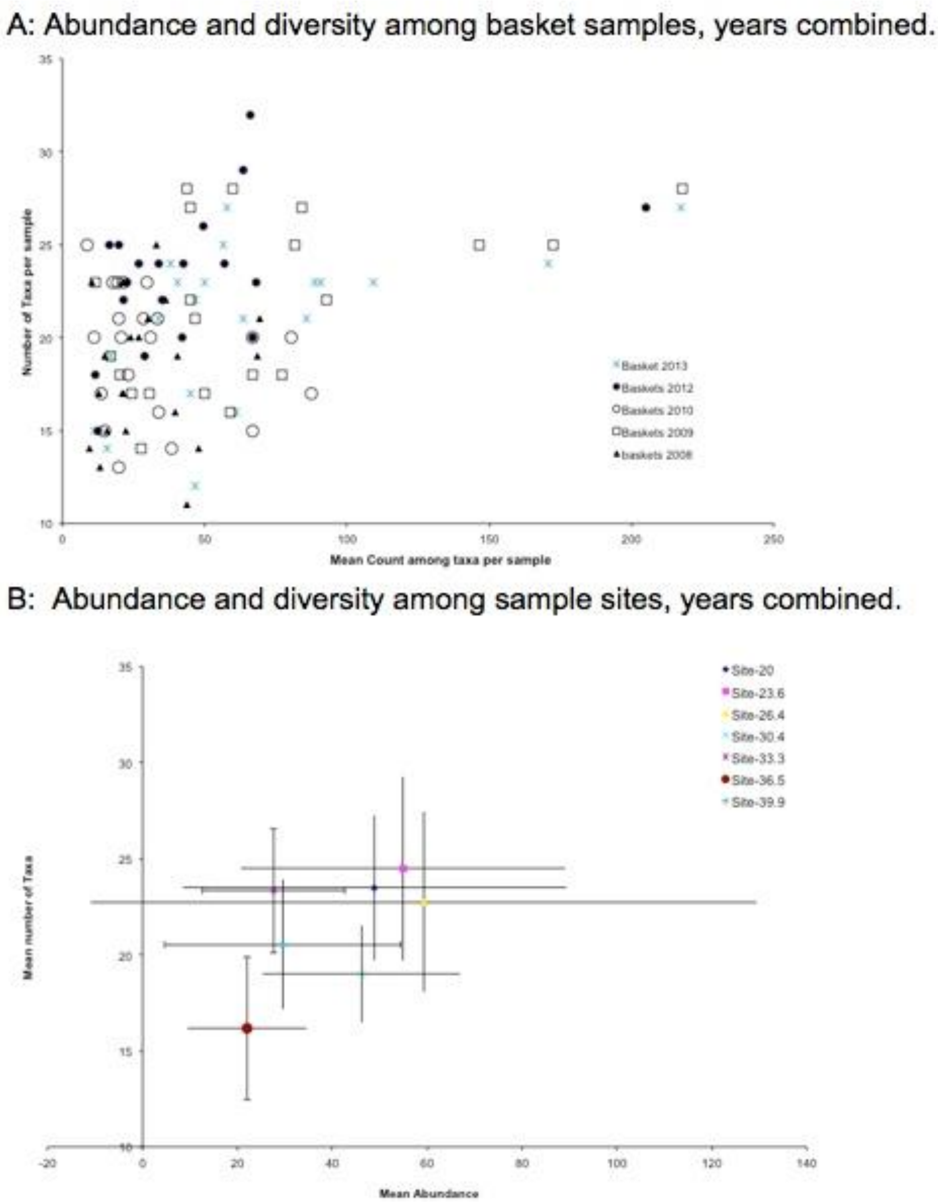


Figure 17. Associations between number of invertebrate taxa and mean abundance in fall basket samples during 2008, 2009, 2010, 2012, and 2013 (samples combined). A: among samples; B: among sample sites. Error bars in B are + or – one standard deviation (taken from Stamford and Vidmanic, 2014).

5.3 Fish Sampling

Fish sampling in the LBR aquatic monitoring program is conducted during a fall standing stock assessment as well as periodic juvenile growth sampling. A total of 4,158 fish were sampled during backpack electrofishing during the annual fall standing stock assessment (Reach 2, *n*=976; Reach 3, *n*=1752; Reach 4, *n*=1430), which was conducted between 4 to

26 September, 2013. 49[2] sites were sampled using a stratified sampling design including 17 in Reach 2, 20 in Reach 3, and 12 in Reach 4. During juvenile growth sessions, which occurred May, July, August, and November, a total of 2,181 fish were caught during the sessions (Reach 2, *n*=319; Reach 3, *n*=1498; Reach 4, *n*=364). Water temperatures less than 5° C throughout the study area during the scheduled winter fish growth and field ecology sampling session (i.e., December) prohibited fish sampling, and consequently winter juvenile growth data was not collected.

5.3.1 *Seasonal Fish Size Index*

During 2013, a total of 6,339 [a] fish were measured in the growth sessions (including the data collected during the fall stock assessment). Rainbow (inclusive of steelhead) made up most of the samples, *n*=4,681; Coho *n*=1,302; Chinook *n*=356. Table 4 presents the size ranges and age classes by month during juvenile growth sessions. Age classification is based on visual assessment of length-frequency histograms.

Table 4. Size ranges (in mm) for each age-class and for all Reaches of salmonids captured in the Lower Bridge River for growth information, May to November 2013.

Species & Age Class	May	July	August	September[a]	November
CH - 0+	31 - 51	45 - 70	52 - 96	59 - 112	74 - 107
CH - 1	73 - 87	-	-	-	-
CO - 0+	30 - 42	31 - 65	36 - 84	43 - 99	60 - 105
CO -1	55 - 91	73 - 86	110	100 - 111	-
RB - 0+	29 - 88	20 - 48	25 - 62	29 - 79	45 - 94
RB - 1	93 - 149	50 - 126	63 - 130	80 - 153	95 - 174
RB - 2	-	130 -155	135 - 180	155 - 185	175 - 264
RB - 3	223-225	220		-	310

[a] Growth data for September was derived from fish sampled during the annual stock assessment.

Mean weights, standard deviation and total count, per species and Age-class, by Reach, are presented in Table 5. Chinook capture peaked with a total of 142 during May sampling. No Age-1 chinook were caught during any of the growth sessions throughout the year, except the May session. A total of 33 chinook were caught at the end of the survey period in November. Chinook alevins were not observed during the November growth session. In addition, November samples included a total of 149 Age 0+ coho and 426 rainbows, with all reaches combined. Total numbers of coho were relatively steady throughout the growth sessions (May, *n*=136; November, *n*=149) but declined in Reach 3 (August, *n*=146; November, *n*=87). Numbers of rainbow trout steadily grew across the year as summer juveniles emerged and were sampled.

[2] One site was omitted from sampling in Reach 2.

Spring and summer sampling sessions (May to July) occurred during higher flows than during Trial 1. Sampling conditions during this time were difficult as turbidity and river stage were both very high (12 m^3s^{-1} to 15 m^3s^{-1}). Fish capture was a challenge, capture efficiencies were poorer than at low flow conditions, and sampling was generally limited to the river margins which likely biased the size range of available fish. These challenges decreased the total number of fish caught (i.e., sample size) for 2013. In many cases, the target number of fish per species and age-class (*n*=30) was not reached. Consequently, interpretation of seasonal fish size index data was inconclusive.

While data could not be sufficiently analyzed due to low sample sizes, effects on fish distribution and habitat availability were visually apparent at the 12 m^3s^{-1} to 15 m^3s^{-1} flows. As has been observed routinely at the higher flows (yrs. 2011 – 2012; Sneep and Hall 2012), age-1+ rainbow trout (RB) were generally not found in the same areas where they are typically captured or observed at lower flows.

Table 5. Collected fish growth data by Species & Age Class mean and standard deviation (SD), weight (g) and total count (n) by month and by Reach.

Species & Age Class	Sampling Month	Reach 2			Reach 3			Reach 4		
		Mean	n	SD	Mean	n	SD	Mean	n	SD
CH - 0+	May	0.7	52	0.4	0.6	81	0.2	0.5	2	0.1
CH - 0+	July	1.6	4	0.5	3.5	17	0.9	-	-	-
CH - 0+	August	5.3	8	1.62	5.5	63	2.0	-	-	-
CH - 0+	September[a]	7.2	37	2.5	8.6	42	2.9	7.6	10	2.0
CH - 0+	November	9.3	9	3.0	13.3	18	2.0	10.0	6	1.0
CH - 1	May	-[b]	-	-	6.0	5	0.8	4.6	2	0.5
CH - 1	July	-	-	-	-	-	-	-	-	-
CH - 1	August	-	-	-	-	-	-	-	-	-
CH - 1	September[a]	-	-	-	-	-	-	-	-	-
CH - 1	November	-	-	-	-	-	-	-	-	-
CO - 0+	May	0.3	2	0.1	0.4	101	0.2	0.3	33	0.1
CO - 0+	July	0.9	26	0.4	1.3	150	0.7	2.0	30	1.0
CO - 0+	August	3.7	4	1.98	3.1	146	1.5	4.2	30	1.2
CO - 0+	September[a]	5.1	100	1.9	4.2	345	1.8	5.6	159	2.5
CO - 0+	November	5.6	32	1.9	8.1	87	2.5	7.9	30	2.7
CO - 1	May	7.6	2	0.8	5.7	17	2.2	-	-	-
CO - 1	July	-	-	-	5.0	3	3.4	-	-	-
CO - 1	August	-	-	-	-	-	-	15.5	1	-
CO - 1	September[a]	-	-	-	13.2	3	1.8	14.1	1	-
CO - 1	November	-	-	-	-	-	-	-	-	-
RB - 0+	May	4.7	17	2.0	2.4	90	1.7	5.4	4	1.6
RB - 0+	July	0.3	26	0.2	0.3	152	0.2	0.3	27	0.2
RB - 0+	August	1.2	31	0.69	1.0	160	0.6	0.9	30	0.5
RB - 0+	September[a]	1.9	814	1.0	1.9	1244	1.3	2.2	1140	1.2
RB - 0+	November	3.9	82	2.6	4.8	154	2.3	4.8	81	2.4
RB - 1	May	-	-	-	20.5	17	9.8	15.7	2	0.9
RB - 1	July	11.7	8	9.6	10.1	59	5.5	7.1	7	5.6
RB - 1	August	12.5	3	5.60	14.1	106	5.6	19.3	3	3.7
RB - 1	September[a]	15.7	23	12.1	20.5	114	10.7	17.7	111	11.1
RB - 1	November	28.2	13	15.5	35.2	49	19.3	23.9	62	12.4
RB - 2	May	-	-	-	-	-	-	-	-	-
RB - 2	July	-	-	-	38.7	4	8.3	-	-	-
RB - 2	August	-	-	-	45.4	5	14.1	42.0	4	23.1
RB - 2	September[a]	50.9	2	2.6	71.5	4	27.6	50.0	9	6.4
RB - 2	November	-	-	-	78.5	13	13.7	107.5	7	27.4
RB-3	May	-	-	-	-	-	-	65.3	2	62.1
RB-3	July	-	-	-	103.4	1	-	-	-	-
RB-3	August	-	-	-	-	-	-	-	-	-
RB-3	September[a]	-	-	-	-	-	-	-	-	-
RB-3	November	-	-	-	-	-	-	-	1	-

[a] Growth data for September was derived from fish sampled during the annual stock assessment.
[b] Dash mark in cells indicate where no fish were observed.

