Campbell River Project Water Use Plan

Salmon River and Quinsam River Smolt and Spawner Abundance Assessments

Implementation Year 3

Reference: JHTMON-8

Year 3 Annual Monitoring Report

Study Period: March 1, 2016 to April 30, 2017

Laich-Kwil-Tach Environmental Assessment Ltd. Partnership and Ecofish Research Ltd.

November 9, 2017

JHTMON-8: Salmon River and Quinsam River Smolt and Spawner Abundance Assessments

Year 3 Annual Monitoring Report




BC Hydro Water License Requirements
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November 9, 2017

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Published by Ecofish Research Ltd., Suite F, 450 8th St., Courtenay, B.C., V9N 1N5

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Citation:

Abell, J., S. Sharron, P. Dinn, J. Ellenor, M. Thornton, and T. Hatfield. 2017. JHTMON-8: Salmon River and Quinsam River Smolt and Spawner Abundance Assessments – Year 3 Annual Monitoring Report. Consultant's report prepared for BC Hydro by Laich-Kwil-Tech Environmental Assessment Ltd. Partnership and Ecofish Research Ltd., November 9, 2017.

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EXECUTIVE SUMMARY

Water Use Plans (WUPs) were developed for BC Hydro's hydroelectric facilities through a consultative process. As the Campbell River Water Use Plan process reached completion, a number of uncertainties remained with respect to the effects of BC Hydro operations on aquatic resources. The JHTMON-8 monitoring program focuses on the Salmon and Quinsam rivers, which have high fisheries values and include diversion structures that divert a portion of the total annual flow elsewhere in the Campbell River watershed for hydroelectric power generation.

The JHTMON-8 objectives, management questions, hypotheses and current status are presented in Table 1.

Table 1. Status of JHTMON-8 objectives, management questions and hypotheses after Year 3.

Study Objective	Management Questions	Management Hypotheses	Year 3 (2016/2017) Status
Reduce uncertainty about factors that limit fish abundance in the Salmon and Quinsam rivers	1. What are the primary factors that limit fish abundance in the Campbell River System and how are these factors influenced by BC Hydro operations? 2. Have WUP-based operations changed the influence of these primary factors on fish abundance, allowing carrying capacity to increase? 3. If the expected gains in fish abundance have not been fully realized, what factors if any are masking the response and are they influenced by BC Hydro operations?	*$H_0$1: Annual population abundance does not vary with time (i.e., years) over the course of the Monitor* *$H_0$2: Annual population abundance is not correlated with annual habitat availability as measured by Weighted Usable Area (WUA)* *$H_0$3: Annual population abundance is not correlated with water quality* *$H_0$4: Annual population abundance is not correlated with the occurrence of flood events* *$H_0$5: Annual population abundance is not correlated with food availability as measured by aquatic invertebrate sampling* *$H_0$6: Annual smolt abundance is not correlated with the number of adult returns (Quinsam R. only)*	Year 3 of this ten-year study has been successfully completed. Where historical comparisons have been made, results show that $H_0 1$ can be rejected as population abundance varies among years. The study is on track to answer the management questions following analysis of data to be collected in future years.

The three management questions in Table 1 will be addressed by testing six null hypotheses that are designed to test whether juvenile fish abundance varies between years ($H_0 1$) and, if so, whether abundance is related to the following factors: habitat availability ($H_0 2$), water quality ($H_0 3$), floods ($H_0 4$), food abundance ($H_0 5$), and the abundance of returning adult fish ($H_0 6$). Species of primary interest are Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*O. kisutch*) and steelhead (*O. mykiss*), although the study involves compiling adult escapement data for a wider range of anadromous salmonid species for both rivers, as well as collecting abundance data for life stages (predominantly outmigrating juveniles) of a range of species in the Quinsam River at the salmon counting fence.

Table 2 below summarizes the field sampling programs scheduled to be undertaken annually as part of JHTMON-8. All sampling programs were successfully completed in Year 3 (2016).

Table 2. Summary of field sampling programs undertaken for JHTMON-8.

River	Sampling program	Lead organization[1]	Method	Timing
Salmon	Adult Steelhead survey	LKT	Snorkel surveys	March – April
	Juvenile Steelhead abundance	LKT	Closed site multi-pass electrofishing	September
	Juvenile Coho abundance	DFO/LKT	Closed site multi-pass netting	October
	Salmon escapement surveys	DFO	Various	September – November
	Water quality sampling	LKT	*In situ* and laboratory analysis	May – October
	Invertebrate sampling	LKT	Drift sampling	May – October
Quinsam	Quinsam River Hatchery juvenile downstream migration (various species)	DFO/LKT	Fish fence	March – June
	Salmon escapement surveys	DFO	Various	September – November
	Water quality sampling	LKT	*In situ* and laboratory analysis	May – November
	Invertebrate sampling	LKT	Drift sampling	May – October

[1]LKT, Laich-Kwil-Tach Environmental Assessment Ltd. Partnership; DFO, Fisheries and Oceans Canada

Although the study is at an early stage, fish abundance data so far support rejection of $H_0 1$ for at least some species; i.e., fish abundance measured in Year 1 to Year 3 has varied among years in cases where comparisons have been made. Key results from Year 3 were:

- Adult steelhead counts in the Salmon River were low in 2016 relative to historical counts. The total count for the primary index reach (Lower Index; 50 fish) was the fifth lowest count out of the 19 years sampled and was approximately equal to the 20th percentile of the dataset. This count was higher than the count for Year 1 (39 fish) but lower than the count for Year 2.

- Juvenile steelhead fry abundance in the Salmon River (36 fry per 100 m^2 (FPU)) was below the mean for the sampling period (1998–2016; 52 FPU) and a target set for the watershed of 60 FPU. Abundance was intermediate between the values for the previous two years of the JHTMON-8 program. The depth-velocity adjusted density was higher downstream of the diversion, although there was no clear difference in density between sites upstream and downstream of the diversion. Sites downstream of the diversion included both the highest and lowest densities.

- The range of juvenile Coho Salmon biomass estimated for the three sites downstream of the Salmon River Diversion (1.3–3.0 g/m^2) was comparable with Year 1 and Year 2. Estimated biomass at the three sites upstream of the diversion was 0–1.6 g/m^2; values at these sites have varied considerably among years and sites.

- Estimated salmon escapements for 2015 (i.e., Year 2) were obtained from DFO. These data show that Pacific Salmon escapement was generally low in the Salmon River. In the Quinsam River, escapement of Chinook Salmon (3,190) and Coho Salmon (8,483) in 2015 equalled or approximated the historical medians. Pink Salmon escapement (457,169) in the Quinsam River in 2015 was relatively high, although escapement was <50% that of the record-high escapements estimated in 2013 and 2014.

- In the Quinsam River, total estimated outmigration of Pink Salmon fry in 2016 (Year 3) was 9.2 million. Outmigration of Coho Salmon in 2016 (30,684 wild smolts) was comparable with 2014 and 2015. Estimated total outmigration of wild Chinook Salmon fry and steelhead smolts in 2016 was 1,528 and 9,002 respectively; however, the accuracy of outmigration estimates for these species is expected to be relatively low because capture efficiency was based on mark-recapture experiments conducted with another species (Coho Salmon), and total counts were relatively low.

Water quality data collected at a single index site on both rivers were broadly consistent with results from previous years. Results so far show that both rivers are oligotrophic, with near-neutral pH and low turbidity during baseflow condition. Most water quality variables were in the optimum ranges for salmonid growth, although a notable exception was the occurrence in both rivers of high water temperatures during the growing season that exceed optimum ranges for several salmonid species and life stages. Also, dissolved oxygen concentrations recorded on the Quinsam River were below the provincial guideline for the protection of buried embryos/alevins. These measurements overlapped with reported incubation periods for Chinook Salmon, resident Rainbow Trout and steelhead. Dissolved oxygen measured in September also indicated that the guideline was not met during the start of the Pink Salmon incubation period on the Quinsam River.

In Year 3, we conducted a review to identify hydrologic metrics to test $H_0 4$, which relates to floods (Table 1). A range of metrics was identified based on a subset (Group 2) of the Indicators of Hydrologic Alteration (Richter *et al.* 1996), including measures of both high and low flows. Values for each metric were calculated based on discharge data collected on both streams by the Water Survey of Canada during 2014–2015, which were the study years for which quality-assured data were available. For both years, discharge was low during the summer low-flow period, with minimum mean daily discharge of <0.5 m^3/s measured in the mainstem of both rivers, downstream of the diversion facilities (when they were not operating). It was also notable that maximum discharge was particularly high during the incubation periods for Pacific Salmon species that emerged in 2015, reflecting effects of floods during December 2014. We propose to update this analysis annually to evaluate whether hydrologic disturbance is likely to limit juvenile salmonid productivity. In future years, we will consider calculating additional metrics (e.g., based on the duration of high flows), which can be easily calculated by modifying the code that we prepared this year.

Invertebrate drift sampling was undertaken throughout the growing season at a single index site on both rivers. Invertebrate drift was sampled approximately monthly from May through October, with the exception of May when sampling was undertaken weekly. No clear seasonal trend in invertebrate biomass was observed in the Salmon River, whereas a general decline in invertebrate biomass was observed through the growing season in the Quinsam River. Mayflies, true flies and caddisflies were particularly dominant taxa (in terms of biomass) on both streams. Cluster analysis using all results collected to date showed that there were consistent seasonal differences in invertebrate assemblages among years.

The report describes proposed analyses to be undertaken when further data are collected; these analyses will address the management questions. The status of proposals to improve and develop the study has been updated.

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1. INTRODUCTION

1.1. Background to Water Use Planning

Water use planning exemplifies sustainable work in practice at BC Hydro. The goal is to provide a balance between the competing uses of water that include fish and wildlife, recreation, and power generation. Water Use Plans (WUPs) were developed for all of BC Hydro's hydroelectric facilities through a consultative process involving local stakeholders, government agencies and First Nations. The framework for water use planning requires that a WUP be reviewed on a periodic basis and there is expected to be monitoring to address outstanding management questions in the years following the implementation of a WUP.

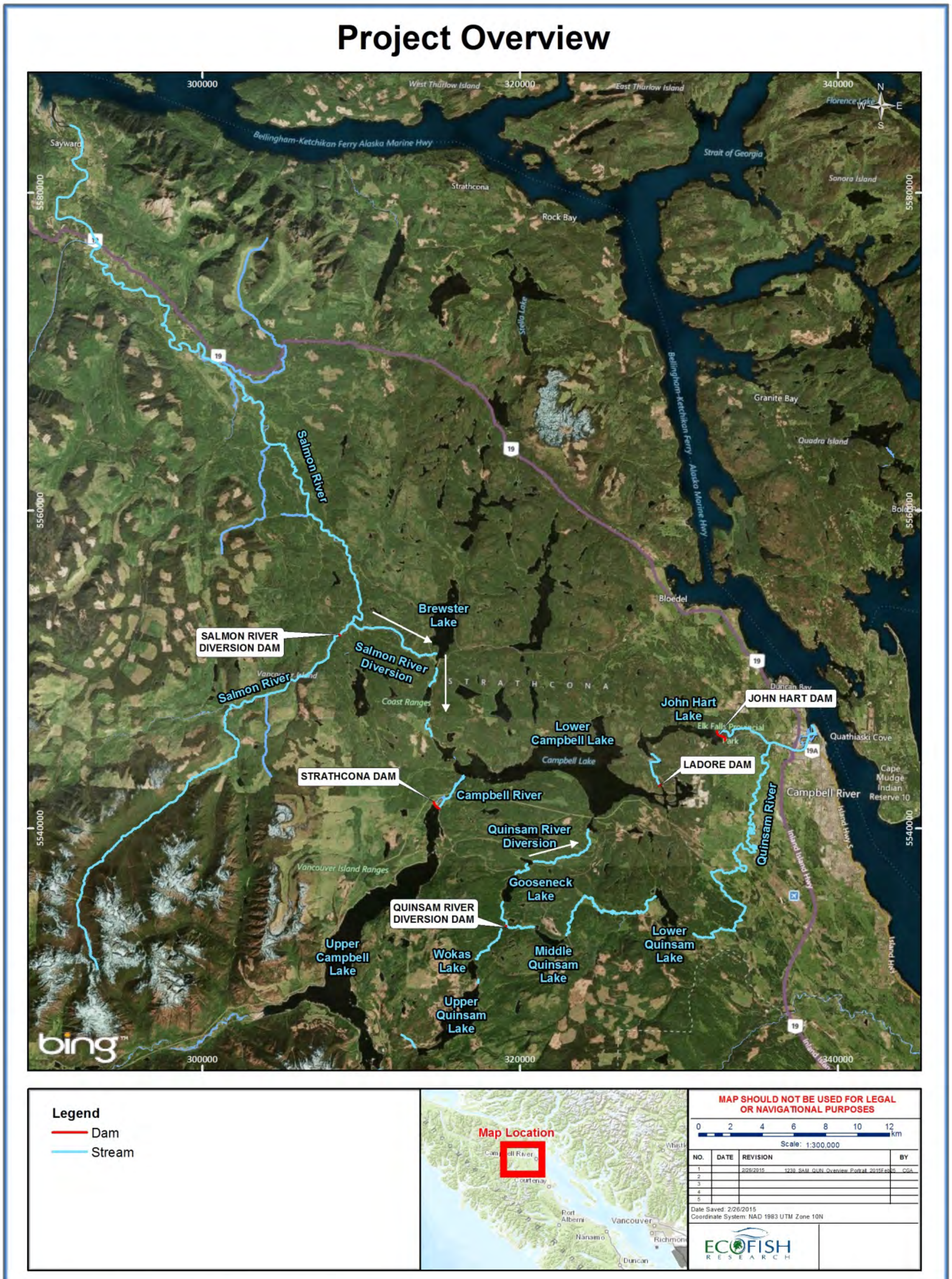
As the Campbell River Water Use Plan process reached completion, a number of uncertainties remained with respect to the effects of BC Hydro operations on aquatic resources. A key question throughout the WUP process was "what limits fish abundance?" For example, are fish abundance and biomass limited by available habitat, food, environmental perturbations or ecological interactions? Answering this question is an important step to better understanding how human activities in the watershed affect fisheries, and to effectively manage water uses to protect and enhance aquatic resources. To address this uncertainty, monitoring programs were designed to assess whether fish benefits are being realized under the WUP operating regime, and to evaluate whether limits to fish production could be improved by modifying operations in the future. The *Salmon River and Quinsam River Smolt and Spawner Abundance Assessments* (JHTMON-8) is one of the monitoring studies that are part of wider monitoring of the Campbell River WUP. JHTMON-8 focuses on monitoring fish populations and environmental factors that may influence fish abundance in the Salmon and Quinsam rivers; this will help to better understand the potential biological effects of BC Hydro operations at the Salmon River and Quinsam River diversion facilities.

1.2. BC Hydro Infrastructure, Operations and the Monitoring Context

1.2.1. Overview

The Salmon and Quinsam rivers are both located to the west of the city of Campbell River on the east coast of Vancouver Island, British Columbia. Both the Salmon River and the Quinsam River diversion facilities divert a portion of water from the river mainstems to generate hydroelectricity downstream at Ladore and John Hart generation stations (Map 1). Details of the diversion infrastructure and operations are summarized below based on the Campbell River System WUP (BC Hydro 2012). The Salmon River Diversion facility was operational in 2016; however, BC Hydro has commenced planning to decommission the facility, with instream works scheduled to start in 2017. (see Section 1.2.2). At the time that this report was prepared, no changes had been made to the JHTMON-8 study design to reflect the proposed decommissioning.

Map 1. Overview of the Salmon River and Quinsam River watersheds.



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1.2.2. The Salmon River and Diversion

The Salmon River flows from headwaters in Strathcona Provincial Park in a general northwards direction to the ocean at Sayward. Major tributaries include Grilse Creek, the Memekay River and the White River, all of which drain the western side of the Salmon River watershed. The area of the watershed is approximately 1,300 km^2 and mean annual discharge (MAD) near the mouth is 63 m^3/s (Burt 2010). The Salmon River has high fisheries values and the river supports a range of salmonid and non-salmonid fish species, including those that are both anadromous and resident (Burt 2010). The Salmon River supports all five species of Pacific salmon (*Oncorhynchus* spp.) as well as both resident and anadromous Rainbow Trout (*Oncorhynchus mykiss*), Cutthroat Trout (*Oncorhynchus clarkii*) and Dolly Varden (*Salvelinus malama*). Lamprey (*Lampetra* spp.) and Sculpin (*Cottus* spp.) species are also present.

The Salmon River Diversion infrastructure was initially constructed in 1958. The diversion dam is a 69 m long rock-filled timber crib dam that diverts water into the Campbell River watershed. Water is diverted from the mainstem of the Salmon River via an intake channel, through a radial gate and into a concrete-lined canal that conveys water to Brewster Lake, which is upstream of Lower Campbell Lake Reservoir. Non-diverted water is returned to the mainstem downstream, either via the main spillway, an undersluice, a trimming weir, or the fishway.

Blasting was undertaken in 1975 and 1976 to remove a rock obstruction in a canyon at river km 38 that formed both a velocity and vertical obstruction to fish migrating upstream (Ptolemy *et al.* 1977 cited in Burt 2010). Subsequent surveys showed that juvenile steelhead were present upstream of the canyon where they were previously absent.

A fish (smolt) screen was installed in 1986 to prevent out-migrating smolts from being diverted into the Campbell River watershed. The fishway was installed in 1992 to aid upstream passage of fish past the diversion dam. Historically, there have been issues with the performance of both the fish screen and the fish way (Burt 2010) and BC Hydro recently completed an evaluation of several options to address these issues. BC Hydro's preferred option was to decommission the facility, which will restore natural fish passage to upstream salmonid spawning and rearing habitats. Planning for the decommissioning commenced in 2016 and the diversion dam was successfully removed in September 2017 .

The Salmon River Diversion was operational in 2016 (Year 3). Currently, a total of 493.39 million m^3 is licensed to be diverted annually, and the 7.8 km diversion canal has a maximum design discharge capacity of 45 m^3/s. The Campbell River System WUP stipulates maximum down ramping rates for the Salmon River and the Diversion Canal (Table 3), maximum diversion flows to enhance fish screen efficiency (Table 4), and minimum flows that must be maintained in the Salmon River downstream of the diversion dam when sufficient flows are naturally available (4.0 m^3/s).

Table 3. Salmon River maximum permitted down ramping rates (BC Hydro 2012).

Stream	Salmon River discharge (m^3/s)	Salmon River maximum down ramping rate ($m^3/s/h$)
Salmon River	< 8.0	1.0
	8.0 to 10.0	2.0
	>10.0	10.0
Salmon River Diversion	0 to 43.0	10.0

Table 4. Salmon River maximum permitted diversion flows (BC Hydro 2012).

Date	Maximum diversion (m^3/s)	Fish screen operation
Jan 1 to Mar 31	43	N/A
Apr 1 to Dec 31	15	On

Nutrient enrichment for salmonid enhancement has occurred in the Salmon River watershed since 1989 (Pellett 2011a). Fertilization locations, methodology and application rates have varied throughout this period, as the project changed from an experimental study to an operational-scale program that was designed to improve habitat suitability (food abundance), primarily for winter run steelhead and Coho Salmon. Monitoring has primarily focused on Grilse Creek (upstream of the diversion dam), which was the only site where nutrients were continuously applied throughout 1989–2010. Enrichment was not undertaken during 2011 through 2013 so that unenriched conditions could be monitored to better quantify the effects of fertilization. Enrichment was again undertaken in 2014 and 2015; however, funding for the enrichment program in subsequent years has since been discontinued (Pellet, pers. comm. 2015).

1.2.3. The Quinsam River and Diversion

The Quinsam River is the only major tributary of the lower Campbell River, entering the Campbell River approximately 3.5 km upstream of the mouth. The Quinsam flows through a series of lakes and has a mainstem length of 45 km (excluding lakes), a watershed area of 283 km^2, and a mean annual discharge near the mouth of 8.5 m^3/s. The river has high fisheries values, supporting the same assemblage of native salmonid species that is found in the Salmon River (Burt 2003). The Quinsam River Hatchery was constructed in 1957 and is located 3.3 km upstream from the confluence with the Campbell River. The hatchery has been active in the watershed, augmenting populations of Chinook Salmon, Pink Salmon, Coho Salmon and Cutthroat Trout since 2014 (Year 1), with Chum Salmon and steelhead also released in previous years (DFO 2016). Smolt and fry life stages that are ready for downstream migration to the ocean are released from the hatchery during the spring. In addition, juvenile Coho Salmon, steelhead and (less frequently) Chinook Salmon have been outplanted to the upper watershed since 1978 to promote adult returns upstream of the hatchery (Burt 2003).

The Quinsam River Diversion comprises a small concrete gravity storage dam, a concrete gravity diversion dam, a concrete flume and the natural waterways that convey water to Lower Campbell Lake Reservoir. Non-diverted water is conveyed to the Quinsam River via an undersluice gate or the free crest weir. The dams were both constructed in 1957.

A total of 100 million m^3 is licensed to be diverted annually and the design capacity of the Quinsam River Diversion is 8.50 m^3/s. As for the Salmon River Diversion Dam, the WUP stipulates maximum down ramping rates (Table 5) and minimum flows (when naturally available) in the Quinsam River downstream of the diversion dam (Table 6).

Table 5. Quinsam River maximum permitted down ramping rates (BC Hydro 2012).

Stream	Discharge (m^3/s)	Maximum down ramping rate ($m^3/s/h$)
Quinsam River	> 4.0	8.5
	≤ 4.0	1.0
Quinsam Diversion	> 2.0	N/A
	≤ 2.0	1.0

Table 6. Minimum permitted discharge in the Quinsam River (BC Hydro 2012).

Date	Minimum discharge in Quinsam River (m^3/s)
Jan 1 to Apr 30	2.0
May 1 to Oct 31	1.0
Nov 1 to Dec 31	0.6

1.3. Management Questions and Hypotheses

The JHTMON-8 monitoring program aims to address the following three management questions:

1. What are the primary factors that limit fish abundance in the Campbell River System and how are these factors influenced by BC Hydro operations?
2. Have WUP-based operations changed the influence of these primary factors on fish abundance, allowing carrying capacity to increase?
3. If the expected gains in fish abundance have not been fully realized, what factors if any are masking the response and are they influenced by BC Hydro operations?

In addressing the questions, the monitoring program is designed to test the following five null hypotheses separately for both the Salmon and Quinsam rivers:

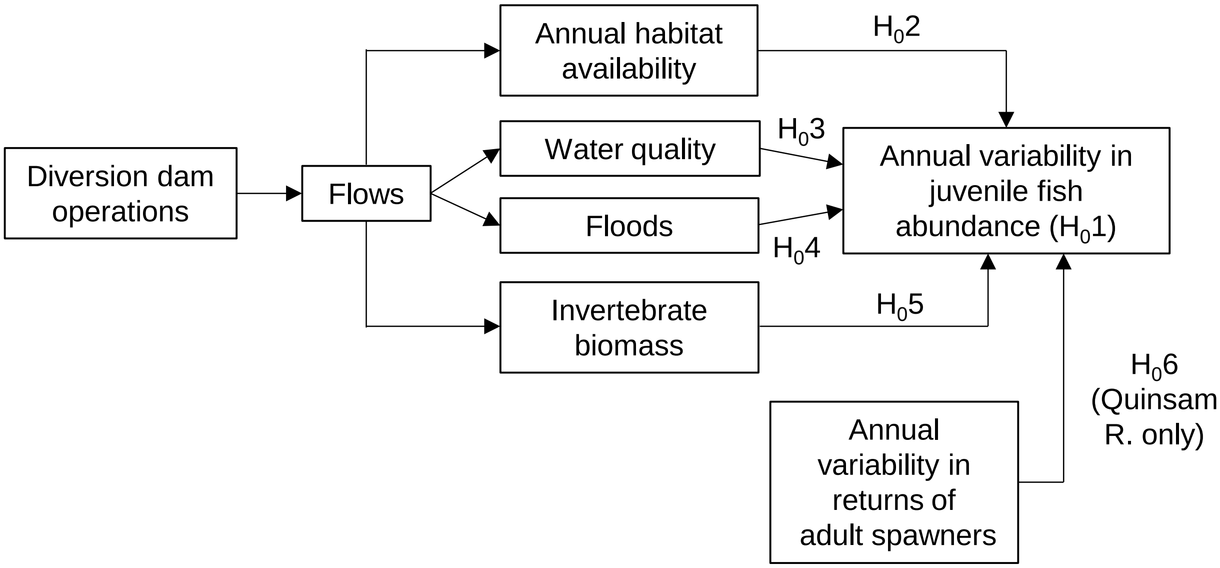
> $H_0$1: Annual population abundance does not vary with time (i.e., years) over the course of the Monitor.
>
> $H_0$2: Annual population abundance is not correlated with annual habitat availability as measured by Weighted Usable Area (WUA).
>
> $H_0$3: Annual population abundance is not correlated with water quality.
>
> $H_0$4: Annual population abundance is not correlated with the occurrence of flood events.
>
> $H_0$5: Annual population abundance is not correlated with food availability as measured by aquatic invertebrate sampling.

There is one additional null hypothesis to be tested for the Quinsam River System where adult escapement and smolt abundance data are collected separately for a wide range of species:

- $H_0$6: Annual smolt abundance is not correlated with the number of adult returns.

The basis of JHTMON-8 is outlined conceptually in Figure 1. The monitoring program is designed to first establish whether there is among-year variability in fish abundance ($H_0$1). The program is then designed to collect data to examine whether inter-annual variability in fish abundance is related to important environmental factors that could be influenced by BC Hydro operations, specifically: Weighted Usable Area of habitat ($H_0$2); water quality ($H_0$3); an accumulated flood risk index during the spawning and incubation periods ($H_0$4), or; invertebrate abundance (food availability; $H_0$5). The study will also investigate whether annual variability in juvenile fish abundance is affected by annual variability in salmon spawner escapement ($H_0$6) – a factor that is influenced by marine survival and not by diversion dam operations. At present, it has been proposed to test $H_0$6 using data only for the Quinsam River (LKT 2014) because data collected at the Quinsam River Hatchery salmon counting fence are expected to have higher precision and accuracy. By contrast, the methods employed to measure fish abundance on the Salmon River have a higher level of error and may not provide data that are precise and accurate enough to test $H_0$6. Nonetheless, we have recommended that effort is also made to test $H_0$6 using data collected for the Salmon River once monitoring is complete (Abell *et al.* 2015a).

Figure 1. Effect-pathway diagram showing the context of the six hypotheses that the JHTMON-8 monitoring program sets out to address.



1.4. Scope of the JHTMON-8 Study

1.4.1. Overview

The JHTMON-8 study has been designed to build upon monitoring that is already occurring in the Quinsam and Salmon watersheds. This allows the study to integrate established work programs and provides an opportunity to incorporate historical data into the analyses. Table 7 summarizes the field sampling programs that were undertaken during Year 3 of JHTMON-8, and are scheduled to continue annually for a total of ten years.

Table 7. Summary of field sampling programs undertaken for JHTMON-8.

River	Sampling program	Lead organization[1]	Method	Timing
Salmon	Adult Steelhead survey	LKT	Snorkel surveys	March – April
	Juvenile Steelhead abundance	LKT	Closed site multi-pass electrofishing	September
	Juvenile Coho abundance	DFO/LKT	Closed site multi-pass netting	October
	Salmon escapement surveys	DFO	Various	September – November
	Water quality sampling	LKT	*In situ* and laboratory analysis	May – October
	Invertebrate sampling	LKT	Drift sampling	May – October
Quinsam	Quinsam River Hatchery juvenile downstream migration (various species)	DFO/LKT	Fish fence	March – June
	Salmon escapement surveys	DFO	Various	September – November
	Water quality sampling	LKT	*In situ* and laboratory analysis	May – November
	Invertebrate sampling	LKT	Drift sampling	May – October

[1]LKT, Laich-Kwil-Tach Environmental Assessment Ltd. Partnership; DFO, Fisheries and Oceans Canada

The species of primary interest on the Salmon River are anadromous Rainbow Trout (steelhead) and Coho Salmon; surveys to enumerate juvenile Coho Salmon and both juvenile and adult steelhead provide the majority of the fisheries data for the Salmon River for JHTMON-8. Species of primary interest in the Quinsam River include Chinook Salmon, Coho Salmon and steelhead, although Pink Salmon is also of interest. Fisheries data for the Quinsam River are primarily obtained via operation of a salmon counting fence at Quinsam River Hatchery to enumerate downstream juvenile migration of a range of species. In addition to these juvenile abundance datasets, adult escapement data obtained by Fisheries and Oceans Canada (DFO) for a range of Pacific salmon species during routine monitoring are also considered for both rivers as part of JHTMON-8.

Further information about the scope and objectives of specific sampling programs is provided below.

1.4.2. Fish Population Assessments

The JHTMON-8 juvenile fish sampling program was designed to ensure that the error associated with fish sampling methods is sufficiently small to detect any between-year variability in fish abundance. The fish abundance data will first be used to test $H_0$1: '*annual population abundance does not vary with time (i.e., years) over the course of the Monitor*' (Section 1.3). Interim analysis to examine whether there are statistically significant variations in fish abundance between years will be undertaken during Year 5, with final analysis undertaken during Year 10. This analysis will consider the two rivers and individual species separately. Where possible, suitable historical data will be incorporated into the analyses to extend the datasets and provide context to any variability observed during the monitor.

The program was designed to enumerate both adult and juvenile life stages to allow relationships between the numbers of adult spawning fish and juvenile recruitment to be examined. This enables testing of $H_0$6: *'annual smolt abundance is not correlated with the number of adult returns'*, which will help to tease apart the extent to which any variations in abundance reflect either variations in adult returns (dependent on marine conditions and harvest) or variations in juvenile survival (dependent on freshwater conditions). Testing this hypothesis will therefore indicate whether the watershed is fully 'seeded' for each species. This hypothesis was proposed to only be tested for the Quinsam River, where the salmon counting fence is monitored to provide estimates of total juvenile fish out-migration. However, relationships will also be examined between metrics of juvenile fish productivity at individual sites in the Salmon River (e.g., mean steelhead 0+ fry per unit), and metrics of adult abundance (e.g., peak adult density), to attempt to distinguish any variability in juvenile fish abundance that is due to fluctuations in adult spawner abundance from variability that may be caused by environmental factors that are potentially influenced by BC Hydro operations (see Abell *et al.* 2015a for further details). Testing $H_0$6 will involve comparing the productivity of naturally-spawned Coho and Chinook salmon with the productivity of colonization programs that out-plant juvenile fish to areas in the upper Quinsam River watershed, e.g., Lower Quinsam Lake. This comparison will further help to examine whether spawning areas are fully seeded. This will need to consider the potential for lower fitness of hatchery-reared fish compared with wild fish, as has been observed during previous field studies in the watershed (Burt, pers. comm. 2016).

Based on initial consideration of historical data for the Salmon River (Abell *et al.* 2015a), we anticipate that significant variability in annual population abundance will be detected (i.e., the null hypothesis will be rejected) for at least some of the species and life stages that are monitored. It will therefore be necessary to use these data to test four of the five remaining hypotheses to determine whether there are any relationships between the observed variability in fish abundance, and variations in key environmental factors, namely: habitat ($H_0 2$), water quality ($H_0 3$), floods ($H_0 4$) and food availability ($H_0 5$).

1.4.3. Water Quality

Healthy fish populations require water quality variables to be within confined ranges. This range of suitable conditions varies depending on the individual variable, fish species and life stage. The objective of the JHTMON-8 water quality monitoring is to measure biologically important water quality variables to provide data to test $H_0 3$: '*annual population abundance is not correlated with water quality'* (Section 1.3). Analysis will later be undertaken towards the end of the ten-year monitor to examine whether there is a relationship between fish abundance and water quality. If a relationship is detected (i.e., the null hypothesis is rejected), then further work would be required to examine whether water use activities in the watershed affect water quality and, if so, how this may impact fish communities, both positively and negatively.

Thus, a key objective of this aspect of the study is that water quality data are collected that suitably reflect variability of water quality in time and space, and are representative of the conditions experienced by fish communities. A single mainstem index site was selected on each river that was assumed to be representative of water quality in the wider watershed.

1.4.4. Floods

High flows have potential to adversely affect fish populations due to a variety of mechanisms; these include: redd scour, delayed redd construction, redd desiccation due to spawning occurring along channel margins during high flows, sediment intrusion, physical shock, or reduced holding opportunities shortly after emergence (reviewed in Gibbins *et al.* 2008). Discharge data are collected at numerous sites on both study streams by the Water Survey of Canada. These data will be used to quantify the occurrence of high flow events during individual years to test $H_0 4$: '*annual population abundance is not correlated with the occurrence of flood events*' (Section 1.3).

During Year 3, we evaluated suitable hydrological metrics to quantify key flow characteristics that have potential to influence fish productivity[1]. Based on this, we quantified the maximum daily mean discharge each year that occurs during the spawning and incubation periods of key species on both study streams. In future years, we will consider calculating additional metrics (e.g., based on the duration of high flows), which can be easily calculated by modifying the code that we prepared this year. Analysis will be later undertaken to determine whether variability in these values explains

[1] This task was scheduled for Year 3 during a background review conducted at the start of the study (Abell *et al.* 2015a).

variability in fish abundance, providing a test of $H_0$4. The proposed analysis will focus on the spawning and incubation life stages because these life stages have been shown to be particularly sensitive to the effects of high flows (e.g., Cattanéo *et al.* 2002). We recognize that there is a range of mechanisms by which high flows can affect these life stages (see list above); therefore, if $H_0$4 is rejected, it may be necessary to undertake further analysis to characterize the most sensitive periods and threshold flows at which high flow events adversely affect juvenile fish abundance. We also recognize that, although $H_0$4 specifically focuses on floods, other aspects of hydrological variability could affect juvenile fish productivity. For example, the occurrence of low flows during summer can potentially limit the abundance of juvenile fish species that rear in freshwater throughout the summer, e.g., Coho Salmon (Matthews and Olson 1980). Accordingly, we propose to calculate a range of annual minimum flow metrics for each stream so that this analysis can be extended to evaluate whether low flows affect juvenile fish abundance. Further details are provided in Section 2.3.

1.4.5. Invertebrate Drift

Invertebrates typically form the bulk of the diet of both juvenile and resident adult salmonids in rivers (Quinn 2005). Invertebrate populations can vary due to a range of factors and therefore variability in the abundance and biomass of invertebrates can be an important factor that limits the growth of salmonids in rivers. The objective of the JHTMON-8 invertebrate sampling is to provide data to test $H_0$5: "*annual population abundance is not correlated with food availability as measured by aquatic invertebrate sampling*" (Section 1.3). Analysis will later be undertaken towards the end of the ten-year monitor to examine whether there are any relationships between fish abundance and food availability, as inferred from invertebrate sampling. If a relationship is detected (i.e., the null hypothesis is rejected), then further work would be required to examine whether water use activities in the watershed affect invertebrate communities and, if so, how this may impact fish communities, both positively and negatively.

A key objective is therefore to collect invertebrate data that reflect variability of watershed invertebrate communities in time and space, and are thus representative of the food available to fish communities. Invertebrate drift includes: dislodged benthic invertebrates, terrestrial invertebrates entrained in the stream, and invertebrates originating from riparian areas. A single mainstem index site was selected on each river that was assumed to be representative of the invertebrate communities present in the wider watershed. Invertebrate drift biomass is measured as a proxy for food availability, although invertebrate community composition is also examined to provide information on food quality. Drift sampling is undertaken during the growing season when rearing juvenile salmonid are actively feeding. In addition, a single kick net sample is collected from each river in September. Kick sampling targets benthic invertebrates, and is therefore less representative of the total abundance of food available to fish. However, kick sampling based on the CABIN protocol (Environment Canada 2012) has been used more widely to characterize stream invertebrate communities throughout Canada. Data collected using this method can be used to evaluate the wider ecological integrity of the streams, based on comparisons with the Environment Canada database of Georgia Basin reference sites (e.g., see Strachan *et al.* 2009).

2. METHODS

2.1. Fish Population Assessments

2.1.1. Salmon River Adult Steelhead Survey

Annual spring snorkel surveys have been conducted as part of adult steelhead stock production monitoring on the Salmon River since 1998. These have historically been undertaken by British Columbia Conservation Foundation (BCCF) and Ministry of Environment (MoE) staff. Since 2014, this work has been led by LKT, with BCCF (K. Pellett) providing supervision until Year 2 to ensure ongoing consistency of methods. Surveys of an index reach ('Lower Index') is the primary stock assessment method, with surveys typically undertaken during the second week of March. Surveys of two additional index reaches ('Rock Creek' and 'Upper Index') have also been undertaken in April during most of the years since 2000. These reaches are upstream of the Lower Index reach: the Rock Creek reach extends upstream of the diversion dam and the Upper Index reach extends downstream of the dam (Map 2).

These surveys provide valuable information to inform the JHTMON-8 study as they indicate whether any variability in juvenile steelhead abundance (see Section 2.1.2) is influenced by the abundance of returning adult fish. A caveat to this is that the adult snorkel surveys provide estimates of maximum density for select reaches rather than absolute escapement estimates for the watershed, although it is assumed that the two metrics are correlated.

All three reaches were successfully surveyed in 2016, with survey timings consistent with historical surveys. The Lower Index was surveyed on March 18, and both the Rock Creek and Upper Index reaches were surveyed on April 11. Each reach was snorkelled during a single day by two experienced technicians. Surveys were conducted in a downstream direction, with particularly steep and potentially dangerous sections bypassed on foot. Surveyors recorded the number, length and condition of adult steelhead, in addition to associated variables (Table 8). Incidental observations of other salmonids were recorded, although observations of trout with fork length < 250 mm were not consistently recorded at all reaches.

Table 8. Variables measured during snorkel surveys of adult steelhead.

Variable	Unit/Classification
Weather	Observation
Air/water temperature	°C
Effective visibility	Measured or estimated (m)
Fish size class	fry/parr/adults; 150–250 mm, 251–350 mm, 351–450 mm, and > 450 mm
Fish species	Steelhead (ST)/Cutthroat Trout (CT)/resident Rainbow Trout (RB)
Fish condition	Bright/moderately coloured/mid-spawn/post-spawn/undetermined
Redd observations	Number

2.1.2. Salmon River Juvenile Steelhead Abundance

2.1.2.1. Field Methods

Juvenile steelhead[2] populations were sampled with multipass removal electrofishing at five sites upstream and five sites downstream of the Salmon River Diversion (Table 9; Map 2). Site locations were based on those historically sampled by BCCF during 1998–2013, with minor adjustments made to the positions of stop nets to account for changes in stream morphology. Sites were historically selected to specifically target fry (not parr) habitat. The main criteria used to select sampling locations were:

- Water depth (maximum 1.0 m, average 0.1 to 0.4 m);
- Water velocity (maximum 1.0 m/s, average 0.1 to 0.5 m/s);
- Cover and substrate (non-embedded boulder, cobble, and/or gravel);
- Area of site (target 100 m^2); and
- Proximity to previous sampling location (as close as possible).

Table 9. Details of juvenile steelhead sampling sites in the Salmon River.

Location	Site [1]	Historic Site #	Historic Site Name/Description	River km	Sampling Date	Mesohabitat	UTM Zone	UTM Easting	UTM Northing
Downstream of Diversion	SAM-EF01B	1	~1.9 km downstream of Pallans (23.94 km)	22.04	8-Sep-16	Riffle	10U	297400	5571498
	SAM-EF02	2	WSC Station (Kay Creek)	35.44	8-Sep-16	Riffle	10U	304030	5564241
	SAM-EF03	3	Memekay Mainline Bridge	52.60	7-Sep-16	Riffle	10U	309310	5556475
	SAM-EF04	4	Smolt Screen	58.02	7-Sep-16	Riffle	10U	309036	5552478
	SAM-EF07	7	Memekay River (lower bridge)	27.93	7-Sep-16	Riffle	10U	302056	5566097
Upstream of Diversion	SAM-EF05	5	Washout, old bridge 5km u/s/ diversion	67.73	7-Sep-16	Riffle	10U	304267	5548471
	SAM-EF06	6	Washout 500 m u/s of Grilse confluence	69.25	6-Sep-16	Riffle	10U	301417	5546997
	SAM-EF08	8	Grilse Ck. (100 m u/s of lower bridge)	70.77	6-Sep-16	Riffle	10U	300741	5547323
	SAM-EF09	9	Grilse Ck. (300 m d/s of upper bridge)	74.27	6-Sep-16	Riffle	10U	297133	5546961
	SAM-EF10	10	Grilse Ck. (500 m d/s of upper bridge)	75.91	6-Sep-16	Riffle	10U	296773	5546524

[1] SAM-EF01B replaced SAM-EF01 ('Pallans') in 2016 due to changes to channel morphology.

Fish were captured using closed-site multipass removal electrofishing methods in accordance with guidelines (Lewis *et al.* 2004; Hatfield *et al.* 2007). Sites were enclosed using stop nets (15.2 m long × 1.2 m deep, mesh size = 3.2 mm). Each pass consisted of two full circuits of the enclosure, and two to three passes were conducted at each site. Data collected included:

- Sampling effort (seconds) expended during each pass

[2] For consistency with the historical sampling program, we use the term 'juvenile steelhead' to refer to juvenile (fry and parr) Rainbow Trout. We acknowledge that this may include resident and anadromous individuals.