5.3.2 *Standing Stock Assessment*

Estimated mean biomass of chinook, coho and rainbow by age-class within the sampled areas are presented in Table 6. Since the same sites are sampled each year, these values represent a reasonable index of biomass that can be compared between years. Standing stock assessment data were used to calculate estimated biomass by species and age class and per Reach; these data were averaged by Reach. The relative biomass contribution of each species and age-class per Reach and a comparison of total biomass values for all study years (1996- 2013) are presented in Figure 19 and Figure 20.

Table 6. Estimated mean biomass (g/100 m^2) of salmonids captured in the Lower Bridge River during the standing stock assessment, 4 to 26 September, 2013.

Species & Age Class	Reach 2[3]	Reach 3	Reach 4
CH-0+	17.6	20.8	6.6
CH-1	0.0	0.0	0.0
CO-0+	33.1	85.4	98.3
CO-1	0.0	2.7	2.3
RB-0+	97.0	156.6	258.6
RB-1	22.2	139.5	190.5
RB-2	5.4	17.6	42.3
RB-3	0.0	0.0	0.0
Total	**175**	**423**	**599**

Table 7. Estimated total mean biomass (g/100 m^2) of salmonids captured in the Lower Bridge River during the standing stock assessment through Flow Trial 2: 2011-2013.

Year	Reach 2	Reach 3	Reach 4	Total
2011	164	411	856	1,431
2012	139	402	807	1,348
2013	175[3]	423	599	1,197
Trial 2 Average	**159**	**412**	**754**	**1,325**

Total biomass estimates peaked for Trial 2 in 2011, and appeared to stay at similar levels in 2012 (Table 7). As such, comparisons below focus on comparing to either 2011 or 2012. In 2013, estimates of the total mean biomass within sample sites for all Reaches dropped to 1,197g/100m^2, down from 2012 levels of 1,348 g/100m^2 (Figure 18). In contrast to a drop in mean biomass estimates in Reach 4, mean biomass estimates in Reaches 2 and 3

[3] Values for Reach 2 in 2013 are based on 17 sites, as compared to 18 in previous years.

increased compared to both 2012 and 2011. In a Reach comparison, total estimated biomass was highest in Reach 4, and lowest in Reach 2. All of the target species (i.e., chinook, coho, and rainbow) were represented in each reach; however not all age-classes were represented per reach. As was observed in 2011, the highest estimates for age-0+ coho and age-0+ RB were in Reach 4. Age-1 chinook were not captured in any of the sampled reaches. No age-1+coho were caught in Reach 2 and very few were sampled in Reaches 3 and 4 (Table 6).Rainbow trout (inclusive of Steelhead) made up a total proportion of 78% of the total LBR biomass among all Reaches in 2013.

Biomass estimates for all ages of chinook and coho appeared to be lower than in 2011 and 2012, while rainbow biomass estimates appeared to rise in 2013. However, additional statistical analysis is required to test the significance, and this level of analysis is planned for the synthesis assessment, which is in progress. Total chinook biomass across all reaches for 2013 was 45 g/100m$^{2.}$ The same total was estimated for 2012. Biomass estimates for 2013 and 2012 juvenile chinook, across all reaches, were 59% lower than total biomass estimates were in 2011, the previous pink salmon year under Trial 2. (Figure 19 and Figure 20). The proportions of fish per reach appeared to be similar between 2012 and 2013. In 2013 the highest biomass estimate for chinook age-0+ occurred in Reach 3 at 20.8 g/100m^2. Chinook standing stock biomass estimates are summarized by Flow Trial and Reach in Figure 19. In 2013 coho biomass declined 55% from a 2011 peak, down 24% from 2012, totaling 217 g/100m^2. Rainbow estimates continued to rise, particularly in Reach 3. Rainbows, mainly age-0+ and age-1, made up 78% of the total biomass in Reaches 2, 3 and 4 for 2013. This is higher than 2011, where they comprised 60% of the total.

Reach 4 exhibited the entire observed decline in biomass for 2013. Total biomass dropped to a low of 599g/100m^2 (Table 6); down from 2012 levels of 807g/100m^2 (Table 7). In past years, biomass estimates during the flow Trials have indicated a stabilization for Reach 4 within the range of 700 – 800 g/100m^2, which is comparable to Reach 3 estimates prior to the Trial 1 flow release (Sneep and Hall 2012). Estimated total biomass in Reach 4, by Standing Stock Site Name, is presented in Table 8. Declines were spread across the reach[4]; total biomass at 9 out of 12 study sites displayed marked declines from 2012 levels (Figure 18). Rainbow trout juveniles, particularly ages-0+ and 1+, make up the majority of biomass in this reach. Coho estimates were similar to 2012 levels in Reach 4 but appeared to drop 66% since 2011. Chinook biomass estimates were similar to past years. Levels have been low, and remain low through Trial 2. The mean Trial 1 estimate for total biomass in Reach 4 was 755 g/100 m^2 (ranging between 666 and 826 g/100 m^2).

[4] To minimize sampling crew effect on biomass estimates, all 3 crews sampled sites in Reach 4 in 2013, as in years past.

Table 8. Estimated total biomass (g/100 m^2) for each site within Reach 4 for all species and age classes for years 2012 and 2013.

Site Name	2012	2013
40500	1,174	608
40200	209	154
40100	251	114
39401	623	365
39400	970	735
39201	1,296	954
39200	151	327
37300	598	587
37200	352	603
37150	1,426	761
37001	895	408
37000	1,743	1,565

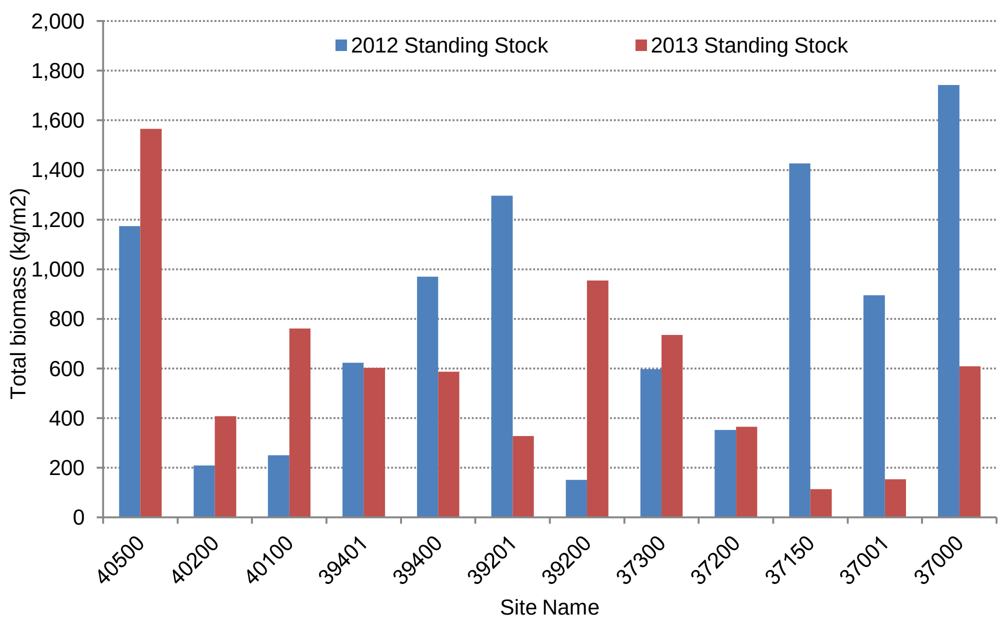


Figure 18. Estimated total biomass (g/100 m^2) for each site within Reach 4 for all species and age classes for years 2012 and 2013.[5]

Reach 3 biomass estimates during 2013 totaled 423g/100 m^2. This is lower than pre-flow release estimates, which ranged from ca. 600 to 1,200 g/100m^2 from 1996 to 1999 (mean ≈ 840 g/100m^2). However, this value is similar to the estimates for Trial 1 which varied

[5] Sites are located along a linear gradient and named according to River Km starting from upstream at site 40500 and working downstream to site 3700.

between ca. 330 and 588 g/100m^2 (mean ≈ 461g/100m^2) and reflected a mean drop of ca. 379 g/100m^2 between pre-flow and flow Trial 1 (Sneep and Hall, 2012). Under Trial 2, Reach 3 estimates for 2012 follow a similar trend as 2011, which was reported as 411 g/100m^2 (Sneep and Hall, 2012).

Total Reach 2 estimates have remained stable throughout the entire study period, relative to the changes observed in the upper reaches. The total biomass estimate for 2013 was slightly higher than other years under Trial 2, at 175g/100 m^2, which appeared to increase from 2012 levels of 139g/100 m^2 and 2011 levels of 164 g/100 m^2. Coho and rainbow trout fry (age-0+) stayed relatively the same as 2011, however chinook fry biomass estimates have dropped by 66% and 61%, as compared to 2011 and 2012 respectively, to a low of 17.6 g/100m^2.

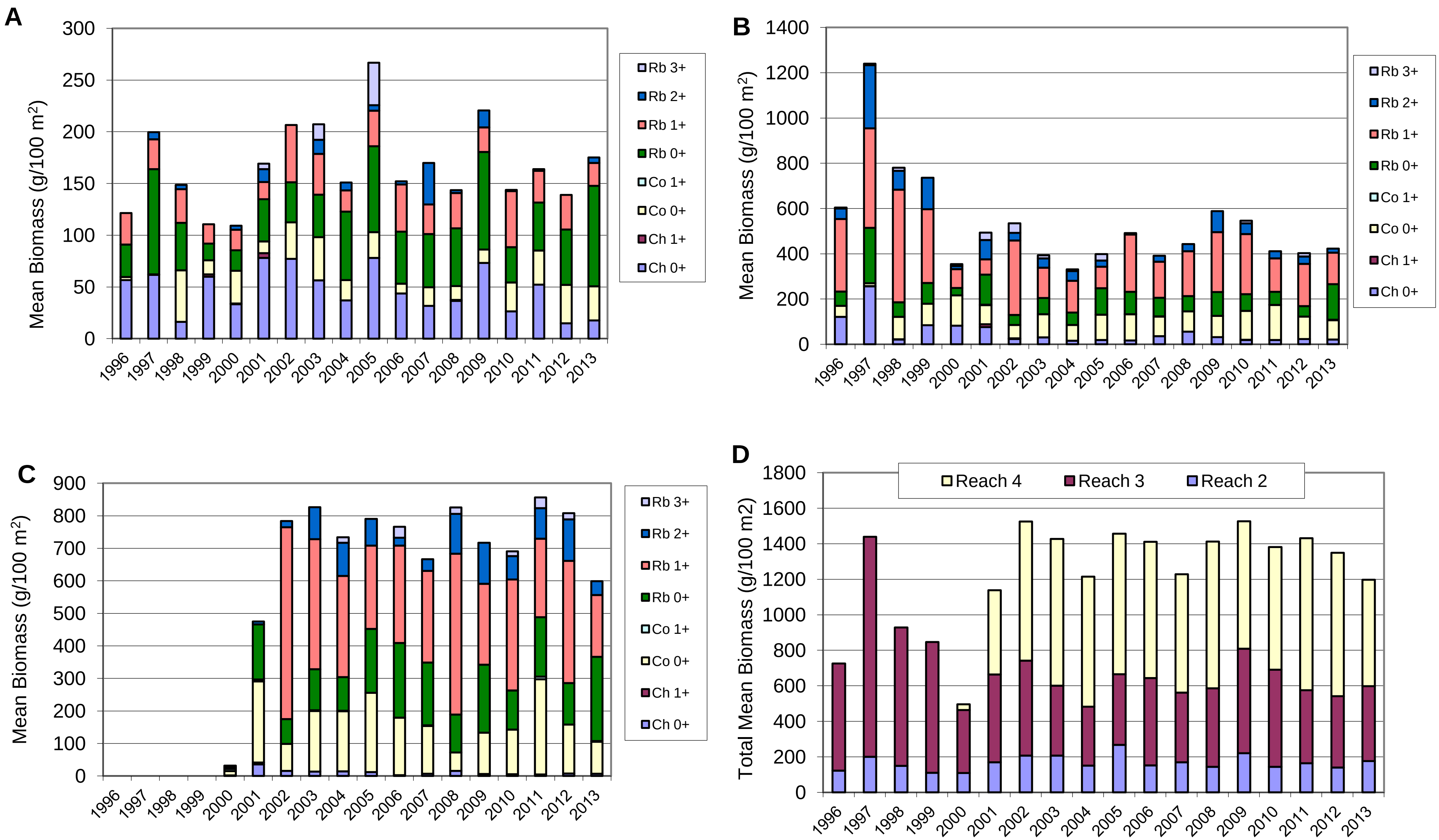


Figure 19. A – D. (A): Total mean biomass by species and age-class for Reach 2, (B): Total mean biomass by species and age-class for Reach 3, (C): Total mean biomass by species and age-class for Reach 4, (D): Total mean biomass by species and age-class for all reaches.

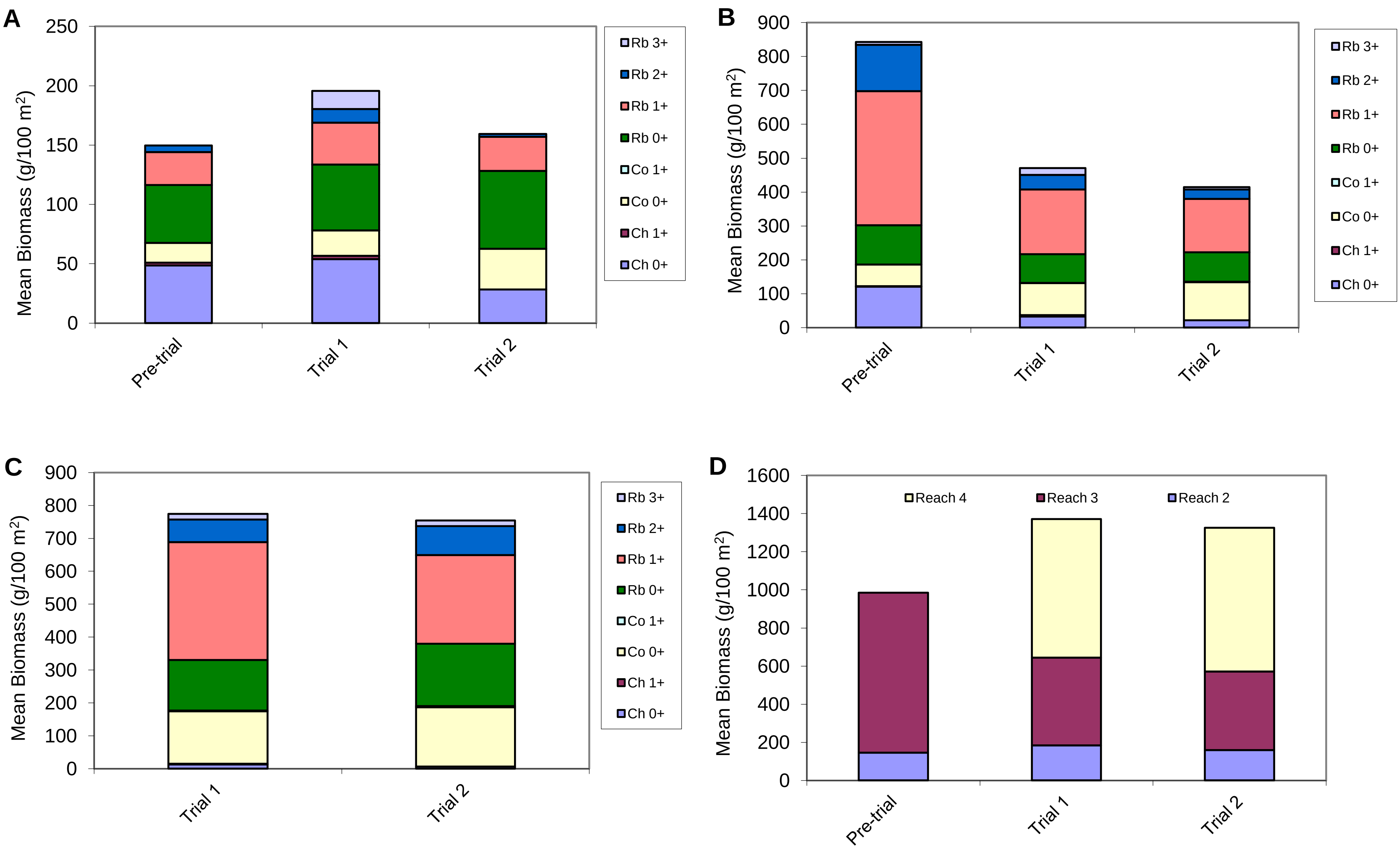


Figure 20. A – D. (A): Total mean biomass by species and age-class for Reach 2, (B): Total mean biomass by species and age-class for Reach 3, (C): Total mean biomass by species and age-class for Reach 4, (D): Total mean biomass by species and age-class for all reaches.

5.3.3 *Chinook Life History*

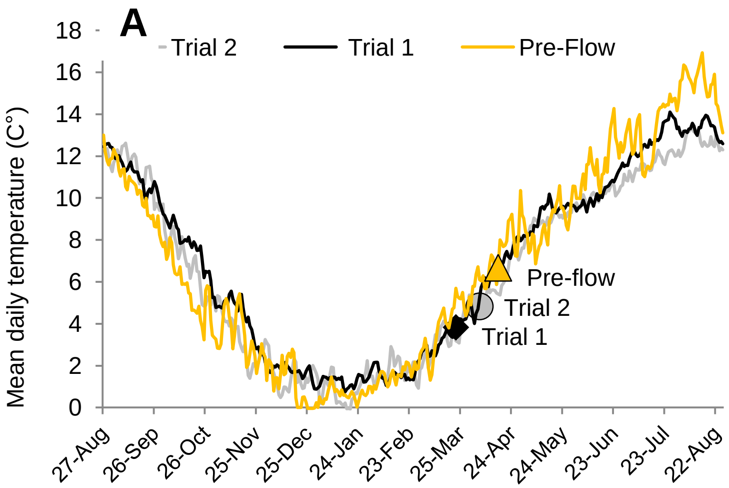
Chinook fry abundance, which dropped at the start of the Flow Trials relative to the pre-flow estimates, appears to have further declined. The causes of this apparent decline within the LBR study area are currently not well understood, but relevant literature indicates that temperature and dissolved oxygen are correlated with survival, development and growth in chinook salmon (Geist et al 2006). Development in freshwater fish, invertebrates and other cold-blooded organisms responds to temperature conditions (i.e., ATUs: accumulated thermal units above a threshold). Both chronic and acute temperature thresholds have been documented for survival of some fish species, (Olden and Naiman 2010). Research shows that survivorship from egg to emergence generally occurs when the water temperature ranges below 16.5 C (Geist et al 2006) during the first 40 days of post-fertilization egg development. Fall temperatures in Reaches 3 and 4 that are warmer than the pre-flow conditions, may be contributing to early emergence in the LBR. Emergence timing is important and must be timed with adequate food supply and appropriate habitat. An early emergence of chinook alevins, relative to the pre-release incubation period, was observed in several years since 2002 under the Trial 1 flows (Sneep and Hall 2011). Given this information, there is still uncertainty if and how the altered temperature regime is contributing to this observed decline in fry. As part of the adaptive management program, a reduction in fall flow magnitude, as per the modified flow reduction schedule, was implemented during Trial 2. Reducing flows to a low of 1.5 m^3s^{-1} (from 2.0 m^3s^{-1}) was intended to partially mitigate this warming effect and avoid exacerbating the influence of Carpenter Reservoir flow on the incubation of eggs in the fall. Reducing the volume of flow at this time of the year should amplify the cooling effect of the air temperature on river water, and reduce the acceleration of egg development. It is not clear what affect this modification in the flow schedule, and subsequent modest temperature reduction has had on chinook alevin emergence and fry recruitment. Emergence dates based on estimated spawning date and temperatures at three index sites over the flow trail are presented in Figure 21 and discussed below.