- The number, species, length (+/- 1 mm) and weight (+/- 0.01 g) of each fish caught per pass
- Scales samples from a sub-sample of fish that were close to size/age class boundaries
- Wetted width (three or four measurements) and site length
- Physical stream characteristics (cover types, substrate size, habitat type, stream gradient, compaction, sand in substrate, and roughness)

After electrofishing was complete, hydraulic habitat variables were measured along a transect placed across the width of the sampling site. A minimum of ten wetted stations spaced a minimum of 0.25 m apart were placed along each transect. The following variables were measured at each station: distance from wetted edge, water depth, water velocity, available cover, and net locations. If a single transect was not long enough to accommodate 10 wetted stations then an additional transect was completed at the site.

Water temperature and conductivity were measured using *in situ* meters calibrated prior to sampling. Photographs from standardized locations were also taken at each sampling site.

2.1.2.2. Data Analysis

Individual Fish Data

For juvenile steelhead, we defined age class structure and described length-weight relationships, Fulton's condition factor (K), and length at age. Fulton's condition factor (K) was calculated for all captured fish as:

$$K = \text{weight} \times \text{length}^{-3} \times 100{,}000$$

where weight was recorded in g and length in mm. Scale samples were examined under a dissecting microscope to age individual fish: representative scales were photographed and apparent annuli were noted on a digital image. Fish age was determined by two independent observers using a double blind methodology. The data produced by each observer were then compared to identify any discrepancies. Where discrepancies occurred, they were discussed and final age determination was based on professional judgement of the senior biologist.

Fish were separated into age classes for fish abundance and biomass analysis. To define discrete age class size bins (size classes), the length-frequency histograms for fish captured during electrofishing were reviewed along with all of the length at age data from the scale analysis. Based on these data, discrete fork length ranges were defined for each of the following age classes: fry (0+), parr (1+), parr (2+) and adult (≥3+), although no 2+ parr or adult fish were captured during sampling in 2016. These discrete fork length ranges allow all fish to be assigned to an age class based on fork length for population analysis. Fork length ranges may differ from year to year and are therefore determined annually. Summary statistics of fish length, weight, and Fulton's condition factor were summarized by age class for both the upstream and downstream reaches.

Population Analysis

Total abundance and biomass were calculated for steelhead fry (0+) using removal depletion equations in MicroFish V3.0 (Van Deventer 2006). Fish abundance and biomass by age class at individual sites were then standardized to fish per 100 m^2.

Abundance and biomass estimates were also adjusted to account for differences in habitat suitability of each sampling site. The habitat suitability of each electrofishing site was determined based on depth and velocity measured at each transect data, and habitat suitability indices (HSI) for steelhead fry (0+) developed for BC Water Use Planning (WUP) projects (curves dated February 2001 provided by R. Ptolemy, MoE). Habitat suitability is expressed as a usability percentage, which is calculated by computing the weighted usable width (WUW) of each transect within the sampling enclosures, and dividing by the wetted width of the transect. The transect usability at each site was then used to adjust the fish density estimates. Results are expressed in terms of fish per unit area (FPU: fish/100 m^2), and are reported as both non-adjusted (FPU_{obs}) and usability-adjusted estimates (FPU_{adj}), and as non-adjusted and adjusted biomass per unit area (BPU_{obs} and BPU_{adj}: g/100 m^2). Abundance and biomass densities are presented for individual sites and as averages for upstream and downstream of the diversion reaches.

Results were compared with historical data collected at the same sites by BCCF from 1998 to 2013, and by LKT and Ecofish in 2014 and 2015.

2.1.3. Salmon River Juvenile Coho Salmon Abundance

2.1.3.1. Field

The abundance of juvenile Coho Salmon has been measured in the Salmon River during the fall by DFO since 2008. This work has been integrated into the JHTMON-8 study to continue collection of abundance data for a species of primary interest in the study. Continuation of this established monitoring program means that historical data collected between 2008 and 2013 can be used to increase the time span considered during analysis to address JHTMON-8 management questions.

The program involves sampling at six sites, with three sites upstream of the diversion dam and three sites downstream (Table 10; Map 2). Sites are representative of the juvenile Coho Salmon habitat generally present. Sites were typically ~ 20 m long and comprised pools. As part of LKT's standardized approach to data collection and quality assurance, new site names were assigned to the sampling sites for data recording purposes in 2015. Correspondence between these and existing site names is shown in Table 10, although note that precise sampling areas have varied within stream reaches between years in response to differences in water levels and channel morphology. In 2016, it was necessary to slightly reposition sites SAM-BS03 and SAM-BS06 as fallen trees were present in the middle of the sites, which prohibited sampling with a beach seine net. These sites were repositioned by approximately 25 m and 55 m respectively, with the new sites named SAM-BS03B and SAM-BS06B. Data collected at these new sites are considered comparable with historic data as the sites were located in the same tributaries and consisted of comparable habitat (pools).

Sampling was conducted on September 22 and 23, 2016. Sites were isolated using barrier nets placed at the upstream and downstream ends to form full enclosures that included the full width of the channel (Figure 2). Multi-pass beach and pole seine netting were then used to remove fish. Two to four passes were undertaken with the objective of observing declining catches to permit estimation of capture efficiency to allow estimation of total fish abundance. Fish caught were retained until sampling was complete. Fork lengths of all juvenile Coho Salmon were tallied using 1 mm size bins. Weight (g) of individual fish in each size bin was recorded, with a maximum of three measurements recorded per size bin for each pass. Scales were retained for a subsample (n = 13) of fish. These were analyzed at Ecofish's laboratory in Campbell River to establish fork length categories that corresponded to age classes. Length categories were established separately for each site.

The length of each site was measured and three width measurements were recorded at all six sites. Both wetted width and width of the channel with depth > 10 cm were measured. The latter width measurements were used to calculate the area of each site when estimating fish density as they are more representative of the habitats used by juvenile Coho Salmon.

2.1.3.2. Data Analysis

The weighted mean mass (g/fish, $\widehat{m}_j$) was calculated for each age class (0+, 1+ and 2+) at each site as:

$$\widehat{m}_j = \frac{\sum_{i_{min}}^{i_{max}}(n_{i,j} \cdot \overline{m}_{i,j})}{N_j}$$

where i_{max} is the maximum fork length (±1 mm) measured at a site, i_{min} is the minimum fork length (±1 mm) measured at a site, n_i is the number of fish recorded in size bin i for age class j, $\overline{m}_i$ is mean mass of fish in size bin i for age class j and N_j is the total number of fish caught at a site in age class j.

A total weighted mean mass (g/fish, $\widehat{M}$) at each site was calculated as:

$$\widehat{M} = \frac{\sum_{0+}^{2+}(\widehat{m}_j \cdot N_j)}{N}$$

where N is the total number of fish caught at a site.

Total juvenile Coho Salmon abundance ($\widehat{N}$) was estimated at each site using DFO's standard capture efficiency model for analyzing multiple pass removal data. Total biomass at each site (g/m^2) was subsequently estimated as:

$$Biomass = \frac{\widehat{N} \cdot \widehat{M}}{Area_{>0.1\,m}}$$

where $Area_{>0.1\,m}$ is the area (m^2) of the site with depth > 0.1 m.

Table 10. Juvenile Coho Salmon sampling site details and correspondence with historical site names.

Site	Historic name	Stream	Relation to Salmon River Diversion	Coordinates (NAD 83)		
				Zone	E (m)	N (m)
SAM-BS01	Crowned	Crowned Creek	Upstream	10U	301818	5543950
SAM-BS02	G02	Grilse Creek	Upstream	10U	300117	5547376
SAM-BS03B	Gmain	Grilse Creek	Upstream	10U	300101	5547313
SAM-BS04	Paterson	Paterson Creek	Downstream	10U	309986	5552605
SAM-BS05	Marilou	Marilou Creek	Downstream	10U	307472	5557836
SAM-BS06B	BTCKFlCh	Big Tree Creek	Downstream	10U	303433	5566486

Figure 2. Establishing stop nets at SAM-BS02 (Grilse Creek) juvenile Coho Sampling site on September 22, 2016.

2.1.4. Salmon and Quinsam River Salmon Escapement

Annual salmon spawner escapement counts have been undertaken on the Salmon and Quinsam rivers since the 1950s by DFO and its predecessors. Although these data are collected as part of wider salmon stock assessment work, they provide an important source of data to support the JHTMON-8 study. The results of summer and fall 2015 surveys were finalized during Year 3. These were obtained from DFO's New Salmon Escapement Database (nuSEDS) and are reported here to provide data to support analysis scheduled for later during JHTMON-8 to examine relationships between abundance of adult spawning fish and corresponding counts of juvenile fish in successive years.

Methods used in the 2015 surveys are summarized in Table 11 and Table 12 for the Salmon and Quinsam rivers respectively, based on information provided in the nuSEDS database (DFO 2017). Surveys of individual species conducted by DFO conform to one of six estimate classification types, ranging from Type-1 (most rigorous, almost every fish counted individually) to Type-6 (least rigorous, determination of presence/absence only). The estimate classification types are reported in the two tables of methods, with further general details about survey types provided in Table 13.

Table 11. Methods used during 2015 salmon spawner escapement counts on the Salmon River (DFO 2017). See Table 13 for descriptions of survey types.

	Salmon species				
	Chinook	**Chum**	**Coho**	**Pink**	**Sockeye**
Estimate classification	4	6	4	Unknown	
Number of surveys	5	5	4	5	
Date of first inspection	July-10	July-10	July-10	July-10	Not inspected
Date of last inspection	October-07	October-07	October-07	October-07	
Estimation method	Area under the curve	N/A	Area under the curve	Expert opinion[1]	

[1.] General comment: "Utilized a custom value due to a missing number of weeks during the peak of the run"

Table 12. Methods used during 2015 salmon spawner escapement counts on the Quinsam River (DFO 2017). See Table 13 for descriptions of survey types.

	Salmon species				
	Chinook	**Chum**	**Coho**	**Pink**	**Sockeye**
Estimate classification	2	3	2	2	3
Number of surveys	Unknown	UNK	UNK	UNK	UNK
Date of first inspection	August-02	October-20	August-02	July-17	August-02
Date of last inspection	November-30	November-21	December-09	November-30	December-15
Estimation method	Mark and recapture: Petersen	Fixed site census	Fixed site census	Fixed site census	Fixed site census

Table 13. Summary of definitions of salmon spawner escapement estimate classification types reported in Table 11 and Table 12 (DFO 2017).

Estimate classification type	Abundance estimate type	Resolution	Analytical methods	Reliability (within stock comparisons)	Units	Accuracy	Precision
1	True	High resolution survey method(s): total, seasonal counts through fence or fishway with virtually no bypass	Simple	Reliable resolution of between year differences >10% (in absolute units)	Absolute abundance	Actual or assigned estimate and high	± 0%
2	True	High resolution survey method(s): high effort (5 or more trips), standard methods (e.g. equal effort surveys executed by walk, swim, overflight, etc.)	Simple to complex multi-step, but always rigorous	Reliable resolution of between year differences >25% (in absolute units)	Absolute abundance	Actual or assigned estimate and high	Actual estimate, high to moderate
3	Relative	Medium resolution survey method(s): high effort (5 or more trips), standard methods (e.g. mark-recapture, serial counts for area under curve, etc.)	Simple to complex multi-step, but always rigorous	Reliable resolution of between year differences >25% (in absolute units)	Relative abundance linked to method	Assigned range and medium to high	Assigned estimate, medium to high
4	Relative	Medium resolution survey method(s): low to moderate effort (1-4 trips), known survey method	Simple analysis by known methods	Reliable resolution of between year differences >200% (in relative units)	Relative abundance linked to method	Unknown assumed fairly constant	Unknown assumed fairly constant
5	Relative	Low resolution survey method(s): low effort (e.g. 1 trip), use of vaguely defined, inconsistent or poorly executed methods.	Unknown to ill defined inconsistent or poorly executed	Uncertain numeric comparisons, but high reliability for presence or absence	Relative abundance, but vague or no i.d. on method	Unknown assumed highly variable	Unknown assumed highly variable
6	Presence or absence	Any of above	N/A	Moderate to high reliability for presence/absence	Present or absent	Medium to high	Unknown

2.1.5. Quinsam River Hatchery Salmon Counting Fence Operations to Enumerate Downstream Juvenile Migration

Technical staff provided by LKT worked under the instruction of DFO hatchery staff to enumerate fish at the Quinsam River Hatchery salmon counting fence in spring, 2016. Methods were based on those described in Ewart and Kerr (2014); specific details about 2016 operations are based on information provided by the hatchery Enhancement Technician (Scott, pers. comm. 2016). Data were collated and quality assured by Quinsam River Hatchery.

Fish were caught using inclined plane traps (Wolf traps) that capture a proportion of the fish that migrate downstream through the fence, with the aim to capture salmonid fry and smolts as they out-migrate to the ocean (Figure 3). Sampling was undertaken from March 23 to June 14, 2016, with traps deployed continuously during this period. The proportion of the river that was 'fished' varied depending on fish abundance, with a smaller number of traps (three) used during March and April when Pink Salmon fry were out-migrating and highly abundant. Specifically, three traps were installed from March 23 to April 20 (with the exception of March 25–28 when river conditions were too high for trap installation), with two additional traps then added for the remainder of the period. Pink Salmon fry typically migrate at night and therefore traps were set overnight from approximately 15:00 to 09:00 during sampling in March 23 to April 20. For the remainder of the sampling period, traps were set constantly during the times when fish were not being processed. Target species during this time were: steelhead (kelts and smolts), Coho Salmon (smolts), Chinook Salmon (fry), Chum Salmon (fry), Sockeye Salmon (fry), Cutthroat Trout (kelts and smolts) and Dolly Varden (smolts).

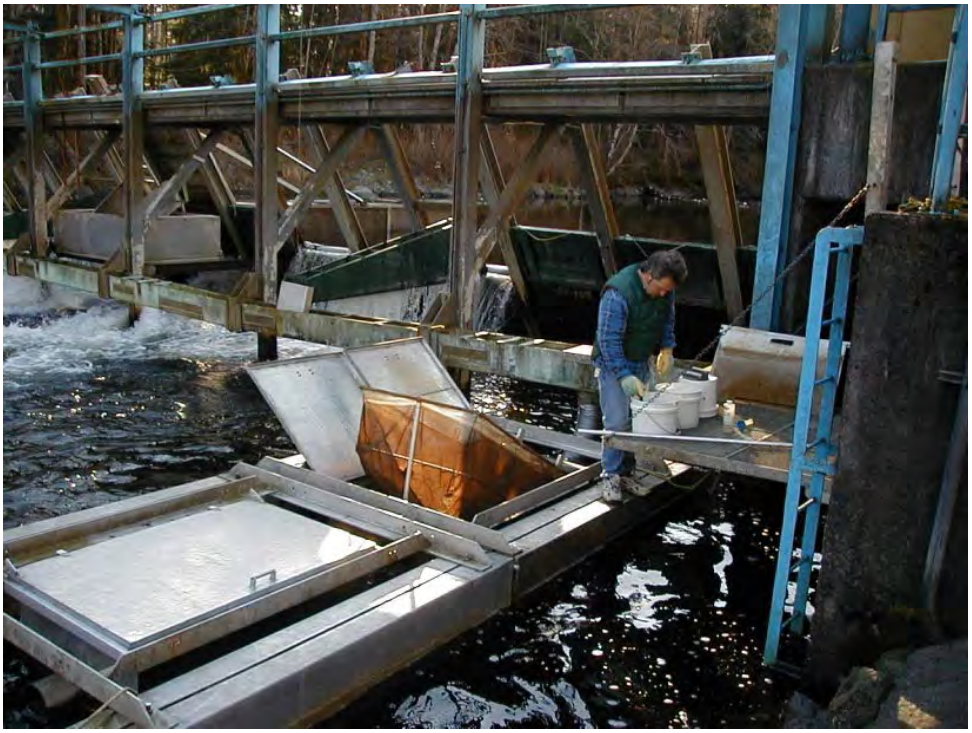
Total downstream migration estimates for individual species and life stages were calculated by multiplying fish capture numbers by capture efficiency coefficients. The capture efficiency coefficients were derived from mark-recapture studies in the system. For Pink Salmon fry, capture efficiency was estimated based on the results of two releases of wild fish marked with Bismarck brown dye. The fish were captured in the trap, marked with the dye, and released approximately 350 m upstream of the fence. Releases were undertaken on April 5 and April 8, 2016, with a total of 8,161 fish released. The resulting capture efficiency coefficients were used to estimate the abundance of Pink Salmon fry and also to estimate the abundance of other species captured during the Pink Salmon fry trapping period (i.e., steelhead, Cutthroat Trout, and Chum Salmon). Capture efficiency was calculated as k/K (where k is the number of marked fish recaptured and K is the total number of fish marked in the study).

Separate catch efficiency estimates were derived for Coho Salmon smolts based on four releases of wild Coho Salmon smolts marked with pelvic fin clips (alternating between right and left between experiments). Again, smolts were captured in the traps and released upstream of the traps. Releases were undertaken on April 29, May 4, May 12 and May 18, 2016, with a total of 774 fish released. The capture efficiency estimates were also used to estimate abundance of other salmonid species caught after April 23 (i.e., steelhead, Cutthroat Trout, Chinook Salmon, Sockeye Salmon, and Chum Salmon). Further details about the mark recapture methods are provided in Ewart and Kerr (2014).

For Coho Salmon and Chinook Salmon, separate counts were recorded for wild and 'colonized' smolts. Colonized refers to fish that were incubated at the hatchery and transplanted to the upper Quinsam River watershed as fry. As per hatchery protocols, 20% of transplanted fish are marked with an adipose fin clip. The abundance of colonized Coho Salmon was therefore estimated by multiplying the number of marked fish captured in the traps by five. Wild and colonized fry/smolts were further distinguished by size class (colonized juveniles are generally larger than wild juveniles), with size breaks generated from the length data for adipose-clipped fish.

In 2015, 167,030 Coho Salmon fry were released into the upper Quinsam River watershed by hatchery staff between April 29 and May 20. In 2015 (Year 2), hatchery-incubated Chinook Salmon were released in the watershed for the first time in approximately 10 years. Chinook Salmon fry were again released into lower Quinsam Lake in 2016, with 147,549 fry released on May 12 and May 13.

Figure 3. View upstream from river left towards the salmon counting fence. Reproduced from Ewart and Kerr (2014).



2.2. Water Quality

2.2.1. Water Chemistry

2.2.1.1. Salmon River and Quinsam River Water Chemistry Monitoring

One water quality site was established in the Salmon River (SAM-WQ; Map 2) and one in the Quinsam River (QUN-WQ; Map 3) in 2014. Both sites were selected based on the guidelines of the British Columbia Field Sampling Manual (Clarke 2003) and the Ambient Fresh Water and Effluent Sampling Manual (RISC 2003).

The Salmon River site (SAM-WQ; Figure 4) was located downstream of the Salmon River Diversion, in a run immediately downstream of a braided section of the river with sandy banks. The Quinsam River site (QUN-WQ; Figure 5) is located ~950 m downstream of the confluence with the Iron River, and downstream of the Quinsam Coal Mine and the salmon carcass nutrient enhancement site. Coordinates, site elevation, and sampling dates (*in situ* and laboratory samples) for both sites are provided in Table 14.

Table 14. Water quality index site details and sampling dates in Years 1, 2 and 3.

Waterbody	Site Name	UTM Coordinates (Zone 10)		Elevation (m)	Sampling Dates
		Easting	Northing		
Salmon River	SAM-WQ	309308	5556385	172	21-May-14; 17-Jun-14; 23-Jul-14; 18-Aug-14; 23-Sep-14; 03-Nov-14; 13-May-15; 16-Jun-15; 22-Jul-15; 12-Aug-15; 17-Sep-15; 15-Oct-15; 17-May-16; 14-Jun-16; 12-Jul-16; 16-Aug-16; 13-Sep-16; 11-Oct-16
Quinsam River	QUN-WQ	327433	5534757	193	23-May-14; 18-Jun-14; 22-Jul-14; 19-Aug-14; 24-Sep-14; 04-Nov-14; 12-May-15; 17-Jun-15; 23-Jul-15; 13-Aug-15; 16-Sep-15; 14-Oct-15; 18-May-16, 15-Jun-16, 13-Jul-16; 17-Aug-16, 14-Sep-16; 12-Oct-16

Figure 4. Looking upstream to SAM-WQ on July 12, 2016.

Figure 5. Looking upstream to QUN-WQ on July 13, 2016.

Consistent with previous years, water quality was monitored six times at each site on a monthly basis during May through October, 2016. Standard methods were employed to collect samples and measure water quality; methods were consistent with previous years. Sample collection and analyses were completed according to procedures set out in the Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia (RISC 1997a). Water chemistry variables were chosen based on provincial standards (Lewis *et al.* 2004). The variables sampled in Year 3 are presented in Table 15 (*in situ*) and Table 16 (laboratory), although total gas pressure (TGP) was not sampled in Year 3 based on a recommendation following Year 1 (Abell *et al.* 2015b). Laboratory method detection limits (MDL) occasionally differ (Table 16) due to matrix effects in the sample, or variations in laboratory analytical instruments.

Table 15. Water quality variables measured *in situ* and meters used for measurement.

Parameter	Unit	Meter
Water temperature	°C	YSI Pro Plus and P4 Tracker
pH	pH units	YSI Pro Plus
Salinity	ppt	YSI Pro Plus
Conductivity	µS/cm	YSI Pro Plus
Specific conductivity	µS/cm	YSI Pro Plus
Oxidation reduction potential	mV	YSI Pro Plus
Dissolved oxygen	mg/L	YSI Pro Plus
Dissolved oxygen	% Saturation	YSI Pro Plus

Table 16. Variables analyzed in the laboratory by ALS Environmental and corresponding units and method detection limit (MDL).

Parameter	Unit	MDL
General Water Quality		
Specific conductivity	µS/cm	2
pH	pH	0.1
Total suspended solids	mg/L	1
Turbidity	NTU	0.1
Alkalinity, Total (as $CaCO_3$)	mg/L	2
Nutrients		
Ammonia (as N)	µg/L	5
Nitrate (as N)	µg/L	5
Nitrite (as N)	µg/L	1
Total phosphorus	µg/L	2
Orthophosphate	µg/L	1

2.2.1.2. Quality Assurance/Quality Control

In situ water quality meters were maintained and operated following manufacturer recommendations. Maintenance included calibration, cleaning, periodic replacement of components, and proper storage. Triplicate *in situ* readings were recorded from each meter at each site on each sampling date unless otherwise noted.

For samples collected for laboratory analysis, sampling procedures and assignment of detection limits were determined following the guidelines of the BC Field Sampling Manual (Clarke 2003) and the Ambient Fresh Water and Effluent Sampling Manual (RISC 2003). Duplicate samples were collected on each sampling date at each site. In Year 3, a field blank and travel blank were also collected during the May 17-18 field trip, resulting in >50% of Year 3 samples being quality assurance/quality control (QA/QC) samples. This exceeds guideline recommendations; the BC field sampling manual recommends that 20 to 30% of samples consist of QA/QC samples, while the RISC (1997a) manual recommends a minimum of 10% of samples. Samples for laboratory analysis were collected in clean 1 L plastic bottles provided by a certified laboratory. Samples were packaged in clean coolers that were filled with ice packs and couriered to ALS Environmental in Burnaby within 24 to 48 hours of collection. Standard Chain of Custody procedure was strictly adhered to. ALS Environmental performed in house quality control checks including analysis of replicate aliquots, measurement of standard reference materials, and method blanks. Summaries of the quality assurance/quality control (QA/QC) qualifiers and comments from laboratory analysis are provided in Appendix A and Appendix B.

It is a common occurrence in Vancouver Island streams to have concentrations of a number of variables (notably nutrients) that are less than, or near to, the MDL. When this occurs, there are a number of different possible methods that can be used to analyze these values. In this report, any values that were less than the MDL were assigned the actual MDL values and averaged with the results of the other replicates. In these cases the 'real' average is less than the average reported.

2.2.1.3. Comparison with Guidelines for the Protection of Aquatic Life

Water quality guidelines for the protection of aquatic life and typical ranges of water quality variables in BC waters that were considered for this report are provided in Appendix C. Any results for water chemistry variables that approached or exceeded guidelines for the protection of aquatic life or ranges typical for BC are noted in Section 3.2.2.

For most water quality variables measured in this study, there are provincial water quality guidelines for the protection of aquatic life. For total phosphorus, there are no provincial guidelines; however, there are federal guidelines (CCME 2004). For the remaining variables without provincial guidelines (i.e., orthophosphate, alkalinity, and specific conductivity) there are no federal guidelines either.

2.2.2. Water and Air Temperature

2.2.2.1. Salmon River and Quinsam River Temperature Monitoring

Water and air temperature monitoring was successfully completed in Year 3. Water temperature data have now been collected at the water quality index sites on both rivers for the period May 2014 to October 2016, although there is a gap in the Salmon River dataset from October 2014 to May 2015 due to lost temperature loggers. Air temperature has been measured near-continuously throughout this period; these measurements provide data that could be used to model water temperatures elsewhere in the watershed if later required.

Water temperature was recorded at intervals of 15 minutes using self-contained TidbiT v2 loggers (Onset, MA, USA). These TidbiT loggers had an operating range of -20°C to +70°C with an accuracy of ±0.2°C and have a resolution of 0.02°C. For most of the record duration, water temperature at each of the monitoring stations was logged using duplicate TidbiT loggers installed on separate anchors. This redundancy is intended to prevent gaps in the data if one of the loggers malfunctions or is lost; however, both TidbiT loggers were lost at SAM-WQ during high flows in late October 2014, and monitoring did not resume until May 2015.

Air temperature was measured using one HOBO Air Temperature U23 Data Logger (range of -40°C to 70°C, accuracy of ±0.21°C) at each water quality index site. The temperature loggers recorded air temperature at a regular interval of 15 minutes. The loggers were placed on trees that were close (< 100 m) to each site. Temperature measurements were made near-continuously at each site between May 2014 and October 2016.

2.2.2.2. Data Analysis

Water temperature data were analyzed as follows. First, erroneous data were identified and removed. Sources of erroneous data include occasional drops in water level which can expose the sensors to the atmosphere, and high flows which can move sediment and bury the sensors. Second, the records from duplicate loggers (when available) were averaged and records from different download dates were combined into a single time-series for each monitoring station. The time series for all stations were then interpolated to a regular interval of 15 minutes, starting at the full hour.

Time series of daily average water and air temperature data were plotted; the hourly rates of change in water temperature were also plotted. Analysis of the water temperature data involved computing a range of summary statistics (Table 17) that were chosen based on the provincial water temperature guidelines for the protection of freshwater aquatic life (Oliver and Fidler 2001; Table 18). The following statistics were computed: mean, minimum, and maximum water temperatures for each month of the record; hourly rate of change of temperature; days with mean daily temperature >18°C, >20°C, and <1°C; the length of the growing season; and the accumulated thermal units in the growing season. The number of degree days in the growing season was not calculated for the Salmon River due to a lack of temperature data for the start and end dates of the growing season (data were downloaded in October) as well as due to gap in records (as mentioned above). Statistics were based on the data collected at, or interpolated to, intervals of 15 min.

Mean weekly maximum temperatures (MWMxT) were calculated for both datasets and compared to optimum temperature ranges for different fish species and their life stages as outlined in the provincial guidelines (Oliver and Fidler 2001).

Table 17. Parameters calculated based on water and air temperature data.

Parameter	Description	Method of Calculation
Monthly water- and air-temperature statistics	Average, minimum, and maximum temperatures on a monthly basis	Calculated from temperatures observed at or interpolated to 15-min intervals.
Rate of water temperature change	Hourly rate of change in water temperature	Calculated from temperatures observed at or interpolated to 15-min intervals. The hourly rate of change was set to the difference between temperature data points that are separated by one hour and was assigned to the average time for these data points.
Degree days in growing season	The beginning of the growing season is defined as the beginning of the first week that average stream temperatures exceed and remain above 5°C; the end of the growing season is defined as the last day of the first week that average stream temperature dropped below 4°C (as per Coleman and Fausch 2007).	Daily average water temperatures were summed over this period (i.e., from the first day of the first week when weekly average temperatures reached and remained above 5°C until the last day of the first week when weekly average temperature dropped below 4°C)
Number of days with extreme daily-mean temperature	>18°C , >20°C , and <1°C	Total number of days with daily-mean water temperature >18°C , >20°C , and <1°C
MWMxT	Mean Weekly Maximum Temperature	A 1-week moving-average filter is applied to the record of daily-maximum water temperatures inferred from hourly data; e.g., if MWMxT = 15°C on August 1, 2008, this is the average of the daily-maximum water temperatures for the 7 days from July 29 to August 4. MWMxT is calculated for every day of the year.

Table 18. Water temperature guidelines for the protection of freshwater aquatic life (Oliver and Fidler 2001).

Category	Guideline
All streams	the rate of temperature change in natural water bodies not to exceed 1°C/hr
	temperature metrics to be described by the mean weekly maximum temperature (MWMxT)
Streams with known fish presence	mean weekly maximum water temperatures should not exceed ±1°C beyond the optimum temperature range for each life history phase of the most sensitive salmonid species present[1]
Streams with Bull Trout or Dolly Varden	maximum daily temperatures should not exceed 15°C
	maximum spawning temperature should not exceed 10°C
	preferred incubation temperatures should range from 2- 6°C
	±1°C change from natural condition[1]
Streams with unknown fish presence	salmonid rearing temperatures not to exceed MWMxT of 18°C
	maximum daily temperature not to exceed 19°C
	maximum temperature for salmonid incubation from June until August not to exceed 12°C

[1] provided that natural conditions are within these guidelines, if they are not, natural conditions should not be altered (Deniseger, pers. comm. 2009)

2.3. Hydrology

The Water Survey of Canada measures discharge at multiple gauges on both study streams (Table 19). Available discharge data collected since the start of the study were plotted to evaluate flow conditions at the following sites downstream of the diversion facilities: 'Salmon R. above Memekay R.' and 'Quinsam R. near Campbell R.' sites (Table 19). To provide historical context, discharge was plotted alongside summary statistics (10^{th}, 50^{th} and 90^{th} percentiles) for the periods of record. At the time of reporting, quality assured historical data were only available until the end of 2015 (Year 2).

In addition, several annual hydrological metrics were calculated for each study stream to quantify key flow characteristics that have potential to influence fish productivity (Table 20). The metrics quantify the occurrence of high flows during biologically sensitive periods of the year to support analysis to test $H_0$4, which relates to floods (Section 1.4.4). For Pacific Salmon species (fall spawners), the maximum discharge during the incubation period was calculated based on the discharge measured between the start of incubation in fall the previous year, and the end of incubation during spring of the current year. Low flow metrics were also calculated for each stream to support analysis to test whether low summer flows affect the abundance of juvenile salmonids that rear in freshwater through the summer (Coho Salmon and steelhead). All metrics are based on a subset (Group 2) of the Indicators of Hydrologic Alteration (Richter *et al.* 1996) that were developed to quantify the magnitude and duration of hydrological extremes. Metrics were either calculated based on annual records of mean daily discharge (m^3/s), or using records for the spawning and incubation periods of specific fish species, based on fish periodicity information reported by Burt (2010; Salmon River) and Burt (2003; Quinsam River). Metrics were calculated using the Indicators of Hydrologic Alteration package developed for R (R Core Team 2016) by The Nature Conservancy. For the Salmon River, metrics were calculated based on discharge data collected at the gauge above Memekay River (08HD007); for the Quinsam River, metrics were calculated based on discharge data collected at the gauges at Argonaut Bridge (08HD021) and near the confluence with the Campbell River (08HD005).

Table 19. Hydrometric gauges maintained by Water Survey of Canada on the two study streams. See Map 2 and Map 3 for site locations.

Stream	Site Name	Site Code	Period of Record		Position Relative to Diversion
			Start	End	
Salmon River	Salmon R. above Campbell Lake Diversion	08HD015	1981	Ongoing	Upstream
	Salmon R. below Campbell Lake Diversion	08HD032	1981	Ongoing	Downstream
	Salmon R. above Memekay R.	08HD007	1960	Ongoing	Downstream
	Salmon R. near Sayward	08HD006	1965	Ongoing	Downstream
Quinsam River	Quinsam R. at Argonaut Bridge	08HD021	1993	Ongoing	Downstream
	Quinsam R. below Lower Quinsam Lake	08HD027	1997	Ongoing	Downstream
	Quinsam R. near Campbell R.	08HD005	1957	Ongoing	Downstream

Table 20. Hydrological metrics calculated for each study stream.

Stream	Hydrological Metric	Data Period
Salmon River	Max. discharge during Coho Salmon incubation	Oct 1–April 15
	Max. discharge during steelhead incubation	March 1–June 30
	1-day minimum discharge	Calendar year
	7-day minimum discharge	Calendar year
	30-day minimum discharge	Calendar year
Quinsam River	Max. discharge during Chinook Salmon incubation	Oct 15–April 30
	Max. discharge during Coho Salmon incubation	Oct 15–April 22
	Max. discharge during steelhead incubation	Feb 15–June 15
	Max. discharge during Pink Salmon incubation	Sep 15–April 8
	1-day minimum discharge	Calendar year
	7-day minimum discharge	Calendar year
	30-day minimum discharge	Calendar year

2.4. Invertebrate Drift

2.4.1. Sample Collection

One invertebrate drift sampling site was established on the Salmon River (Map 2, Figure 6) and one on the Quinsam River (Map 3, Figure 7), both located close (<150 m) to the water quality index sites. Sites were located in riffle or run habitats, upstream of any obvious source of debris that could clog the nets or areas that receive frequent sediment disturbance. Invertebrate sampling was conducted on a monthly basis from May to October, with weekly sampling conducted during May in Year 3 – the month that is sampled weekly is rotated between study years to quantify the variance associated with monthly data. In total, sampling occurred on nine dates on each river. Table 21 presents details of the sampling dates and times.

Invertebrate drift sampling followed methods recommended in Hatfield *et al.* (2007) and Lewis *et al.* (2013). Upon arrival at site, local areas with velocities of approximately 0.2 to 0.4 m/s were identified with a model 2100 Swoffer meter with a 7.5 cm propeller and a 1.4 m top-set rod. This range of velocities is ideal for sampling invertebrate drift as velocities are slow enough to prevent clogging of the nets. Due to flow conditions at the time of sampling, it was not always possible to deploy the nets in areas with velocities of 0.2 m/s to 0.4 m/s (as per Hatfield *et al.* 2007), and nets sampled higher or lower water velocities at times.

Five drift nets were deployed simultaneously across the channel. The mouth of each drift net was positioned perpendicular to the direction of stream flow, and nets were spaced apart to ensure that each individual net did not obstruct flow into an adjacent net. The drift net mouth dimensions were 0.3 × 0.3 m and the nets (250 μm mesh) extended 1 m behind the mouth. Nets were anchored such that there was no sediment disturbance upstream of the net before and during deployment. All nets were deployed so that the top edge of the net was above the water surface so that both invertebrate drift in the water column and on the water surface could be sampled.

At the start of sampling, measurements were made of water depth in each net and the water velocity at the midpoint of the water column that was being sampled by each net. These measurements were repeated hourly to permit calculation of the volume of water sampled with each net. Any large debris (e.g., leaves) that had entered the nets was periodically removed from the nets (after it had been washed of any invertebrates which were returned to the nets). Nets were deployed for approximately four hours on each sample date (Table 21). Once the nets were removed, the contents of all five nets were transferred into sample jars (500 mL plastic jars with screw top lids) for processing as a single sample. This is a method change from Year 1 (2014), when contents of each net were processed separately. Samples were preserved in the field with a 10% solution of formalin (formalin = 37-40% formaldehyde).

Additional invertebrate samples were collected using kick net sampling on September 13, 2016 at SAM-IV and September 14, 2016 at QUN-IV. At both sites, the CABIN standardized sampling method was followed (Environment Canada 2012), with a single drift net (described above) used as a kick net. The samples were collected and preserved in separate jars; however, the samples were mistakenly combined with the September drift samples during taxonomic analysis. This meant that the results for the samples collected on the September dates were not comparable with other drift samples, or with kick samples collected in previous years. Accordingly, results for samples collected on this date are not presented in tables and figures, although the contributions of dominant taxa to sample biomass were quantified to provide information about the combined invertebrate community present in the benthos and water column.

Table 21. Invertebrate drift sample site locations, sample timing, and sampling duration during 2016.

Stream	Site	Sample Date	UTM Coordinate (Zone 10)		Start	Finish	Sampling
			Easting (m)	Northing	Time[1]	Time[2]	Duration[3,4]
Salmon River	SAM-IV	03-May-2016	327,361	5,534,796	06:45	10:50	4:05
		10-May-2016	327,361	5,534,796	06:52	10:56	4:04
		17-May-2016	327,361	5,534,796	07:01	11:01	4:00
		24-May-2016	327,361	5,534,796	06:54	10:54	4:00
		14-Jun-2016	327,361	5,534,796	06:35	10:37	4:02
		12-Jul-2016	327,361	5,534,796	06:58	11:00	4:02
		16-Aug-2016	327,361	5,534,796	07:36	11:37	4:01
		13-Sep-2016	327,361	5,534,796	09:11	13:11	4:00
		11-Oct-2016	327,361	5,534,796	08:35	12:35	4:00
Quinsam River	QUN-IV	04-May-2016	309,304	5,556,468	06:51	10:51	4:00
		11-May-2016	309,304	5,556,468	06:58	10:58	4:00
		18-May-2016	309,304	5,556,468	07:02	11:04	4:02
		25-May-2016	309,304	5,556,468	06:45	10:46	4:01
		15-Jun-2016	309,304	5,556,468	06:32	10:32	4:00
		13-Jul-2016	309,304	5,556,468	07:00	11:07	4:07
		17-Aug-2016	309,304	5,556,468	07:38	11:38	4:00
		14-Sep-2016	309,304	5,556,468	08:30	12:36	4:06
		12-Oct-2016	309,304	5,556,468	08:39	12:39	4:00

[1] Indicates when the first net was set

[2] Indicates when the last net was removed

[3] Indicates the time duration between the first and last net retrieved

[4] For data analysis, start and finish times for individual nets were used to calculate the volume of water filtered for each net

Figure 6. View upstream towards SAM-IV, July 12, 2016.

Figure 7. View downstream from river right towards QUN-IV, May 11, 2016.

2.4.2. Laboratory Processing

Samples were sent to Ms. Dolecki of Invertebrates Unlimited in Vancouver, BC for processing. Ms. Dolecki is a taxonomist with Level II (genus) certification for Group 2 (Ephemeroptera, Plecoptera, and Trichoptera (EPT)) and for Chironomidae from the North American Benthological Society.

The drift and kick net samples were first processed by removing the formalin (pouring it through a 250 μm sieve), followed by immediate picking of the very large and rare taxa. Samples were split into subsamples if the number of invertebrates was over 1,000. The invertebrates were enumerated using a Leica stereo-microscope with 6 to 8 × magnification, with additional examination of crucial body parts undertaken at higher magnifications (up to 400 ×) using an Olympus inverted microscope where necessary. Individuals from all samples were identified to the highest taxonomic resolution possible and it was noted whether a taxon was aquatic, semi-aquatic, or terrestrial. Life stages were also recorded.

Digitizing software (Zoobbiom v. 1.3; Hopcroft 1991) was used to measure the length and biomass (mg dry weight) of a sub-sample of individuals, with the average biomass of individuals in each taxon calculated. For abundant taxa, up to 25 randomly chosen individuals per taxon were digitized to address the variability in size structure of the group. For the rare taxa, all individuals in the taxon were measured. The damaged or partial specimens were excluded from the measurements. For pupae and emerging Chironomidae, up to 50 individuals were measured.

To provide QA/QC, all the samples were re-picked a second time to calculate the accuracy of picking. This assured that > 90% accuracy was attained, and the accuracy of the methods employed is expected to be over 95%.

2.4.3. Data Analysis

Variables were chosen and calculated as per Lewis *et al.* (2013), and all taxa (aquatic, semi-aquatic, and terrestrial) were considered. Density (# of individuals) and biomass (mg dry weight) of each sample were expressed as units per m^3 of water, where volume is the amount of water that was filtered through a single net during a set. Volume filtered by each net was calculated based on the duration that the nets were deployed and the average discharge measured at each net.

Family richness (i.e., the number of families present) was calculated for each sample. Simpson's diversity (1-λ, Simpson 1949) was calculated from family level density data to provide a measure that reflects both richness and the relative distribution or 'evenness' of invertebrate communities. The Canadian Ecological Flow Index (CEFI) was calculated using family level data for aquatic taxa following Armanini *et al.* (2011). Taxa present in <5% of the samples were not excluded from the CEFI calculation (Armanini, pers. comm. 2013). Relative abundances of taxa at each site were calculated considering only aquatic taxa, and only aquatic taxa used to develop the CEFI index were considered when calculating the index. The top five families contributing to biomass at each site on each date were also identified.