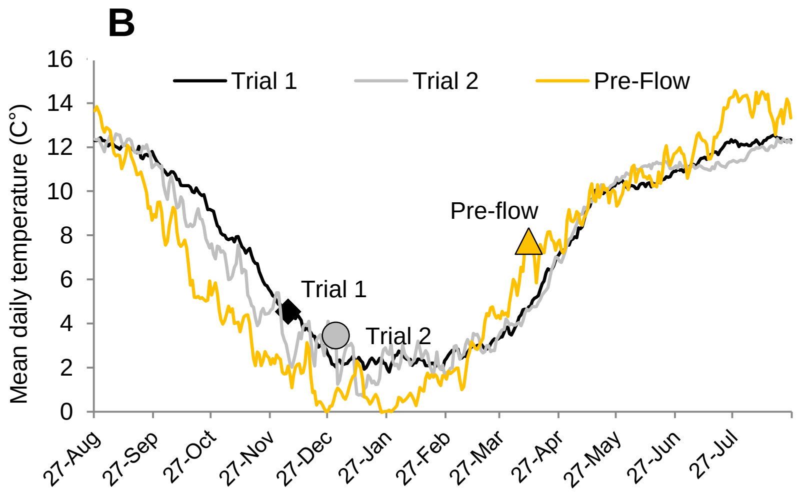
Early emergence was not observed in the 2013 November sample session or the December field visits so earlier emergence timing could not be confirmed. Despite a lack of samples, it is possible that emergence timing was still several months early given mean daily water temperature readings in Reaches 3 and 4 during the fall incubation season were generally warmer than pre-flow conditions. Trial. Predicted emergence dates, (calculated based on an estimated Chinook spawning date of August 27 and 962 thermal units[6]), correlated ATUs[7] overlaid on mean daily temperature by Reach, over the course of the Flow Trial experiment are displayed in Figure 21. Graphs (A), (B) and (C): show predicted emergence dates for chinook salmon alevins for Reaches 2, 3 and 4, respectively. Graph (D) summarizes dates for all three graphs. Observed temperatures for Reaches 2, 3 and 4 are below the 15.5-16C temperature threshold for the fall salmon spawning period, so survival from egg to emergence may not be inhibited by incubation temperature alone. However, if alevins emerge in winter, conditions are harsh, food availability is low, and appropriate habitat may not be available, which likely results in high mortality or low over-winter survival and growth rates. Predicted estimated emergence dates were 10 days earlier in Reach 2 than Pre-Flow dates (A); Reach 3 estimates were more than 90 days earlier (B); while

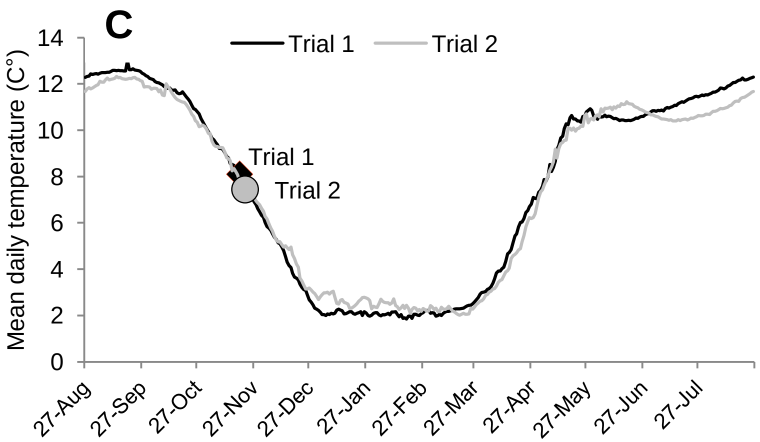
[6] Taken from historical LBR calculation dates

[7] ATUs represent the accumulated thermal units that accumulate daily as the embryos develop, with each 1°C representing one thermal unit

Reach 4 alevins are predicted to emerge in late-November (Figure 21). Data suggest a modest improvement under the Trial 2 hydrograph, relative to Trial 1, as was expected under the modified flow.







D

Flow Regime	Site 20.0	Site 30.4	Site 39.9
Pre-flow	*16-Apr*	*11-Apr*	*N/A*
Trial 1	*22-Mar*	*06-Dec*	*19-Nov*
Trial 2	*06-Apr*	*31-Dec*	*22-Nov*

Figure 21. A – D. (A): Predicted emergence dates overlaid on mean daily temperature for Chinook salmon alevins for Reach 2, (B): for Reach 3, (C): for Reach 4, and (D): Predicted emergence dates for all three graphs summarized.

It is still uncertain how temperature and other factors are influencing early life history, migration and dispersal in the LBR. Juvenile salmonids have been shown to have diverse life-histories, and change their behavior in response to environmental conditions (Walsworth et al 2014). Juvenile chinook in the LBR have displayed varying behavior and physiology at the individual and site-based levels (Bradford and Higgins 2001). A knowledge gap exists in early life history information of how juveniles have responded to the increased flow. We have observed that abundance has generally declined annually sometime after the initiation of the flow release and higher spring flows. Questions linger as to how flow affects physiology and migration behavior for LBR chinook. Conner et al (2003) found differing survival rates of migrating juvenile chinook depending on when they undertook migration. Subyearling fall chinook that migrated downstream in May had survival rates of 65 – 90%, versus lower rates of 5 – 20% for those that waited to migrate until later in the summer when water temperatures were warmer. Juvenile chinook in the LBR could be changing their migration and rearing behavior based on potential early emergence, higher flow, and other environmental cues associated with the flow release. Collecting data to specifically address this issue and provide more insight into the early life history and dispersal of chinook has become important for understanding the impacts of the flow release on this important Bridge River species. Consequently, a pilot study was implemented in an attempt to gain information about early dispersal and behavior patterns using otolith microchemistry techniques.

The otolith pilot study was implemented during Year 2, and attempted to examine the early life history and dispersal of chinook salmon by analyzing a set of juvenile chinook otoliths for microchemistry parameters. Although this approach has been used to identify the rearing locations and movements of juvenile chinook salmon in nearby watersheds (Shrimpton et al. 2009), it did not work at the site-specific level within the LBR and a model to discriminate the reach-based rearing habitats selected during the juvenile phase could not be developed (Clark et. Al. 2014) to meet the requirements of this program. Clark et al (2014) stipulated that the limited variability in water chemistries across sites with the LBR inhibit discrimination techniques from being employed within water and otolith chemistries; i.e., there was not enough chemical variation observed to separate groups of chinook salmon to site level, nor to develop a model that could be used to predict riverine habitat use. A copy of this report can be obtained from St'at'imc Eco-Resources or BC Hydro. Consequently, alternative methods will be investigated during 2014 that will aim to provide insight into life history and movement of juvenile chinook in the LBR above the Yalakom confluence. Methods that will be investigated include an in-stream egg development experiment, as well as using an inclined plane trap to intercept juvenile chinook during outmigration to document the migration size, timing and duration for this population.

6.0 RESULTS AND DISCUSSION

6.1.1 *Answering the Management Questions and Current Challenges*

This report summarized data collected in implementation Year 2 (i.e., 2013) for BRGMON-1 in the Bridge-Seton WUP. It presents data from 2013, and provides context descriptively while it compares and contrasts with other years in Trial 2 (2011, 2012). In an attempt to present a preliminary analysis and set the stage for an additional synthesis assessment, some descriptive comparisons for certain parameters (e.g., temperature, biomass and habitat) go one step beyond 2013 data summation and are presented across the flow trials. However, this report is not intended to provide a synthesis assessment across the flow trials, and does not attempt to differentiate statistical differences between temperature, biomass and growth rates across the Flow Trials.

The key relevant management questions, listed below, drive the program and are intended to directly describe and reduce uncertainties about the effects of flow on the Lower Bridge River aquatic ecosystem:

1) How does the in-stream flow regime alter the physical conditions in aquatic and riparian habitats of the Lower Bridge River ecosystem?

2) How do differences in physical conditions in aquatic habitat resulting from the in-stream flow regime influence community composition and productivity of primary and secondary producers in the Lower Bridge River?

3) How do changes in physical conditions and trophic productivity resulting from flow changes together influence the recruitment of fish populations in the Lower Bridge River?

4) What is the appropriate 'shape' of the descending limb of the 6 m^3s^{-1} hydrograph, particularly from 15 m^3s^{-1} to 3 m^3s^{-1}?

Questions 1-3 are addressed below, and question 4 is addressed in Section 6.0 Flow Rampdown Survey Result. As part of a structured decision-making process (Failing et al 2004; Failing et al 2012) key benefits from the aquatic ecosystem were identified, and parameters were chosen and monitored during 2013 as they have been historically over the course of the flow trial experiment. The focus of the LBR WUP include the physical conditions in the aquatic and riparian habitats, biomass and growth of juvenile salmonids, and periphyton and benthic invertebrate abundance and diversity as a proxy for river health. Due to the nature of an adaptive management program such as the LBR and the importance of integrating new knowledge and information into assessments as time progresses, it is important to annually evaluate if the program is on track to answering these questions and address any challenges. Towards this effort, the discussion below attempts to summarize how the flow regime influenced the physical conditions and habitat, the primary and secondary benthic invertebrate response, and ultimately how these factors influenced the recruitment of juvenile fish populations in the LBR.

6.1.2 *Thermal Regime Characterization*

Terzaghi dam has significantly altered the thermal regime in the Lower Bridge River. Among other things e.g. sedimentation and water quality, the integrity of the entire system depends on the natural dynamics of the thermal regime (Olden and Naiman 2010). It is well documented that temperature influences both growth and reproduction of the organisms contained within aquatic communities. Thermal regimes have distinct ecological relevance. They differ in their variability, predictability of annual temperatures and monthly temperatures, and thermal events (i.e., the magnitude, frequency, duration time and rate of change in event). Fish and invertebrates depend on certain temperatures as environmental cues, to complete their life cycle. Fish assemblages are therefore influenced by individual and interactive effects of flow and thermal modification (Olden and Naiman 20010). In addition to physiological responses, behavioral responses have also been observed in other river systems. At elevated temperatures, Kuehne et al (2012) found multiple and cumulative stressors changed juvenile behavior and these responses ultimately influenced development, reproduction, development, and affected growth of organisms within the aquatic community. Modified thermal regimes with elevated temperatures and extreme muted variation as shown in Figure 7 (C) in Reach 4 demonstrate where some of these effects might have occurred in the LBR. In an effort to reduce uncertainty about the effects of the altered thermal regime on aquatic and salmonid productivity, some of these data are compiled and assessed.

Changes in the thermal regime in the LBR were evident in the 2013 data and in the other Trial 1 and Trial 2 years. High and low temperature events for 2013 were basically eliminated in Reach 4 (Figure 7), and therefore showed overall muted diurnal variation throughout the year. Compared to pre-flow conditions, temperatures were also warmer in Reach 3 across the critical fall spawning and early egg incubation period. Both the mean and the minimum temperatures were several degrees warmer in the upper reaches during fall. Temperatures were, in general, cooler in the spring and summer. These changes have been observed following initiation of the flow release under the 3 m^3s^{-1} and now 6 m^3s^{-1} water budget. Despite having a comprehensive juvenile fisheries and aquatic ecosystem dataset for the LBR, we still do not fully understand the mechanism behind the observed decline in juvenile chinook abundance given that this result was not predicted when the study was originally designed. Alevins could be emerging early; they could be changing their life history behavior and migrating earlier in response to higher flows, colder temperatures or poor environmental conditions; or perhaps the habitat created in Reach 4 is inferior to that of Reaches 2 and 3 for this species, and unsuitable for necessary life stages. Interacting and cumulative factors are potentially involved, which may not be fully described by the adopted study design.

Habitat surveys were completed during the low fall flows, i.e., ~1.5 m^3s^{-1} . Data summaries indicate that in general, habitat classifications remained similar to proportions of habitat types during a 3 m^3s^{-1} flow so proportions of habitat area, broadly classified, have not changed the conclusions or reduced the uncertainty in the response of the aquatic environment. In general data are highly variable and confounding, and analyses presented here are based on descriptive data and relative comparisons. Regardless, data from 2013 point to the corroboration of the "thermal inversion" hypothesis, which predicted that growing season temperatures would be reduced by on average 2°C and fall/early winter temperatures, would increase by 2°C. The thermal inversion modeling helped formulate part of the "Low Good" hypothesis in the SDM process, which predicted that reservoir releases would negatively affect habitat quality in the LBR (Failing et al 2004; 2012).

We recognize that the Yalakom River has strong tributary influence on the LBR. Data suggest that the LBR aquatic riverine ecosystem responds positively to Yalakom River tributary inflow. The other tributaries in Reach 3 moderate the effects of flow release as well, but do so to a more moderate extent due to less flow. The unregulated, instream Yalakom River flow helps buffer the impacts of the hypolimnetic flow release on the aquatic ecosystem. In particular, the natural thermal regime of the Yalaklom aids in thermal recovery and/or mitigation of impacts, particularly in Reach 2. Benthic invertebrates and biomass assessments both reflect this observation and potentially corroborates the use of Reach 2 as a "control" reach in the flow trial experiment.

6.1.3 *Periphyton, Benthic Invertebrate and Fish Response*

Benthic invertebrates form a main food source for LBR rearing fish. Healthy invertebrate communities and their contributions to stream integrity are integral to salmonid life history and influence growth rates, survival and recruitment of juvenile fish. River health as reported by benthic invertebrate abundance and diversity does not appear to be influenced by a change in the flow regime. Invertebrate data was confounded by variability; predicted gains in invertebrate community diversity and abundance from moving to a higher annual flow are not significant. However it was clear that the Yalakom River had a strong influence on the aquatic productivity. Benthic invertebrate biodiversity was greatest downstream of the Yalakom River confluence, as has been observed across other years in both Trials 1 and 2.

2013 data suggest that Reach 4 was characterized by slower overall chlorophyll a accumulation, slower productivity and lower invertebrate diversity and community structure. These data follow similar trends, i.e., observed time lags and overall lower productivity, to what was documented when Reach 4 habitat was first colonized after initiation of the flow release (Decker et al 2008). Further, analyses and historical data suggest that the upstream habitat created in Reach 4 has likely not been fully restored or reached its full potential.

Biomass and growth rates are a key benefit as defined under the WUP. Data suggest that overall total juvenile salmon biomass declined in 2013 . Observational data suggest an overall decline in Trial 2; most of this decline has occurred in Reach 4. In addition, both chinook and coho estimates have declined markedly. As predicted under the Structured Decision-making and adaptive management research by Failing et al (2004; 2012), biomass peaked during the 3cms and has begun to decline in the following years under Flow Trial 2. While Reaches 3 and 4 have varied over the years and changed between flow trials, Reach 2 has had relatively stable estimates across the flow Trials for total biomass. Biomass results for Reach 2 may reflect the moderating influence of the Yalakom River on the effects of the flow release in that reach. Growth rates in 2013 are variable, and no obvious trends were apparent. More data, particularly one more non-pink year (i.e., 2014) would give us a total of two pink and two non-pink (spawning) data years for Trial 2. These data would better inform current conclusions and further reduce uncertainties associated with the effects of the instream flow release on the aquatic ecosystem.

6.1.4 *Data Limitations*

There are many limitations inherent in the monitoring program and data collection efficacy and efficiencies that affect the data quality and interpretation. Catch efficiencies have gone down with the initiation of the high flow. This is partially due to a full transition of field crew in 2012, as well as high river stage, velocity and turbidity. These expected measurement errors were acknowledged during the structured decision-making process, where experts examine and predicted the potential of high measurement error under the higher hydrograph in Trial 2, (Failing et al 2012). Despite catch inefficiencies, estimated total biomass for Reaches 2, 3 and 4 combined were within expected levels for Trial 2, as predicted by the SDM process (Failing et al 2004; 2012).

Previous research and monitoring to determine the colonization time lag in the newly rewetted reach of the LBR in 2000 showed an immediate delayed utilization of habitat in the newly wetted Reach 4 (Decker et al 2008). They also suggested that colonization of the habitat with juveniles was largely driven by reproduction, rather than upstream migration. If this pattern is still apparent in the LBR, then spawning success would be a direct factor influencing the recruitment of juvenile salmon, particularly juvenile chinook, in Reach 4 of the LBR. At present, only 1 fall season of salmon enumeration has occurred under the fish counter for BRGMON-3, the adult WUP program. Consequently, it is difficult to assess how adult enumeration was correlated with juvenile growth data for 2013 and ultimately influenced recruitment. More data (additional years) need to be collected in BRGMON-3 to correlate escapement numbers with current and historical data, which may then be assessed alongside juvenile data to inform recruitment inferences.

6.1.5 *Future Research and Monitoring*

Large uncertainties still confound questions regarding the long-term ecological benefits and costs from the release of instream flow from Carpenter Reservoir. Ecosystems are complex, and have multiple interactive and cumulative factors and linkages. Management success is predicated on being able to accurately predict the response of the aquatic ecosystem to flow changes. While this data report reduced uncertainty regarding the predicted and observed benefits of the flow release, there remain challenges to precisely and accurately predict how instream flow changes influence the productivity of the LBR. We recommend that multivariate testing approaches be adopted to integrate the analysis of biotic and abiotic components of the program. Further thermal regime characterization and subsequent restoration is required. Managers should consider developing goals within components of the program, such as the rampdown and critical spawning periods that include performance measures for thermal targets. Examples could include targets for magnitude, frequency and duration of temperature events (e.g. daily maximum temperatures, frequency and duration of high and low pulses, 30-day minimum/ maximum temperatures, timing of annual seasonal events), and target temperatures during growing degree periods, etc. Data used to create these performance measures should include the Yalakom River and Pre-flow conditions as potential thermal regime references.

Developing more of a geographic and spatial context to the program would reduce uncertainty regarding the impacts of the primary and interactive effects of flow release on the LBR aquatic ecosystem. Transitioning to a spatial context for data collection and analysis would also facilitate more efficient comparison of results and could greatly aide in interpretation and communication of benefits to stakeholders. Spatial components would allow for more site-specific exploration of the trade offs of the costs and benefits of potential flow regimes. Such results could be used in adaptive management of the LBR and providing the best information to inform decisions.

Finally, future research should focus on first characterizing, and then accounting for all ecosystem services provided by the aquatic ecosystem in relation to the parameters chosen within the monitoring program. While describing ecosystem services in the LBR goes beyond the current TOR, these assessments would complement the data set for the program and potentially relate the benefits from the LBR aquatic system and different flow releases to human well-being. LBR ecosystem service assessments should start by using the objectives and measures identified during the SDM process for LBR restoration and should focus on using current and historical data to relate the change in services to the change in flow management (e.g. Trials 1 and 2). Ultimately, these data should be used to inform trade-offs regarding the additive affects of multiple and cumulative stressors on the costs and benefits of the ecosystem services across different flow management options.

7.0 FLOW RAMPDOWN SURVEY RESULTS

7.1 Flow Rampdown Survey Results

7.1.1 *Terzaghi Dam Flow Release and River Stage Results*

Quarter-hourly river level (relative stage) recorded by three data loggers located at or near the reach breaks (i.e., Rkms 36.8, 26.1, and 20.0), and mean hourly flow releases from Terzaghi Dam for the rampdowns in July/ August and October 2013 (hereafter reported as August and October, respectively), are presented in Figure 22 during: (A) July/August, and (B) September/ October. Manual readings, located at the top of Reach 4 (plunge pool), the break between Reaches 4 and 3 (Rkm 36.8), the middle of Reach 3 (Rkm 33.3), and the Yalakom River were also recorded from both permanent and temporary staff gages throughout the rampdown events.