PRIMER (Plymouth Routines in Multivariate Ecological Research) v. 6 software was used to generate a Bray-Curtis similarity matrix for samples collected from each study stream. The similarity matrix was generated from square-root-transformed density data for aquatic, semi-aquatic, and terrestrial taxa at the highest taxonomic resolution available for each taxon. The square root transformation down-weights the effect of the most abundant taxa, allowing for a better representation of the invertebrate community as a whole, rather than having similarity measures dominated by only the most abundant taxa. The similarity matrix was generated by calculating a similarity coefficient for all possible pairs of sample dates with respect to the taxonomic composition and abundance of different taxa on both sample dates.

The resulting Bray-Curtis similarity matrices were then examined using cluster analysis dendrograms in PRIMER to detect similarities among samples. The clustering method used is a hierarchical clustering with group-average linking. The method takes a Bray-Curtis similarity matrix as a starting point and successively fuses the samples into groups, and the groups into larger clusters. The method starts with the highest mutual similarities, and then gradually lowers the similarity level at which groups are formed. The significance level for clustering was set at 5% using the SIMPROF tool in PRIMER (1000 permutations were used to calculate the mean similarity profile and 999 to generate the null distribution of the departure statistic). Further discussion of the cluster analysis can be found in Clarke and Warwick (2001) and Clarke and Gorley (2006).

The Bray-Curtis similarity matrices were also examined using non-metric, multi-dimensional scaling (MDS) ordination plots in PRIMER to detect trends in similarity among samples. MDS uses an algorithm that successively refines the positions of the points (samples) until they satisfy, as closely as possible, the dissimilarity between samples (Clarke and Warwick 2001). This algorithm was repeated 1,000 times for each similarity matrix (i.e., with density from each site on each date as samples). The result is a two-dimensional ordination plot in which points that are close together represent samples that are very similar in community composition with respect to the taxa present and their abundances. Conversely, points that are far apart represent samples with a very different community composition. Further discussion of the MDS analysis can be found in Clarke and Warwick (2001) and Clarke and Gorley (2006).

3. RESULTS

3.1. Fish Population Assessments

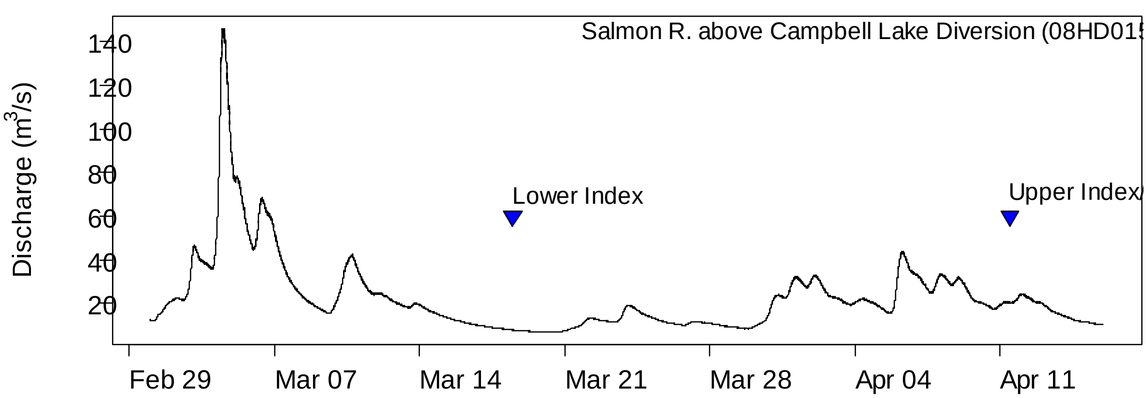
3.1.1. Salmon River Adult Steelhead Survey

All three reaches were successfully surveyed in 2016, with survey timings consistent with historical surveys. Surveys were conducted during near-baseflow conditions (Figure 8); estimated visibility was 6–9 m and water temperatures were 4.0–7.0°C (Table 22).

Survey observations are presented in Table 23; 2016 adult steelhead counts are summarized in Figure 9. Adult steelhead density was highest in the lower sections of both the Upper Index reach (5.4 fish/km) and the Lower Index reach (5.1 fish/km; Table 23). Overall, adult steelhead density was lowest in the Rock Creek reach (0.6 fish/km; Table 23), which was the only survey reach upstream of the diversion dam. Low numbers of steelhead redds were observed, with a total of four redds observed upstream of the diversion dam and five redds observed downstream of the diversion dam (Table 23). Adult steelhead were predominantly moderately coloured or in mid-spawn condition, with no clear difference in condition between reaches. Few steelhead were in bright condition; e.g., 8% of individuals in the Lower Index (surveyed first) were classified as 'bright', compared with 26% in Year 1 (2014) and 50% in Year 2 (2015). Low numbers of trout were incidentally recorded in all reaches (a total of two Rainbow Trout and one Cutthroat Trout), although this partly reflects that crews were unable to record resident trout with fork length < 250 mm in the lower reach of the Lower Index due to time constraints[3].

Adult steelhead abundance was low relative to historical counts (Figure 10–Figure 12). The total count for the Lower Index reach (50) was the fifth lowest count out of the 19 years sampled and was approximately equal to the 20th percentile of the dataset. This count was higher than the count for Year 1 (39) but lower than the count for Year 2 (72). The total count for the Upper Index reach (47) was the lowest of the nine years that have been sampled. Similarly, total abundance for the Rock Creek reach (4; upstream of the diversion dam) was low relative to historical counts, which have exhibited high variability (range: 0–70). Survey conditions (i.e., visibility and flow; Table 22) were comparable with previous years and fish condition observations (Figure 9) indicate that the surveys were appropriately scheduled to sample adult fish abundance, i.e., fish condition indicated that surveys were undertaken approximately during the middle of the spawning period. Thus, results show that adult steelhead abundance was low overall in 2015, both upstream and downstream of the diversion dam.

Figure 8. Instantaneous discharge measured at the WSC gauge upstream of the Salmon River Diversion (Map 2) during 2016 adult steelhead surveys (triangles). Data from WSC (2016).



[3] 44 Cutthroat Trout were recorded in this section in 2015 when crews recorded all trout that were observed.

Table 22. Salmon River adult steelhead survey details and conditions, 2016.

Date	Survey reach	Section	Upstream limit	Downstream limit	Distance (km)	Time in	Time out	# swimmers	Total effort (hh:mm)	Air T[1] (°C)	Water T (°C)	Visibility (m)
2016-04-11	Rock Creek	N/A	Rock Creek Mainline Bridge	Diversion Dam	6.2	11:07:00	14:00:00	2	5:46	12.0	6.5	6
2016-04-11	Upper Index	Upper	Diversion Dam	Memekay Mainline Bridge	5.6	11:35:00	13:45:00	2	4:20	12.0	6.5	7
		Lower	Memekay Mainline Bridge	Norberg Creek Confluence	5.9	11:00:00	13:05:00	2	4:10	9.5	7.0	7
2016-03-18	Lower Index	Upper	Cable crossing nr Kay Creek confluence	Big Tree Creek confluence	7.2	10:00:00	13:30:00	2	7:00	7	4.0	6
		Lower	Big Tree Creek confluence	Pallans	4.3	11:10:00	13:45:00	2	5:10	7	4.5	9

1. T, temperature

Table 23. Salmon River snorkel survey observations, 2016.

Date	Reach	Section	Species[1]	Total observed	Density (#/km)	Adult fork length (mm)						Marks	Redd count	Sex (ST only)		
						Fry	Parr	151–250	251–350	351–450	450+			M	F	UNK
2016-04-11	Rock Creek	N/A	ST	4	0.6	0	0	0	0	0	4	0	4	1	2	1
			RB	1	0.2	0	0	0	1	0	0	0	0	N/A	N/A	N/A
2016-04-11	Upper Index	Upper	ST	15	2.7	0	0	0	0	0	15	0	2	8	3	4
		Lower	ST	32	5.4	0	0	0	0	0	32	0	2	16	14	2
2016-03-18	Lower Index	Upper	ST	28	3.9	0	0	0	0	0	28	0	0	11	7	10
			RB	1	0.1	0	1	0	0	0	0	0	0	N/A	N/A	N/A
		Lower[2]	ST	22	5.1	0	0	0	0	0	22	0	1	11	11	0
			CT	1	0.2	0	0	0	0	1	0	0	0	N/A	N/A	N/A

1. ST, steelhead; RB, resident Rainbow Trout; CT, Cutthroat Trout

2. Additional trout were observed; only trout > 250 mm were recorded.

Figure 9. Salmon River adult steelhead total counts and condition, 2016. Note that counts were conducted on different dates (Table 22).

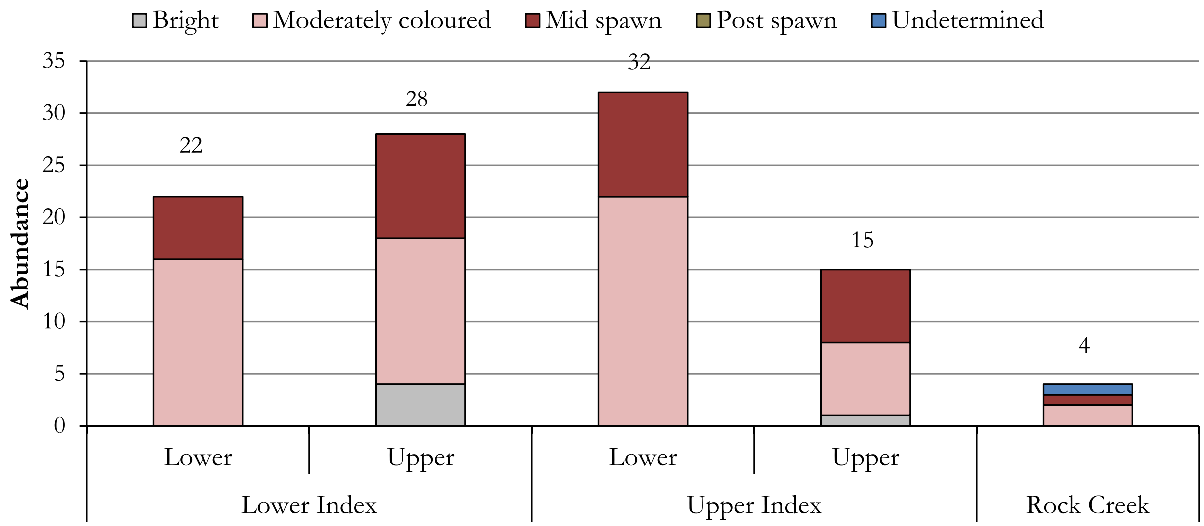


Figure 10. Historical and 2016 adult steelhead counts for the Lower Index reach, Salmon River. Absence of bars for some years indicates that no survey was conducted. Historical data (pre-JHTMON-8) from Pellett (2013). Dashed horizontal lines denote percentiles.

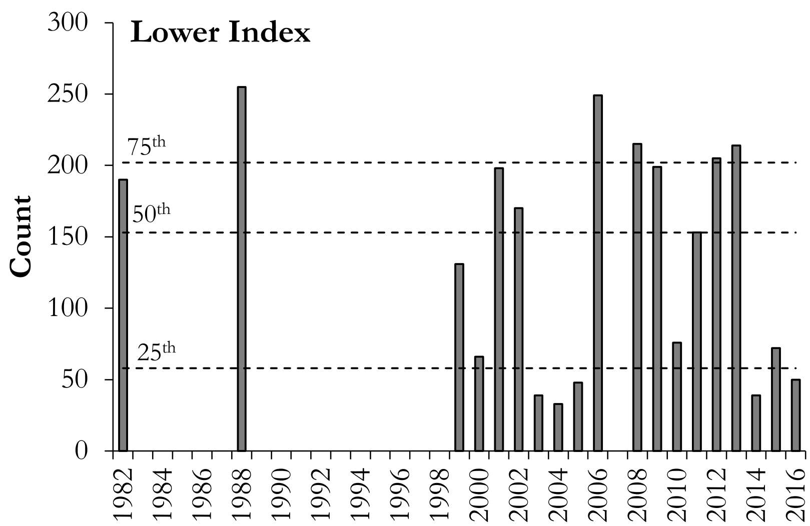


Figure 11. Historical and 2016 adult steelhead counts for the Upper Index reach, Salmon River. All data relate to surveys undertaken in April. Dashed horizontal lines denote percentiles.

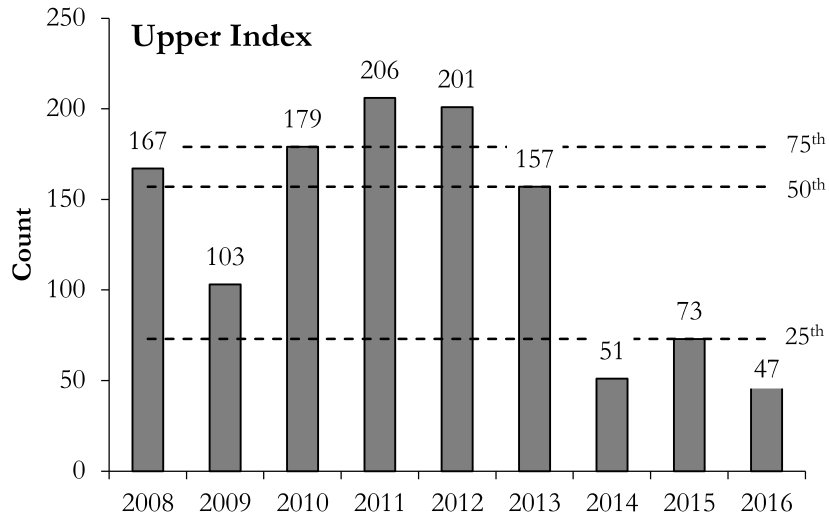
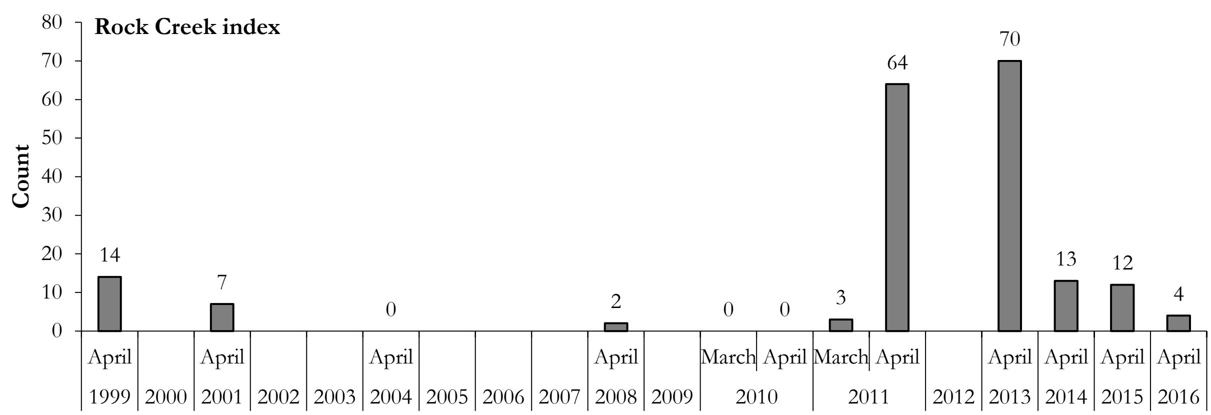


Figure 12. Historical and 2016 adult steelhead counts for the Rock Creek Index reach, Salmon River. Absence of bars for some years indicates that no survey was conducted, unless labelled '0'. Pre-JHTMON-8 data from Pellett (2013).



3.1.2. Salmon River Juvenile Steelhead Abundance

3.1.2.1. Flow and Habitat

Electrofishing was undertaken on September 6–8, 2016, consistent with the timing of historical sampling. Flow conditions were appropriate for effective sampling (Figure 13); discharge measured upstream of the diversion dam (WSC gauge 08HD015) was 3.15–4.44 m^3/s and discharge measured downstream of the diversion dam (WSC gauge 08HD032) was 2.92–4.30 m^3/s.

Habitat characteristics of the ten sites sampled for juvenile steelhead in 2016 are shown in Table 24. All sites were located in riffle mesohabitat; site areas ranged from 76.0 m^2 to 110.6 m^2. Gradient varied between 1.0% and 2.0%; water temperature during sampling varied between 11.7°C and 15.0°C (Table 24). Boulder or cobble were the dominant cover and substrate type, except for SAM-EF01B, where large woody debris was the dominant cover type and large gravel was the dominant (40%) substrate type.

Figure 13. Closed-site electrofishing at SAM-EF01B on September 8, 2016.

Table 24. Habitat characteristics for juvenile steelhead abundance sampling sites in the Salmon River watershed, 2016.

Location	Site	Meso-habitat	Site Length (m)	Site Width (m)	Site Area (m^2)	Gradient (%)	Water Temp. (˚C)	Cover Type[1] D	Cover Type[1] SD	Substrate Composition (%)[2] BR	BO	CO	LG	SG	F
Below Diversion	SAM-EF01B	Riffle	16.7	5.2	87.0	2.0	15.0	LWD	UC/CO	0	0	25	40	20	15
	SAM-EF02	Riffle	10.8	8.4	90.7	1.0	14.5	CO	BO	0	10	50	25	15	0
	SAM-EF03	Riffle	16.4	5.7	92.8	2.0	14.0	BO	CO	0	40	30	20	10	0
	SAM-EF04	Riffle	14.7	6.8	100.0	2.0	13.0	BO	CO	0	40	30	15	10	5
	SAM-EF07	Riffle	16.8	5.0	83.4	1.0	12.0	BO	CO	0	50	30	10	5	5
Above Diversion	SAM-EF05	Riffle	17.1	6.2	105.3	2.0	11.7	BO	CO/OV	0	25	25	25	20	5
	SAM-EF06	Riffle	8.8	8.7	76.0	2.0	12.0	BO	OV/LWD	0	40	40	15	2	3
	SAM-EF08	Riffle	13.9	7.9	109.5	2.0	12.6	CO	OV/LWD/BO	0	15	60	20	3	2
	SAM-EF09	Riffle	19.3	5.7	110.6	1.0	13.0	CO	BO	0	10	70	10	5	5
	SAM-EF10	Riffle	15.8	6.5	102.4	2.0	12.5	CO	BO	0	30	40	25	5	0

[1] D = Dominant, SD = Sub-dominant, LWD = Large woody debris, B = Boulders, CO =Cobble, UC = Undercut banks, OV = Overhanging vegetation

[2] BR = Bedrock, BO = Boulder, CO = Cobble , LG = Large gravel, SG = Small gravel, F = Fines

3.1.2.2. Catch Summary

Electrofishing effort varied from 1,811 seconds to 2,479 seconds among sites, with three passes completed at eight sites, and two passes completed at two sites (Table 25). In total, 245 juvenile steelhead were captured; 104 fish were captured in sites downstream of the diversion and 141 fish were captured upstream of the diversion. The average catch per site was 21 fish downstream of the diversion and 28 fish upstream of the diversion.

Table 25. Sampling effort and catch summaries for juvenile steelhead sites sampled in the Salmon River watershed, September 2016.

Location	Site	Date	Total Electrofishing Effort (sec)[1]				Electrofishing Catch (# of RB)[1]			
			Pass 1	Pass 2	Pass 3	Total	Pass 1	Pass 2	Pass 3	Total
Below Diversion	SAM-EF01B	08-Sep-16	1,005	806	n/a	1,811	7	0	n/a	7
	SAM-EF02	08-Sep-16	1,054	820	605	2,479	6	1	0	7
	SAM-EF03	07-Sep-16	893	643	628	2,164	44	8	4	56
	SAM-EF04	07-Sep-16	984	670	628	2,282	13	5	4	22
	SAM-EF07	07-Sep-16	795	680	602	2,077	8	3	1	12
		Below Diversion Total				**10,813**				**104**
		Below Diversion Average				**2,163**				**21**
Above Diversion	SAM-EF05	7-Sep-16	950	611	655	2,216	24	5	1	30
	SAM-EF06	6-Sep-16	902	760	605	2,267	7	2	0	9
	SAM-EF08	6-Sep-16	1,032	805	n/a	1,837	35	4	n/a	39
	SAM-EF09	6-Sep-16	830	653	611	2,094	21	10	2	33
	SAM-EF10	6-Sep-16	827	617	650	2,094	21	9	0	30
		Above Diversion Total				**10,508**				**141**
		Above Diversion Average				**2,102**				**28**
	Combined Total					**21,321**				**245**
	Combined Average					**2,132**				**25**

[1] "n/a" indicates that an electrofishing pass was not completed.

3.1.2.3. Juvenile Steelhead Length-Weight Relationships

Juvenile steelhead fork length ranged from 47 mm to 127 mm below the diversion, and 36 mm to 136 mm above the diversion (Figure 14). The distribution shows a clear peak between 45 mm and 65 mm. The low frequency of larger fish greater than 80 mm reflects the focus on sampling age 0+ fry.

Scale samples were analyzed to determine age for 17 juvenile fish at the Ecofish laboratory in Campbell River, BC. Based on review of these results (Figure 15) and the fork length histograms (Figure 14), discrete fork length ranges were defined for each age class and year. Fish with fork length ≤ 80 mm were classed as fry (0+) and those measuring between 83 mm and 136 mm were classed as aged 1+. No fish had fork length of 81 mm to 82 mm and no fish larger than 136 mm were captured. No 2+ fish were captured in 2016.

Figure 14. Fork length histogram for juvenile steelhead captured in the Salmon River watershed, September 2016.

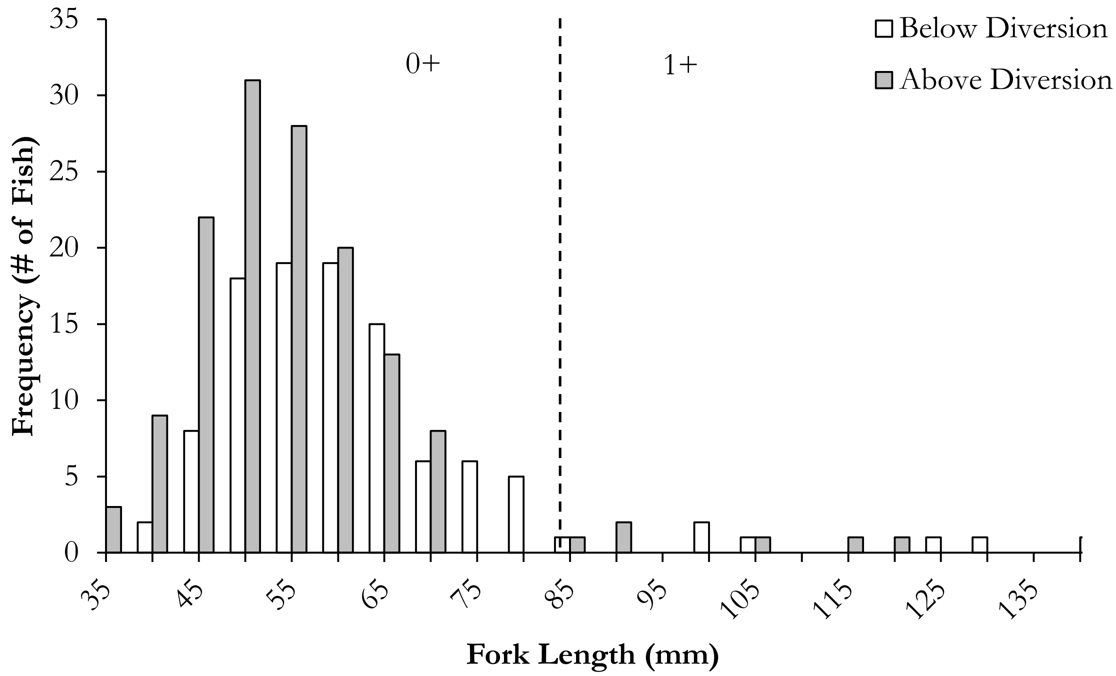


Figure 15. Length at age of juvenile steelhead captured in the Salmon River watershed, September 2016.

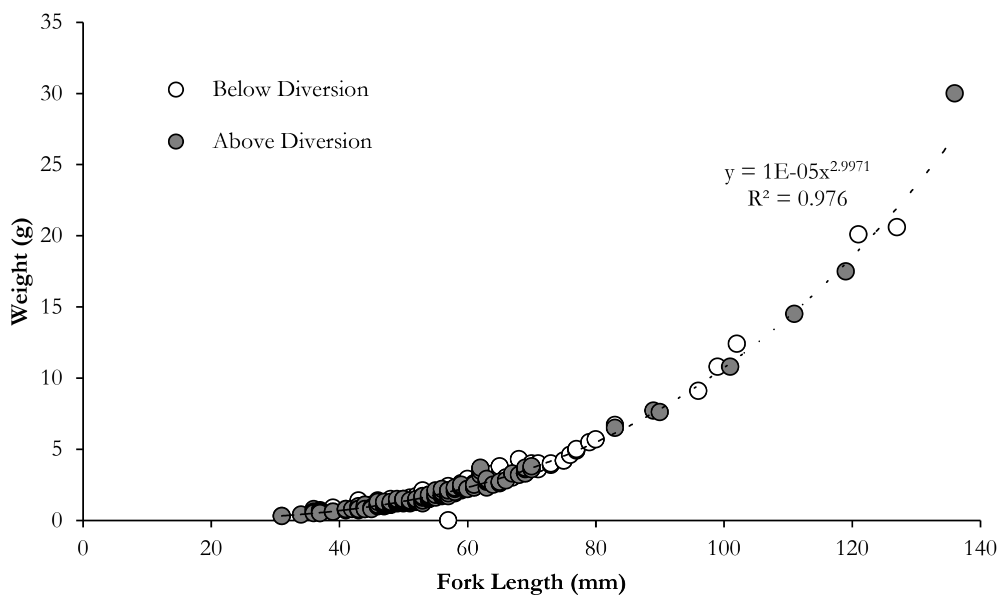
Fork length was measured for all 245 juvenile steelhead captured in 2016, and weight was also measured for 244 fish (Table 26). Length-weight relationships for the 244 fish are shown in Figure 16. These relationships are well-described by a power function, which indicates that fork length accounts for 98% of the variance in juvenile steelhead weight.

Table 26 shows the fork length, weight and condition of juvenile steelhead. Overall, the average condition was similar among age classes, and averaged 1.08 above the diversion and 1.13 below the diversion. These values approximate the nominal condition factor of 1.10 that the BC Ministry of Environment deems representative of well-conditioned juvenile Rainbow Trout/steelhead (Ptolemy, pers. comm. 2016). On average, 0+ fry sampled below the diversion had higher fork length (57 mm compared with 51 mm) and greater weight (2.3 g compared with 1.6 g) than 0+ fry sampled above the diversion.

Table 26. Summary of fork length, weight and condition of juvenile steelhead captured during electrofishing at 10 sites in the Salmon River watershed in 2016.

Location	Age	Fork Length (mm)				Weight (g)				Condition Factor (K)			
	Class	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Below Diversion	0+	98	57	37	80	97	2.3	0.5	5.7	97	1.13	0.92	1.76
	1+	6	105	83	127	6	13.3	6.7	20.6	6	1.10	1.01	1.17
Combined Total		104	60	37	127	103	2.9	0.5	20.6	103	1.13	0.92	1.76
Above Diversion	0+	134	51	31	70	134	1.6	0.3	3.8	134	1.08	0.81	1.71
	1+	7	104	83	136	7	13.5	6.5	30.0	7	1.09	1.04	1.19
Combined Total		141	54	31	136	141	2.2	0.3	30.0	141	1.08	0.81	1.71

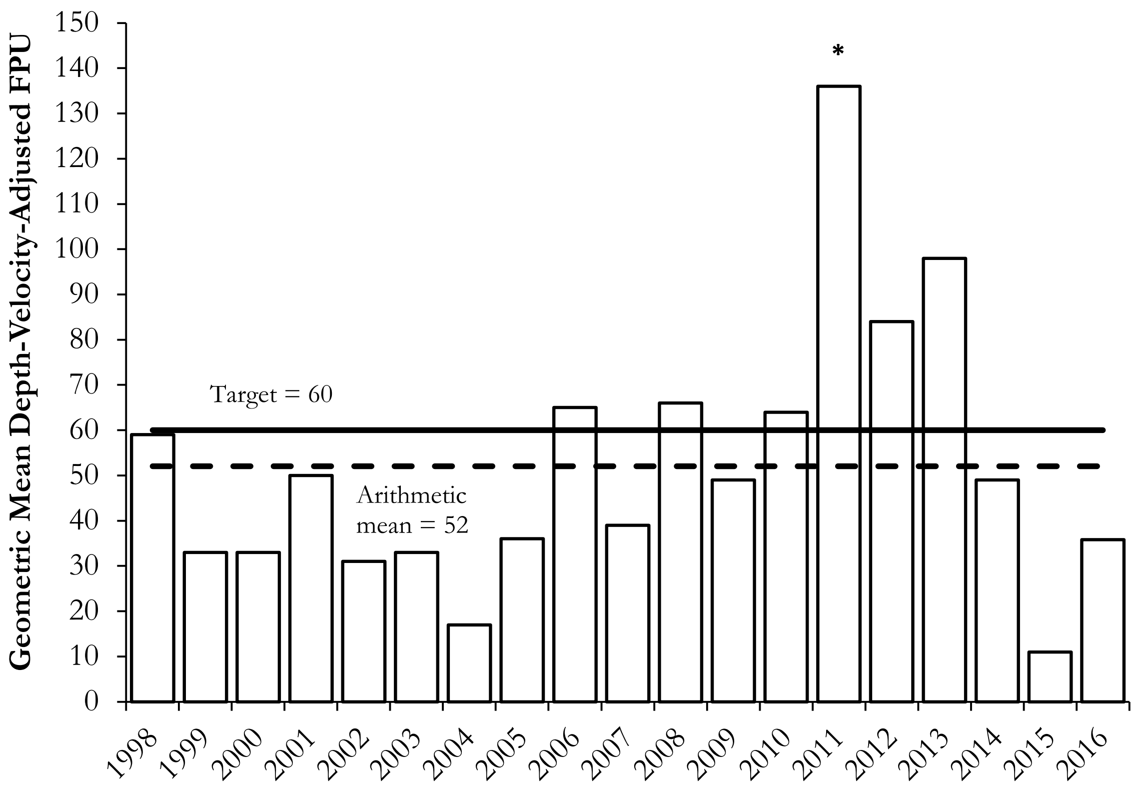
Figure 16. Length-weight regressions for juvenile steelhead (*n* = 244) captured in the Salmon River watershed, September 2016.



3.1.2.4. Fish Abundance

The geometric mean depth-velocity-adjusted-abundance in 2016 was 36 fry per 100 m^2 (fry per unit/FPU), which is below the precautionary target of 60 FPU set for the watershed by provincial biologists. The target of 60 FPU was based on a predicted juvenile Rainbow Trout/steelhead capacity of 162 g/100 m^2 (Lill 2002) and assumes a mean fry weight of 2.7 g (Pellett 2014). The mean FPU was below the arithmetic mean for the sampling period (1998–2016; 52 FPU) and intermediate between the values for the previous two years of the JHTMON-8 program: 2014 (49 FPU) and 2015 (11 FPU).

Figure 17. Geometric mean depth-velocity-adjusted-abundance of steelhead fry (fry per unit, FPU) sampled in the Salmon River watershed in 1998–2016.



* Only sites upstream of the diversion dam were sampled in 2011 (Pellet 2011b)

The density of steelhead fry in the Salmon River and tributaries was variable among sites in 2016 (Figure 18), with a coefficient of variation of 82%. Variability among sites was greatest downstream of the diversion dam. The highest density of fish was observed at SAM-EF03 (146 FPU), and the lowest density at SAM-EF02 (11 FPU). On average, fry density did not differ substantially between sites upstream and downstream of the diversion; mean observed density was slightly higher upstream of the diversion (25.7 FPU compared to 21.5 FPU), but the adjusted density was higher downstream of the diversion (53.9 FPU compared to 43.7 FPU), reflecting higher average habitat usability at the sites upstream of the diversion (62% compared with 47%). Mean depth-velocity adjusted biomass at sites upstream of the diversion (69.5 g/100m^2) was 42% lower than at sites downstream of the diversion (119.0 g/100m^2), reflecting lower adjusted fry density and lower mean weight at sites upstream of the diversion.

Figure 18. Depth-velocity-adjusted steelhead fry abundance (fish per unit area; FPU) sampled at each site in the Salmon River watershed in 2016.

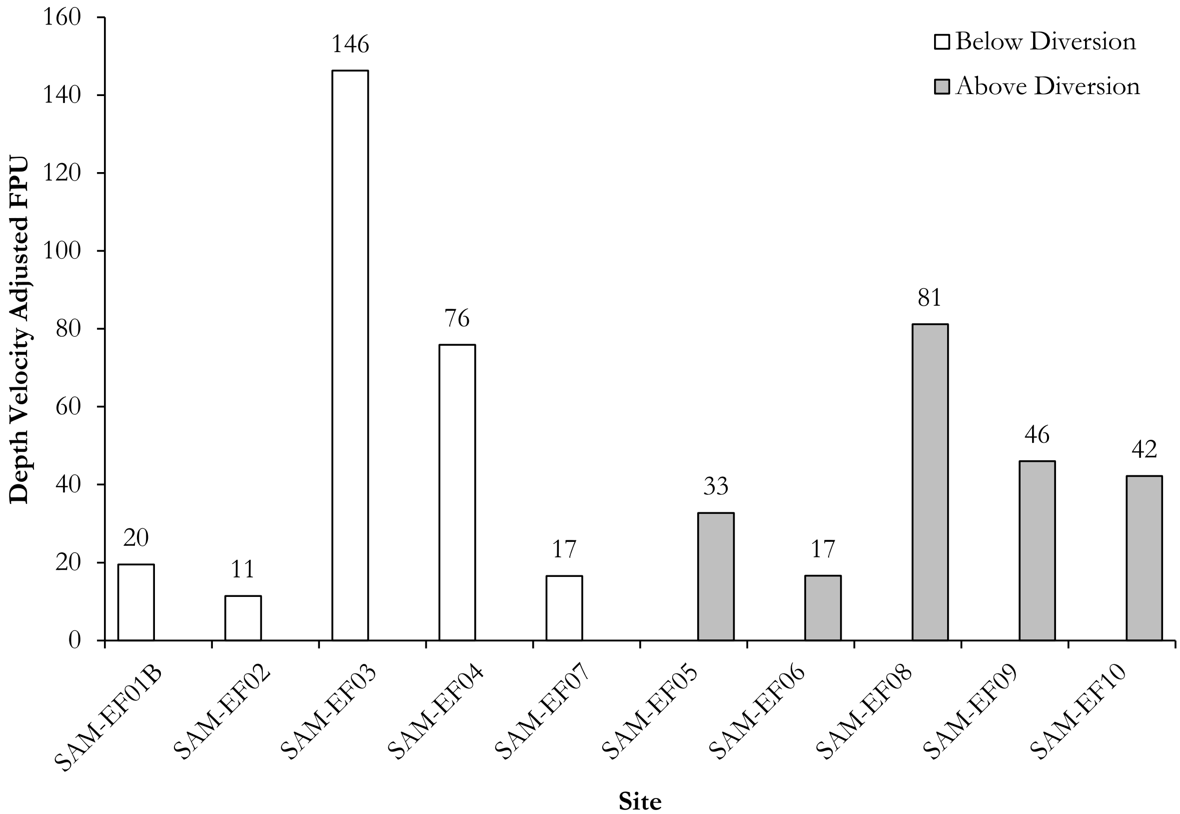


Table 27. Steelhead fry abundance and biomass results from electrofishing sites located upstream and downstream of the Salmon River Diversion, September 2016.

Location	Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]		Maximum Densities[5,6]	
			FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)	FPU_{max} (#/100 m^2)	BPU_{max} (g/100 m^2)
Below Diversion	SAM-EF01	35%	6.9	26.4	19.5	74.8	59	224.9
	SAM-EF02	68%	7.7	21.8	11.4	32.3	80	224.9
	SAM-EF03	41%	59.3	105.0	146.3	259.3	127	224.9
	SAM-EF04	32%	24.0	49.4	75.9	156.2	109	224.9
	SAM-EF07	58%	9.6	41.9	16.6	72.2	52	224.9
	Mean	**47%**	**21.5**	**48.9**	**53.9**	**119.0**	**85.2**	**224.9**
Above Diversion	SAM-EF05	78%	25.6	57.1	32.7	72.9	101	224.9
	SAM-EF06	55%	9.2	24.5	16.6	44.1	85	224.9
	SAM-EF08	42%	33.8	51.7	81.2	124.1	147	224.9
	SAM-EF09	67%	30.7	46.1	46.0	69.0	150	224.9
	SAM-EF10	69%	29.3	25.9	42.2	37.3	255	224.9
	Mean	**62%**	**25.7**	**41.0**	**43.7**	**69.5**	**147.4**	**224.9**
All Sites Combined	**Mean**	**54%**	**23.6**	**45.0**	**48.8**	**94.2**	**116.3**	**224.9**

[1] FPU_{obs} = Observed fish per unit (100 m^2) based on population estimates computed using MicroFish V3.0
[2] BPU_{obs} = Biomass of fish per unit (100 m^2) based on population estimates computed using MicroFish V3.0
[3] FPU_{adj} = FPU_{obs}/Usability (%)
[4] BPU_{adj} = BPU_{obs}/Usability (%)
[5] FPU_{max} = Theoretical maximum biomass/mean weight (g) of the age class (by site)
[6] BPU_{max} = Theoretical maximum biomass based on mean growing season alkalinity measured at SAM-WQ in Year 1 and 2 (19.7 mg/L as $CaCO_3$) and a model provided by R. Ptolemy (Rivers Biologist, Ministry of Environment) ((alkalinity^0.62)×36). Note that this is extremely similar to the value that has been historically reported (224.5 g/100 m^2) based on an older, slightly different model and historic alkalinity measurements (e.g., see BCCF 2013).

Figure 19 shows the geometric mean depth-velocity adjusted fish density for sites above and below the diversion since 1998. In 2016, the geometric mean density was slightly higher for sites upstream of the diversion (39 FPU) compared with sites downstream of the diversion (33 FPU), although the difference between the two groups of sites was minor relative to some other years. The general result (i.e., higher mean density upstream of the diversion) was counter to that based on arithmetic means (Table 27). Geometric mean values are used here to compare results among years because these values are less sensitive to the influence of particularly low or high values (e.g., SAM-EF03) than the arithmetic mean.

Figure 20 shows geometric mean adjusted densities of steelhead fry compared with the peak adult steelhead count from the 11.5 km Lower Index reach on the Salmon River (Kay Creek to Pallans). The general positive relationship between the two variables indicates that spawning and rearing habitats are not at carrying capacity, i.e., increased peak adult density is correlated with increased fry density the following years, indicating that habitats are not fully seeded. The 2016 datum indicates that, although steelhead fry and adult density were low overall, the relationship between fry and adult density was consistent with historical data, i.e., the data point lies close to the regression line. This suggests that early juvenile survival in 2016 was average relative to previous years.

Figure 19. Geometric mean depth-velocity-adjusted juvenile steelhead (all age classes) fish per unit area (FPU) at sites upstream and downstream of the Salmon River Diversion, 1998–2016.