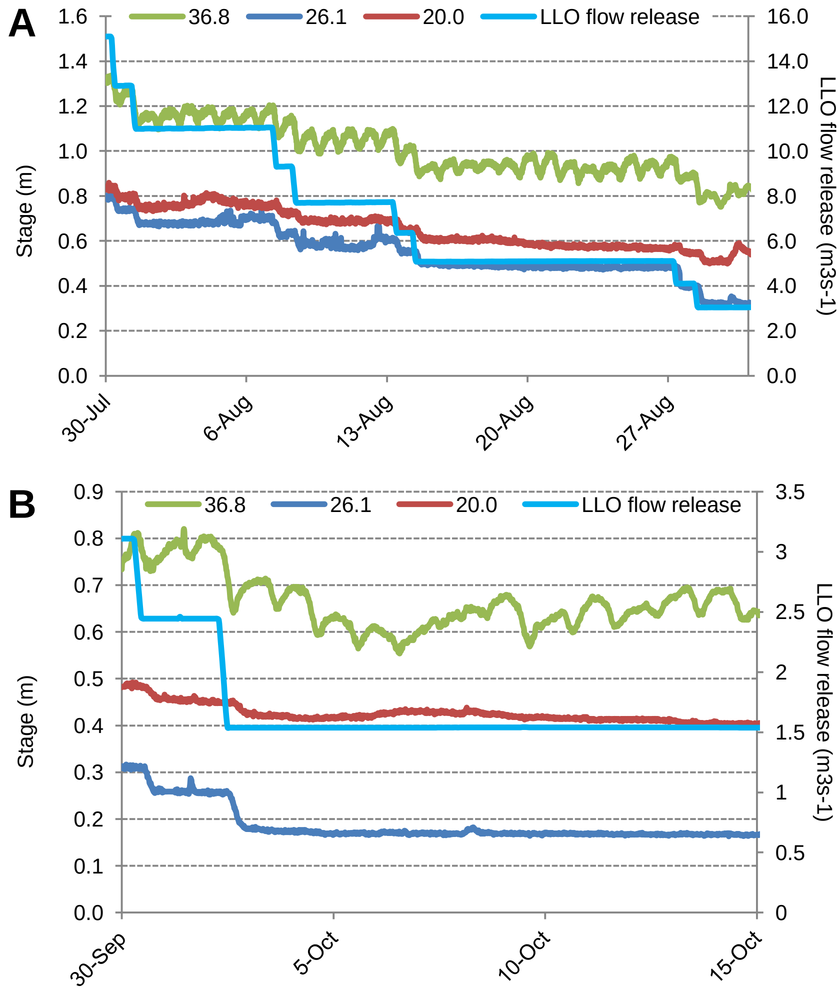


Figure 22. 15 minute stage levels at or near the reach breaks on the Lower Bridge River (1° axis), and hourly flow releases from Terzaghi Dam (2° axis), (A) August 2013, and (B) 1- 15, October 2013.

During the August ramp down event, the relative stage data decreased across all sites in correspondence with the decrease in flow coming from the LLO gates at Terzaghi Dam. Rkm 36.8 exhibited fluctuations in the curve due to local, unexplained site affects. The smoother line for site 26.1 is indicative of a more stable local site condition on a 15-minute basis. Manual stage readings as recorded by observers at permanent (i.e., Rkm 36.8 and 33.3) and temporary (i.e., Plunge Pool and Yalakom River) staff gauges clearly demonstrated the stage changes on the ramp down dates in August and October. These temporary readings occur only when staff were physically present on site checking gauges. Therefore, these data do not provide information regarding the relative stage during each period in between the active ramp down sessions.

Table 15A (Appendix A) summarizes the total changes in the river stage elevation and the flow release volume for each ramping date in August and October. The maximum daily flow change was observed both on July 30 and 31, with a drop of 2.1 m^3s^{-1}. The minimum reduction of 0.7 m^3s^{-1} was observed on September 30. Throughout the rampdown, the plunge pool site exhibited the most stage reduction, and these effects diminished as distance from Terzaghi Dam increased. In addition, as was reported in past years, the degree of stage change relative to the volume of flow change increased from the first ramp event to the last. The cross-sectional channel shape is influential; as the river volume drops, the effect of each 1 cm flow reduction on river stage elevation increases. Consequently, to maintain a target stage change rate, the amount of flow reduction that can be accomplished must decrease on each successive ramp down date (Crane Creek Enterprises, 2012).

Due to morphological characteristics and predominately course in-stream substrate, the Lower Bridge River is sensitive to fish stranding. Consequently, potential mortality is directly associated with the ramping rate particularly within higher risk stage elevation ranges. In general, the slower the river is ramped down, the lower the risk for adverse effects on fish. Based on a variety of considerations, a target ramp maximum rate of 2.5cm of stage change per hour was selected for all BC Hydro Bridge River Generation facilities. In addition, daily ramping duration is constrained by a target daily stage change of less than 15 cm at Rkm 36.8, as well as accounting for the time lag effects of ramping to reach the bottom of the study area (up to 6 hours to reach the Yalakom River confluence). Table 9 presents the ramp hourly duration as measured at the Plunge Pool (PP), the maximum hourly change and the mean hourly change for each day of the ramp down in the summer and fall. In future years, data in Table 9 will focus on changes at RKm 36.8 rather than the PP. The minimum and maximum hourly stage change observed at the PP are likely further moderated at RKm 36.8, relative to the PP.

Table 9. Maximum and mean hourly stage changes at the Plunge Pool site on each ramping date, July/August and September/October 2013.

Ramp Date	Ramp Duration (hrs)	Maximum Hourly change (cm)	Mean hourly change (cm)
30-Jul-13	4.5	-3	-1.4
31-Jul-13	4.5	-3.5	-1.7
7-Aug-13	4.75	-3	-1.8
8-Aug-13	4.5	-3	-1.5
13-Aug-13	4	-3	-1.8
14-Aug-13	4.25	-3	-1.6
27-Aug-17	4	-2.5	-1.3
28-Aug-13	4.25	-3	-1.7
30-Sep-13	4	-2	-1.5
2-Oct-13	4.75	-4.5	-1.8

The ramp duration was relatively constant throughout, ranging from 4 hrs to 4.75 hours per day. Maximum stage change observed at the PP was higher than the target 2.5 cm/hr standard for eight out of ten days. Whenever the ramp rate exceeded the target 2.5cm/hr at the plunge pool, crews notified the BC Hydro electrician on site. This normally occurred within the first two hours of the rampdown event. Ramping was immediately halted until the hourly ramp rate returned to below the target maximum levels. As a result, the mean hourly change was well under the 2.5cm/hr target throughout the rampdowns in August and October, with a range of 1.3 to 1.8. A summation of the amount of time it takes to observe the stage changes down the river, after gate manipulation at the dam is presented in Table 4 (Crane Creek Enterprises, 2012). As the LLO gate flow decreases, the velocities within the main river channel decrease. Subsequently, stage effects downstream take longer to observe the more the river is ramped down. This table can be used for planning purposes for future ramp downs.

7.1.2 *Water Temperature and Turbidity*

Hourly water temperatures during the ramp down are presented in Figure 24A (Appendix A). Figure 24A (A) presents July/ August temperatures, while (B) presents September/October temperatures for four sites within the study area (Rkm 39.9; Rkm 36.5; Rkm 33.3; and Rkm 30.4).

As has been observed over the course of both flow trials, the predominant factor influencing temperature in Reach 4 and a large portion of Reach 3 is the flow release coming from the bottom of Carpenter Reservoir. Consequently, the 6 m^3s^{-1} annual water budget resulted in cooler temperatures during the rampdown events in August, relative to the 3 and 0 m^3s^{-1} flow regimes. In October, temperatures were warmer over the rampdown period relative to pre-flow conditions, but slightly cooler than Trial 1. Following the fall (Sep/Oct) rampdown, temperatures during the early incubation period were approximate 1°C cooler, on average, during Trial 2 than observed in Trial 1. This was a result of the reduced fall flow built into the Trial 2 hydrograph relative to the Trial 1 fall flow (i.e.,1.5 m^3s^{-1} instead of 2m^3s^{-1}).

No obvious changes in turbidity measurements were observed during the ramp down events. In August, turbidity was generally between 2 and 9 NTUs and was similar from start to finish of the ramp each day. The October turbidity measurements were slightly higher than August, which is typical for the LBR at this time of year, and were similar from start to finish of the ramp. This higher turbidity in the fall can likely be attributed to Bridge Glacier silt, which settles in the old Bridge River channel at the bottom of Carpenter Lake during summer glacial melt. The sediments from this melt gradually making its way through the dam and into the Lower Bridge River through the LLO gates during the early fall season. No consistent or obvious trends in turbidity were observed in the results that could be attributed to direct impacts from planned flow ramp down events.

7.1.3 *Physical Habitat Attributes*

Data and attributes for each site recorded in 2011, the first year Trial 2, were used to guide rampdown monitoring and salvage activities. A summary of the physical habitat attributes recorded for each of the fish salvage locations during both the August and October ramping periods is provided in Crane Creek Enterprises (2012). No sites were added or omitted for surveys in 2013, and all of the same sites were monitored and salvaged where necessary. It is important to note that due to access issues and safety considerations related to river crossing at high flows, it has not been possible to survey much of the river-right side of the channel on most of the August ramp dates during each of the Trial 2 years.

Figure 25A (see Appendix A) presents a summation of salvage operations, per site, per flow release level in August and October 2013. This figure, in combination with Figure 9 from the 2011 Rampdown data report (Crane Creek Enterprises 2012) should be used as a tool for timing and salvage operations per level of flow release in future years.

7.1.4 *Fish Salvage*

A series of tables below (Tables 10 - 12) summarize the number of fish salvaged by date, type of activity (e.g. incidental "push" or active salvage), species and age-class, and reach. In total, 5,692 fish were salvaged during the ramp down events in August and 442 in October. Salvaging isolated fish, i.e., fish that were still in wetted habitat but were isolated from the main channel, made up the majority of salvage type throughout both of the ramp downs (94% in August, 82% in October). Very few fish out of the total were mortalities (~1%), and this result is similar to that presented in 2011 (i.e., 6%, Crane Creek Enterprises 2012) and 2012 (i.e., 3%, McHugh and Soverel 2013). Even fewer (<1%) were found stranded in dewatered habitat but still alive. The remainder of fish were considered incidental captures, which means that fish were occupying habitat that was still connected to the main flow, and were "pushed" or encouraged to vacate habitat areas that would isolate or dewater as the ramp down continued. Overall, total percentage capture for August was approximately 4% Incidental, 94% Isolated, 1% Mortalities, and <1% Stranded. In October, percentages of capture were approximately 18% Incidental, 82% Isolated, and zero Mortalities and Stranded.

Table 10. Total number of fish salvaged by ramping date, 30 July through 2 October 2013.

Date	Incidental	Isolated	Mortality	Stranded
30-Jul-13	-	121	5	-
31-Jul-13	10	284	15	-
7-Aug-13	97	926	34	-
8-Aug-13	11	16	19	-
9-Aug-13	-	188	-	-
13-Aug-13	150	661	3	-
14-Aug-13	-	484	10	-
27-Aug-13	-	1,029	-	14
28-Aug-13	-	1,582	-	33
August Totals	**268**	**5,291**	**86**	**47**
30-Sep-13	-	159	-	-
2-Oct-13	80	203	-	-
October Totals	**80**	**362**	**-**	**-**

With the exception of 18 fish, all fish salvaged during the August ramp down event were comprised of age-0+ coho and rainbow trout (Table 11). Similar proportions are evident in the October ramping. Age 0+ coho represented ~21%; age- 0+ rainbow trout 79%; All other species and age-classes represented <1% of the remaining catch. Most of these fish (i.e., the age-0+ class) prefer shallow, protected, edge habitats for rearing. Habitats with these characteristics are the most likely to dewater when flows are reduced in the Lower Bridge River.

Table 11. Summary of numbers of fish salvaged by species and age class, August and October, 2013.

Month	Species & Age Class	Incidental	Isolated	Stranded	Mortality	Total	% of total catch
August	CH - 0+	-	3	-	-	3	<1%
	CO - 0+	53	1,097	-	25	1,175	21%
	CO - 1	-	1	-	-	1	<1%
	RB - 0+	195	4,174	47	40	4,456	79%
	RB - 1	-	10	-	3	13	<1%
	RB - 2	-	1	-	-	1	<1%
October	CH - 0+	-	1	-	-	1	<1%
	CO - 0+	32	50	-	-	82	19%
	RB - 0+	48	311	-	-	359	81%

Most of the fish salvaged in August were captured in Reach 4 (63%). In October, 55% of fish were salvaged from sites in Reach 4; 45% were from Reach 3 (Table 12). This is because Reach 4 strand areas tend to be at higher elevations within the river channel. Consequently, Reach 4 sites tend to dewater at higher stage elevation ranges than sites in Reach 3 (Crane Creek Enterprises, 2012).

Table 12. Summary of numbers of fish salvaged by Reach, August and October 2013.

Month	Reach	Incidental	Isolated	Stranded	Mortality	Total	% of total catch
August	3	98	1,680	47	8	1,833	30%
	4	170	3,611		78	3,859	63%
October	3		201	-	-	201	45%
	4	80	161	-	-	241	55%

Error! Reference source not found.21 presents the number of fish captured per site, by salvage condition in August and October, respectively. In August, Eagle Lake and Rkm 35.9 represented the most significant salvage locations, with > 2,500 fish salvaged between the two sites. At Rkm 39.9, Bluenose, and Rkm 37.0 fish numbers exceeded 600, requiring mostly isolated salvage activities. Numbers of fish salvaged at the rest of the sites were less than 200. In October, Site 37.0 was the most significant site in the salvage, requiring the capture of nearly 160 fish. All other sites where active salvage activity occurred in October retrieved fewer than 100 fish. Grizzly Bar and House Rock, two main salvage sites in the 2011 ramp down events, remained connected to main channel flow throughout the rampdown in October due to manual habitat modifications (i.e, trenching and boulder removal). In summation, by implementing salvage activities in August and October, the majority of fish were successfully salvaged prior to stranding or subsequent mortality.

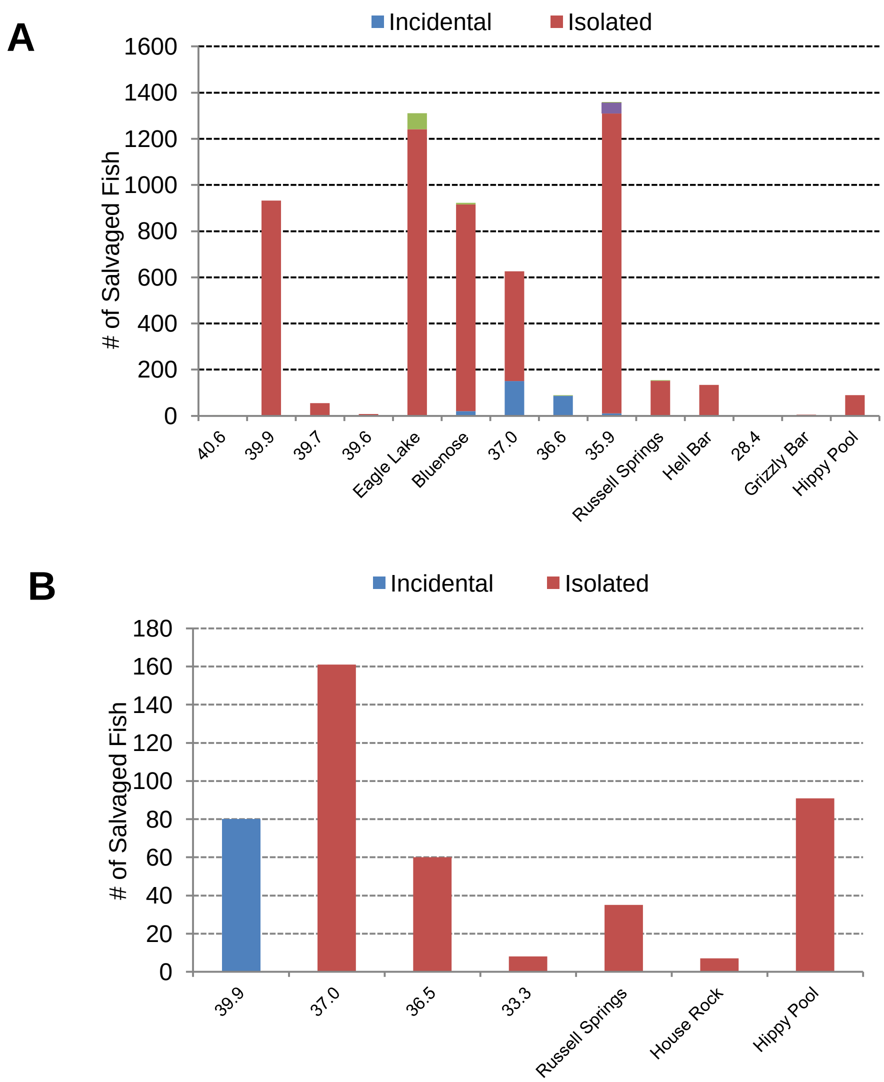


Figure 23. Number of fish salvaged by capture condition at various sites during the rampdown events in August (A) and October (B) 2013.

Table 13 presents the mean, minimum and maximum forklength measured by species and age-class. The maximum size for all specie captured, with the exception of rainbow parr, was less than 98mm. These fish lengths show that the majority of fish that need salvaging are the smaller size classes, and habitats used by this size class generally dewater in the LBR channel more than habitat types used by other species and age classes.

Table 13. Summary of measured forklengths of captured fish during rampdown in August and October, 2013.

Month	Species & Age Class	Total	Min of FL (mm)	Max of FL (mm)	Average of FL (mm)
August	CH - 0+	1	82	82	82
	CO - 0+	205	33	85	55
	CO - 1	2	90	98	94
	RB - 0+	423	23	61	36
	RB - 1	15	67	130	88
October	CH -0+	1	90	90	90
	CO - 0+	45	34	75	49
	RB - 0	76	25	62	44

7.1.5 *SPOG Test*

During rampdown on August 7th, the Terzaghi Dam Spillway Operating Gates (SPOG) were tested. The gates were raised and lowered for a short duration two times, releasing water from the SPOG. Crews were on site for the rampdown survey when the additional flow release occurred. Crews observed minimal increases in water levels associated with the gate testing activities. However as a safety precaution, all crews were out of the river channel for the duration of gate testing. The SPOG testing did not affect the ramping schedule. The change at Rkm 36.8 staff gauge is abnormally high for this date, and this SPOG test may have contributed to this. Turbidity levels were slightly elevated during the initial spill as expected, but changes were minimal and cleared within a few minutes of the spills.

8.0 DISCUSSION AND RECOMMENDATIONS

8.1.1 *Discussion*

Overall, data demonstrated that a successful transition occurred throughout both rampdown events on the LBR in 2013. The initial rampdown event occurred from July-August, and transitioned the river from 15 m^3s^{-1} to 3 m^3s^{-1}. In the subsequent September-October rampdown, flow from the lower-level outlet gate was reduced from 3 m^3s^{-1} to 1.5 m^3s^{-1} as per the Trial 2 hydrograph. Crews were deployed to document and respond to fish stranding and to salvage fish as they became stranded, and water quality was monitored. Consequently, mortality was low, and ramp down efforts were considered a success.

The Lower Bridge River is sensitive to fish stranding. Transition between ‘steps’ was relatively rapid according to the original Trial 1 and Trial 2 hydrographs. As such, there is potential for fish stranding and subsequent mortality when flows are reduced. Consequently, specific ramp down rates were incorporated into the Bridge-Seton WUP, and placed limits on the stage change. As per the BC Hydro Bridge Seton WUP (2012), total change in Reach 4 should not exceed a total of 15cm/ day, or 2.5cm/hr as observed at Rkm 36.8. However, if the ramp down is monitored and fish salvages are implemented, operational changes in excess of the stage change limits are permitted. Total change per day was well under the

15cm/day limit for all days in the rampdown. The 2.5cm limit was exceeded eight out of ten rampdown days for PP, but it was not possible to evaluate whether this limit was surpassed at Rkm36.8. Most of the salvage operations in 2013 were conducted in isolated habitat, where the fish were already stranded. However, due to the low visible mortality at sites, data suggest these effects were mitigated by having salvage crews on site to relocate fish throughout the ramp down. Reaches 3 and 4 were the focus of the rampdown events during the surveys and salvage operations. Given the high flow of water and personnel safety considerations throughout August, the monitoring activities were generally restricted to the channel on river-left. Totals fish numbers, proportions and species compositions for fish salvaged during each ramp day and month are presented in Tables 10-12. Figure 21 showed where salvage operations were required by site over the water level transition.