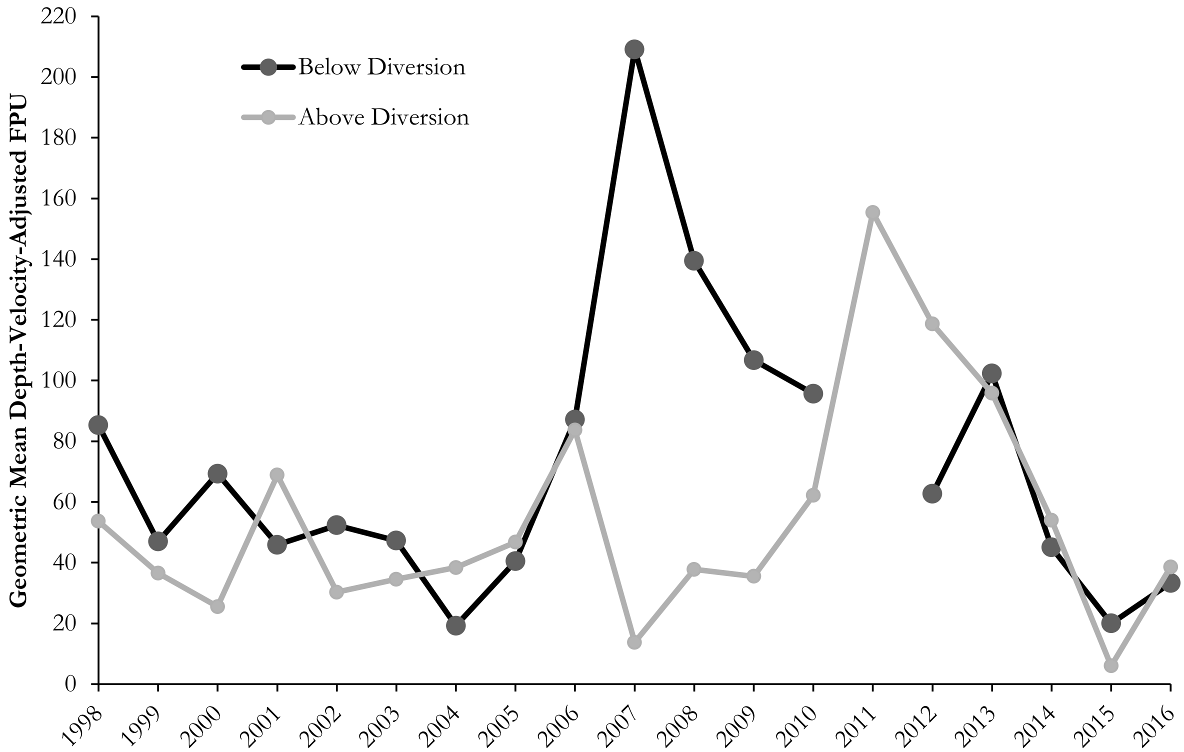
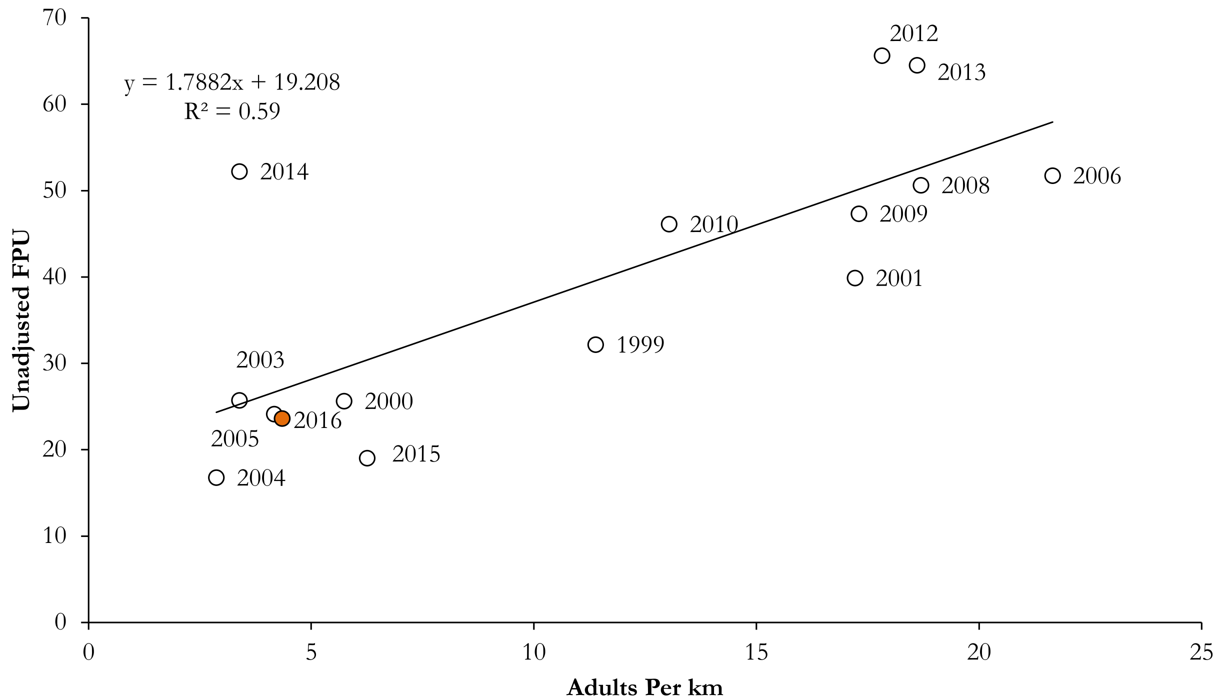


Figure 20. Geometric mean annual juvenile steelhead fish per unit (FPU) vs. adult steelhead counts in the Lower Index reach during the previous year.



3.1.3. Salmon River Juvenile Coho Salmon Abundance

3.1.3.1. Flow and habitat

Juvenile Coho Salmon sampling site characteristics are summarized in Table 28. In Year 3, sampling was conducted on September 22 and 23, 2016, consistent with previous years. Flows during 2016 sampling (3.4–3.8 m^3/s; Table 28) were suitable for effective sampling.

At each site, the total sampling area ranged from 117 m^2 to 224 m^2, with 89% to 99% of the area containing water >0.1 m deep. Water temperatures ranged from 7.8°C to 13.0°C. The warmest temperature was measured at SAM-BS04 (Paterson Creek), which is downstream of the diversion (Map 2). The coldest temperature was recorded upstream of the diversion at SAM-BS01 (Crowned Creek). The water depth was sufficiently low at all sites to permit effective sampling of the entire site (maximum depths 0.4 m to 1.2 m).

Table 28. Salmon River watershed juvenile Coho Salmon sampling site characteristics, 2016.

Location	Site	Sampling Date	Total Area (m^2)	Area >0.1 m Deep (%)	Water Temp. (°C)	Habitat Type	Max. Depth (m)	Discharge at Salmon R. Above Campbell Lake Diversion[1]
Upstream of Diversion	SAM-BS01	22-Sep-2016	132	89%	7.8	Riffle	0.4	3.416
	SAM-BS02	22-Sep-2016	156	98%	10.0	Pool	0.9	3.416
	SAM-BS03B	22-Sep-2016	224	98%	12.0	Pool	1.2	3.416
Downstream of Diversion	SAM-BS04	22-Sep-2016	130	98%	13.0	Pool	1.2	3.416
	SAM-BS05	23-Sep-2016	139	99%	10.9	Riffle	0.9	3.834
	SAM-BS06B	23-Sep-2016	117	93%	11.9	Glide	0.8	3.834

[1] Discharge data from WSC (2016); Gauge #08HD015, discharge at 12:00, m^3/s

3.1.3.2. Catch Results

Catch results for individual sites are summarized in Table 29. In 2016, no juvenile Coho Salmon were caught at SAM-BS01 (consistent with 2014 and 2015), located upstream of the diversion in Crowned Creek (Table 29). A total of 24 to 157 Coho Salmon fry were caught in 3–4 passes at each of the remaining sites; estimated fry density ranged from 0.23 fish/m^2 to 1.11 fish/m^2 at these sites. The total number of juvenile Coho Salmon caught in 2016 was 420.

Fork length-frequency data for sites upstream and downstream of the Salmon River Diversion are summarized in Figure 21. Juvenile Coho Salmon ranged from 41 mm to 95 mm in length (Figure 21). The fish upstream of the diversion were generally smaller than those downstream of the diversion. Upstream of the diversion, the modal fork-length category was 48–54 mm (53% of fish), whereas the modal fork length category was 60–64 mm downstream of the diversion (26% of fish). All three fish >89 mm were caught in the downstream sites.

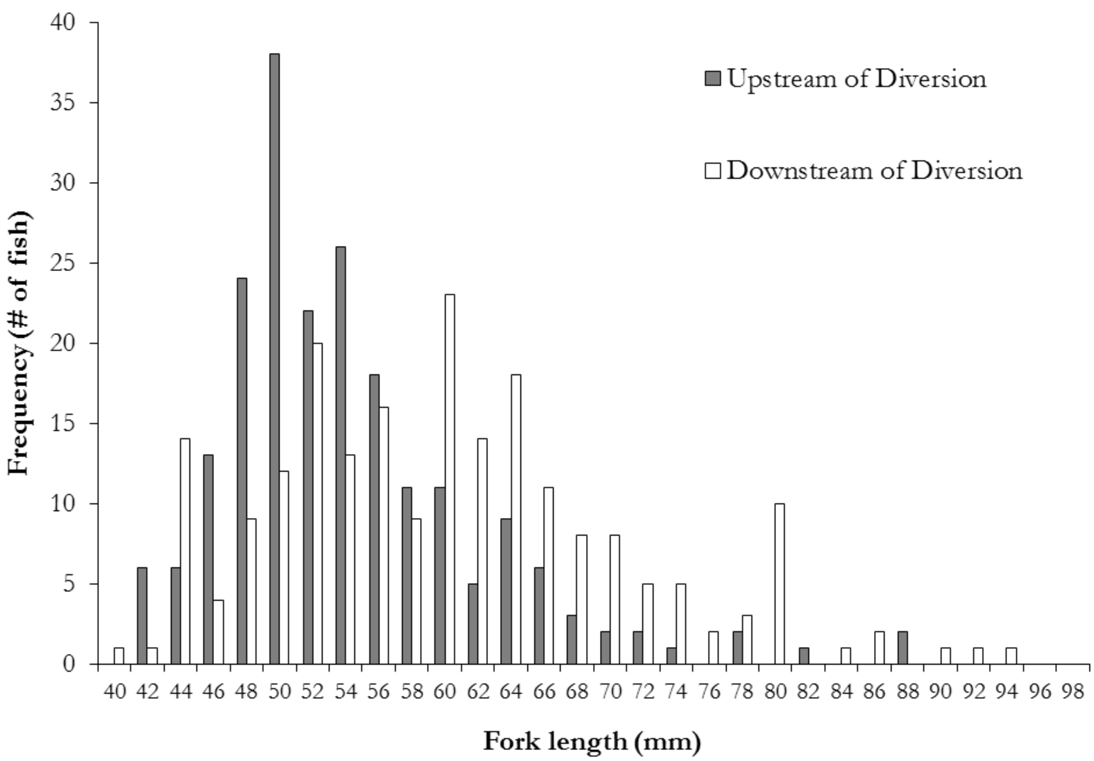
Based on the results of scale analysis, all of the juvenile Coho Salmon caught in 2016 were aged 0+ (i.e., they emerged in 2016). In 2015, only three fish aged 1+ were caught, with one fish caught at each of the three sites downstream of the diversion. In 2014, 1+ Coho Salmon comprised 6–28% of catches at each of the five sites where fish were caught. No 2+ Coho Salmon were caught in any year.

Table 29. Salmon River watershed juvenile Coho Salmon catch results, 2016.

Location	Site	# of Passes	Area (m^2)	Catch Results (# of Fry) Total	0+	1+	2+	Mean Weight (g)	Estimated Fry Abundance[1]	Estimated Fry Density (#/m^2)[1]
Upstream of Diversion	SAM-BS01	2	1	0	0	0	0	n/a	0	0.00
	SAM-BS02	3	1	51	51	0	0	2.2	53	53.91
	SAM-BS03B	4	1	157	157	0	0	2.0	186	188.98
Downstream of Diversion	SAM-BS04	4	1	127	127	0	0	2.7	141	143.58
	SAM-BS05	4	1	61	61	0	0	2.5	62	62.42
	SAM-BS06B	4	1	24	24	0	0	5.2	25	26.51

[1] Following adjustment for capture efficiency

Figure 21. Fork length-frequency histogram of juvenile Coho Salmon captured in the Salmon River watershed, 2016.

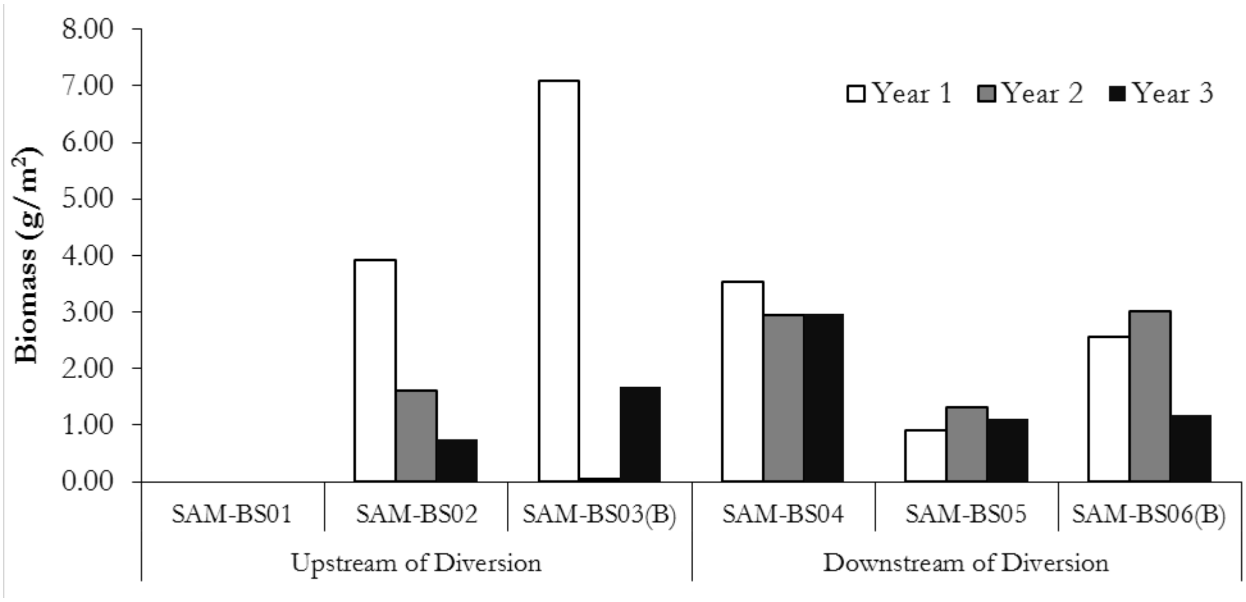


3.1.3.3. Biomass Estimates

Estimated total biomass ranged from 0 g/m^2 to 2.97 g/m^2 with the highest biomass at sites SAM-BS03B and SAM-BS04, which are upstream and downstream of the diversion, respectively (Figure 22). The estimated total biomass values at the other three sites were relatively similar (0.75 g/m^2 to 1.17 g/m^2).

Comparison of estimated total biomass among the three years of the JHTMON-8 program[4] shows that between-year variability is highest for the three sites upstream of the diversion (Figure 22). With the exception of SAM-BS03(B), total biomass estimated during Year 3 was either lower or the same as during Year 2 (Figure 22). The largest decline was observed at SAM-BS06(B) (decrease of 157%). Total biomass estimated at each site during Year 1 was typically higher than during Year 3, although the Year 1 results varied considerably between sites.

Figure 22. Total estimated Juvenile Coho Salmon biomass for each site during Year 1 (2014), Year 2 (2015), and Year 3 (2016).



3.1.4. Salmon and Quinsam River Salmon Escapement, 2015

Salmon escapement data for 2015 (Year 2) for the Salmon and Quinsam rivers are presented in Table 30. Summary statistics for the period of record are also provided in this table to provide points of reference. Figure 23 and Figure 24 present salmon escapement data for the periods of record for the Salmon River and Quinsam River respectively.

[4] Juvenile Coho Salmon abundance data have historically been collected by DFO in the Salmon River since 2008. Date collected prior to 2014 have yet to be compiled; however, this is an ongoing priority for DFO and we expect that these data will be available to support JHTMON-8 analysis at a later stage of the program (Anderson, pers. comm. 2015).

Table 30. 2015 salmon escapement data for the Salmon and Quinsam rivers (DFO 2017).

River	Statistic	Salmon species				
		Chinook[1]	Chum	Coho[1]	Pink	Sockeye
Salmon	2015 count	144	0	258	14,000	Not inspected
	Mean (1953-2015)	856	952	3,313	31,089	32
	Median (1953-2015)	700	400	2,000	7,608	1
	10th percentile (1953-2015)	122	0	300	1,320	0
	90th percentile (1953-2015)	1,500	3,500	7,500	86,045	100
	Percent of years sampled (1953-2015)[2]	100	94	98	100	54
Quinsam	2015 count	3,190	86	8,483	457,169	11
	Mean (1953-2015)	4,056	500	12,392	131,992	55
	Median(1953-2015)	3,190	300	9,310	30,378	25
	10th percentile (1953-2015)	25	81	1,500	1,425	7
	90th percentile (1953-2015)	9,904	1,500	33,173	439,115	138
	Percent of years sampled (1953-2015)[2]	80	95	98	98	75

1. Priority species for JHTMON-8.

2. 'Percent of years sampled' is approximate; uncertainty in data recording means that a count of zero is not always distinguished from a record of 'not measured'.

Figure 23. Salmon escapement for the Salmon River (1953–2015; DFO 2017).

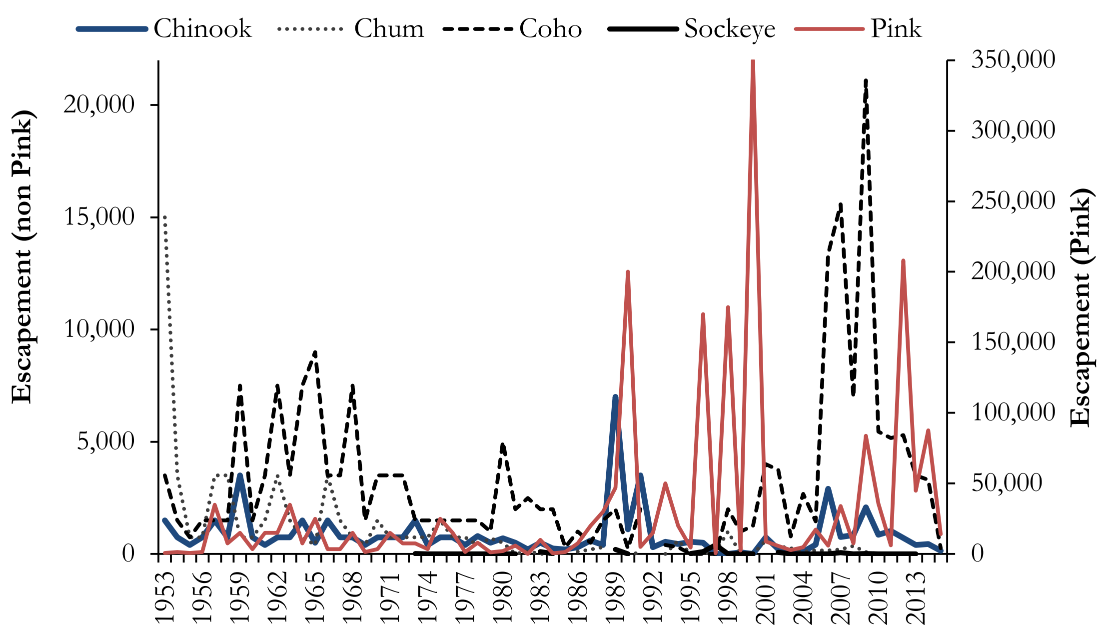
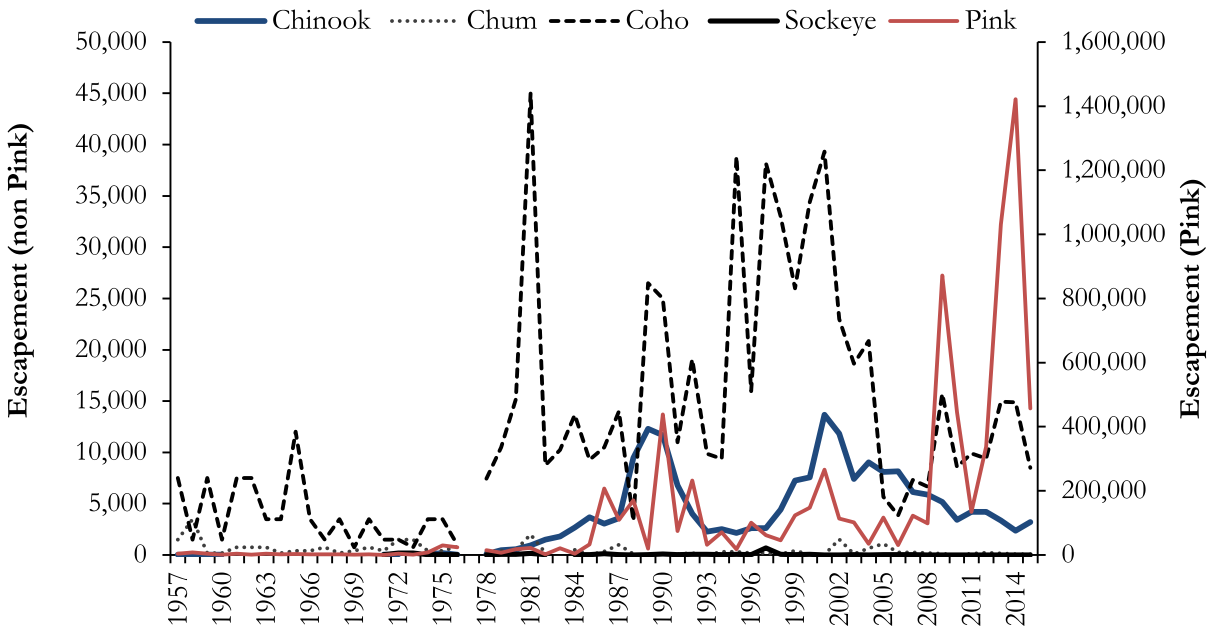


Figure 24. Salmon escapement for the Quinsam River (1957–2015; DFO 2017).



Pink, Coho and Chinook salmon were the dominant returning species in 2015, with escapement of each of these three species highest in the Quinsam River (Table 30). Salmon escapement was generally poor for the Salmon River: Chinook Salmon escapement (144) was the 7th lowest in 63 years and Coho Salmon escapement (258) was the 5th lowest in the 62-year record. Pink Salmon escapement on the Salmon River (14,000) exceeded the historical median, although there is high uncertainty about this estimate as surveys were not completed during the peak of the run (Table 11). Chum Salmon escapement on the Salmon River was recorded as zero. For both Chum Salmon and Coho Salmon, the low counts may at least partly reflect the survey timing as the final inspection date for these species (October 7; Table 11) was around the start of the reported spawning periods for both species (October 1–December 15; Burt 2010), meaning that fish that migrated into the river later in the period were not counted. For context, the final Coho Salmon inspection date in 2013 was November 14, although the final Coho Salmon inspection date in 2014 was the same as in 2015 (October 7). This source of bias is likely to be less important for Chinook Salmon as the final survey date (October 7) was after the reported peak spawning period (14–30 September; Burt 2010).

On the Quinsam River, escapement of Chinook Salmon (3,190) and Coho Salmon (8,483) equalled or approximated the historical medians. Pink Salmon escapement (457,169) in the Quinsam River in 2015 was relatively high (the fourth-highest recorded escapement) although escapement was <50% that of the record-high escapements estimated in 2013 and 2014 (both > 1 million). Pink Salmon escapement has generally increased in the Quinsam River since 2008, although the broodline that spawns in odd-numbered years is typically non-dominant.

3.1.5. Quinsam River Hatchery Salmon Counting Fence Operations to Enumerate Downstream Juvenile Migration

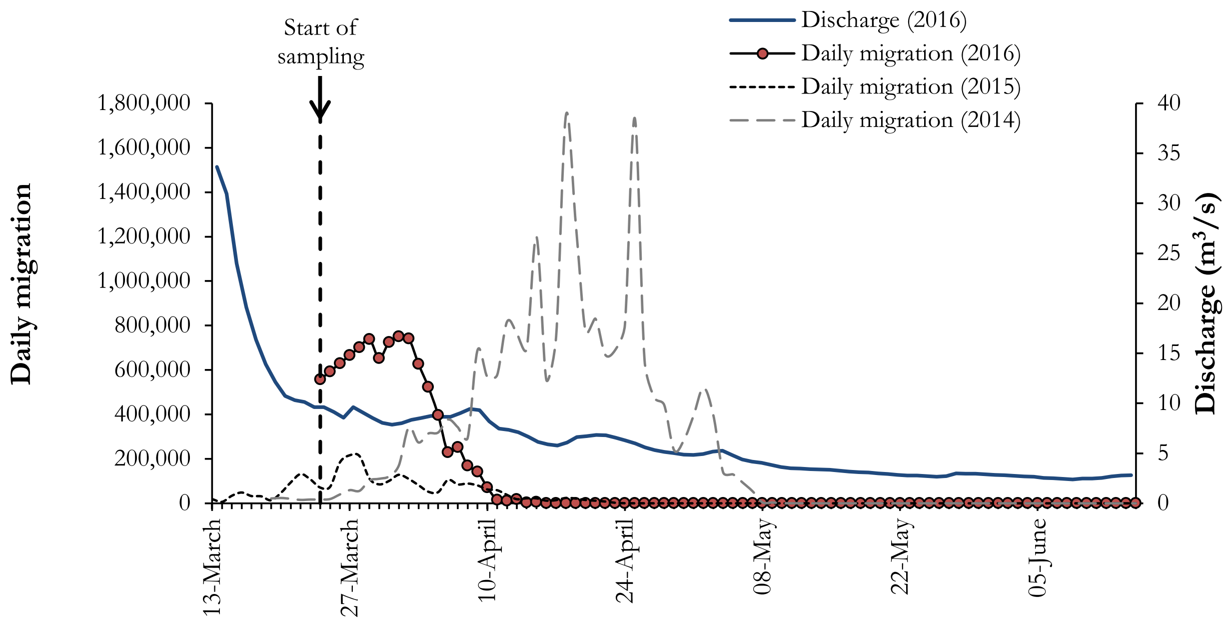
Data collected at the salmon counting fence are summarized in Table 31. High flow in early to mid-March meant that operation of the traps did not start until March 24, meaning that the start of the Pink Salmon migration was not sampled (Figure 25). In addition, counts for March 25–28 were estimated as technicians were unavailable to monitor the traps over the Easter holiday; counts for these days were estimated by linear interpolation between March 24 (11,701 fish) and March 29 (15,519 fish) (P. Scott, pers. comm. 2017). To provide context to evaluate the potential effect of the delayed start, and to compare outmigration with previous years, Figure 25 shows estimated daily outmigration of Pink Salmon fry for 2014–2016. Estimated Pink Salmon fry outmigration was relatively high at the start of sampling in 2016, with peak estimated outmigration occurring eight days after sampling commenced. Peak outmigration in 2014 and 2015 was recorded 14 days and 30 days after the start of sampling, indicating that sampling commenced approximately 1–3 weeks after the start of the Pink Salmon outmigration in 2016.

Table 31. Summary of downstream migration data and total migration estimates from sampling at the Quinsam River Hatchery salmon counting fence, March 4 to June 14, 2016.

Species	Life Stage	Total Counts	Total Estimated Migration[1]	Peak Migration	Migration Period	Comments
Coho Salmon (colonized)	Smolt	1,317	21,144	May 04	Apr 17 - Jun 11	
Coho Salmon (wild)	Smolt	505	30,684	May 05	Apr 20 - Jun 10	
Coho Salmon (2-year)	Smolt	6	80	-	Apr 20 - May 6	
Coho Salmon	Fry	651	22,547	Apr 09	Mar 24 - Jun 13	
Steelhead	Smolt	625	9,002	May 09	Apr 20 - May 29	
Steelhead	Fingerling	109	1,873	May 09	Apr 20 - Jun 5	
Steelhead	Kelts	7	94	Apr 20	Apr 20 - May 7	
Cutthroat Trout	Fingerling	9	194	Apr 29	Apr 21 -Jun 6	
Cutthroat Trout	Smolt	38	589	Apr 28	Apr 20 - May 20	
Cutthroat Trout	Kelts	11	142	May 04	Apr 25 - May 12	
Trout species	Fry	8	297	-	May 29 - Jun 6	
Chinook Salmon	Fry	98	1,528	May 07	Apr 25 - Jun 8	
Chinook Salmon (colonized)	Fry	1,579	42,001	May 29	May 16 - End	Still migrating on Jun 14th
Chum Salmon	Fry	51	1,858	Apr 11	Apr 1 - May 19	
Sockeye Salmon	Fry	13	178	Apr 21	Apr 21 - Apr 22	
Pink Salmon	Fry	194,377	9,226,808	Apr 01	Start - May 26	
Dolly Varden	Smolt	1	14	Apr 28		
Lamprey (2 species)	All	304	4,614	Apr 29	Start - end	
Sculpin	All	124	2,287	Apr 30	Start - Jun 9	

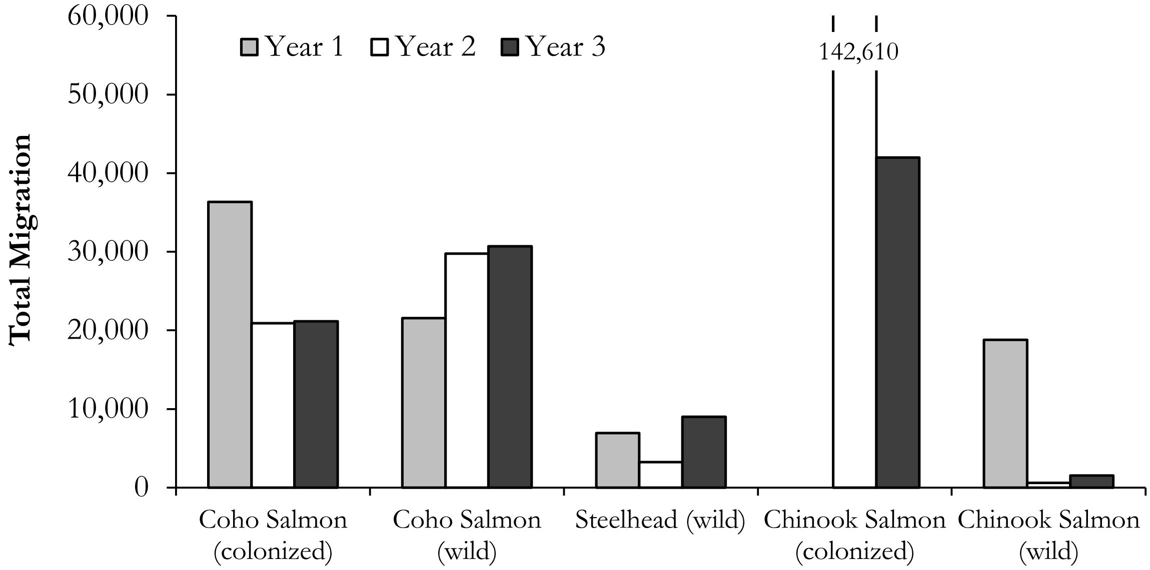
1. Based on capture efficiency measured for Pink Salmon and Coho Salmon.

Figure 25. Estimated Pink Salmon fry outmigration and Quinsam River discharge (WSC gauge 08HD005) during spring 2014–2016. Note that the start of sampling in 2016 was delayed due to high flows.



Total estimated migration of Pink Salmon fry in 2016 (Year 3) was 9.2 million (Table 31). This is an increase of 237% over the 2015 Year 2 abundance (2.7 million) and 58% less than the abundance in 2014 Year 1 (22 million). Total migration estimates for the three JHTMON-8 priority species in the Quinsam River (Coho Salmon, steelhead, and Chinook Salmon) are presented in Figure 26 (see Table 31 for raw count data). Total Coho Salmon smolt abundance for Year 3 (51,828 fish) was similar to the abundance in Year 2 (50,690 fish) and there were only slight increases in the number of colonized Coho Salmon (1.1%) and wild Coho Salmon (3.1%). The total abundance of Coho Salmon smolts in Year 3 is lower than in Year 1 (57,958 fish). The estimated outmigration of steelhead smolts in Year 3 (9,001 fish) was higher than Year 1 (30% increase; 6,930) and Year 2 (176% increase; 3,264). Wild Chinook Salmon fry abundance in Year 3 (1,528 fish) was 160% higher than in Year 2 (587 fish) and 92% lower than Year 1 (18,818 fish).

Figure 26. Total estimated outmigration of priority species on the Quinsam River during Years 1, 2, and 3. Coho Salmon and steelhead were captured at the smolt stage and Chinook Salmon at the fry stage.



The survival of out-planted juvenile salmon was estimated by expressing the estimated outmigration of juvenile colonized salmon as a percentage of the total number of fish that were out-planted (Figure 27). Estimated survival of colonized juvenile Chinook Salmon in Year 3 was 28%; this was lower than Year 2 (66%), which was the first year that this species had been out-planted for approximately 10 years. Note that colonized Chinook Salmon were still outmigrating in low numbers on June 14 when the sampling finished, indicating that the survival estimate may be biased low[5]. Estimated survival of colonized juvenile Coho Salmon in Year 3 was 13%; this was the same as Year 2, although lower than Year 1 (21%). Note that the estimates for Coho Salmon assume that fish outmigrate aged 1+, although a small number of 2+ smolts were recorded at the fence[6].

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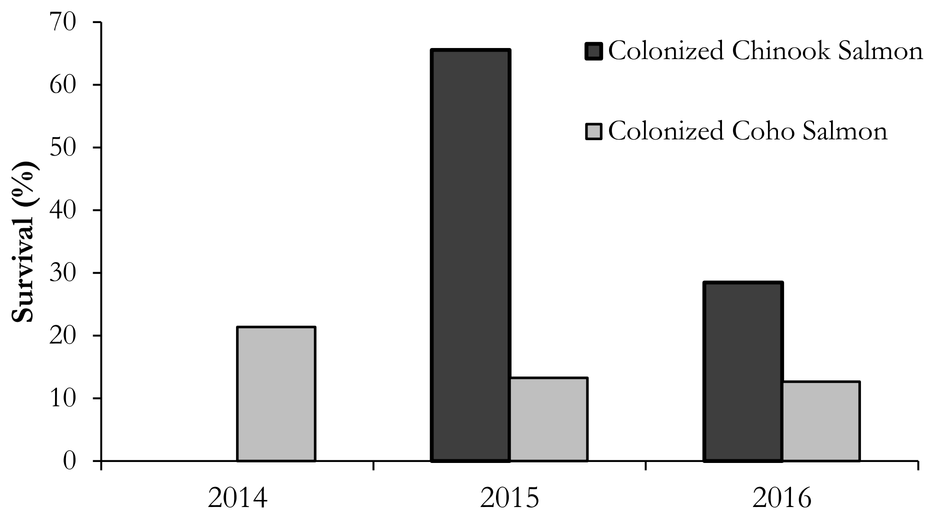
[5] Outmigration of juvenile Chinook Salmon in the Quinsam River is recorded to extend until the third week of July (Burt 2003).

[6] Estimated outmigration of 2+ Coho Salmon was 80 fish. Burt (2003) suggests that 2+ smolts represent fish that were trapped in off-channel habitats, preventing them from out-migrating the previous year.

Figure 27. Estimated survival of out-planted salmon raised at the hatchery, based on the proportion of out-planted fish estimated to outmigrate at the salmon counting fence. Outmigrating Chinook Salmon were out-planted during spring (May) of the same year; outmigrating Coho Salmon were out-planted the previous year. No Chinook Salmon were out-planted in 2014.



3.2. Water Quality

3.2.1. Year 1 and Year 2 Water Quality Data

Results from Year 1 and Year 2 (2014 and 2015) water quality monitoring are presented in Appendix C. Year 3 (2016) results are described below in Section 3.2.2; this includes discussion of any notable differences between results in Year 3 and previous years.

3.2.2. Water Chemistry

3.2.2.1. Salmon River

The *in situ* and lab water chemistry results for the Salmon River at SAM-WQ are summarized in Table 32 (general variables measured *in situ*), Table 33 (dissolved oxygen), Table 34 (general variables measured at ALS labs), and Table 35 (low level nutrients measured at ALS labs). Laboratory reports are presented in Appendix A.

Ranges for individual water quality variables that were measured during the Year 3 sampling in the Salmon River are described below. Instances whereby values exceed the provincial or federal guidelines for the protection of aquatic life, or are not within the normal ranges of BC streams, are discussed in additional detail (see Appendix C for applicable guidelines and typical ranges).

Alkalinity

Alkalinity (as $CaCO_3$) measured at ALS labs in 2016 was similar to previous years. Alkalinity ranged from 12.8 mg/L (May) to 21.6 mg/L (August) (Table 32). Alkalinity concentrations less than 10 mg/L in streams indicate sensitivity to acidic inputs, or poor buffering capacity. Alkalinity in the range of 10 mg/L to 20 mg/L indicates that the watercourse is moderately sensitive to acidic inputs, whereas values greater than 20 mg/L suggest a low sensitivity (RISC 1997b). Thus, the Salmon River is moderately sensitive to acidic inputs during the majority of the growing season.

Specific Conductivity and Total Dissolved Solids

Specific conductivity (i.e., conductivity normalized to 25°C) measured *in situ* in 2016 was similar to previous years. Values ranged from 42.6 µS/cm (May) to 83.4 µS/cm (September) (Table 32). Similarly, lab values for conductivity ranged from 26.3 µS/cm to 50.4 µS/cm, with the lowest value occurring in May and the highest in August. Coastal British Columbia streams generally have a specific conductivity of ~100 µS/cm (RISC 1997b). Thus, results show that the Salmon River has a relatively low concentration of dissolved ions.

Total dissolved solids measured in the lab for the Salmon River ranged from 18 mg/L to 39 mg/L, similar to 2016 (Table 34).

pH

pH values measured in the laboratory ranged from 7.32 (August) to 7.82 (September), whereas *in situ* pH ranged from 6.37 to 7.17 (Table 32 and Table 34 respectively). All values were similar to previous years. Natural fresh waters have a pH range from 4 to 10; British Columbia lakes tend to have a pH ≥ 7.0, and coastal streams commonly have pH values of 5.5 to 6.5 (RISC 1997b).

Turbidity and Total Suspended Solids (TSS)

Turbidity in the Salmon River at SAM-WQ was low in 2016, similar to previous years, indicating high water clarity (values ranged from 0.12 NTU to 0.44 NTU) (Table 32). Similarly, low TSS concentrations were measured throughout the sampling period, with concentrations that were predominantly non-detectable (<1.0 mg/L; Table 34).

Dissolved Oxygen

Dissolved oxygen concentrations in the Salmon River were moderate to high over the course of all three years of monitoring. In British Columbia, surface waters generally exhibit dissolved oxygen concentrations greater than 10 mg/L, and are close to equilibrium with the atmosphere (i.e., ~100%; RISC 1997b). Dissolved oxygen concentrations in 2016 ranged from 9.07 mg/L to 11.01 mg/L, with five of the six measurements < 10.0 mg/L (Table 33). This is generally consistent with growing season measurements in 2015 and 2016 (range: 9.06 mg/L to 11.06 mg/L). All measurements exceeded instantaneous minimum guideline values for the protection of aquatic life (MoE 1997), i.e., they complied with the recommended criteria.

Total Gas Pressure

Monitoring of total gas pressure (TGP) was discontinued in Year 2 following evaluation of results in Year 1, and the limited potential of the Salmon River diversion to cause elevated TGP concentrations.

Nitrogen

Total ammonia (including the ammonium ion) concentrations in the Salmon River at SAM-WQ were less than the MDL of 5.0 μg N/L. (Table 35) in 2016, which is the same result as previous years. Ammonia is usually present at low concentrations (<100 μg N/L) in waters not affected by wastewater discharges (Nordin and Pommen 1986).

Nitrite concentrations were below the MDL of 1.0 μg N/L for all the monthly sampling dates (Table 35) in 2016, which is the same result as previous years. Nitrite is an unstable intermediate ion that serves as an indicator of recent contamination from sewage and/or agricultural runoff; levels are typically <1.0 μg N/L (RISC 1997b).

Nitrate concentrations ranged from <5.0 μg N/L to 82.4 μg N/L over the course of the 2016 monitoring, with the highest concentrations measured in August. These concentrations are similar to previous years and are typical of oligotrophic streams, which typically have nitrate concentrations lower than 100 μg N/L (Nordin and Pommen 1986).

Phosphorus

Orthophosphate was below the detection limit of 1.0 μg P/L over the course of the 2016 monitoring (Table 35), similar to previous years. Very low orthophosphate concentrations are typical of coastal British Columbia streams, which typically have orthophosphate concentrations <1.0 μg P/L (Slaney and Ward 1993; Ashley and Slaney 1997).

Total phosphorus concentrations over the Year 3 sampling period were similar to previous years, ranging from <2.0 μg/L to 5.0 μg/L (Table 35). Low phosphorus concentrations limit productivity in the Salmon River watershed (Pellett 2011a).

Table 32. Salmon River (SAM-WQ) general water quality variables measured *in situ* during Year 3, 2016.

Year	Date	Site	Air Temperature °C				Conductivity µS/cm				Specific Conductivity µS/cm				Temperature °C				pH pH units			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2016	17-May	SAM-WQ	14	14	14	0	29.6	29.6	29.6	0.0	42.6	42.6	42.6	0.0	9.8	9.8	9.8	0.0	6.41	6.37	6.45	0.04
	14-Jun	SAM-WQ	9	9	9	0	46.3	46.3	46.3	0.0	65.3	65.3	65.3	0.0	10.5	10.5	10.5	0.0	6.40	6.40	6.41	0.01
	12-Jul	SAM-WQ	14	14	14	0	56.6	56.4	56.7	0.2	73.8	73.7	73.9	0.1	13.3	13.3	13.3	0.0	6.47	6.43	6.51	0.04
	16-Aug	SAM-WQ	18	18	18	0	65.0	64.9	65.0	0.1	78.3	78.3	78.3	0.0	16.5	16.5	16.5	0.0	6.56	6.53	6.60	0.04
	13-Sep	SAM-WQ	8	8	8	0	61.6	61.5	61.6	0.1	83.3	83.3	83.3	0.0	12.0	11.9	12.0	0.1	7.17	7.17	7.17	0.00
	11-Oct	SAM-WQ	-	-	-	-	29.7	29.7	29.7	0.0	45.4	45.4	45.4	0.0	7.7	7.7	7.7	0.0	6.66	6.66	6.66	0.00

[1] Average of three replicates (n=3) on each date unless otherwise indicated.

Table 33. Salmon River (SAM-WQ) dissolved oxygen measured *in situ* during Year 3, 2016.