Mean water temperatures in Reaches 3 and 4 were generally not altered in August throughout the duration of the rampdown. Temperatures appeared to slightly increase throughout the month, reflecting the influence of a reduced cool flow and warmer ambient air temperatures. During the October rampdown, temperatures appears to be cooler than Trial 1 temperature, while still remaining warmer than Pre-Flow conditions in the upper reaches. Temperatures dropped slightly as a result of the modified reduced fall flow, but remained warmer than pre-flow conditions. Research shows (Geist et al 2006) that a reduction in temperature of more than 2C per day would adversely affect egg development in juvenile salmonids. Water temperatures did not change more than 2C/day during the duration of the rampdown events, and they did not seem to be affected by either rampdown event in August or October.

8.1.2 *Recommendations*

Ramping down the LBR should continue to be done slowly, over many steps. Target rate of flow change should not exceed <2.5cm/ hr. If there is significant stranding in future years current change rates should be decreased by slightly lower rates over the first 2 hrs of the rampdown in August. This may extend the length of the operation, including both gate and salvage operations. Salvage crews should be on site throughout the duration of rampdown and downstream effects. Salvage crews should also make an effort to enourage fish to leave know stranding areas, before areas become isolated. Keeping the stage change to this rate will increase the success of salvage efforts and reduce mortality in isolated and dewatering habitats.

Significant habitat modifications need to be made to at least three major areas in Reaches 3 and 4 of the LBR to reduce stranding potential during rampdown events and subsequent low fall/winter flows. Grizzly Bar is a large side-channel in Reach 3 on the right hand side of the channel (i.e., river-right). This slow moving, wide side channel is important habitat for juvenile salmonid, in particular coho have been observed there in high numbers.
Every October, salvage crews clear by hand the upper inlet area, allowing water to flow unimpeded into the habitat. When this manual labour is conducted by hand, flows keep a portion of the side-channel habitat wetted over the fall and winter periods, reducing over-wintering mortality. However, more of this important habitat could be utilized over winter if habitat modifications as recommended in 2012 (Crane Creek Enterprises) by minor machine work (e.g., excavation and recontouring the inlet) were conducted.

In addition to similar recommendations for Grizzly Bar, Crane Creek Enterprises (2012) also recommended that habitat modifications be made at Eagle Lake to aid in successful salvage operations as this site makes up a large component of the salvage effort. In 2013, the water dropped more drastically here than it had in past year. Therefore, we support those recommendations of at a minimum, creating a trenched gradient using shallow cuts to allow fish connectivity to the mainstem as the area dewaters. Further connectivity improvements could be made between Long-skinny and Eagle Lake, as well as House Rock and the main stem of the LBR. At lower flows, several pools at these sites become isolated. This isolation and subsequent stranding and dewatering could be mitigated, with minor excavation activities by opening or deepening the wetted connections.

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10.0 SUMMARY COST

Table 14. Summary Cost Table: Costs per study are shown as a total per year including inflation and contingency.

Lower Bridge River Aquatic Monitoring	***2013***
BRGMon-1	Implementation Yr 2
Total cost	$230,201

11.0 **APPENDIX A**

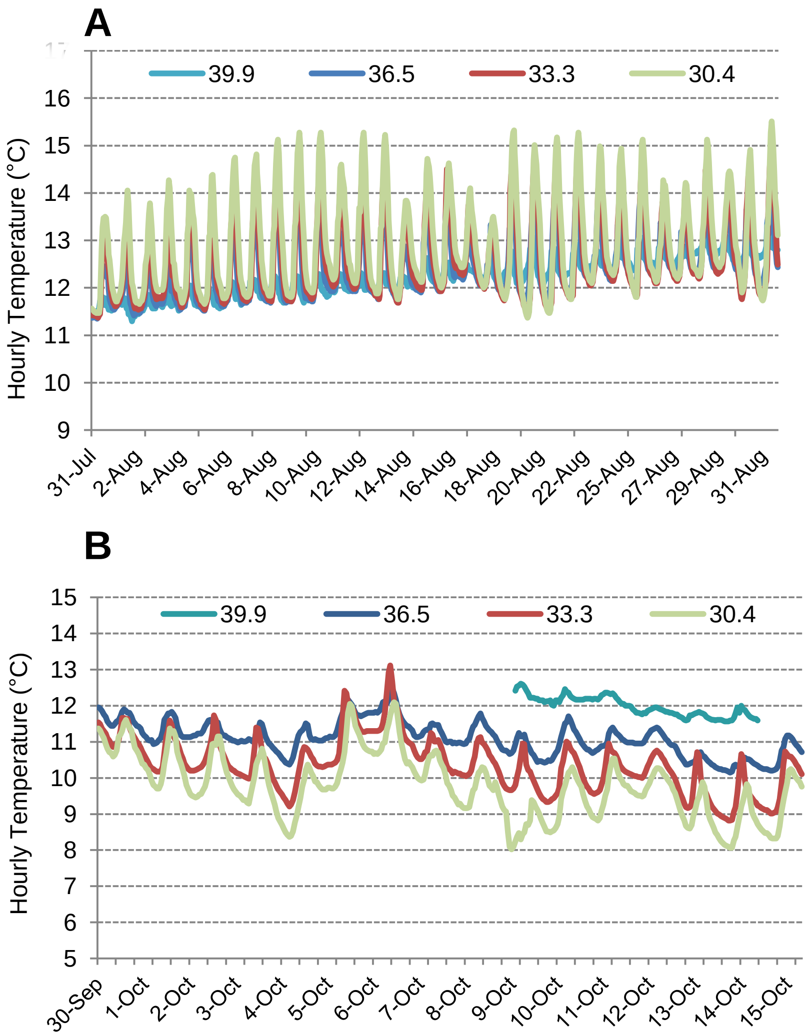

Figure 24A. Hourly water temperatures recorded from the Lower Bridge River at ca. 3 km intervals downstream of Terzaghi Dam, (A) 31 July – 31 August 2013; and (B) 1 – 15 October 2013.

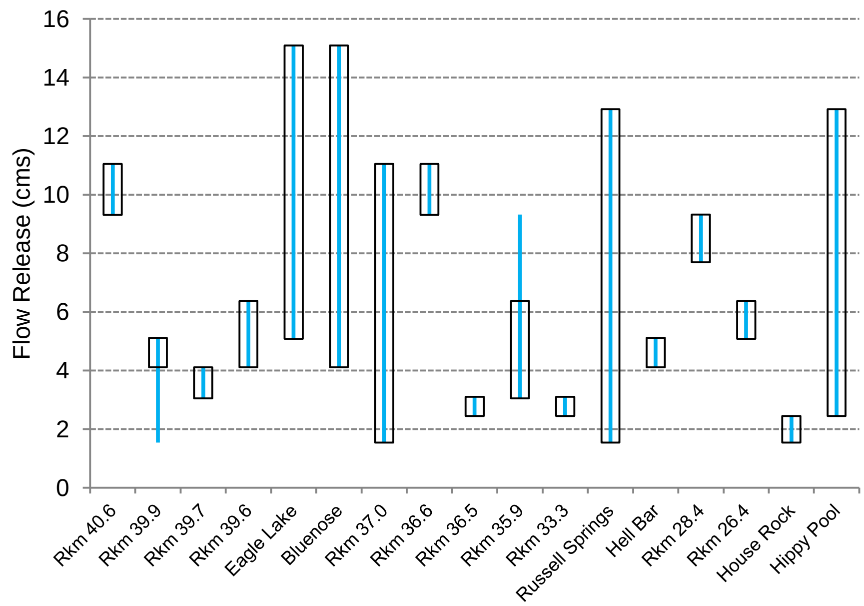

Figure 25A. Range of flows where fish salvage operations were required at each site during flow ramping in 2013. The vertical light blue lines indicate the flow changes that required incidental fish captures as fish were being 'pushed' out of dewatering habitats. The solid black rectangles indicate the flow ranges where isolated habitats were observed and active fish salvaging was conducted.

Table 15A. Summary of stage changes at various locations downstream of Terzaghi Dam on each ramping date, August and October 2013.

Ramp Date	Daily change in flow release (cms)	Change in Stage Elevation (cm)			
		PP	36.8	33.3	Yalakom
30-Jul-13	-2.1	-8.5	-4	-4.5	-4.5
31-Jul-13	-1.8	-10	-6	-7	-1.5
7-Aug-13	-1.7	-9	-10	-5	-6
8-Aug-13	-1.6	-9	-6	-6	-4
13-Aug-13	-1.3	-9	-6	-5	-9
14-Aug-13	-1.2	-9.5	-5	-6.5	-5
27-Aug-17	-1.0	-8	-7	-6	-5
28-Aug-13	-1.1	-8.5	-6.5	-7	-5
August Total	**-11.9**	**-67.5**	**-50.5**	**-47.0**	**-31.1**
30-Sep-13	-0.7	-7.5	-4	-3	-
2-Oct-13	-0.8	-10.5	-7	-6	-3
October Total	**-1.5**	**-18.0**	**-11.0**	**-9.0**	**-3.0**

12.0 DISCLAIMER

No environmental assessment can wholly eliminate uncertainty regarding the potential for unrecognized environmental conditions in connection with water, land or property. Any use that a third party makes of this report, or any reliance on decisions made based on it, is the responsibility of such third parties. Coldstream Ecology, Ltd. accepts no responsibility for damages, if any suffered by any third party because of decisions made or actions based on this report. No other warranty, expressed or implied, is made.

For additional information or answers to any questions, please contact Alyson McHugh of Coldstream Ecology, Ltd. at 250-256-0637 or alyson@coldstreamecology.com