Year	Date	Site	Dissolved Oxygen %				Dissolved Oxygen mg/L			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2016	17-May	SAM-WQ	86.6	86.4	86.7	0.2	9.82	9.81	9.84	0.02
	14-Jun	SAM-WQ	85.1	84.9	85.3	0.2	9.49	9.47	9.51	0.02
	12-Jul	SAM-WQ	92.9	92.7	93.0	0.2	9.72	9.70	9.74	0.02
	16-Aug	SAM-WQ	92.8	92.6	92.9	0.2	9.07	9.06	9.08	0.01
	13-Sep	SAM-WQ	87.8	87.4	88.2	0.4	9.47	9.43	9.52	0.05
	11-Oct	SAM-WQ	92.2	91.8	92.5	0.4	11.01	10.97	11.06	0.05

[1] Average of three replicates (n=3) on each date unless otherwise indicated.

Table 34. Salmon River (SAM-WQ) general water quality variables measured at ALS labs during Year 3, 2016.

Year	Date	Site	Alkalinity, Total (as $CaCO_3$) mg/L				Specific Conductivity µS/cm				Total Dissolved Solids mg/L				Total Suspended Solids mg/L				Turbidity NTU				pH pH units			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2016	17-May	SAM-WQ	12.9	12.8	12.9	0.1	26.4	26.3	26.5	0.1	19	18	20	1	<1.0	<1.0	<1.0	0.0	0.18	0.16	0.20	0.03	7.43	7.40	7.46	0.04
	14-Jun	SAM-WQ	14.8	14.8	14.8	0.0	35.4	35.1	35.6	0.4	28	27	28	1	<1.0	<1.0	<1.0	0.0	0.16	0.14	0.17	0.02	7.48	7.46	7.49	0.02
	12-Jul	SAM-WQ	17.9	17.6	18.1	0.4	37.0	36.9	37.0	0.1	31	30	32	1	<1.0	<1.0	<1.0	0.0	0.14	0.14	0.14	0.00	7.48	7.46	7.49	0.02
	16-Aug	SAM-WQ	21.5	21.3	21.6	0.2	50.3	50.1	50.4	0.2	32	28	36	6	<1.2	<1.0	1.4	0.3	0.13	0.12	0.13	0.01	7.33	7.32	7.34	0.01
	13-Sep	SAM-WQ	20.4	20.3	20.5	0.1	48.1	47.8	48.4	0.4	34	34	34	0	<1.0	<1.0	<1.0	0.0	0.18	0.15	0.20	0.04	7.74	7.65	7.82	0.12
	11-Oct	SAM-WQ	20.2	20.1	20.3	0.1	47.2	46.4	48.0	1.1	37	34	39	4	<1.1	<1.0	1.2	0.1	0.42	0.40	0.44	0.03	7.67	7.63	7.70	0.05

[1] Average of three replicates (n=3) on each date unless otherwise indicated.

Parameters that have a concentration below the method detection limit (MDL) were assumed to have a concentration equal to the MDL for calculation purposes.

Table 35. Salmon River (SAM-WQ) nutrient concentrations measured at ALS labs during Year 3, 2016.

Year	Date	Site	Ammonia, Total (as N) µg/L				Dissolved Orthophosphate µg/L				Nitrate (as N) µg/L				Nitrite (as N) µg/L				Total Phosphorus (P) µg/L			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2016	17-May	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	<5.6	<5.0	6.1	0.8	<1.3	<1.0	1.5	0.4	<2.7	<2.0	3.4	1.0
	14-Jun	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	14.4	14.1	14.7	0.4	<1.0	<1.0	<1.0	0.0	<3.5	<2.0	5.0	2.1
	12-Jul	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	23.6	23.5	23.6	0.1	<1.0	<1.0	<1.0	0.0	<2.8	<2.0	3.5	1.1
	16-Aug	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	81.9	81.4	82.4	0.7	<1.0	<1.0	<1.0	0.0	<2.0	<2.0	<2.0	0.0
	13-Sep	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	40.4	40.2	40.5	0.2	<1.0	<1.0	<1.0	0.0	<2.2	<2.0	2.3	0.2
	11-Oct	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	32.7	32.4	32.9	0.4	<1.0	<1.0	<1.0	0.0	3.0	3.0	3.0	0.0

[1] Average of three replicates (n=3) on each date unless otherwise indicated.

Parameters that have a concentration below the method detection limit (MDL) were assumed to have a concentration equal to the MDL for calculation purposes.

3.2.2.2. Quinsam River

The *in situ* and lab water chemistry results for the Quinsam River at QUN-WQ are summarized in Table 36 (general variables measured *in situ*),

Table 37 (dissolved oxygen measured *in situ*), Table 38 (general variables measured at ALS labs), and Table 39 (low level nutrients measured at ALS labs). Laboratory reports are presented in Appendix B.

Alkalinity

Alkalinity (as $CaCO_3$) measured at ALS labs ranged from 30.4 mg/L (October) to 36.7 mg/L (July; Table 36) in 2016, similar to previous years. Alkalinity concentrations were consistently greater than 20 mg/L, indicating that the Quinsam River has a low sensitivity to acidic inputs (RISC 1997b).

Specific Conductivity and Total Dissolved Solids

In situ specific conductivity (conductivity normalized to 25°C) ranged from 143.4 µS/cm (June) to 176.1 µS/cm (October) (Table 36). Similarly, lab values for specific conductivity ranged from 109.0 µS/cm (July) to 139.0 µS/cm (September). Values were similar to previous years. Coastal British Columbia streams generally have a specific conductivity of ~100 µS/cm (RISC 1997b). Most specific conductivity values in the Quinsam River were higher than typical levels in coastal streams. This potentially reflects the influence of primary productivity in the two lakes upstream of the monitoring site. Alternatively, high values of specific conductivity measured in the past have previously been linked with coal mining activities in the watershed (Redenbach 1990 cited in Burt 2003).

Total dissolved solids measured in the lab for the Quinsam River ranged from 67 mg/L (July) to 88 mg/L (June and August) (Table 34).

pH

pH values measured in the laboratory ranged from 7.50 to 7.86 while *in situ* pH ranged from 6.86 to 7.25 (Table 38 and Table 36, respectively). Natural fresh waters have a pH range from 4 to 10, British Columbia lakes tend to have a pH ≥ 7.0, and coastal streams commonly have pH values of 5.5 to 6.5 (RISC 1997b).

Turbidity and Total Suspended Solids (TSS)

Turbidity in the Quinsam River at QUN-WQ was low in all three monitoring years, indicating high water clarity (values ranged from 0.38 NTU to 1.19 NTU) (Table 38). Similarly, TSS concentrations were consistently non-detectable (<1.0 mg/L).

Dissolved Oxygen

Dissolved oxygen concentrations and % saturation in the Quinsam River were high in October, 2016 (following an increase in flow); however, during the May to September sampling in 2016, the average DO concentration did not meet the more conservative provincial guideline (DO instantaneous minimum of 9 mg/L) for the protection of buried embryos/alevins (Table 37; MoE 1997, Appendix C). The May measurement (8.30 mg/L on May 18) indicates that the 9 mg/L guideline was not achieved during part of the incubation period for resident Rainbow Trout and steelhead (see Table 49 for periodicity information). The September measurement (8.16 mg/L on September 14) indicates that the 9 mg/L guideline value may not have been achieved at during the early stages of the Pink Salmon incubation period, which is reported to start on September 15 (Table 49).

All samples met the guideline for life stages other than buried embryo/alevin (DO instantaneous minimum of 5 mg/L). In British Columbia, surface waters generally exhibit DO concentrations greater than 10 mg/L, and are close to equilibrium with the atmosphere (i.e., ~100%; RISC 1997b).

Total Gas Pressure

Monitoring of total gas pressure (TGP) was discontinued in Year 2 following evaluation of results in Year 1, and the limited potential of the Quinsam River diversion to cause elevated TGP concentrations.

Nitrogen

Total ammonia concentrations in the Quinsam River at QUN-WQ were less than, or close to, the detection limit of 5.0 µg N/L (Table 39) in 2016, similar to previous years. Ammonia is usually present at low concentrations (<100 µg N/L) in waters not affected by waste discharges (Nordin and Pommen 1986).

Nitrite concentrations were below the detection limit of 1.0 µg N/L for all the monthly sampling dates in 2016, the same result as in previous years (Table 35). Nitrite is an unstable intermediate ion serving as an indicator of recent contamination from sewage and/or agricultural runoff; levels are typically <1.0 µg N/L (RISC 1997b).

Nitrate concentrations were low and ranged from 14.4 µg N/L (June) to 39.0 µg N/L (October) over the course of the sampling in 2016, similar to previous years (Table 39). In oligotrophic lakes and streams, nitrate concentrations are usually lower than 100 µg N/L (Nordin and Pommen 1986).

Phosphorus

Orthophosphate was below the detection limit of 1.0 µg P/L or very close to the detection limit in 2016, similar to previous years (Table 39). Very low orthophosphate concentrations are typical of coastal British Columbia streams, which typically have orthophosphate concentrations <1.0 µg P/L (Slaney and Ward 1993; Ashley and Slaney 1997). It is possible that uptake of nutrients by phytoplankton in lakes upstream ("nutrient stripping") also contributes to the low orthophosphate concentrations at the site.

Total phosphorus concentrations over the Year 3 sampling period were low, similar to previous years, ranging from 2.5 µg P/L to 5.5 µg P/L (Table 39).

Table 36. Quinsam River (QUN-WQ) general water quality variables measured *in situ* during Year 3, 2016.

Year	Date	Site	Air Temperature °C				Conductivity µS/cm				Salinity ppt				Specific Conductivity µS/cm				Temperature °C				pH[2] pH units			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2016	18-May	QUN-WQ	12	12	12	0	119.1	119.1	119.2	0.1	0.07	0.07	0.07	0.00	150.1	150.0	150.2	0.1	14.7	14.7	14.7	0.0	7.18	7.16	7.20	0.02
	15-Jun	QUN-WQ	9	9	9	0	112.1	112.0	112.1	0.1	0.07	0.07	0.07	0.00	143.5	143.4	143.6	0.1	14.0	14.0	14.0	0.0	6.86	6.86	6.87	0.01
	13-Jul	QUN-WQ	15	15	15	0	125.5	125.4	125.6	0.1	0.07	0.07	0.07	0.00	154.2	154.1	154.4	0.2	15.7	15.7	15.7	0.0	7.68	7.67	7.68	0.01
	17-Aug	QUN-WQ	19	19	19	0	139.4	139.4	139.4	0.0	0.07	0.07	0.07	0.00	157.4	157.4	157.4	0.0	19.3	19.3	19.3	0.0	7.25	7.24	7.25	0.01
	14-Sep	QUN-WQ	12	12	12	0	138.5	138.5	138.5	0.0	0.08	0.08	0.08	0.00	172.6	172.6	172.7	0.1	15.1	15.1	15.1	0.0	7.40	7.39	7.40	0.01
	12-Oct	QUN-WQ	5	5	5	0	115.2	114.9	115.5	0.3	0.08	0.08	0.08	0.00	175.9	175.5	176.1	0.3	7.7	7.7	7.7	0.0	7.70	7.69	7.71	0.01

[1] Average of three replicates (n=3) on each date unless otherwise indicated.

[2.] pH measured in the laboratory is presented for the July and October sampling dates because the pH meter malfunctioned on these dates.

Table 37. Quinsam River (QUN-WQ) dissolved gases measured *in situ* during Year 3, 2016.

Year	Date	Site	Dissolved Oxygen (In Situ) %				Dissolved Oxygen (In Situ) mg/L			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2016	18-May	QUN-WQ	81.9	81.7	82.0	0.2	8.30	8.30	8.30	0.00
	15-Jun	QUN-WQ	80.0	79.9	80.2	0.2	8.23	8.22	8.24	0.01
	13-Jul	QUN-WQ	79.4	79.3	79.5	0.1	7.89	7.87	7.92	0.03
	17-Aug	QUN-WQ	84.4	84.1	84.6	0.3	7.77	7.75	7.79	0.02
	14-Sep	QUN-WQ	81.0	80.9	81.2	0.2	8.16	8.15	8.17	0.01
	12-Oct	QUN-WQ	98.0	97.6	98.5	0.5	11.70	11.63	11.75	0.06

[1] Average of three replicates (n=3) on each date unless otherwise indicated.

Blue shading indicates that the more conservative provincial guideline (DO instantaneous maximum of 9 mg/L) for the protection of buried embryo/alevin has not been achieved. Note that the guideline for life stages other than buried embryo/alevin is met (DO instantaneous maximum of 5 mg/L)

Table 38. Quinsam River (QUN-WQ) general water quality variables measured at ALS labs during Year 3, 2016.

Year	Date	Site	Alkalinity, Total (as $CaCO_3$) mg/L				Conductivity µS/cm				Total Dissolved Solids mg/L				Total Suspended Solids mg/L				Turbidity NTU				pH pH units			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2016	18-May	QUN-WQ	35.4	35.1	35.6	0.4	132	131	132	1	85	85	85	0	<1.0	<1.0	<1.0	0.0	0.49	0.38	0.59	0.15	7.83	7.80	7.86	0.04
	15-Jun	QUN-WQ	34.3	33.9	34.7	0.6	131	130	131	1	87	86	88	1	<1.0	<1.0	<1.0	0.0	0.45	0.44	0.46	0.01	7.78	7.77	7.78	0.01
	13-Jul	QUN-WQ	36.6	36.5	36.7	0.1	110	109	111	1	70	67	72	4	<1.3	<1.0	1.5	0.4	1.17	1.14	1.19	0.04	7.68	7.67	7.68	0.01
	17-Aug	QUN-WQ	35.5	35.4	35.5	0.1	138	137	138	1	87	86	88	1	<1.1	<1.0	1.1	0.1	0.46	0.44	0.47	0.02	7.51	7.50	7.51	0.01
	14-Sep	QUN-WQ	35.3	35.1	35.4	0.2	139	139	139	0	84	83	84	1	<1.0	<1.0	<1.0	0.0	0.46	0.45	0.46	0.01	7.71	7.70	7.72	0.01
	12-Oct	QUN-WQ	30.6	30.4	30.8	0.3	119	114	123	6	83	81	84	2	<1.0	<1.0	<1.0	0.0	0.72	0.72	0.72	0.00	7.70	7.69	7.71	0.01

[1] Average of three replicates (n=3) on each date unless otherwise indicated

Table 39. Quinsam River (QUN-WQ) low level nutrients measured at ALS labs during Year 3, 2016.

Year	Date	Site	Ammonia, Total (as N) µg/L				Orthophosphate (as P) µg/L				Nitrate (as N) µg/L				Nitrite (as N) µg/L				Total Phosphorus (P) µg/L			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2016	18-May	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	16.3	16.1	16.4	0.2	<1.0	<1.0	<1.0	0.0	3.5	3.0	3.9	0.6
	15-Jun	QUN-WQ	<5.0	<5.0	<5.0	0.0	1.5	1.2	1.7	0.4	15.2	14.4	16.0	1.1	<1.0	<1.0	<1.0	0.0	3.3	2.7	3.9	0.8
	13-Jul	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	16.7	16.3	17.1	0.6	<1.0	<1.0	<1.0	0.0	4.6	4.2	4.9	0.5
	17-Aug	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	24.0	23.9	24.1	0.1	<1.0	<1.0	<1.0	0.0	3.8	3.0	4.6	1.1
	14-Sep	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	18.5	18.4	18.5	0.1	<1.0	<1.0	<1.0	0.0	2.6	2.5	2.7	0.1
	12-Oct	QUN-WQ	9.5	9.2	9.8	0.4	<1.0	<1.0	<1.0	0.0	38.8	38.6	39.0	0.3	<1.0	<1.0	<1.0	0.0	5.5	5.4	5.5	0.1

[1] Average of three replicates (n=3) on each date unless otherwise indicated

3.2.3. Water and Air Temperature Monitoring

3.2.3.1. Salmon River

Summary

The water temperature measurements from 2014 to 2016 at SAM-WQ are shown in Figure 28 and the mean, minimum, and maximum water temperatures for each month of the record are summarized in Table 40. In 2015, mean monthly water temperatures in June (16.9°C) and July (19.1°C) were higher than those in 2014 and 2016, reflecting high air temperatures and low rainfall associated with the drought that occurred in Vancouver Island at that time. However, mean monthly temperatures in 2015 for August (17.6°C) were lower than 2014 and higher than those for 2016. Mean monthly temperatures for September, 2015 (11.7°C) were lower than both 2014 and 2016 (Table 40). Based on the available data, the coolest temperature measurement was 0.0°C in January during 2016 and the warmest temperature measurement was 24.5°C in July during 2015 (Table 40).

From a fisheries biology perspective, the water temperature records for the Salmon River indicate occurrences of warm water temperatures, although maximum summer water temperatures in 2016 were lower than the previous two years (Figure 28). Over the period of record (231 days in 2015), there were 41 days (18%) with daily-mean temperatures above 18°C, as well as nine days (4%) with daily-mean temperatures above 20°C (Table 41). In 2016, there were 15 days with daily-mean temperatures above 18°C and no days were above 20°C. Daily-mean water temperatures below 1°C occurred 6 and 13 days during 2015 and 2016, respectively (Table 41).

Figure 28. Daily average water temperature in the Salmon River (SAM-WQ) between May 2014 and October 2016. The gap in the records (Oct 2014 to May 2015) is due to missing TidbiTs caused by a flood.

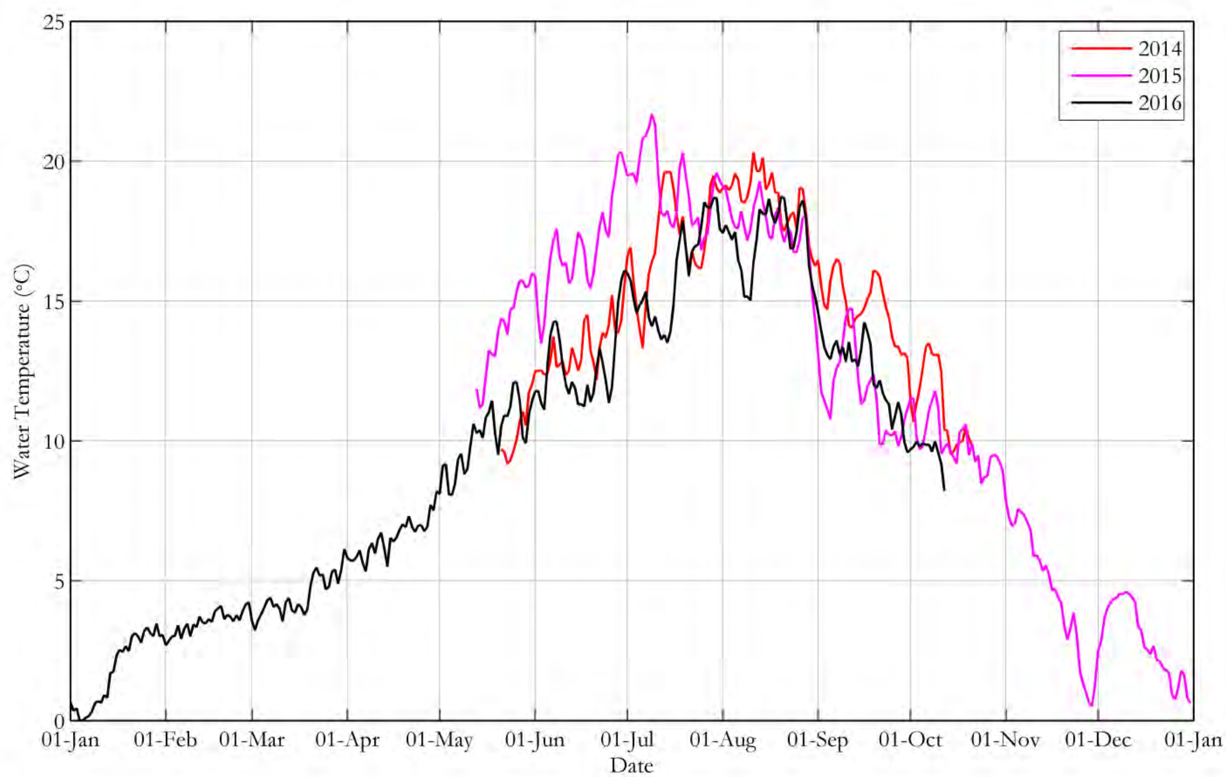


Table 40. Monthly water temperature statistics in the Salmon River (SAM-WQ) from 2014 to 2016. "Avg", "Min", "Max" and "SD" denote the monthly average, minimum, maximum and standard deviation of water temperatures (°C). Blue and orange shadings highlight minimum and maximum temperatures, respectively. Statistics were not generated for months with less than 3 weeks of observations and minimum temperatures are not shaded for years with missing data during fall/winter/spring.

Year	Month	SAM-WQ[1]			
		Avg	Min	Max	SD
2014	May	-	-	-	-
	Jun	13.3	10.2	18.0	1.4
	Jul	17.2	12.6	23.0	2.3
	Aug	18.7	15.3	23.2	1.7
	Sep	14.9	11.7	18.6	1.5
	Oct	-	-	-	-
	Nov	-	-	-	-
	Dec	-	-	-	-
2015	Jan	-	-	-	-
	Feb	-	-	-	-
	Mar	-	-	-	-
	Apr	-	-	-	-
	May	-	-	-	-
	Jun	16.9	11.7	23.3	2.4
	Jul	19.1	14.9	24.5	2.0
	Aug	17.6	13.6	21.7	1.5
	Sep	11.7	8.7	17.1	1.6
	Oct	9.9	8.0	12.7	1.0
	Nov	4.7	0.1	8.3	2.3
	Dec	2.8	0.4	4.8	1.3
2016	Jan	1.8	0.0	3.7	1.2
	Feb	3.5	2.3	4.5	0.4
	Mar	4.5	2.3	7.2	0.9
	Apr	6.6	4.6	9.6	1.0
	May	10.2	6.4	14.0	1.6
	Jun	12.7	9.9	18.3	1.8
	Jul	16.0	11.8	21.7	2.1
	Aug	17.1	13.9	21.6	1.8
	Sep	12.3	8.6	16.5	1.5
	Oct	-	-	-	-

[1]Data collection gap from October 2014 to May 2015 is due to missing Tidbits.

Rates of Change

Large, rapid temperature changes can affect fish growth and survival (Oliver and Fidler 2001). Rates of change in water temperature at SAM-WQ were therefore examined; these are summarized in Table 42 and presented in Figure 29. Hourly rates of temperature change were between -0.4°C/hr and +0.6°C/hr for at least 90% of the time (based on the 5th and 95th percentiles), and were between -0.5°C/hr and +1.0°C/hr for at least 98% of the time (based on the 1st and 99th percentiles).

For all years, the maximum positive rate of water temperature change was 1.3°C/hr and the negative rate of water temperature change was -0.8°C/hr. The majority of rates of hourly temperature change were within ± 1°C/hr (Table 42). Based on our experience on other streams in British Columbia, it is normal for a small percentage of data points to have hourly rates of water temperature change that exceed ±1°C.

Table 41. Summary of the number of exceedances of mean daily water temperature extremes (T_{water}>18°C, T_{water}>20°C, and T_{water}<1°C) in the Salmon River (SAM-WQ) from 2014 to 2016.

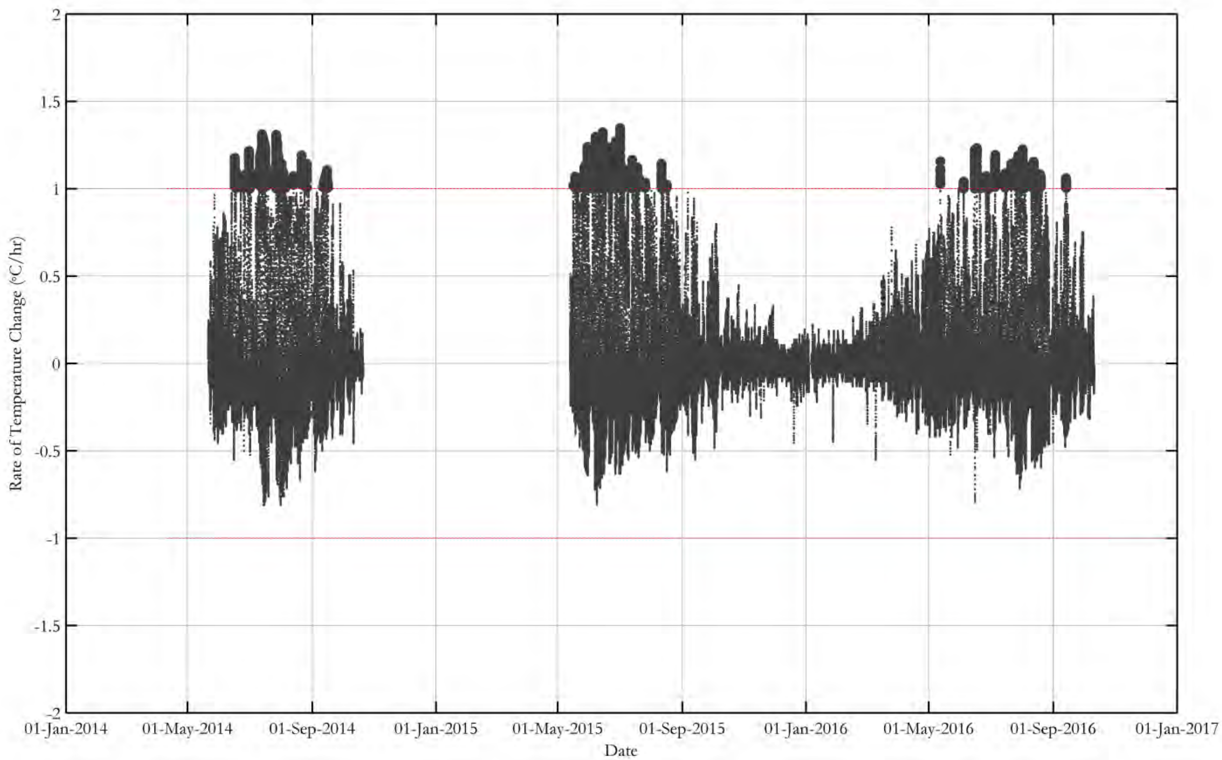
Site	Year	Record Length (days)	Days T_{water}> 20°C	Days T_{water}> 18°C	Days T_{water} < 1°C
SAM-WQ[1]	2014	152	2	35	0
	2015	231	9	41	6
	2016	282	0	15	13

[1]Due to a data collection gap at SAM-WQ from October 2014 to May 2015, a complete calendar year of temperature extremes is not yet available.

Table 42. Statistics for the hourly rates of change in water temperature at SAM-WQ in the Salmon River from 2014 to 2016. Shown is the frequency of rates of change exceeding a magnitude of 1°C/hr.

Station	Start of record	End of record	Number of Datapoints	Occurrence		Max -ve	Percentile				Max+ve
				Number	% of record		1th	5th	95th	99th	
SAM-WQ	21-May-2014	11-Oct-2016	257,143	2088	0.8	-0.8	-0.5	-0.4	0.6	1.0	1.3

Figure 29. Rate of change in hourly water temperature in the Salmon River (SAM-WQ) from 2014 to 2016. Large dots indicate rates with magnitudes exceeding ±1°C/hr.



Mean Weekly Maximum Water Temperatures

The mean weekly maximum water temperature (MWMxT) is a standard metric used to evaluate the exposure of fish to prolonged periods of undesirably cool or warm water temperatures. The guidelines for the protection of aquatic life state "Where fish distribution information is available, then mean weekly maximum water temperatures should only vary + or - 1 degrees C beyond the optimum temperature range of each life history phase (incubation, rearing, migration and spawning) for the most sensitive salmonid species present" (Oliver and Fidler 2001). Accordingly, data collected from 2014 to 2016 were compared with the optimum temperature ranges reported by Oliver and Fidler (2001).

Fish species of primary interest for JHTMON-8 in the Salmon River are steelhead, Coho Salmon and Chinook Salmon. Steelhead and Coho Salmon are present both upstream and downstream of SAM-WQ, while the range for Chinook Salmon extends to the Memekay River confluence, approximately 15 km downstream of SAM-WQ (based on distributions presented in Burt 2010). The MWMxT data are compared to optimum temperature ranges for different fish species in Table 43. For each life stage, Table 43 also shows the percentage of MWMxT data that are above, within, and below the optimum ranges for fish life stages during baseline monitoring. The percentages of MWMxT data that are above and below the optimum ranges by more than 1°C are also presented.

Comparisons to the provincial guidelines are not made when “Percent Complete” is ≤50% (Table 43). In addition, if the water temperature records are only slightly >50% complete for a particular species/life stage, comparisons to the provincial guidelines are interpreted with caution. In particular, the analysis provides useful information about whether water temperatures were excessively warm at times for juvenile steelhead and Coho Salmon during the rearing life stage.

For Chinook Salmon, MWMxT were above upper bounds by > 1°C at times for all four relevant life stages from 2014 to 2016. The MWMxT did not exceed the lower bound of the optimum ranges by > 1°C for the migration and spawning stages. For the incubation and rearing stages, the MWMxT data were more than 1°C below the lower bound for 33.0% of the record during 2015 and 38.2% of record during 2016. Considering all life stages, MWMxT data were within the optimum temperature range for ~10% to ~90% of the records from 2014 to 2016 (Table 43).

For Coho Salmon, MWMxT were above upper bound by > 1°C at times for the migration stage during 2014 and rearing stage during 2015 and 2016 (rearing conditions could not be evaluated in 2014). During 2016, temperatures were below the lower bound by >1% for 40.8% of the time, and above the upper bound by >1% for 16.7% of the time. Considering all life stages, MWMxT data were within the optimum temperature ranges for ~30% to ~75% of the records (Table 43).

For steelhead, MWMxT were above lower bound by > 1°C for ~50% to ~75% of the records for spawning, incubation, and rearing stages in both 2015 and 2016 (not evaluated in 2014). Water temperatures during the steelhead (and Coho Salmon) rearing life stage were generally cooler in 2016 than in 2015. For all three life stages, MWMxT were below the upper bounds by > 1°C for ~10% to ~30% of the records; only ~4% to ~14% of the MWMxT data were within the optimum temperature ranges (Table 43).

Table 43. Mean weekly maximum temperatures (MWMxT) in the Salmon River from 2014 to 2016 compared to optimum temperature ranges for fish species present. Periodicity information is from Burt (2010).

Species	Life Stage: Periodicity	Life Stage: Optimum Temperature Range (°C)	Life Stage: Duration (days)	Year	Percent Complete	MWMxT (°C): Min.	MWMxT (°C): Max.	% of MWMxT: Below Lower Bound by >1°C	% of MWMxT: Below Lower Bound	% of MWMxT: Between Bounds	% of MWMxT: Above Upper Bound	% of MWMxT: Above Upper Bound by >1°C
Chinook Salmon	Migration (Jul. 15 to Sep. 30)	3.3-19.0	77	2014	100	13.1	22.2	0.0	0.0	51.9	48.1	36.4
				2015	100	10.6	21.0	0.0	0.0	50.6	49.4	23.4
				2016	98.7	10.8	21.1	0.0	0.0	63.2	36.8	26.3
	Spawning (Sep. 01 to Oct. 31)	5.6-13.9	61	2014	80.3	10.2	17.7	0.0	0.0	42.9	57.1	46.9
				2015	98.4	8.4	15.4	0.0	0.0	88.3	11.7	8.3
				2016	63.9	10.0	15.2	0.0	0.0	59.0	41.0	5.1
	Incubation (Sep. 01 to Apr. 23)	5.0-14.0	234	2014	-	-	-	-	-	-	-	-
				2015	99.6	0.4	15.4	33.0	52.4	44.6	3.0	1.7
				2016	-	-	-	-	-	-	-	-
	Rearing (Mar. 07 to Jul. 23)	10.0-15.5	137	2014	-	-	-	-	-	-	-	-
				2015	51.8	12.9	23.3	0.0	0.0	9.9	90.1	85.9
				2016	99.3	4.6	18.9	38.2	41.2	42.6	16.2	9.6
Coho Salmon	Migration (Sep. 01 to Nov. 30)	7.2-15.6	91	2014	53.8	10.2	17.7	0.0	0.0	55.1	44.9	24.5
				2015	98.9	1.7	15.4	22.2	26.7	73.3	0.0	0.0
				2016	-	-	-	-	-	-	-	-
	Spawning (Oct. 01 to Dec. 15)	4.4-12.8	76	2014	-	-	-	-	-	-	-	-
				2015	98.7	1.7	11.9	14.7	29.3	70.7	0.0	0.0
				2016	-	-	-	-	-	-	-	-
	Incubation (Oct. 01 to Apr. 15)	4.0-13.0	197	2014	-	-	-	-	-	-	-	-
				2015	99.5	0.4	11.9	21.4	39.3	60.7	0.0	0.0
				2016	-	-	-	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2014	-	-	-	-	-	-	-	-
				2015	63.4	1.0	23.3	25.9	27.2	29.3	43.5	41.4
				2016	77.0	0.4	21.1	40.8	42.2	37.2	20.6	16.7
Rainbow Trout/ Steelhead	Spawning (Mar. 01 to May. 31)	10.0-10.5	92	2014	-	-	-	-	-	-	-	-
				2015	-	-	-	-	-	-	-	-
				2016	98.9	4.2	12.8	64.8	69.2	4.4	26.4	20.9
	Incubation (Mar. 01 to Jun. 30)	10.0-12.0	122	2014	-	-	-	-	-	-	-	-
				2015	-	-	-	-	-	-	-	-
				2016	99.2	4.2	17.0	48.8	52.1	14.0	33.9	19.8
	Rearing (Jan. 01 to Dec. 31)	16.0-18.0	365	2014	-	-	-	-	-	-	-	-
				2015	63.4	1.0	23.3	53.0	56.5	6.9	36.6	31.0
				2016	77.0	0.4	21.1	75.9	79.4	7.1	13.5	9.9

Blue shading indicates provincial guideline exceedance of the lower bound of the optimum temperature range by more than 1°C (Oliver and Fidler 2001).
Red shading indicates provincial guideline exceedance of the upper bound of the optimum temperature range by more than 1°C (Oliver and Fidler 2001).

Air Temperature

Air temperatures measured from May 2014 to October 2016 are shown in Figure 30. The monthly-average air temperature ranged from 0.8°C (January 2016) to 18.1°C (July, 2015; Table 44). The lowest air temperature measured during the monitoring period was -9.5ºC measured in January, 2016, while the highest air temperature was 33.3°C in July, 2015. Average air temperatures during the 2016 growing season were generally slightly cooler than during the two previous years.

Air and water temperatures were highly correlated, with a linear correlation coefficient (*r*) of 0.95. A linear model showed close correspondence between mean daily air and water temperatures (Figure 32), which likely reflects the relatively wide channel upstream (and resulting absence of full canopy cover; Figure 4), rainfall-driven hydrology during the mid to late growing season, and limited presence of wetlands and lakes in the upper watershed (Stefan and Preud'homme 1993). Congruence between the two datasets is greatest in the range 10–20°C; inspection of the data indicates that an S-shaped function (cf. Mohseni and Stefan 1999) would be preferable to a linear function to model water temperature in the Salmon River and the Quinsam River (Section 3.2.3.2) based on air temperature records.

Table 44. **Monthly air temperature at the Salmon River (SAM-AT) form 2014 to 2016. "Avg", "Min", "Max" and "SD" denote the monthly average, minimum, maximum and standard deviation of water temperatures (°C). Blue and orange shadings highlight minimum and maximum temperatures, respectively. Statistics were not generated for months with less than 3 weeks of observations.**

Year	Month	SAM-AT			
		Avg	Min	Max	SD
2014	May	-	-	-	-
	Jun	13.7	6.8	23.6	3.4
	Jul	16.9	7.9	30.4	4.4
	Aug	17.8	9.0	31.9	4.4
	Sep	13.7	4.3	26.2	4.2
	Oct	9.9	0.9	16.7	2.9
	Nov	2.2	-7.9	11.9	4.7
	Dec	1.9	-6.9	9.8	3.7
2015	Jan	1.9	-4.8	8.4	2.6
	Feb	4.5	-2.7	10.2	3.1
	Mar	5.6	-2.5	12.8	3.3
	Apr	6.4	-1.3	20.3	3.9
	May	12.6	0.4	24.3	4.9
	Jun	15.9	6.4	32.3	4.8
	Jul	18.1	8.3	33.3	5.1
	Aug	16.2	7.7	26.2	3.7
	Sep	10.9	1.7	22.3	3.5
	Oct	9.4	1.8	16.0	2.9
	Nov	1.3	-7.3	9.1	3.5
	Dec	1.7	-3.7	8.2	2.8
2016	Jan	0.8	-9.5	9.2	3.3
	Feb	3.5	-1.9	7.8	2.0
	Mar	4.8	-2.1	18.1	3.3
	Apr	9.0	-0.5	22.8	3.7
	May	12.0	1.7	23.7	4.6
	Jun	13.5	3.6	28.7	4.2
	Jul	16.1	8.8	25.8	3.3
	Aug	16.4	8.9	31.0	4.1
	Sep	11.3	0.6	20.9	3.5
	Oct	-	-	-	-

Figure 30. Daily average air temperature at the Salmon River (SAM-AT) between May 2014 and October 2016.

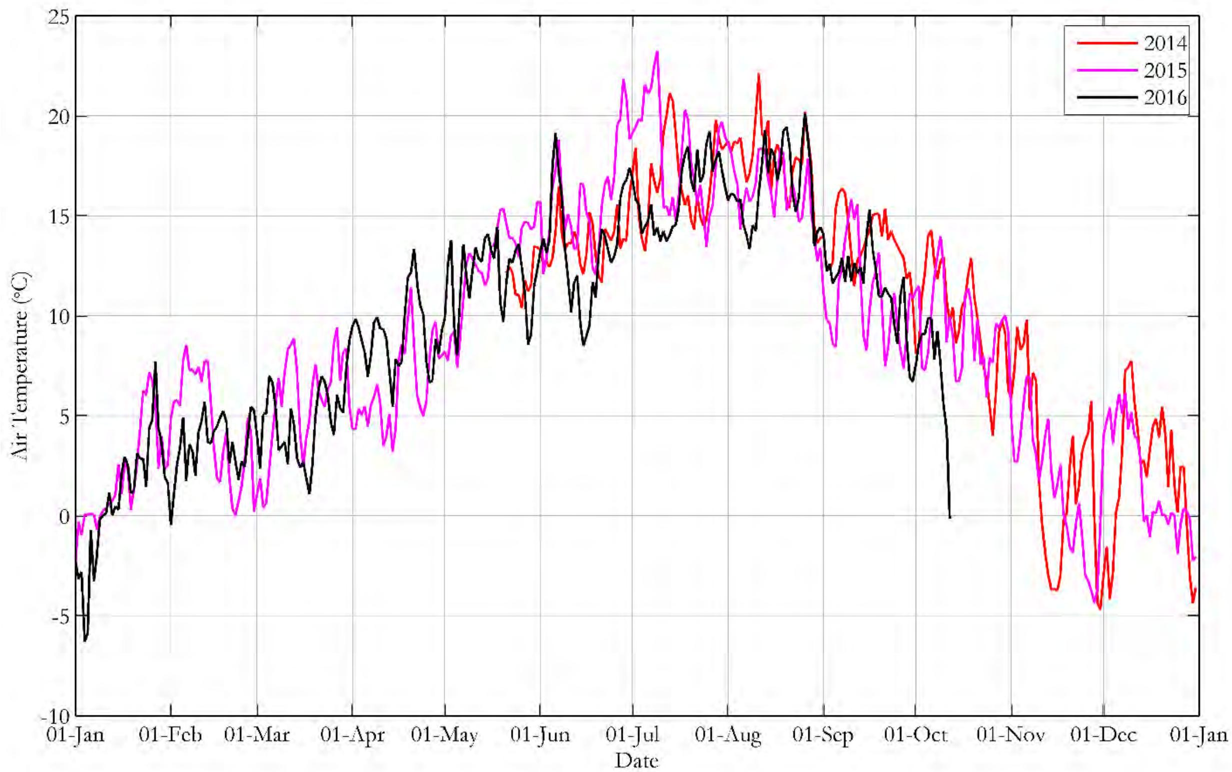
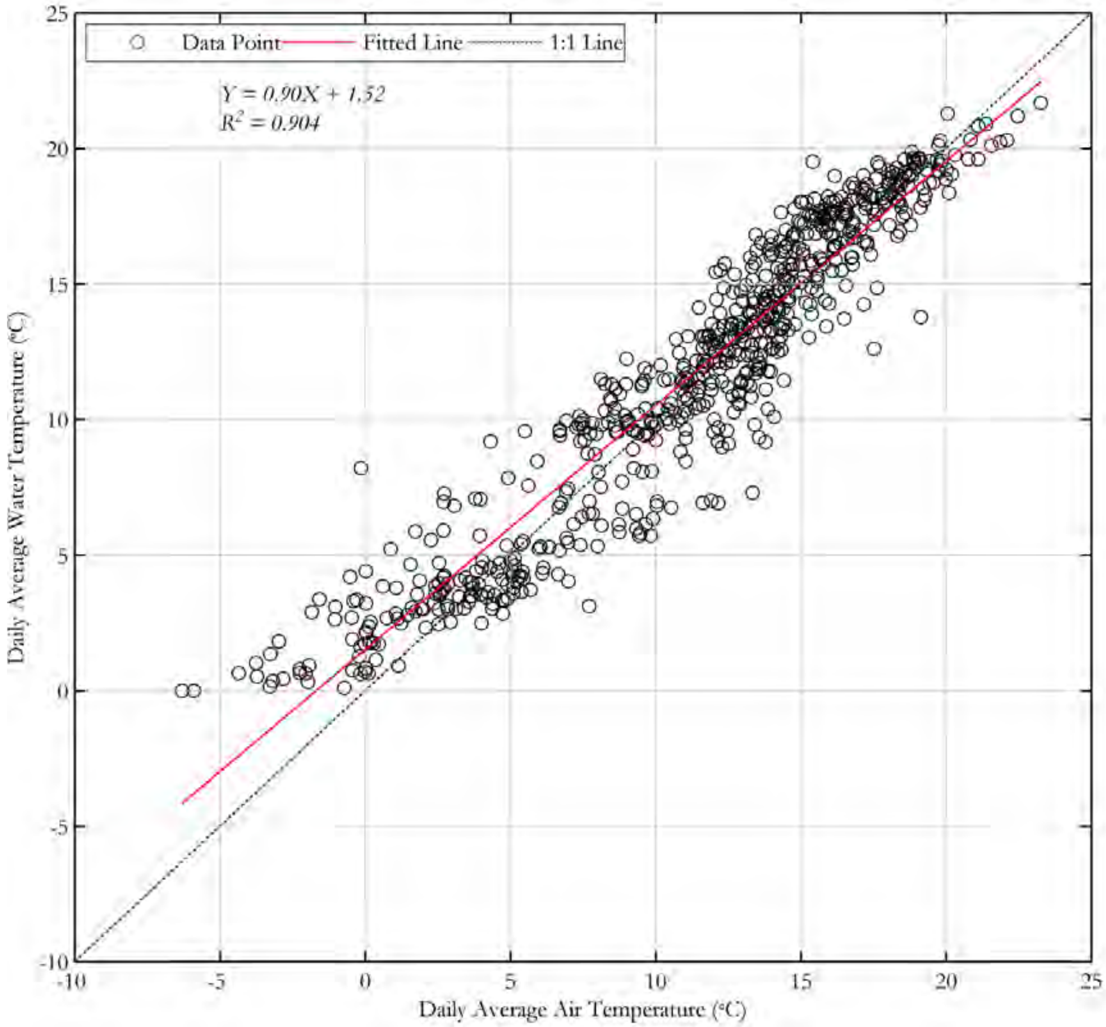


Figure 31. Daily-average water and air temperature in the Salmon River (SAM-WQ) between May 2014 and October 2016.



3.2.3.2. Quinsam River

Summary

Figure 32 shows the daily-average, maximum, and minimum water temperatures at QUN-WQ for May 2014 to October 2016. Over the period of record for Quinsam River, monthly-average water temperature ranged between 2.9°C and 19.8°C (Table 45). The highest monthly-mean water temperature of 19.8°C occurred in August, 2014 and the lowest monthly-mean water temperature of 2.9°C occurred in January, 2016. The coolest monthly-mean water temperature recorded was 1.2°C measured in January, 2016 and the warmest temperature was 23.0°C, measured in both June and July, 2015 (Table 45).

From a fisheries biology perspective, the water temperature records for the Quinsam River indicate occurrences of warm water temperatures. Over the period of record in 2015 (365 days), there were

69 days (19%) with daily-mean temperatures above 18°C, and 16 days (4%) with daily mean temperature above 20°C (Table 46). Similarly, in 2016 there were 51 days (18%) with daily-mean temperatures above 18°C, and 14 days (5%) with daily mean temperature above 20°C.

Figure 32. Daily average water temperature in the Quinsam River (QUN-WQ) between May 2014 and October 2016.

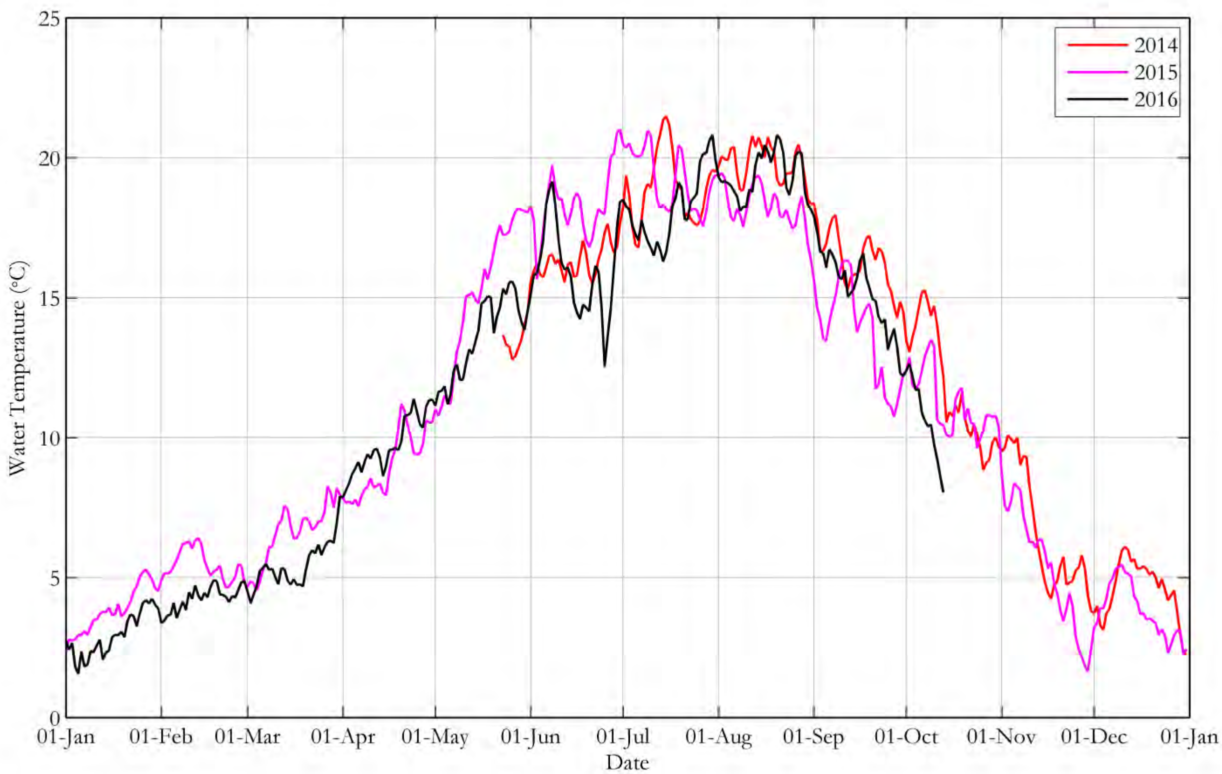


Table 45. **Monthly water temperature in the Quinsam River (QUN-WQ) from 2014 to 2016. "Avg", "Min", "Max" and "SD" denote the monthly average, minimum, maximum and standard deviation of water temperatures (°C). Blue and orange shadings highlight minimum and maximum temperatures, respectively. Statistics were not generated for months with less than 3 weeks of observations. Minimum temperatures are not shaded 2015 as data were not collected during Jan–May.**

Year	Month	QUN-WQ			
		Avg	Min	Max	SD
2014	May	-	-	-	-
	Jun	16.3	14.4	18.8	0.7
	Jul	18.9	16.5	22.7	1.4
	Aug	19.8	17.5	22.2	1.0
	Sep	16.3	13.9	18.6	1.1
	Oct	11.8	8.3	15.5	2.1
	Nov	6.6	3.6	10.3	2.2
	Dec	4.5	2.1	6.2	1.0
2015	Jan	3.8	2.0	5.6	0.8
	Feb	5.5	4.1	6.5	0.6
	Mar	6.6	4.0	8.9	1.1
	Apr	9.0	6.6	12.7	1.3
	May	15.1	9.6	18.5	2.5
	Jun	18.3	15.0	23.0	1.4
	Jul	19.2	16.0	23.0	1.6
	Aug	18.3	15.9	21.2	1.1
	Sep	13.7	10.2	17.0	1.8
	Oct	11.2	9.3	13.7	1.1
	Nov	5.3	1.5	10.0	2.1
	Dec	3.8	2.0	5.6	1.0
2016	Jan	2.9	1.2	4.6	0.8
	Feb	4.3	3.1	5.2	0.5
	Mar	5.5	3.3	9.2	1.0
	Apr	9.8	6.8	12.4	1.2
	May	13.7	10.1	16.2	1.5
	Jun	16.1	11.9	19.8	1.7
	Jul	18.2	15.5	21.2	1.3
	Aug	19.3	17.7	21.3	0.9
	Sep	15.1	11.8	18.1	1.4
	Oct	-	-	-	-

Rates of Change

Rates of change in water temperature at QUN-WQ are summarized in Table 47 and presented in Figure 33. The hourly rates of temperature change at the monitoring stations were between -0.2°C/hr and +0.2°C/hr for at least 90% of the time (based on the 5th and 95th percentiles) and were between -0.3°C/hr and +0.5°C/hr for at least 98% of the time (based on the 1st and 99th percentiles).

The maximum rate of temperature increase was +1.1°C/hr, and the maximum rate of temperature decrease was -1.3°C/hr (Table 47). Rates of temperature change with magnitudes >1°C/hr occurred for 0.02% of the records. Based on our experience on other streams in British Columbia, it is normal for a small percentage of data points to have hourly rates of water temperature change that exceed ±1°C.

Growing Season and Accumulated Thermal Units

The length of the growing season and accumulated thermal units are important indicators of the productivity of aquatic systems. As explained in Table 18, the growing season was taken to begin when the weekly-average water temperature exceeded and remained above 5°C, and to end when the weekly-average temperature dropped below 4°C (as per Coleman and Fausch 2007a).

The growing season at QUN-WQ was determined for 2015, i.e., the only year for which a complete annual record is available (Table 48). The growing season in 2015 commenced on March 2, ended on November 25, covered a period of 269 days, and had 3,561 accumulated thermal units (or degree days). The accumulated thermal units for the 2016 growing season will be presented in the Year 4 report when the data for the remainder of 2016 will be available.

Table 46. Summary of the number of exceedances of mean daily water temperature extremes (T_{water}>18°C, T_{water}>20°C, and T_{water}<1°C) in the Quinsam River at QUN-WQ from 2014 to 2016.

Site	Year	Record Length (days)	Days T_{water}> 20°C	Days T_{water}> 18°C	Days T_{water} < 1°C
QUN-WQ	2014	222	21	54	0
	2015	365	16	69	0
	2016	283	14	51	0

Table 47. Statistics for the hourly rates of change in water temperature at QUN-WQ in the Quinsam River. Shown is the frequency of rates of change exceeding a magnitude of 1°C/hr.

Station	Start of record	End of record	Number of Datapoints	Occurrence		Max -ve	Percentile				Max+ve
				Number	% of record		1th	5th	95th	99th	
QUN-WQ	23-May-2014	12-Oct-2016	335,156	82	0.02	-1.3	-0.3	-0.2	0.2	0.5	1.1

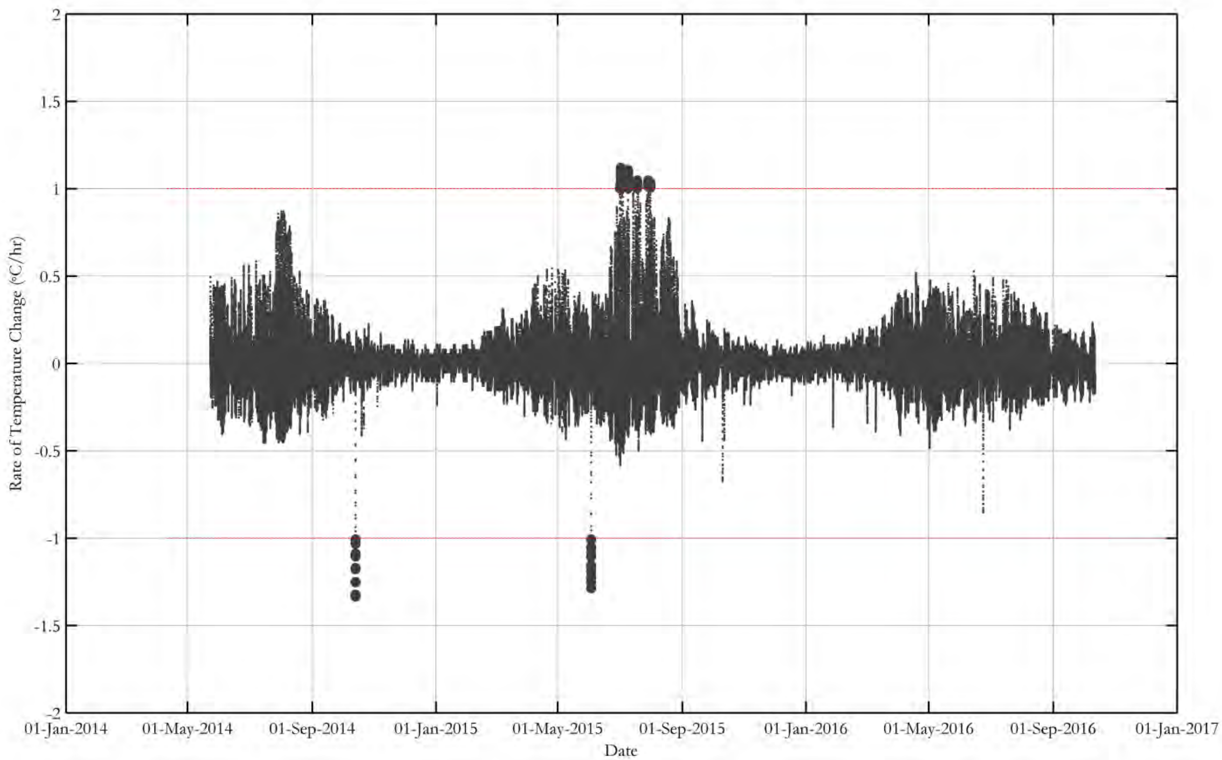
Table 48. The growing season and growing degree days at QUN-WQ in the Quinsam River (2014 to 2016).

Station	Year	Number of days with valid data	Growing Season				
			Start Date	End Date	Length (days)	Gap (days)	Degree Days
QUN-WQ	2014†	222	-	4-Dec-2014	-	-	-
	2015	365	2-Mar-2015	25-Nov-2015	269	0	3,561
	2016‡	283	14-Mar-2016	-	-	-	-

†Growing season could not be estimated because a complete data set for the course of the growing season is not available.

‡Growing season will be reported once the dataset spans a complete growing season.

Figure 33. Rate of change in hourly water temperature in the Quinsam River (QUN-WQ) from 2014 to 2016. Large dots indicate rates with magnitudes exceeding ±1°C/hr.



Mean Weekly Maximum Water Temperatures

Fish species of primary interest for JHTMON-8 in the Quinsam River are steelhead, Coho Salmon and Chinook Salmon, although Pink Salmon is also particularly important to fishery managers. Steelhead and Coho Salmon are present both upstream and downstream of QUN-WQ, although falls and cascades downstream of Lower Quinsam Lake are complete barriers to Chinook Salmon and Pink Salmon (Burt 2003). Thus, results for these two latter species should be interpreted with caution.

The MWMxT data for 2014, 2015, and 2016 are compared to optimum temperature ranges for fish species in Table 49. For each life stage, Table 49 also shows the percentage of MWMxT data that are above, within, and below the optimum ranges for fish life stages during baseline monitoring. The percentages of MWMxT data above and below the optimum ranges by more than 1°C are also shown. Comparisons to the provincial guidelines are not made when records are ≤50% complete for the period of interest (Table 49). In addition, if the water temperature records are only slightly >50%

complete for a particular species/life stage, comparisons to the provincial guidelines should be interpreted with caution.

Considering all years and all species/life stages, MWMxT in the Quinsam River exceeded optimum ranges by more than 1°C an average of 24.4% of the time, and were below optimum ranges an average of 23.0% of the time (Table 49).

For Chinook Salmon, temperatures were within optimum ranges during the migration stage. During the spawning period, 1.6% (2014) to 18.0% (2015) of MWMxT data were > 1°C cooler than the lower bound of the optimum range of 5.6°C for spawning, and 3.3% of the data in 2014 were > 1°C warmer than the upper bound of the optimum range of 13.9°C for spawning. MWMxT did not exceed the upper bound of the optimum ranges by > 1°C for the incubation stage in either 2014 or 2015; while 9.6% (2014) to 27.4% (2015) of MWMxT data were > 1°C cooler than the lower bound of the optimum range of 5.0°C for incubation. During the rearing stage, 17.6% (2016) to 21.9% (2015) of MWMxT data were > 1°C cooler the lower bound of the optimum range, while 26.5% (2016) to 48.9% (2016) of data were warmer than upper bound (Table 49).

For Coho Salmon, temperatures were typically below the upper bound of the optimum ranges for migration, spawning, and incubation stages; 1.3% (2014; incubation) to 45.8% (2015; migration) of MWMxT data were > 1°C cooler than the lower bound of the optimum ranges. For the rearing stage (year round), temperatures were within the optimum bounds for a minority (23.8–34.6%) of the time. In all years, temperatures were recorded that were more than 1°C cooler and warmer than the lower and upper bound of the optimum ranges, respectively. The occurrence of temperatures that were more than 1°C warmer than the upper bound was lower in 2016 (26.9%) than in the previous two years.

For Pink Salmon, the analysis indicates that high water temperatures occurred notably during migration and spawning. In 2016, temperatures exceeded the upper bound of the optimum range by > 1°C for 50.7% of the adult migration period and 38.5% of the spawning period. During the incubation stage, MWMxT data were within the optimum range for 71.1% (2016) to 77.9% (2015) of the period.

For steelhead, MWMxT were rarely (0–22.0% of the records) within the optimum ranges for any life stage. Most notably, water temperatures during the spawning stage in 2015 and 2016 were below the optimum range for 86.7% to 100% of the records, and > 1°C below the lower bound for 75.0% to 85.0% of the time. In 2016, water temperatures were within the optimum bounds for 13.3% of the spawning stage, 16.7% of the incubation stage, and 13.1% of the rearing stage. Note that the guideline temperature ranges for steelhead life stages are based on those for 'Rainbow Trout' (Oliver and Fidler 2001) and are not specific to fish with an anadromous life history (i.e., steelhead). Data specific to steelhead (Carter 2005 and references therein) indicate that steelhead are adapted to tolerate MWMxT considerably lower than the optimum ranges presented in (Table 49) during spawning and incubation, although survival is likely to be affected by temperatures that exceed these ranges. Thus, the occurrence of MWMxT in the Quinsam River that are below the optimum ranges for Rainbow Trout spawning and incubation do not necessarily indicate poor conditions for these steelhead life stages.

Table 49. Mean weekly maximum temperatures (MWMxT) in the Quinsam River from 2014 to 2016 compared to optimum temperature ranges for fish species present. Periodicity information is from Burt (2003).

Species	Life Stage			Year	Percent Complete	MWMxT (°C)		% of MWMxT				
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min.	Max.	Below Lower Bound by >1°C	Below Lower Bound	Between Bounds	Above Upper Bound	Above Upper Bound by >1°C
Chinook Salmon	Migration (Sep. 23 to Nov. 23)	3.3-19.0	61	2014	100	5.2	16.2	0.0	0.0	100.0	0.0	0.0
				2015	100	4.0	12.9	0.0	0.0	100.0	0.0	0.0
				2016	-	-	-	-	-	-	-	-
	Spawning (Oct. 01 to Nov. 30)	5.6-13.9	61	2014	100	4.3	15.0	1.6	27.9	57.4	14.8	3.3
				2015	100	2.7	12.9	18.0	24.6	75.4	0.0	0.0
				2016	-	-	-	-	-	-	-	-
	Incubation (Oct. 15 to Apr. 30)	5.0-14.0	197	2014	100	2.8	11.8	9.6	21.3	78.7	0.0	0.0
				2015	100	2.4	12.5	27.4	49.2	50.8	0.0	0.0
				2016	-	-	-	-	-	-	-	-
	Rearing (Mar. 07 to Jul. 23)	10.0-15.5	137	2014	-	-	-	-	-	-	-	-
				2015	100	6.9	22.5	21.9	28.5	19.0	52.6	48.9
				2016	99.3	5.4	19.3	17.6	22.8	36.8	40.4	26.5
Coho Salmon	Migration (Sep. 15 to Dec. 31)	7.2-15.6	107	2014	100	2.9	17.1	45.8	46.7	44.9	8.4	5.6
				2015	100	2.7	14.7	44.9	49.5	50.5	0.0	0.0
				2016	-	-	-	-	-	-	-	-
	Spawning (Oct. 15 to Jan. 15)	4.4-12.8	91	2014	100	2.8	11.3	11.0	28.6	71.4	0.0	0.0
				2015	100	2.4	11.4	34.1	48.4	51.6	0.0	0.0
				2016	-	-	-	-	-	-	-	-
	Incubation (Oct. 15 to Dec. 31)	4.0-13.0	77	2014	100	2.9	11.3	1.3	7.8	92.2	0.0	0.0
				2015	100	2.7	11.4	9.1	35.1	64.9	0.0	0.0
				2016	-	-	-	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2014	60.9	2.9	21.8	23.3	24.2	23.8	52.0	38.1
				2015	100	2.7	22.5	38.5	42.9	26.5	30.6	28.4
				2016	77.3	2.4	20.8	31.1	32.2	34.6	33.2	26.9
Pink Salmon	Migration (Aug. 01 to Oct. 15)	7.2-15.6	76	2014	100	11.6	21.8	0.0	0.0	27.6	72.4	65.8
				2015	100	11.0	20.6	0.0	0.0	52.6	47.4	39.5
				2016	93.4	9.8	20.8	0.0	0.0	32.4	67.6	50.7
	Spawning (Sep. 15 to Oct. 15)	7.2-12.8	30	2014	100	11.6	17.1	0.0	0.0	13.3	86.7	80.0
				2015	100	11.0	14.7	0.0	0.0	73.3	26.7	13.3
				2016	86.7	9.8	16.2	0.0	0.0	42.3	57.7	38.5
	Incubation (Sep. 15 to Apr. 07)	4.0-13.0	204	2014	100	2.8	17.1	1.5	9.3	77.9	12.7	11.8
				2015	100	2.4	14.7	10.8	26.5	71.1	2.5	1.5
				2016	-	-	-	-	-	-	-	-
Rainbow Trout/ Steelhead	Spawning (Feb. 15 to Apr. 15)	10.0-10.5	60	2014	-	-	-	-	-	-	-	-
				2015	100	5.3	9.8	85.0	100.0	0.0	0.0	0.0
				2016	100	4.7	10.2	75.0	86.7	13.3	0.0	0.0
	Incubation (Feb. 15 to Jun. 15)	10.0-12.0	121	2014	-	-	-	-	-	-	-	-
				2015	100	5.3	19.3	42.1	49.6	14.0	36.4	34.7
				2016	99.2	4.7	18.6	37.5	43.3	16.7	40.0	33.3
	Rearing (Jan. 01 to Dec. 31)	16.0-18.0	365	2014	60.9	2.9	21.8	45.7	48.0	22.0	30.0	22.4
				2015	100	2.7	22.5	66.1	69.4	4.4	26.2	17.8
				2016	77.3	2.4	20.8	55.8	66.8	13.1	20.1	13.4

Blue shading indicates provincial guideline exceedance of the lower bound of the optimum temperature range by more than 1°C (Oliver and Fidler 2001).
Red shading indicates provincial guideline exceedance of the upper bound of the optimum temperature range by more than 1°C (Oliver and Fidler 2001).

Air Temperature

Figure 34 shows the daily average air temperature for the period of record from May 2014 to October 2016. The monthly average air temperatures are shown in Table 50. The mean monthly air temperature ranged from 1.7°C to 18.7°C. The lowest air temperature measured during the monitoring period was -8.2°C measured in January, 2016, while the highest air temperature was 32.9°C in June, 2015. The maximum monthly mean air temperature (18.7°C) was in July, 2015.

Air and water temperatures were highly correlated (Figure 35), with a linear correlation coefficient (r) of 0.95. Daily mean water temperatures typically exceeded daily mean air temperatures, which likely partly reflected the influence of warming in lakes upstream.

Table 50. Monthly air temperature statistics at the Quinsam River (QUN-AT) from 2014 to 2016. "Avg", "Min", "Max" and "SD" denote the monthly average, minimum, maximum and standard deviation of water temperatures (°C). Blue and orange shadings highlight minimum and maximum temperatures, respectively. Statistics were not generated for months with less than 3 weeks of observations.

Year	Month	QUN-AT			
		Avg	Min	Max	SD
2014	May	-	-	-	-
	Jun	14.3	4.6	23.9	3.8
	Jul	17.8	8.4	32.1	4.9
	Aug	18.5	8.8	30.5	4.7
	Sep	14.1	4.4	27.3	4.4
	Oct	10.1	1.2	18.4	2.9
	Nov	3.1	-7.6	12.4	4.7
	Dec	2.4	-7.1	10.4	3.7
2015	Jan	3.1	-4.6	9.5	2.7
	Feb	5.2	-1.9	10.9	3.1
	Mar	6.1	-2.4	14.6	3.5
	Apr	7.0	-1.0	20.7	4.1
	May	13.7	0.6	26.5	5.1
	Jun	16.9	5.4	32.9	5.2
	Jul	18.7	8.6	31.5	5.3
	Aug	16.8	7.9	29.0	4.4
	Sep	11.5	2.7	24.6	3.8
	Oct	9.9	1.8	19.8	3.0
	Nov	1.7	-7.8	9.7	3.6
	Dec	1.8	-5.8	8.9	3.0
2016	Jan	1.7	-8.2	9.2	3.4
	Feb	3.9	-2.0	10.2	2.2
	Mar	5.5	-2.1	19.3	3.6
	Apr	9.8	0.6	25.3	4.2
	May	12.9	2.8	25.2	4.8
	Jun	14.5	4.1	29.8	4.7
	Jul	16.7	8.9	27.8	3.8
	Aug	17.5	9.0	31.3	4.8
	Sep	11.8	2.6	22.8	3.5
	Oct	-	-	-	-

Figure 34. Daily average air temperature at the Quinsam River (QUN-AT) between May 2014 and October 2016.

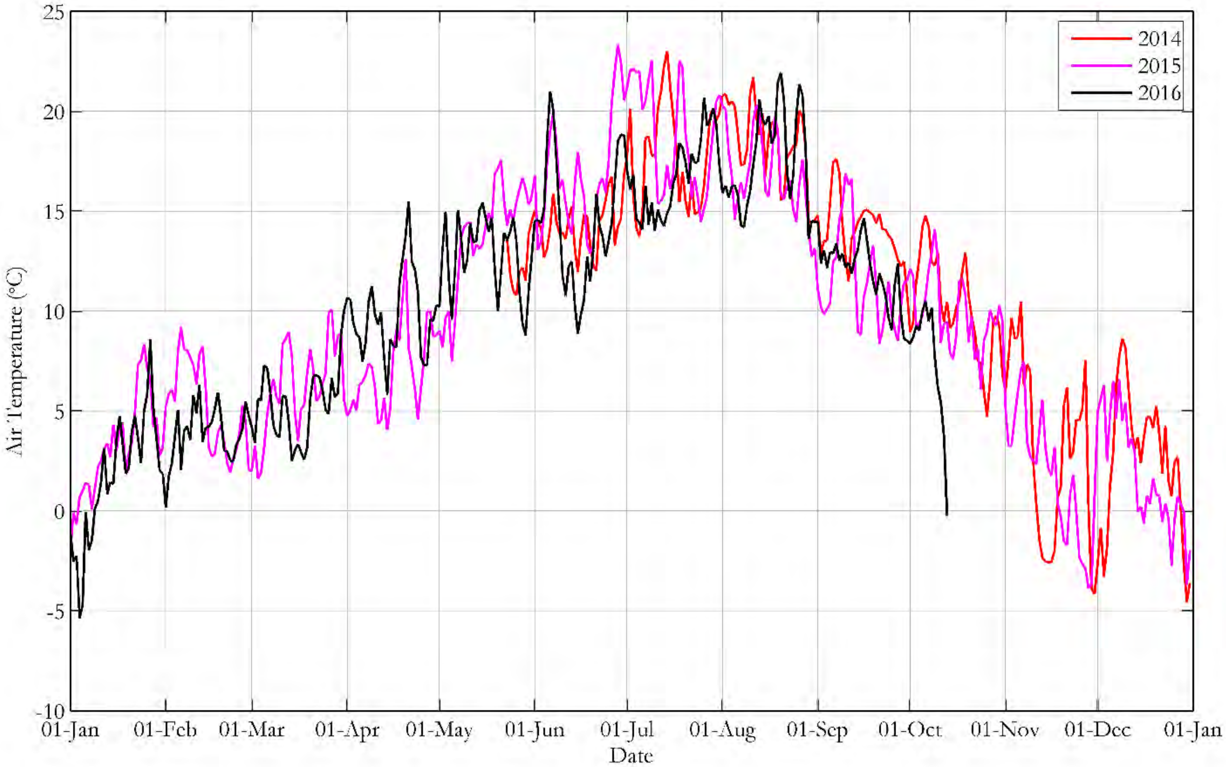
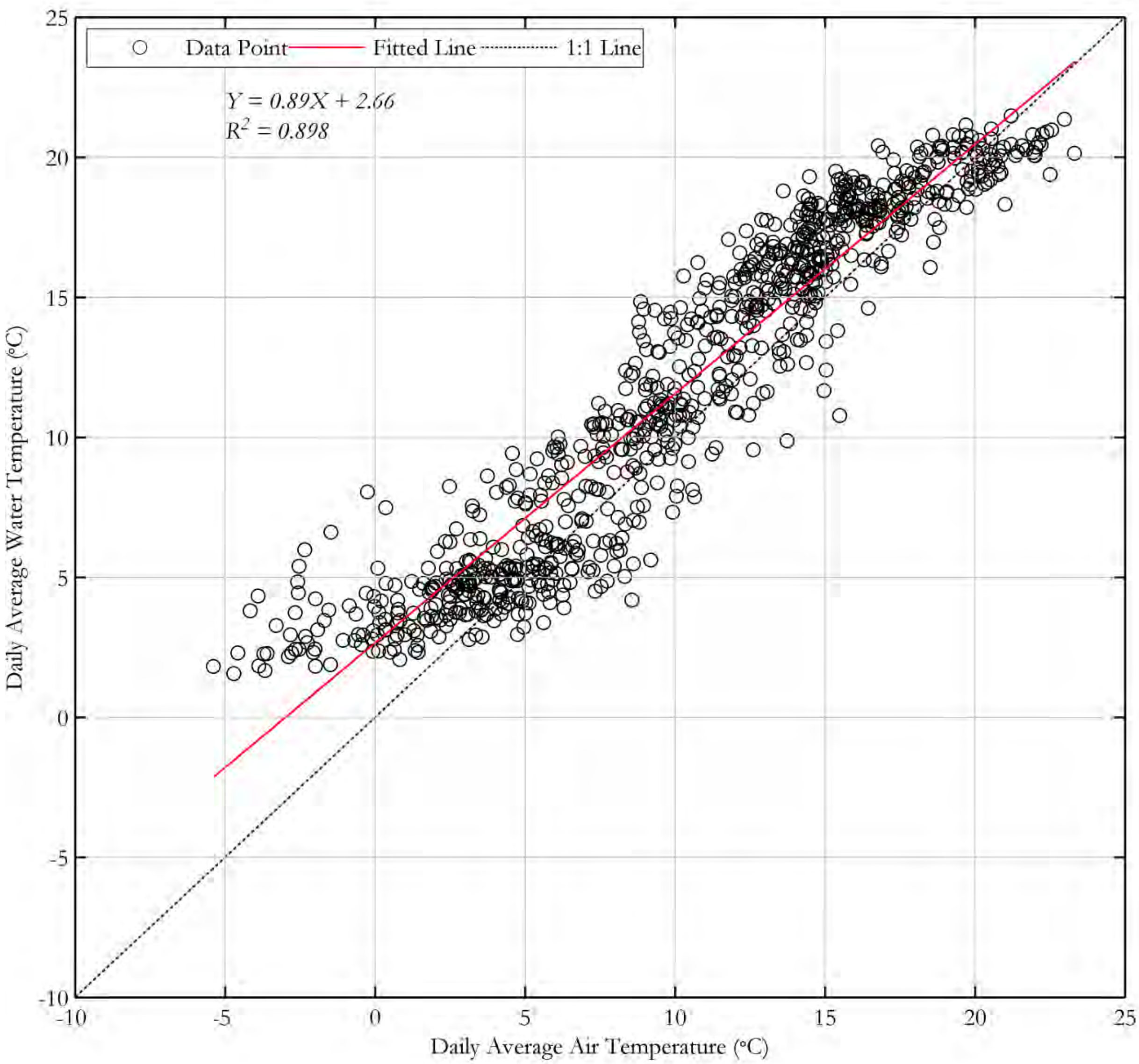


Figure 35. Daily-average water and air temperature in the Quinsam River (QUN-AT) between May 2014 and October 2016.



3.3. Hydrology

Quality assured data collected by the Water Survey of Canada were available until the end of 2015 (Year 2). Hydrographs for 2014 and 2015 at sites on the Salmon River and Quinsam River are presented in Figure 36 and Figure 37; hydrological metrics for these years are presented in Table 51.

For both years, discharge was low during the summer low-flow period, with minimum mean daily discharge of <0.5 m^3/s measured in the mainstem of both rivers, downstream of the diversion facilities (when they were not operating). It is also notable that maximum discharge was particularly high during the incubation periods for Pacific Salmon species that emerged in 2015, reflecting floods during December 2014, e.g., maximum discharge in December 2014 was 296 m^3/s in the Salmon River, measured at the WSC gauge upstream of Memekay River (Figure 36).

Figure 36. Discharge measured on the Salmon River upstream of Memekay River (Map 2) during 2014–2015.

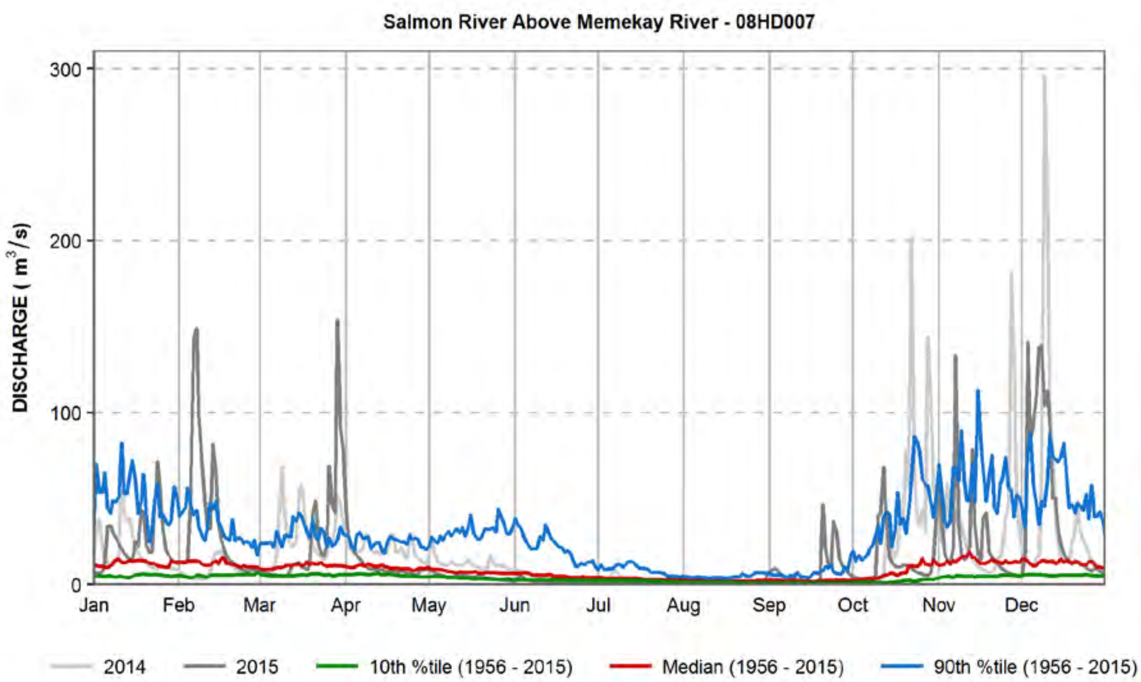


Figure 37. Discharge measured on the Quinsam River upstream of Campbell River (Map 3) during 2014–2015.

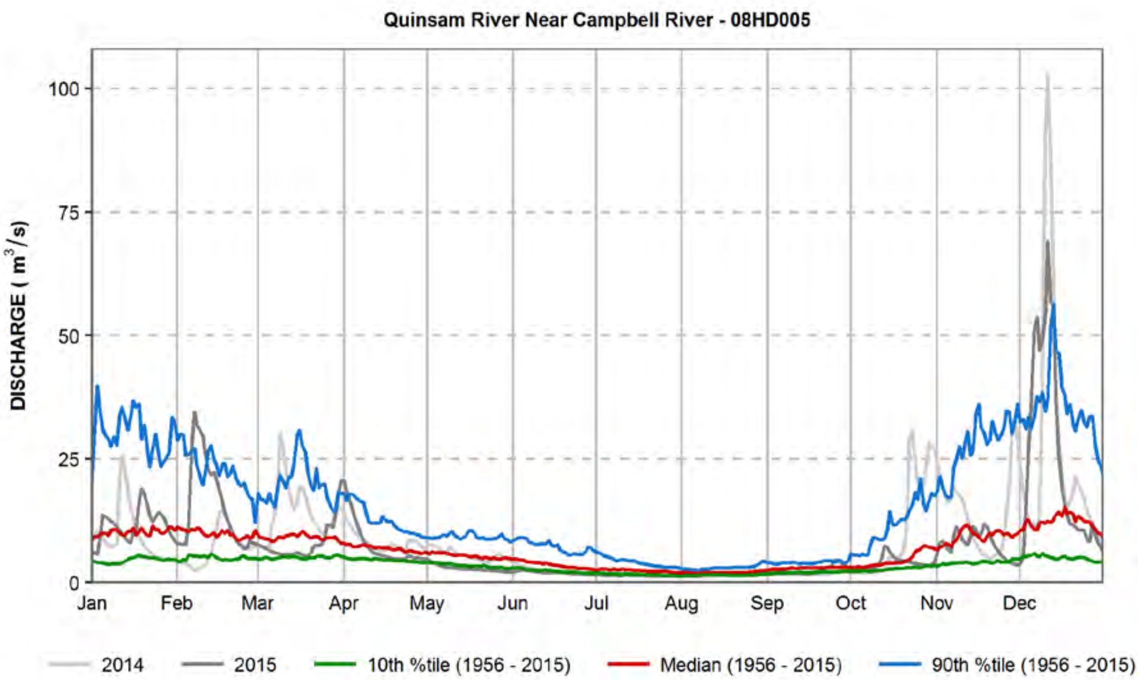


Table 51. Hydrological metrics calculated for 2014 and 2015. See Map 2 and Map 3 for hydrometric gauge locations.

Stream	Gauge	Year	Hydrological Metric (m^3/s)						
			Minimum Mean Discharge			Maximum Discharge During Spawning and Incubation Periods[1]			
			1-Day Min.	3-Day Min.	30-Day Min.	Coho Salmon	Steelhead	Chinook Salmon	Pink Salmon
Salmon River	08HD007	2014	0.47	0.48	0.57	68.70	68.70	-	-
		2015	0.48	0.49	0.70	296.00	154.00	-	-
Quinsam River	08HD021	2014	0.44	0.45	0.56	3.63	3.63	3.63	3.63
		2015	0.27	0.27	0.33	45.90	7.91	45.90	45.90
	08HD005	2014	1.15	1.16	1.30	30.40	30.40	30.40	30.40
		2015	1.23	1.24	1.32	103.00	20.90	103.00	103.00

1. '-' denotes that the value was not calculated as juvenile abundance of this species is not monitored. For fall spawners, this metric was calculated based on the discharge between the start of spawning the previous year and fry emergence during the current year.

3.4. Invertebrate Drift

3.4.1. Salmon River Invertebrate Drift

The invertebrate drift density (individuals/m^3), biomass (mg/m^3), Simpson's family-level diversity index (1-λ), richness (# families), and CEFI index at each site on each sample date are provided in Table 52. Mean, standard deviation and coefficients of variation values are shown for Year 1 (2014) data only, which is the only year when samples from all five drift nets were analyzed separately.

Biomass values are also plotted in Figure 38. All values except for the CEFI index (for which only aquatic taxa are considered) were calculated based on results for all taxa (aquatic, semi-aquatic, and terrestrial). Results for the combined sample collected on September 13, 2016 are not presented in figures and tables as they were confounded by an error made during sample processing (see Section 2.4.1).

3.4.1.1. Density

In 2016, invertebrate drift density in the Salmon River was generally lowest at the start of the growing season, averaging 0.84–1.38 individuals/m^3 in May (weekly sampling; Table 52). The coefficient of variation for the four weekly samples was 21%. Density was typically higher later in the growing season, with relatively high values measured in July (4.63 individuals/m^3) and October (4.38 individuals/m^3). This was contrary to Year 1 and Year 2 when density peaked in mid-summer (Table 52).

3.4.1.2. Biomass

Invertebrate drift biomass in the Salmon River was variable across sampling dates in 2016, with values ranging five-fold from 0.05 mg/m^3 (July 12) to 0.25 mg/m^3 (May 24; Figure 38). Biomass was inconsistent between the four weekly samples in May, with a coefficient of variation of 64%. There was no clear relationship between biomass and abundance.

Three of the mean biomass measurements were higher than values recorded in previous years, with particularly high values recorded on May 24 (0.25 mg/m^3) and October 11 (0.24 mg/m^3). Given that these values were unusually high, it is useful to know whether they reflected high density of individuals, or a small number of exceptionally large individuals that were caught by chance (sampling error) and not representative of the taxa that are generally present in invertebrate drift. If the latter was the case, then it would be desirable to omit the unrepresentatively large individual(s) from the analysis to avoid calculating an unrealistically high value.. The dominant taxon that contributed to biomass in the sample on May 24 was Limnephilidae (44%; Table 53), which is a family of cased caddisflies. This was followed by Baetidae (22%; Table 53), which is a family of mayflies. Together these families comprised 440 (29%) and 195 (13%) of the 1,528 individuals that were captured and, therefore, these families contributed disproportionately to total biomass relative to their abundance, i.e., the individuals were relatively heavy. Nonetheless, the data indicate that the high biomass measured on May 24 reflected high abundance of relatively large individuals (i.e., a hatch), rather than a small number of exceptionally large invertebrates. This suggests that the result does not reflect sampling error and is an accurate reflection of the invertebrate drift community present at the time of sampling. The dominant taxa that contributed to biomass in the sample on October 11 were Plecoptera (stoneflies; 19%) and Hydryphantidae (a family of water mites; 19%). Total biomass on October 11 was more evenly distributed between different taxa compared to the May 24 sample. This similarly indicates that the result provides an appropriate measure of the invertebrate biomass at the time of sampling and does not reflect bias due to the presence of a small number of exceptionally large individuals of one taxon.

3.4.1.3. Simpson's Family Level Diversity (1- λ)

Simpson's family level diversity values ranged from 0.38 to 0.91, with no clear seasonal pattern. The minimum value was lower than values in Year 1 and Year 2, and corresponded to the July 12 sample with unusually high density (4.63 individuals/m^3) and the lowest biomass. The total number of individuals in this sample was dominated by Limnephilidae larvae (78%); thus, the sample was dominated by a large number of small caddisflies.

3.4.1.4. Richness (# of Families)

Mean family richness ranged from 34 families (May 3) to 49 families (May 10), with no clear seasonal trend (Table 52).

3.4.1.5. Canadian Ecological Flow Index

Low CEFI values are described as <0.25 (Armanini *et al.* 2011) and all CEFI values in the Salmon River were greater than this threshold (Table 52). CEFI values ranged from 0.34 in June and August to 0.39 on May 10. CEFI values were generally lowest in mid-summer, indicating a shift to taxa that are less specific in their current velocity requirements (cf. Armanini *et al.* 2011).

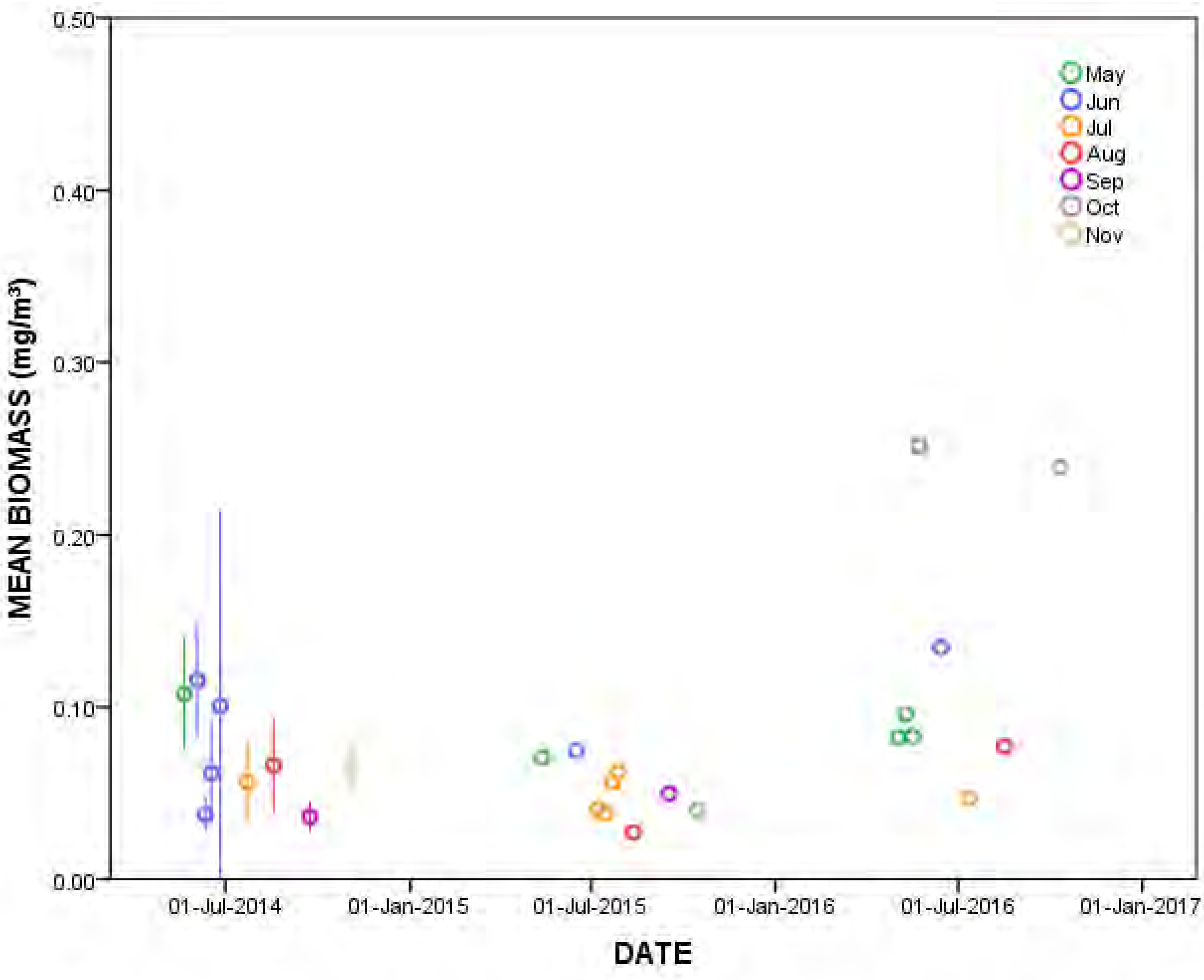
Table 52. Salmon River invertebrate drift mean density (individuals/m^3), biomass (mg/m^3), Simpson's diversity index (1-λ, family level), richness (# of families) and CEFI index. Each drift net was analyzed separately in 2014, while nets were combined into one sample in subsequent years.

All Taxa (Aquatic, Semi-Aquatic, and Terrestrial)														
Year	Date	No. of Reps.	Density (#/m^3)			Biomass (mg/m^3)			CEFI Index[1]			Simspon's Diversity Index[2]	Richness (# of Families)[2]
			Mean	S.D.	C.V. (%)	Mean	S.D.	C.V. (%)	Mean	S.D.	C.V. (%)		
2014	21-May	5	0.85	0.26	30.06	0.11	0.03	31.09	0.37	0.01	1.86	0.86	74
	03-Jun	5	0.92	0.24	25.77	0.12	0.03	29.09	0.34	0.01	2.80	0.91	80
	11-Jun	5	0.72	0.29	40.33	0.04	0.01	27.14	0.34	0.01	2.19	0.89	48
	17-Jun	5	1.10	0.37	34.00	0.06	0.03	49.98	0.37	0.01	2.28	0.85	59
	26-Jun	5	0.86	0.33	38.49	0.10	0.11	113.95	0.35	0.01	2.91	0.89	55
	23-Jul	5	1.48	0.52	35.28	0.06	0.03	45.09	0.33	0.01	3.91	0.82	38
	18-Aug	5	3.11	1.43	46.04	0.07	0.03	41.65	0.34	0.01	1.92	0.75	37
	23-Sep	5	1.28	0.21	16.20	0.04	0.01	23.50	0.34	0.01	1.52	0.91	37
	03-Nov	5	0.89	0.21	23.50	0.06	0.01	18.80	0.37	0.01	2.97	0.89	76
2015	13-May	1	1.12	-	-	0.07	-	-	0.34	-	-	0.92	47
	16-Jun	1	3.32	-	-	0.07	-	-	0.35	-	-	0.84	44
	08-Jul	1	2.27	-	-	0.04	-	-	0.32	-	-	0.77	29
	15-Jul	1	2.03	-	-	0.04	-	-	0.32	-	-	0.67	30
	22-Jul	1	3.66	-	-	0.06	-	-	0.33	-	-	0.65	26
	28-Jul	1	1.77	-	-	0.06	-	-	0.32	-	-	0.78	32
	12-Aug	1	0.91	-	-	0.03	-	-	0.33	-	-	0.74	35
	17-Sep	1	1.19	-	-	0.05	-	-	0.34	-	-	0.82	30
	15-Oct	1	1.20	-	-	0.04	-	-	0.37	-	-	0.82	40
2016	03-May	1	0.84	-	-	0.08	-	-	0.36	-	-	0.84	34
	10-May	1	1.38	-	-	0.10	-	-	0.39	-	-	0.62	49
	17-May	1	1.02	-	-	0.08	-	-	0.36	-	-	0.79	35
	24-May	1	1.22	-	-	0.25	-	-	0.35	-	-	0.83	40
	14-Jun	1	1.86	-	-	0.13	-	-	0.34	-	-	0.83	45
	12-Jul	1	4.63	-	-	0.05	-	-	0.33	-	-	0.38	37
	16-Aug	1	1.32	-	-	0.08	-	-	0.34	-	-	0.88	37
	11-Oct	1	4.38	-	-	0.24	-	-	0.38	-	-	0.91	44

[1] Calculation considers only aquatic taxa

[2] Replicates were averaged where applicable prior to calculating metric

Figure 38. Salmon River mean invertebrate drift biomass (mg/m^3) ± 1 standard deviation (SD). SD was only calculated for 2014, when five drift nets were analyzed separately per site. Sampling occurred weekly during one month each year.



3.4.1.6. Top Five Families Contributing to Biomass

A summary of the top five families contributing to biomass in the invertebrate drift community on each sample date is provided in Table 53. Note that in some instances, a taxonomic level higher than family is listed (e.g., Plecoptera), as this was the lowest taxonomic level enumerated.

The invertebrate community was dominated (in terms of biomass) by mayflies (Baetidae, Ephemeroptera, and Heptageniidae), true flies (Chironomidae and Simuliidae), caddisflies (Limnephilidae and Lepidostomatidae) and mites (Hygrobatidae, Hydryphantidae, Torrenticolidae, and Sperchontidae). Butterflies/moths (Lepidoptera), stoneflies (Plecoptera), roundworms (Nematoda) and spiders (Araneae) were also occasionally within the top five families during sampling. Mayflies were particularly dominant early in the growing season in May, while mites were more dominant later in the growing season. Stoneflies only contributed to the top five taxa in October, when they were the dominant taxon.

The kick samples and drift samples collected on September 13 were combined (see Section 2.4.1) and are therefore not directly comparable with the results for the other samples presented in Table 53 (drift samples only). The top five families that contributed to invertebrate biomass in this combined samples were: Heptageniidae (mayflies; 77.6%), Perlodidae (stoneflies; 3.5%), Tipulidae (true flies; 3.1%), Baetidae (mayflies, 2.4%). The skewed composition of this sample towards Heptageniidae likely reflects larvae being dislodged from the benthos during kick sampling.

Table 53. Salmon River: top five families contributing to invertebrate drift biomass.

3-May-16		10-May-16		17-May-16		24-May-16	
Family	% of Total Biomass	Family	% of Total Biomass	Family	% of Total Biomass	Family	% of Total Biomass
Limnephilidae	27.4	Baetidae	29.5	Limnephilidae	35.7	Limnephilidae	43.9
Baetidae	16.7	Araneae	12.0	Baetidae	21.2	Baetidae	22.0
Heptageniidae	11.8	Limnephilidae	7.5	Simuliidae	9.7	Ephemeroptera	5.3
Araneae	7.9	Lepidoptera	6.5	Chironomidae	7.6	Chironomidae	5.0
Chironomidae	7.9	Chironomidae	6.5	Heptageniidae	5.3	Lepidostomatidae	3.3

14-Jun-16		12-Jul-16		16-Aug-16		11-Oct-16	
Family	% of Total Biomass	Family	% of Total Biomass	Family	% of Total Biomass	Family	% of Total Biomass
Limnephilidae	34.1	Simuliidae	13.1	Limnephilidae	37.5	Plecoptera	19.2
Chironomidae	9.2	Chironomidae	10.3	Simuliidae	24.9	Hydryphantidae	18.8
Nematoda	9.1	Sperchontidae	10.1	Torrenticolidae	5.3	Baetidae	11.4
Lepidostomatidae	7.4	Limnephilidae	8.3	Chironomidae	4.9	Heptageniidae	10.6
Baetidae	4.2	Hygrobatidae	8.2	Sperchontidae	4.2	Simuliidae	5.4

<u>Legend</u>

Mayflies	True Flies	Caddisflies	Mites	Butterfly/Moth	Stoneflies	Roundworms	Spiders

3.4.1.7. Multivariate Analysis

The results of the cluster analysis (based on density data) are provided in the dendrogram in Figure 39. Density data from the highest available taxonomic resolution were analyzed on each sample date. Results are presented for all samples collected to date. Black lines indicate branching of groups with a dissimilar community composition at a 5% significance level (SIMPROF test); red lines denote groups that are not significantly different in their community composition at a 5% significance level (SIMPROF test).

The analyses show seasonal differences in community composition. The invertebrate drift community compositions of samples collected early in the growing season (May and June) are generally similar to each other and dissimilar to samples collected later in the growing season. Samples collected at weekly intervals during individual months (rotated each year) are generally similar; this indicates that single samples collected during individual months are representative of that specific month.

The multi-dimensional scaling (MDS) of the Bray Curtis similarity matrix (generated from density data at the highest taxonomic resolution available in the dataset) is shown in an ordination plot in Figure 40. Points that are close together represent samples that are very similar in community composition, while points that are far apart correspond to samples with very different community composition. The MDS plot was generated using density data from each sample date. The MDS has a stress value of 0.17. Stress values ≤0.1 correspond to a good ordination with negligible possibility of a misleading interpretation with respect to differences in community composition among samples (Clarke and Warwick 2001). Stress values between 0.1 and 0.2 provide a useful 2-dimensional MDS representation as long as there is agreement in groupings between dendrograms (i.e., Figure 39) and the MDS plot (i.e., Figure 40) (Clark and Warwick 2001). The relationships displayed by the MDS plot support those described above in relation to the dendrogram. In particular, this provides further support for the distinction in community composition between the early growing season (May–June) and later growing season (July–October), even when results for multiple years are considered.

Figure 39. Salmon River cluster analysis results on the Bray-Curtis similarity matrix, by date.

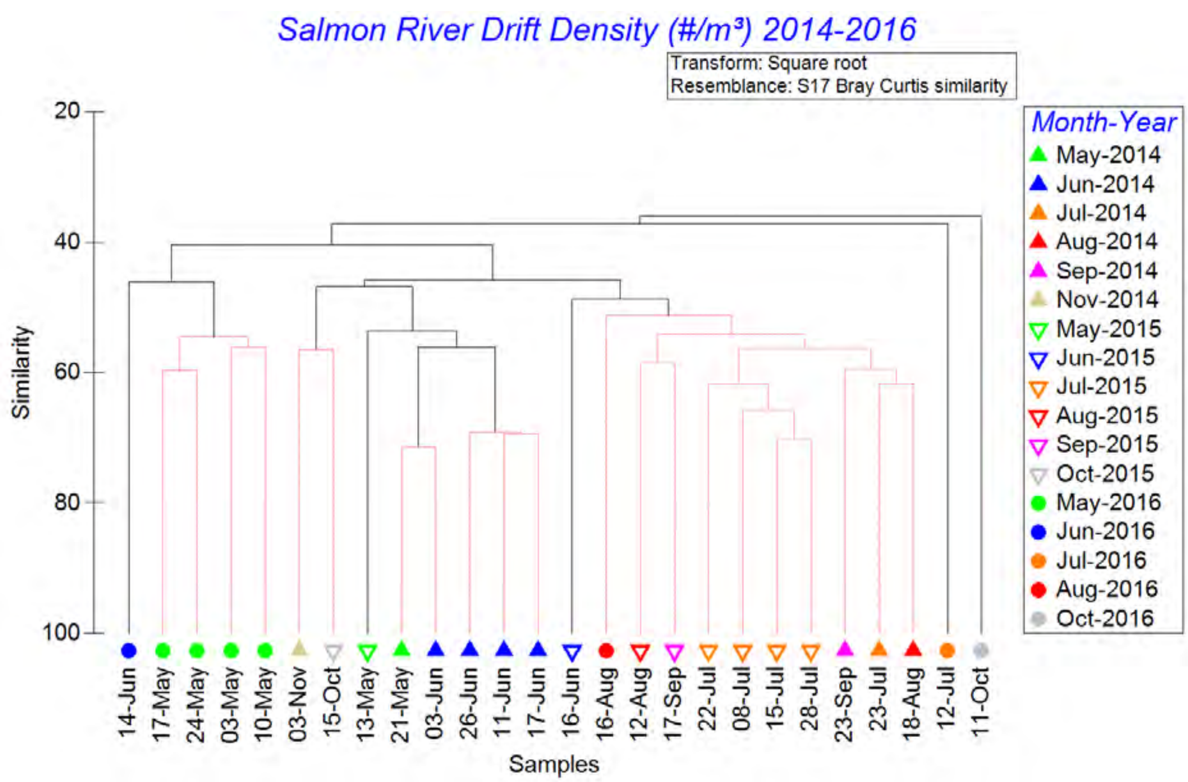
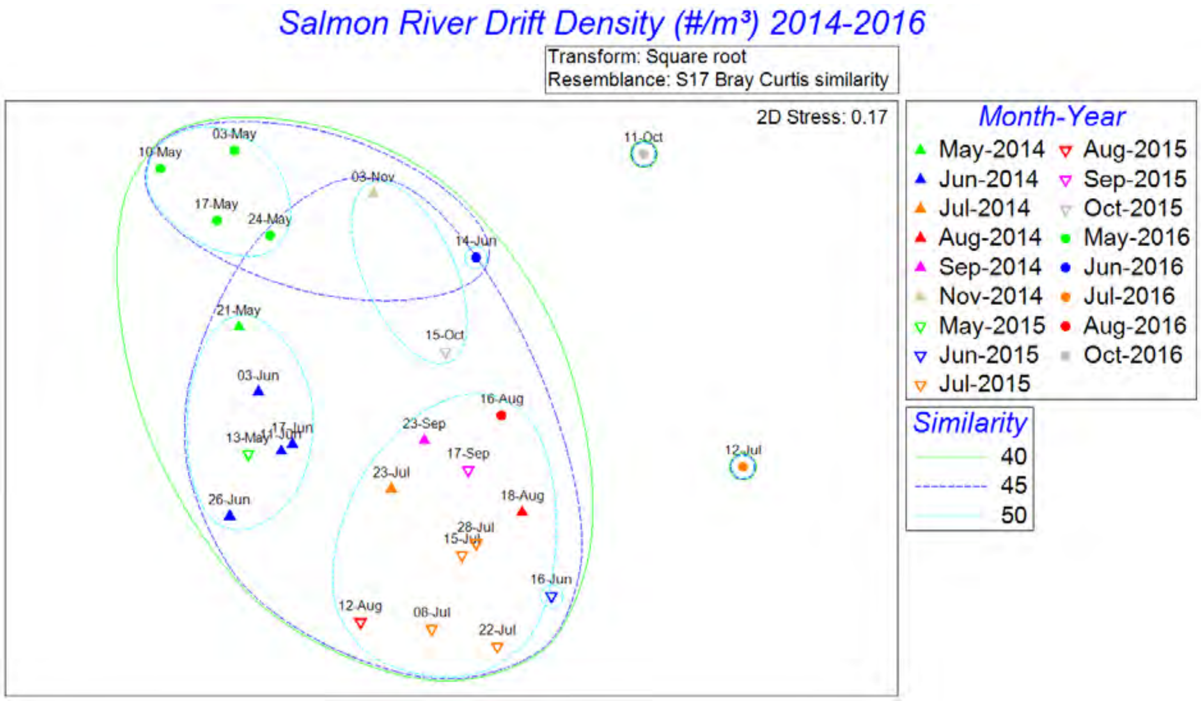


Figure 40. Salmon River non-metric, multi-dimensional scaling ordination plot by date.



3.4.2. Quinsam River Invertebrate Drift

The invertebrate drift density (individuals/m³), biomass (mg/m³), Simpson's family-level diversity index (1-λ), richness (# families), and CEFI index at each site on each sample date are provided in Table 54. Mean, standard deviation and coefficients of variation values are shown for Year 1 (2014) data only, which is the only year when samples from all five drift nets were analyzed separately. Biomass results are also plotted in Figure 41. All values except for the CEFI index (where only aquatic taxa are considered) were calculated based on results for all taxa (aquatic, semi-aquatic, and terrestrial). Results for the combined sample collected on September 14, 2016 are not presented in tables and figures as they were confounded by an error made during sample processing (see Section 2.4.1).

3.4.2.1. Density

The invertebrate drift density in the Quinsam River was variable across sampling dates. Density ranged from 1.71 to 5.33 individuals/m³ (Table 54). Density measured at weekly intervals during May ranged from 1.87 to 3.76 individuals/m³ (Table 54). The coefficient of variation for the four monthly samples was 28%.

3.4.2.2. Biomass

The invertebrate drift biomass in the Quinsam River was generally highest early in the growing season (May and June), consistent with a weak trend of declining biomass throughout the growing season that was observed in the previous two years (Figure 41). The lowest biomass was observed on August 17 (0.10 mg/m^3) and the highest on May 25 (0.25 mg/m^3). The coefficient of variation for the four monthly samples was 21%. The range of biomass values measured in 2016 was consistent with the previous two years (Table 54).

3.4.2.3. Simpson's Family Level Diversity (1- λ)

Mean Simpson's family level diversity values varied throughout the season, with no clear trend (Table 54). Diversity ranged from 0.66 on July 13 to 0.92 on October 12.

3.4.2.4. Richness (# of Families)

Mean family richness results show no apparent seasonal trend, with 38 to 59 families recorded in each sample. Minimum and maximum values were recorded in the samples collected in May.

3.4.2.5. Canadian Ecological Flow Index

Low CEFI values are described as <0.25 (Armanini *et al.* 2011) and all CEFI values in the Quinsam River were greater than this threshold (Table 52). CEFI values ranged from 0.31 in July to 0.36 on the first two sampling dates in May. CEFI values were generally lowest in mid-summer, indicating a shift to taxa that are less specific in their current velocity requirements (cf. Armanini *et al.* 2011).

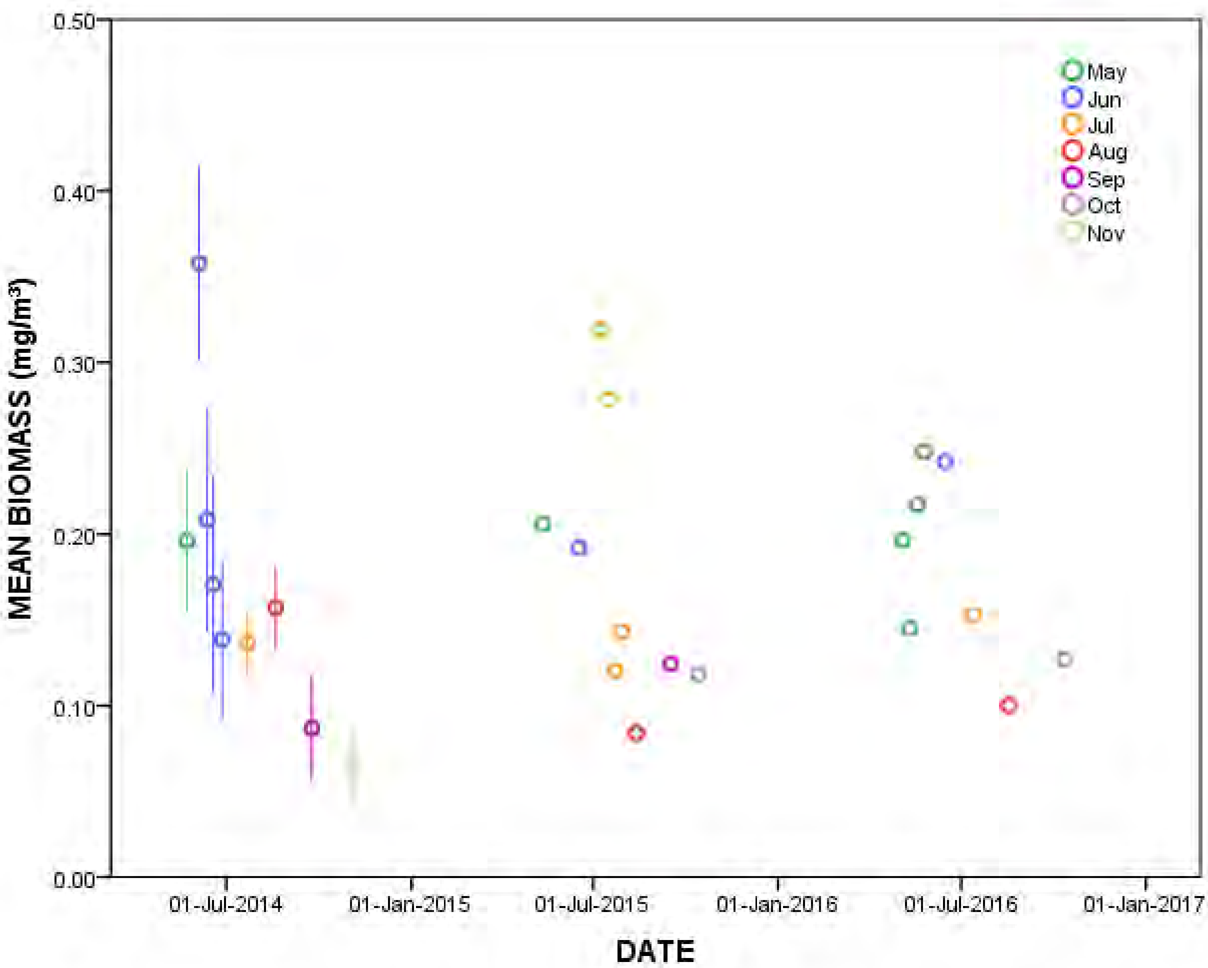
Table 54. Quinsam River invertebrate drift mean density (individuals/m^3), biomass (mg/m^3), Simpson's diversity index (1-λ, family level), richness (# of families) and CEFI index. Each drift net was analyzed separately in 2014, while nets were combined into one sample in subsequent years.

All Taxa (Aquatic, Semi-Aquatic, and Terrestrial)													
Year	Date	No. of Reps.	Density (#/m^3)			Biomass (mg/m^3)			CEFI Index[1]			Simspon's Diversity Index[2]	Richness (# of Families)[2]
			Mean	S.D.	C.V. (%)	Mean	S.D.	C.V. (%)	Mean	S.D.	C.V. (%)		
2014	23-May	5	0.96	0.12	12.52	0.20	0.04	21.16	0.37	0.01	2.83	0.84	66
	04-Jun	5	2.74	0.22	8.06	0.36	0.06	15.97	0.36	0.02	4.50	0.80	66
	12-Jun	5	2.58	0.30	11.72	0.21	0.07	31.35	0.36	0.01	2.36	0.74	65
	18-Jun	5	3.12	0.64	20.61	0.17	0.06	36.87	0.36	0.01	1.62	0.76	63
	27-Jun	5	2.47	0.45	18.36	0.14	0.05	33.23	0.35	0.01	2.09	0.81	70
	22-Jul	5	4.19	0.73	17.47	0.14	0.02	14.07	0.36	0.00	0.64	0.82	60
	19-Aug	5	6.88	3.26	47.47	0.16	0.02	15.66	0.35	0.01	1.85	0.66	59
	24-Sep	5	2.36	0.85	35.86	0.09	0.03	35.64	0.32	0.01	3.35	0.81	52
	04-Nov	5	0.65	0.22	33.38	0.07	0.02	33.45	0.33	0.01	1.57	0.93	80
2015	12-May	1	1.38	-	-	0.21	-	-	0.35	-	-	0.78	52
	17-Jun	1	4.41	-	-	0.19	-	-	0.33	-	-	0.65	50
	09-Jul	1	6.38	-	-	0.32	-	-	0.34	-	-	0.74	61
	16-Jul	1	2.52	-	-	0.28	-	-	0.35	-	-	0.81	73
	23-Jul	1	4.38	-	-	0.12	-	-	0.33	-	-	0.76	53
	29-Jul	1	4.58	-	-	0.14	-	-	0.34	-	-	0.64	39
	13-Aug	1	4.34	-	-	0.08	-	-	0.31	-	-	0.78	42
	16-Sep	1	1.71	-	-	0.12	-	-	0.35	-	-	0.79	33
	14-Oct	1	2.07	-	-	0.12	-	-	0.34	-	-	0.87	50
2016	04-May	1	2.49	-	-	0.20	-	-	0.36	-	-	0.78	38
	11-May	1	1.87	-	-	0.15	-	-	0.36	-	-	0.79	43
	18-May	1	2.82	-	-	0.22	-	-	0.35	-	-	0.78	48
	25-May	1	3.76	-	-	0.25	-	-	0.34	-	-	0.83	59
	15-Jun	1	3.25	-	-	0.24	-	-	0.33	-	-	0.82	64
	13-Jul	1	5.33	-	-	0.15	-	-	0.31	-	-	0.66	71
	17-Aug	1	1.76	-	-	0.10	-	-	0.33	-	-	0.77	78
	12-Oct	1	1.71	-	-	0.13	-	-	0.35	-	-	0.92	84

[1] Calculation considers only aquatic taxa

[2] Replicates were averaged where applicable prior to calculating metric

Figure 41. Quinsam River mean invertebrate drift biomass (mg/m³) ± 1 standard deviation (SD). SD was only calculated for 2014, when five drift nets were analyzed separately per site. Sampling occurred weekly during one month each year.



3.4.2.6. Top Five Families Contributing to Biomass

A summary of the top five families contributing to biomass in the invertebrate drift community on each sample date is provided in Table 55. Note that in some instances, a taxonomic level higher than family is listed (e.g., Ephemeroptera, Lepidoptera), as this was the lowest taxonomic level enumerated.

The invertebrate community was dominated (in terms of biomass) by mayflies (Baetidae, Ephemeroptera, Heptageniidae and Leptophlebiidae) and true flies (Chironomidae, Simuliidae, Ceratopogonidae and Tipulidae). Caddisflies (Limnephilidae, Hydropsychidae, and Rhyacophilidae), mites (Tetranychidae), stoneflies (Plecoptera and Capniidae), true bugs (Gerridae and Cicadellidae), beetles (Chrysomelidae and Haliplidae), butterflies/moths (Lepidoptera) and spiders (Aranea) were also recorded within the top five families during sampling.

Considering all sample dates, Baetidae (mayflies) and Chironomidae (true flies) were most frequently among the top five contributors, with both taxa among the top five taxa on seven of the eight sample dates. The contribution to biomass of Baetidae ranged from 4.7% to 23.9%. Baetidae was the top contributor on all sampling dates in May. The contribution to biomass of Chironomidae ranged from 9.6% to 43.2%.

The kick samples and drift samples collected on September 14 were combined (see Section 2.4.1) and are therefore not directly comparable with the results for the other samples presented in Table 53 (drift samples only). The top five families that contributed to invertebrate biomass in this combined sample were: Chironomidae (true flies; 17.0%%), Gerridae (true bugs; 14.5%), Naididae (oligochaete worms; 12.4%), Leptophlebiidae (mayflies; 9.2%) and Perlidae (stoneflies; 8.5%). The oligochaete worms were present in high abundance and likely reflected the influence of kick sampling.

Table 55. Quinsam River: top five families contributing to invertebrate drift biomass.

4-May-16		11-May-16		18-May-16		25-May-16	
Family	% of Total Biomass	Family	% of Total Biomass	Family	% of Total Biomass	Family	% of Total Biomass
Baetidae	25.1	Baetidae	23.9	Baetidae	19.4	Baetidae	20.8
Simuliidae	16.0	Chironomidae	22.0	Cicadellidae	17.0	Limnephilidae	17.6
Chironomidae	10.6	Gerridae	12.7	Chironomidae	13.2	Chironomidae	9.6
Ephemeroptera	8.2	Heptageniidae	7.5	Tipulidae	7.4	Haliplidae	5.2
Limnephilidae	7.3	Tetranychidae	6.5	Limnephilidae	6.4	Cicadellidae	4.5

15-Jun-16		13-Jul-16		17-Aug-16		12-Oct-16	
Family	% of Total Biomass	Family	% of Total Biomass	Family	% of Total Biomass	Family	% of Total Biomass
Simuliidae	36.6	Chironomidae	43.2	Simuliidae	29.6	Hydropsychidae	14.9
Baetidae	14.7	Rhyacophilidae	5.5	Chironomidae	13.8	Coleoptera	10.9
Araneae	12.9	Ceratopogonidae	4.9	Heptageniidae	6.1	Lepidoptera	7.9
Chironomidae	10.9	Baetidae	4.7	Baetidae	5.1	Capniidae	6.9
Tipulidae	4.7	Leptophlebiidae	3.5	Chrysomelidae	4.6	Simuliidae	6.1

Legend

Mayflies	True Flies	Caddisflies	Mites	Butterfly/Moth
Stoneflies	Spiders	Beetles	True Bugs	

3.4.2.7. Multivariate Analysis

The results of the cluster analysis (based on density data) are provided in the dendrogram in Figure 42. Density data from the highest available taxonomic resolution were analyzed on each sample date. Results are presented for all samples collected to date. Black lines indicate branching of groups with a dissimilar community composition at a 5% significance level (SIMPROF test); red lines denote groups that are not significantly different in their community composition at a 5% significance level (SIMPROF test).

As for the Salmon River (Section 3.4.1.7), the analyses show seasonal differences in community composition, with distinct groups that predominantly comprise samples from the early (May–June), mid (July–September) and late (October–November) growing season. Samples collected at weekly intervals during individual months (rotated each year) are generally similar; this indicates that single samples collected during individual months are representative of that specific month.

The multi-dimensional scaling (MDS) of the Bray Curtis similarity matrices (generated from density data at the highest taxonomic resolution available in the dataset) is shown in an ordination plot in Figure 43. The MDS plot was generated using density data from each sample date. The MDS has a stress value of 0.16. Stress values ≤0.1 correspond to a good ordination with negligible possibility of a misleading interpretation with respect to differences in community composition among samples (Clarke and Warwick 2001). Stress values between 0.1 and 0.2 provide a useful 2-dimensional MDS representation as long as there is agreement in groupings between dendrograms (Figure 42) and the MDS plot (Figure 43) (Clark and Warwick 2001). The relationships displayed by the MDS plot support those described above in relation to the dendrogram, with distinction between the samples collected during different periods in the growing season, even when results for multiple years are considered.

Figure 42. Quinsam River cluster analysis results on the Bray-Curtis similarity matrix.

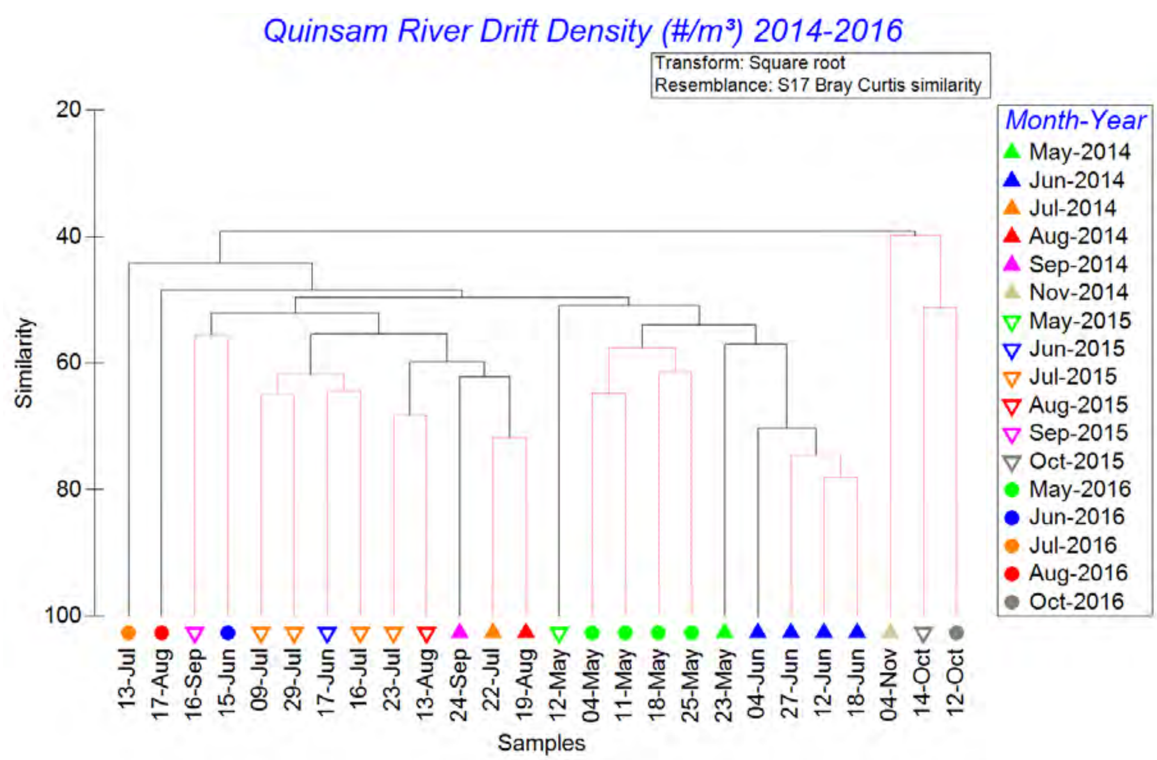
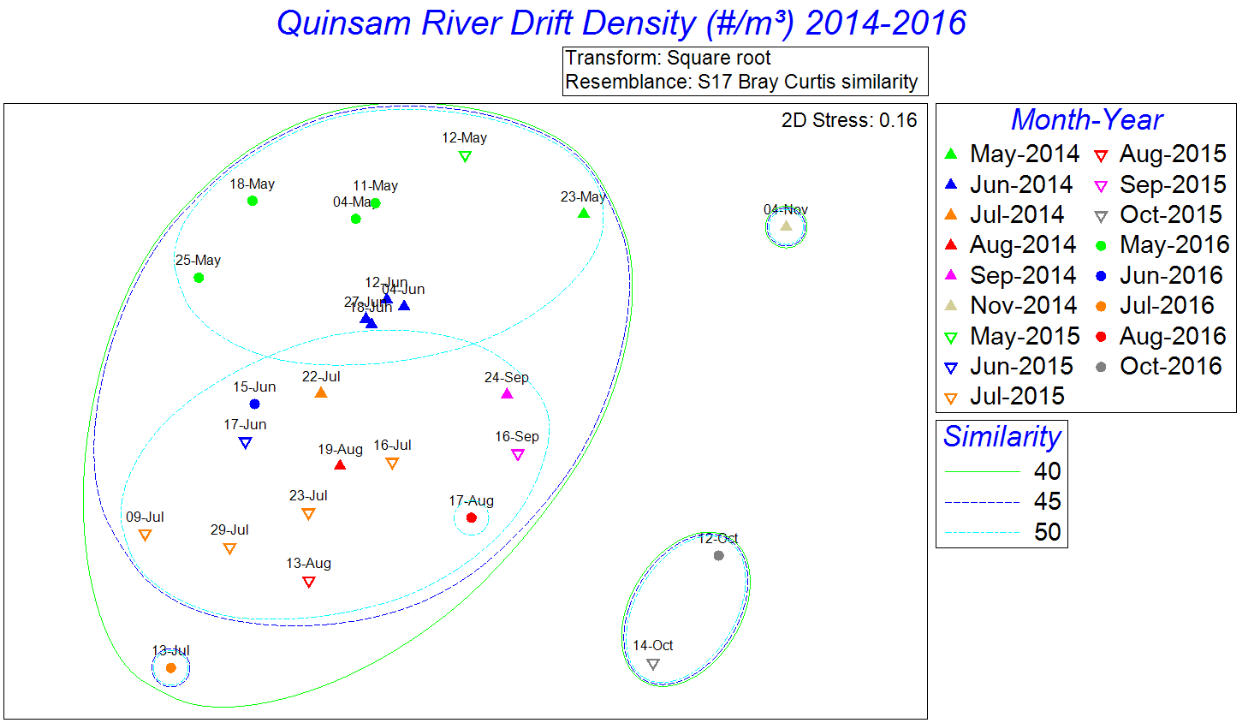


Figure 43. Quinsam River non-metric multi-dimensional scaling ordination plot by date.



4. DISCUSSION

A summary of the current status of each of the six hypotheses is provided below, including brief details of analyses that should be undertaken to test each hypothesis when data for more years are available. Interim analysis is scheduled for Year 5 and final analysis is scheduled for Year 10. Further details of the proposed data analysis methods are outlined in Section 1.4 and in Abell *et al.* (2015a).

$H_0$1: Annual population abundance does not vary with time (i.e., years) over the course of the Monitor

Although this study is at an early stage, JHTMON-8 results and historical data compiled so far show considerable inter-annual variability in juvenile fish abundance. Key results from Year 3 monitoring related to this hypothesis are:

- Adult steelhead counts in the Salmon River were low in 2016 relative to historical counts. The total count for the primary index reach (Lower Index; 50 fish) was the fifth lowest count out of the 19 years sampled and was approximately equal to the 20th percentile of the dataset. This count was higher than the count for Year 1 (39 fish) but lower than the count for Year 2 (72 fish; see Section 3.1.1). The count for the reach that is surveyed upstream of the diversion dam (Rock Creek; 4 fish) was also low, with abundance lower than Year 1 (13 fish) and Year 2 (12 fish).

- Juvenile steelhead fry abundance in the Salmon River (36 fry per 100 m^2 (FPU)) was below the mean for the sampling period (1998–2016; 52 FPU) and intermediate between the values for the previous two years of the JHTMON-8 program: 2014 (49 FPU) and 2015 (11 FPU). There was no clear difference in density between sites upstream and downstream of the diversion. On average, mean observed fry density was slightly higher upstream of the diversion (25.7 FPU compared to 21.5 FPU), but the depth-velocity adjusted density was higher downstream of the diversion (53.9 FPU compared to 43.7 FPU). Sites downstream of the diversion included both the highest and lowest densities.

- The range of juvenile Coho Salmon biomass estimated for the three sites downstream of the Salmon River Diversion (1.3–3.0 g/m^2) was comparable with Year 1 and 2. Estimated biomass values at the three sites upstream of the diversion were 0–1.6 g/m^2; values at these sites have varied considerably among years and sites.

- Data indicated that there were differences in the size of salmonid fry between sites upstream and downstream of the diversion dam. On average, 0+ steelhead fry sampled downstream of the diversion had higher fork length (57 mm compared with 51 mm) and weighed more (2.3 g compared with 1.6 g) than 0+ steelhead fry sampled upstream of the diversion. Similarly, 0+ Coho Salmon fry sampled at sites downstream of the diversion had mean weight of 2.5–5.2 g, whereas the mean weight of 0+ Coho Salmon fry sampled at sites upstream of the diversion was 2.0–2.2 g. Although H_01 specifically relates to juvenile fish abundance and not size, these results indicate that there are systematic differences throughout the watershed in salmonid rearing conditions, reflecting variability in one or more environmental factors. Analysis will be undertaken at the end of the monitor to attempt to identify the factors that cause such variability (discussed further below).

- Salmon escapement data for 2015 (i.e., Year 2) show that Pacific Salmon escapement was generally low in the Salmon River: Chinook Salmon escapement (144) was the 7th lowest in 63 years and Coho Salmon escapement (258) was the 5th lowest in the 62-year record. The low Coho Salmon count is likely to at least partly reflect that the final inspection (October 7) occurred relatively early in the reported spawning period (October 1 to December 15; Burt 2010).

- In the Quinsam River, escapement of Chinook Salmon (3,190) and Coho Salmon (8,483) in 2015 equalled or approximated the historical medians. Pink Salmon escapement (457,169) in the Quinsam River in 2015 was relatively high (the fourth-highest recorded escapement) although escapement was <50% that of the record-high escapements estimated in 2013 and 2014 (both > 1 million).

- In the Quinsam River, total estimated outmigration of Pink Salmon fry in 2016 (Year 3) was 9.2 million. This is an increase of 237% over the 2015 (Year 2) abundance (2.7 million) and 58% less than the 2014 (Year 1) abundance (22 million). Outmigration of Coho Salmon in

2016 (30,684 wild smolts) was comparable with 2014 and 2015. Estimated total outmigration of wild Chinook Salmon fry and steelhead smolts in 2016 was 1,528 and 9,002 respectively; however, the accuracy of outmigration estimates for these species is expected to be relatively low because capture efficiency was based on mark-recapture experiments conducted with another species (Coho Salmon), and observed counts were relatively low. Estimated survival of colonized juvenile Coho Salmon in Year 3 was 13%; this was the same as Year 2, although lower than Year 1 (21%). Estimated survival of colonized juvenile Chinook Salmon in Year 3 was 28%; this was lower than Year 2 (66%), which was the first year that this species has been out-planted for approximately 10 years.

Proposed analysis methods to examine trends in juvenile fish abundance are described in Abell *et al.* (2015a, b; also see Lawson *et al.* 2004). Initial analysis should be undertaken in Year 5 with final analysis undertaken in Year 10. Analysis should examine variation in time of absolute values of juvenile abundance (e.g., FPU), in addition to variation in juvenile fish abundance metrics that have been normalized based on the abundance of adult spawners. Normalizing juvenile fish abundance will isolate variability in juvenile fish abundance that is due to variability in freshwater survival, from variability that is due to fluctuations in the abundance of adult fish. Such normalization is important to avoid misleading inferences about the role of environmental factors in driving population fluctuations (Walters and Ludwig 1981). For the Quinsam River, smolt to spawner ratios can be calculated using DFO adult escapement data and salmon counting fence records, following estimation of smolt age (see discussion of $H_0 6$ below). For the Salmon River, juvenile fish abundance metrics can be normalized based on metrics of adult abundance (e.g., see Figure 20) to provide a measure of adult survival. One limitation to this is that the accuracy and precision of adult escapement surveys are variable between years, streams and species (Table 11, Table 12). Also, the juvenile abundance surveys on the Salmon River provide relative rather than absolute measurements of juvenile abundance, i.e., measurements at index sites rather than estimating total abundance of a cohort. To address these limitations, it will be necessary to critically examine the methods used each year to measure adult escapement and identify any years when surveys were conducted with particularly low accuracy or precision, i.e., based on the 'estimate classification type' (Table 13). It will also be necessary to consider potential sources of measurement error during juvenile abundance surveys, e.g., any instances when high flows may have confounded results. Such potentially anomalous results should be identified and individually evaluated, with values subsequently either adjusted or removed from the analysis if necessary.

$H_0 2$: Annual population abundance is not correlated with annual habitat availability as measured by Weighted Usable Area (WUA)

Weighted Usable Area (in m^2) provides an index of habitat availability that is calculated using relationships developed between flow and the area of different habitats (Lewis *et al.* 2004). The metric is weighted based on Habitat Suitability Index scores; these provide a relative measure (between 0 and 1) of the suitability of a particular habitat for the species and life stage of interest.

To test this hypothesis, it will be necessary to analyze fish abundance data collected during this study, in concert with WUA determined as part of separate studies to derive relationships between habitat and flow for sites on the Salmon and Quinsam rivers. For the Quinsam River, results of work already undertaken during the WUP process can be used to provide information about flow-habitat relationships in the mainstem downstream of the diversion (BC Hydro 2013). For the Salmon River, an instream flow study has been proposed (LKT 2016) to derive flow-habitat relationships as a component of JHTMON-6. The results of such a study are required to test this hypothesis on the Salmon River.

Analysis to test this hypothesis should be undertaken separately for individual species and watersheds. Initially, analysis should focus on the ten-year period of the monitor. It will subsequently be valuable to also consider historical data, although this will depend on whether it is deemed appropriate to accept the flow-habitat relationship as representative of conditions at the time of fish abundance monitoring.

$H_0$3: Annual population abundance is not correlated with water quality

Year 3 water quality results were generally consistent with Year 1 and Year 2 data. Both study streams are typical of coastal BC watersheds with low nutrient concentrations (oligotrophic), near-neutral pH and low turbidity during baseflow. Alkalinity and conductivity is low in the Salmon River and moderate in the Quinsam river, with these differences potentially reflecting the influence of lakes upstream in the Quinsam River and/or differences in watershed geology or land use. Results show that measurements of some water quality variables were, at times, outside of the preferred ranges for fish species present in the watersheds. Specifically, water temperatures were recorded on both rivers that exceeded guideline temperatures for suitable salmonid rearing conditions, while dissolved oxygen concentrations less than the provincial guideline for the protection of buried embryos/alevins were recorded at times in the Quinsam River during the growing season. The low dissolved oxygen measurements were during reported incubation periods (Burt 2003) for resident Rainbow Trout and steelhead. Measurements also indicated that dissolved oxygen concentrations were below the guideline value during the start of the Pink Salmon incubation period.

Analysis to test this hypothesis should be undertaken separately for individual species, water quality variables and watersheds. Initially, analysis should focus on the ten-year period of the monitor, although there are opportunities to use water temperature data collected by other parties to extend the time period over which the potential effects water temperature are considered (see Dinn *et al.* 2016). Analysis will initially involve evaluating scatter-plots, time series graphs and correlation metrics to examine whether there is a link between variability in water quality variables and juvenile fish abundance. Depending on the outcomes, individual water quality variables may then be included as predictor variables in statistical models to quantify the effect of water quality on juvenile fish abundance. The results of monitoring of historical nutrient enrichment in the Salmon River watershed (1989–2015) should also be considered. These results were collated by BCCF and reviewed as part of Year 2, with results showing that low nutrient concentrations can limit juvenile steelhead production in the watershed (Dinn *et al.* 2016).

At this stage, the water quality metrics that will be used for this analysis have not been confirmed; e.g., it has not been confirmed which variables will be considered as potential predictors of fish abundance, and how metrics will be calculated based on multiple measurements of each variable throughout the growing season. It is desirable that a subset of potential predictor variables is identified prior to conducting the final analysis to avoid "data dredging" by trialling a large number of predictor variables in statistical models, which can increase the likelihood of obtaining spurious results. These metrics should therefore represent variables that best encompass the concept of "water quality" in the context of fish habitat. This task of identifying suitable water quality metrics is currently scheduled for Year 4 (see Section 5.2), based on the schedule of tasks that was proposed during a background review conducted at the start of the study (Abell *et al.* 2015a).

$H_0$4: Annual population abundance is not correlated with the occurrence of flood events

This hypothesis will be tested by quantifying high flow metrics separately for each watershed based on discharge measured at gauges maintained by the Water Survey of Canada. Relationships between the occurrence of floods and juvenile fish abundance will then be analyzed.

In Year 3, we conducted a review to identify hydrologic metrics to test this hypothesis[7]. A range of metrics was identified (Table 20) based on a subset (Group 2) of the Indicators of Hydrologic Alteration (Richter *et al.* 1996). Metrics include measures of both high and low flows to provide an opportunity to extend the analysis to consider hydrologic variability more widely, reflecting that the occurrence of low summer flows can be a significant limiting factor for juvenile salmonid productivity (e.g., Grantham *et al.* 2012), in addition to the occurrence of floods.

In Year 3, we calculated hydrologic metrics for 2014 and 2015, which were the study years for which quality-assured data were available. For both years, discharge was low during the summer low-flow period, with minimum mean daily discharge of <0.5 m^3/s measured in the mainstem of both rivers, downstream of the diversion facilities (when they were not operating). It was also notable that maximum discharge was particularly high during the incubation periods for Pacific Salmon species that emerged in 2015, reflecting floods during December 2014. We plan to consider additional metrics in future years, e.g., that quantify the duration of high flows.

$H_0$5: Annual population abundance is not correlated with food availability as measured by aquatic invertebrate sampling

Invertebrate drift data have now been collected for three growing seasons in both streams. Results show that invertebrate drift biomass tends to decline during the growing season, although this trend was not observed in the Salmon River in Year 3 (relatively high values were measured in May and

[7] The project Terms of Reference state that "measures of flood events will be supplied by BC Hydro" (BC Hydro 2013). In Year 3, it was confirmed that LKT will propose metrics for review by BC Hydro (Watson, pers. comm. 2017).

October). Analysis of similarity in the invertebrate assemblages sampled to date shows consistent trends among years, with distinct communities present early in the growing season (May and June) relative to later in the growing season (Figure 40, Figure 43). Invertebrate drift biomass is generally lower in the Salmon River (Figure 38) than the Quinsam River (Figure 41).

These trends have potential implications for juvenile salmonid productivity, although data for further years are required before relationships between aquatic invertebrate drift and fish abundance can be examined. However, analysis undertaken by BCCF has already shown that juvenile steelhead productivity is limited by food availability in the Salmon River watershed. A more-detailed review of these results and their implications for the JHTMON-8 program is presented in the background water quality review that was conducted as a component of Year 2 (Dinn *et al.* 2016).

Analysis to test this hypothesis will involve analyzing relationships between invertebrate biomass and juvenile fish abundance. Invertebrate biomass will be trialled as predictor variables in statistical models to quantify the effect (if any) of this variable on juvenile fish abundance. It is expected that other metrics of invertebrate productivity (e.g., invertebrate density) will also be trialled. As with water quality, the study is currently premised on the assumption that invertebrate drift measured at a single index site is representative of conditions experienced by fish in the wider watershed.

$H_0$6: Annual smolt abundance is not correlated with the number of adult returns (Quinsam River)

No analysis has been undertaken to test this hypothesis at this time; this hypothesis will be tested during later analysis to determine whether robust spawner-recruitment relationships can be derived. Initial analyses could commence approximately midway through the 10-year study and should incorporate historical data to maximize the sample sizes available.

5. PROPOSALS TO IMPROVE THE STUDY IN FUTURE YEARS

5.1. Status of Proposals Made in Year 1 and Year 2

Table 56 summarizes the current status of the nine proposals[8] made in Year 1 and Year 2. Proposals #1 to #6 remain underway. Proposal #1 and #2 relate to incorporating historical data collected at the Quinsam River Hatchery salmon counting fence into the dataset available for JHTMON-8 analysis. DFO is currently confirming the status of historical paper records collected pre-1996 (Fortkamp, pers. comm. 2017) before a plan to quality assure and digitize historical records can be developed. The feasibility of incorporating this additional task into the current study scope will depend on the status of the records and whether additional analysis of raw data is required. Proposal #3 relates to obtaining historical (2008–2013) juvenile Coho Salmon abundance data for the Salmon River and DFO has confirmed that the outstanding data are being compiled (Anderson,

[8] These were termed "recommendations" in the Year 1 Report but we now use the term "proposals" as "recommendations" can have a specific meaning in the context of WUP monitoring that is different to our intended meaning. Specifically, these proposals relate to relatively minor methodological changes that we intend to adopt within the scope of the current project to improve the existing study.

pers. comm. 2015). Proposals #4 to #6 relate to proposals made in the background water quality review completed in Year 2 (Dinn *et al*. 2016). These relate to considering additional water quality data in JHTMON-8 analysis that have been, or will be, compiled during the monitor. Given their commonality, these three proposals will be combined into a single proposal in future tables. Proposals 7–9 were successfully addressed in Year 3.

Table 56. Current status of proposals made in Year 1 and Year 2 to improve the JHTMON-8 study.

#	Environmental Component	Proposal to Improve the Study	Year Added	Implementation Status
1	Fisheries	Historical data (1996–2013) from Quinsam River Salmon Counting Fence operations that were provided in Year 2 should be presented alongside data collected during the JHTMON-8 program.	2	These data were reviewed in Year 3. Further analysis is required to derive outmigration estimates for some years from raw count data. A plan to complete this analysis will be developed once it is confirmed whether outstanding historical data can be digitized (see #2 below).
2		Outstanding historical data (1970s-1995) from the Quinsam River Salmon Counting Fence operations should be collated and digitized (currently only available in hard copy).	2	DFO has been contacted to discuss how to efficiently achieve this. The feasibility of incorporating this additional task into the current study scope will depend on the status of the records and whether additional analysis of raw data is required
3		Historical Salmon River juvenile Coho Salmon abundance data collected by DFO should be quality assured and compiled.	1	Historical juvenile Coho data have been requested from DFO and this is currently being processed.
4	Water quality (based on background review; Dinn *et al*. 2016)	Future JHTMON-8 analysis should incorporate water quality data collected by BCCF to reflect the influence of fertilization in the Salmon River watershed.	1	Data were compiled and reviewed during Year 2 as part of the historical review (Dinn *et al*. 2016). This included developing a plan to analyze data at the end of the monitor to test JHTMON-8 hypotheses.
5		Ongoing analysis of Quinsam River water quality data undertaken by Environment Canada should be reviewed at the end of the JHTMON-8 program.	2	This will occur at the end of the JHTMON-8 program and involve a review of any key documents that are published during the monitor relating to ongoing water quality monitoring undertaken by Environment Canada at the mouth of the Quinsam River.
6		Analysis of water temperature data collected by the Quinsam River Hatchery should be undertaken as part of JHTMON–8.	2	Temperature records provided by the Quinsam Hatchery will be analyzed in Year 5 and Year 10.
7	Water quality (other)	Analyze relationships between air and water temperatures for each watershed.	2	This was completed in Year 3. This analysis will be updated in future years.
8	Invertebrate drift	The month that is sampled weekly should be rotated in Year 3 to August, with the remainder of the growing season sampled monthly.	2	Sampling was successfully rotated in Year 3 (to May). Sampling is scheduled to occur on a weekly basis during August in Year 4. This rotation will continue in future years.
9	Hydrology	Historical discharge records for gauges maintained by Water Service of Canada should be compiled. Appropriate metrics to use in analysis to test $H_0 4$ (regarding floods) should be identified.	2	This was completed in Year 3. This analysis will be updated in future years.

5.2. Updated JHTMON-8 Proposals

An updated list of JHMON-8 proposals is presented in Table 57. This reflects the progress made in Year 3 towards outstanding proposals. In addition, one new proposal has been added (#7), which relates to a task that was scheduled for Year 4 during a background review conducted at the start of the study (Abell *et al*. 2015a)

Table 57. Proposals to improve future JHTMON-8 data collection and analysis.

#	Environmental Component	Proposal to Improve the Study	Year Added
1	Fisheries	Historical data for Quinsam River Salmon Counting Fence operations (1996–2013) should be analyzed to derive outmigration estimates for previous years.	2
2		Outstanding historical data (1970s-1995) from the Quinsam River Salmon Counting Fence operations should be reviewed to confirm whether it is feasible to collate and digitize the data as part of the current study scope (data are currently only available in hard copy).	2
3		Historical (2008-2013) Salmon River juvenile Coho Salmon abundance data collected by DFO should be quality assured and compiled.	1
4	Water quality (based on background review; Dinn *et al*. 2016)	Year 10 JHTMON-8 analysis should incorporate water quality data collected by BCCF during nutrient enrichment monitoring in the Salmon River watershed.	1
5		Final JHTMON-8 conclusions should consider conclusions presented in any key documents that are published during the monitor that relate to ongoing water quality monitoring by Environment Canada at the mouth of the Quinsam	2
6		Water temperature data collected by the Quinsam River Hatchery should be included in water temperature analysis conducted at Year 5 and Year 10 to increase the spatial resolution of the analysis	2
7	Water quality (other)	Identify water quality metrics that can be used to test H_03	3

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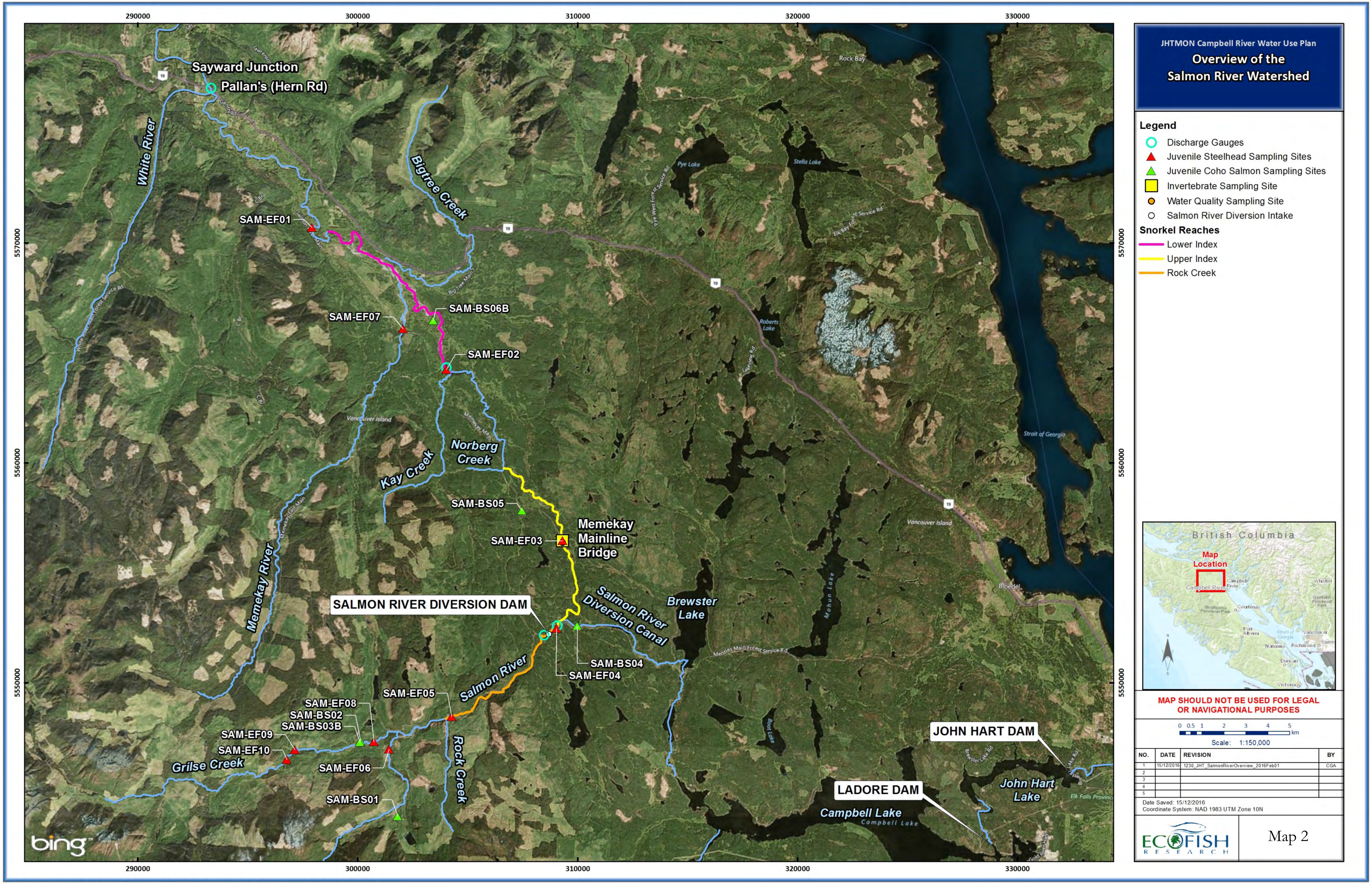
PROJECT MAPS



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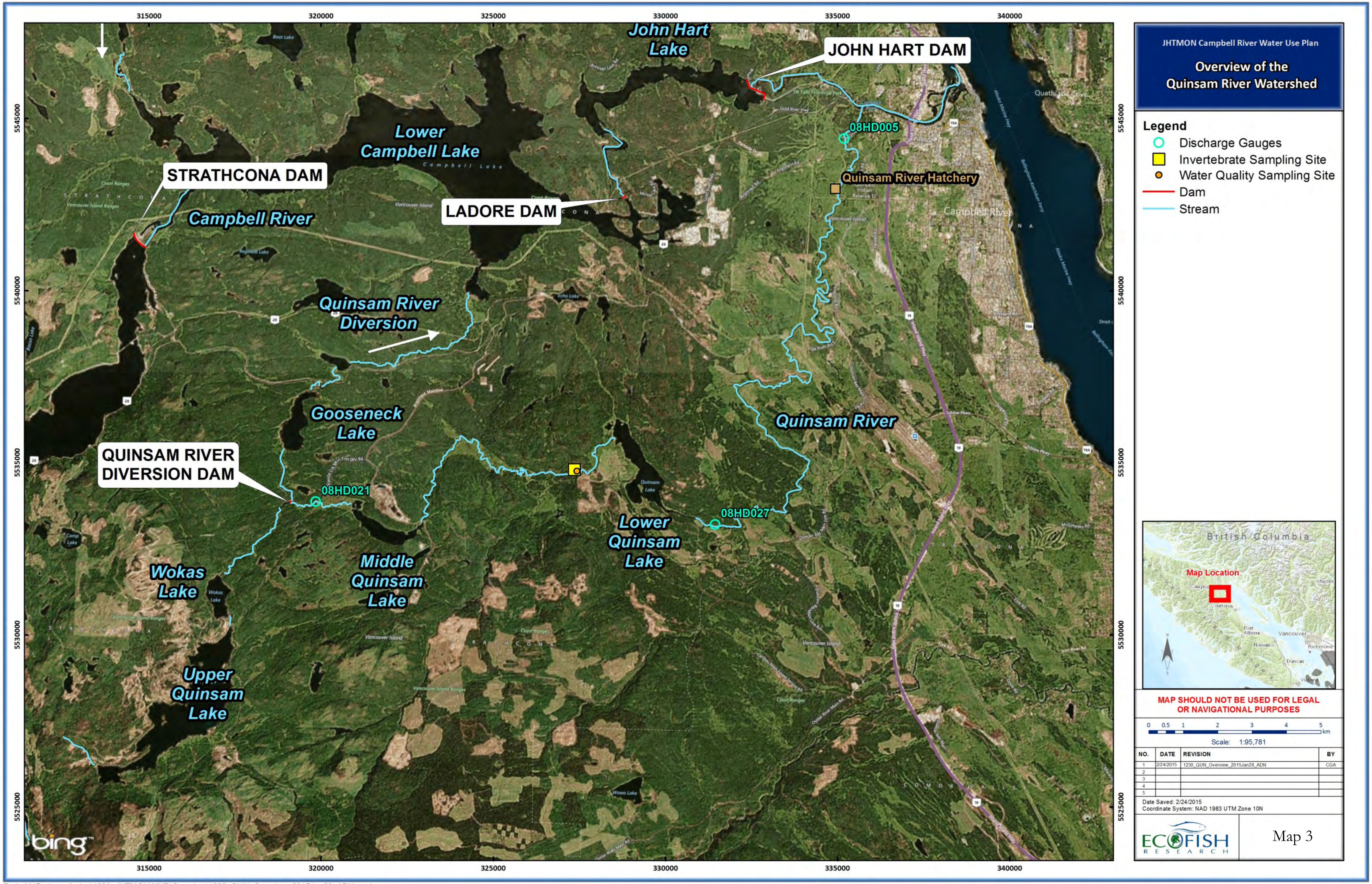

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APPENDICES

Appendix A. ALS Laboratory Water Quality Results and QA/QC for the Salmon River, 2016.

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 18-MAY-16
Report Date: 07-JUN-16 16:22 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1770932

Project P.O. #: 1230-16.03.05
Job Reference: 1230 JHT-MON8
C of C Numbers: OL-2020
Legal Site Desc:

Comments: Please note, it is suspected that a field sampling error occurred when sampling the unpreserved bottle for SAM-WQB and SAM-FIELD BLANK. The lab data in this finalized report has been adjusted accordingly.

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1770932-1	L1770932-2	L1770932-3	L1770932-4
	Description	Water	Water	Water	Water
	Sampled Date	17-MAY-16	17-MAY-16	17-MAY-16	17-MAY-16
	Sampled Time	10:38	10:38	10:38	10:38
	Client ID	SAM-WQB	SAM-TRIP BLANK	SAM-WQA	SAM-FIELD BLANK
Grouping	**Analyte**				
WATER					
Physical Tests	Conductivity (uS/cm)	26.5	<2.0	26.3	<2.0
	pH (pH)	7.46	5.74	7.40	5.70
	Total Suspended Solids (mg/L)	<1.0	<1.0	<1.0	<1.0
	Total Dissolved Solids (mg/L)	18	<10	20	<10
	Turbidity (NTU)	0.16	<0.10	0.20	<0.10
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	12.8	<2.0	12.9	<2.0
	Ammonia, Total (as N) (mg/L)	<0.0050	0.0121 RRV	<0.0050	<0.0050
	Nitrate (as N) (mg/L)	0.0061	<0.0050	<0.0050	<0.0050
	Nitrite (as N) (mg/L)	0.0015	<0.0010	<0.0010	<0.0010
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Total Dissolved (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020
	Phosphorus (P)-Total (mg/L)	0.0034	<0.0020	<0.0020	<0.0020

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Nitrite (as N)	DLDS	L1770932-1, -3, -4
Duplicate	Nitrite (as N)	DLDS	L1770932-2

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
RRV	Reported Result Verified By Repeat Analysis

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

P-TD-COL-VA	Water	Total Dissolved P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

Reference Information

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

OL-2020

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5
Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3464898								
WG2314464-2 CRM		**VA-ALKL-CONTROL**						
Alkalinity, Total (as CaCO3)			105.7		%		85-115	25-MAY-16
WG2314464-5 CRM		**VA-ALKM-CONTROL**						
Alkalinity, Total (as CaCO3)			112.6		%		85-115	25-MAY-16
WG2314464-8 CRM		**VA-ALKH-CONTROL**						
Alkalinity, Total (as CaCO3)			109.1		%		85-115	25-MAY-16
WG2314464-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-10 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-12 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-14 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-16 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-18 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-20 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-4 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-7 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
Batch R3468121								
WG2316569-2 CRM		**VA-ALKL-CONTROL**						
Alkalinity, Total (as CaCO3)			105.4		%		85-115	27-MAY-16
WG2316569-5 CRM		**VA-ALKM-CONTROL**						
Alkalinity, Total (as CaCO3)			105.1		%		85-115	27-MAY-16
WG2316569-8 CRM		**VA-ALKH-CONTROL**						
Alkalinity, Total (as CaCO3)			110.7		%		85-115	28-MAY-16
WG2316569-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	27-MAY-16
WG2316569-4 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	27-MAY-16
WG2316569-7 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	27-MAY-16
EC-PCT-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
EC-PCT-VA	**Water**							
Batch R3465514								
WG2314095-14 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			100.8		%		90-110	25-MAY-16
WG2314095-11 MB								
Conductivity			<2.0		uS/cm		2	25-MAY-16
Batch R3466057								
WG2314628-9 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			98.4		%		90-110	26-MAY-16
WG2314628-6 MB								
Conductivity			<2.0		uS/cm		2	26-MAY-16
NH3-F-VA	**Water**							
Batch R3465932								
WG2315784-2 LCS								
Ammonia, Total (as N)			100.2		%		85-115	27-MAY-16
WG2315784-1 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	27-MAY-16
Batch R3466430								
WG2315768-6 LCS								
Ammonia, Total (as N)			101.1		%		85-115	27-MAY-16
WG2315768-5 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	27-MAY-16
NO2-L-IC-N-VA	**Water**							
Batch R3465536								
WG2312213-2 LCS								
Nitrite (as N)			99.9		%		90-110	20-MAY-16
WG2312213-21 LCS								
Nitrite (as N)			101.3		%		90-110	20-MAY-16
WG2312213-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	20-MAY-16
WG2312213-10 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	20-MAY-16
WG2312213-13 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	20-MAY-16
WG2312213-19 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	20-MAY-16
WG2312213-4 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	20-MAY-16
WG2312213-7 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	20-MAY-16

Quality Control Report

Test		Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-L-IC-N-VA		**Water**							
Batch	**R3469153**								
WG2317124-2	**LCS**								
Nitrite (as N)				99.8		%		90-110	30-MAY-16
WG2317124-21	**LCS**								
Nitrite (as N)				96.7		%		90-110	30-MAY-16
WG2317124-1	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	30-MAY-16
WG2317124-10	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	30-MAY-16
WG2317124-13	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	30-MAY-16
WG2317124-16	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	30-MAY-16
WG2317124-19	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	30-MAY-16
WG2317124-4	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	30-MAY-16
WG2317124-7	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	30-MAY-16
NO3-L-IC-N-VA		**Water**							
Batch	**R3465536**								
WG2312213-2	**LCS**								
Nitrate (as N)				103.6		%		90-110	20-MAY-16
WG2312213-21	**LCS**								
Nitrate (as N)				103.9		%		90-110	20-MAY-16
WG2312213-1	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	20-MAY-16
WG2312213-10	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	20-MAY-16
WG2312213-13	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	20-MAY-16
WG2312213-16	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	20-MAY-16
WG2312213-19	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	20-MAY-16
WG2312213-4	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	20-MAY-16
WG2312213-7	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	20-MAY-16
WG2312213-5	**MS**		**L1770932-2**						

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-L-IC-N-VA	**Water**							
Batch R3465536								
WG2312213-5 MS		**L1770932-2**						
Nitrate (as N)			108.2		%		75-125	20-MAY-16
P-T-PRES-COL-VA	**Water**							
Batch R3464041								
WG2313218-10 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			103.9		%		80-120	25-MAY-16
WG2313218-6 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			105.9		%		80-120	25-MAY-16
WG2313218-11 DUP		**L1770932-3**						
Phosphorus (P)-Total		<0.0020	<0.0020	RPD-NA	mg/L	N/A	20	25-MAY-16
WG2313218-5 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	25-MAY-16
WG2313218-9 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	25-MAY-16
WG2313218-12 MS		**L1770932-4**						
Phosphorus (P)-Total			101.5		%		70-130	25-MAY-16
P-TD-COL-VA	**Water**							
Batch R3461476								
WG2311277-10 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total Dissolved			111.6		%		80-120	19-MAY-16
WG2311277-14 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total Dissolved			105.7		%		80-120	19-MAY-16
WG2311277-9 MB								
Phosphorus (P)-Total Dissolved			<0.0020		mg/L		0.002	19-MAY-16
PH-PCT-VA	**Water**							
Batch R3465514								
WG2314095-12 CRM		**VA-PH7-BUF**						
pH			7.00		pH		6.9-7.1	25-MAY-16
Batch R3466057								
WG2314628-7 CRM		**VA-PH7-BUF**						
pH			6.99		pH		6.9-7.1	26-MAY-16
PO4-DO-COL-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PO4-DO-COL-VA	**Water**							
Batch R3461757								
WG2311937-4 MS		**L1770932-3**						
Orthophosphate-Dissolved (as P)			102.9		%		70-130	19-MAY-16
TDS-VA	**Water**							
Batch R3464919								
WG2313700-8 LCS								
Total Dissolved Solids			95.8		%		85-115	24-MAY-16
WG2313700-7 MB								
Total Dissolved Solids			<10		mg/L		10	24-MAY-16
TSS-LOW-VA	**Water**							
Batch R3464931								
WG2313672-4 LCS								
Total Suspended Solids			98.7		%		85-115	24-MAY-16
WG2313672-6 LCS								
Total Suspended Solids			87.6		%		85-115	24-MAY-16
WG2313672-3 MB								
Total Suspended Solids			<1.0		mg/L		1	24-MAY-16
WG2313672-5 MB								
Total Suspended Solids			<1.0		mg/L		1	24-MAY-16
TURBIDITY-VA	**Water**							
Batch R3461466								
WG2311536-11 CRM		**VA-FORM-40**						
Turbidity			100.3		%		85-115	19-MAY-16
WG2311536-8 CRM		**VA-FORM-40**						
Turbidity			100.5		%		85-115	19-MAY-16
WG2311536-12 DUP		**L1770932-2**						
Turbidity		<0.10	<0.10	RPD-NA	NTU	N/A	15	19-MAY-16
WG2311536-10 MB								
Turbidity			<0.10		NTU		0.1	19-MAY-16
WG2311536-7 MB								
Turbidity			<0.10		NTU		0.1	19-MAY-16

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
Total Suspended Solids by Grav. (1 mg/L)							
	1	17-MAY-16 10:38	24-MAY-16 23:44	7	8	days	EHT
	2	17-MAY-16 10:38	24-MAY-16 23:44	7	8	days	EHT
	3	17-MAY-16 10:38	24-MAY-16 23:44	7	8	days	EHT
	4	17-MAY-16 10:38	24-MAY-16 23:44	7	8	days	EHT
pH by Meter (Automated)							
	1	17-MAY-16 10:38	25-MAY-16 09:35	0.25	191	hours	EHTR-FM
	2	17-MAY-16 10:38	25-MAY-16 09:35	0.25	191	hours	EHTR-FM
	3	17-MAY-16 10:38	25-MAY-16 09:35	0.25	191	hours	EHTR-FM
	4	17-MAY-16 10:38	26-MAY-16 08:05	0.25	213	hours	EHTR-FM
Anions and Nutrients							
Nitrite in Water by IC (Low Level)							
	2	17-MAY-16 10:38	30-MAY-16 06:01	3	13	days	EHT

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1770932 were received on 18-MAY-16 17:55.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

BR164129

Short Holding Time

Rush Processing

ALS E

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2020

Report To		Reporting		Service Requested
Company:	ECOFISH RESEARCH LTD	Distribution:	☐Fax ☐Mail ☑Email	⊙ Regular (Standard Turnaround Times - Business Days) - R
Contact:	Kevin Ganshorn	☐Cirtteria on Report (select from Guidelines below)		O Priority (3 Days) - surcharge will apply - P
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5	Report Type:	☑Excel ☑Digital	O Priority (2 Days) - surcharge will apply - P2
		Report Format:	CROSSTAB_ALSQC	O Emergency (1-2 day) – surcharge will apply - E
		Report Email(s):	kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com	O Same Day or Weekend Emergency - surcharge will apply - E2
				O Specify date required - X
Phone:	250-334-3042 Fax: 250-334-3097			
Invoice To	☑Email ☐Mail	EDD Format:	ECF100	
Company:	ECOFISH RESEARCH LTD	EDD Email(s):	kganshorn@ecofishresearch.com bbennett@ecofishresearch.com tkasubuchi@ecofishresearch.com	
Contact:	Accounts Payable			
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5	**Project Info**		
		Job #:	1230 JHT-MON8	
		PO/AFE:	1230-16.03.05	
Email:	accountspayable@ecofishresearch.com	LSD:		
Phone:	250-334-3042	Quote #:		
Lab Work Order # (lab use only)	L1770932	ALS Contact: Ariel Tang, B.Sc.	Sampler: Leah Hull	

Analysis Requests — Please indicate below Filtered, Preserved or both(F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Nitrate in Water by IC (Low Level)	Nitrite in Water by IC (Low Level)	Total Dissolved P in Water by Colour	Total Dissolved Solids by Gravimetric	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)		
	SAM-FIELD BLANK			17-May-2016	10:38	Water	3	R	R	R	R	R	R	R	R	R	R	R	R		
	SAM-TRAVEL BLANK			↓	↓	Water	3	R	R	R	R	R	R	R	R	R	R	R	R		
	SAM-WQA					Water	3	R	R	R	R	R	R	R	R	R	R	R	R		
	SAM-WQB					Water	3	R	R	R	R	R	R	R	R	R	R	R	R		

L1770932-COFC

Special Instructions/Comments	The questions below must be answered for water samples (check Yes or No)	Guidelines
	Are any sample taken from a regulated DW system? ☐Yes ☒No If yes, please use an authorized drinking water COC Is the water sampled intended to be potable for human consumption? ☐Yes ☒No	

SAMPLE CONDITION (lab use only): ☐Frozen ☐Cold ☐Ambient ☐Cooling Initiated

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations:
Leah Hull	18-May 2016	14:30	JC	18 May	17:55	6 °C				☐Yes If Yes add SIF

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 15-JUN-16
Report Date: 24-JUN-16 12:52 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1784062

Project P.O. #: 1230-16.03.05
Job Reference: 1230-16.03.05
C of C Numbers: OL-2022
Legal Site Desc:

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1784062-1	L1784062-2			
	Description	Water	Water			
	Sampled Date	14-JUN-16	14-JUN-16			
	Sampled Time	10:50	10:50			
	Client ID	SAM-WQA	SAM-WQB			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	35.6	35.1			
	pH (pH)	7.49	7.46			
	Total Suspended Solids (mg/L)	<1.0	<1.0			
	Total Dissolved Solids (mg/L)	28	27			
	Turbidity (NTU)	0.17	0.14			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	14.8	14.8			
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050			
	Nitrate (as N) (mg/L)	0.0147	0.0141			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010			
	Phosphorus (P)-Total Dissolved (mg/L)	<0.0020	<0.0020			
	Phosphorus (P)-Total (mg/L)	0.0050	<0.0020			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Nitrite (as N)	DLDS	L1784062-1, -2
Duplicate	Nitrate (as N)	DLDS	L1784062-1, -2
Matrix Spike	Nitrate (as N)	MS-B	L1784062-1, -2

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

P-TD-COL-VA	Water	Total Dissolved P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis

Reference Information

methods are available for these types of samples.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

OL-2022

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5
Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3482319								
WG2328958-2 CRM		**VA-ALKL-CONTROL**						
Alkalinity, Total (as CaCO3)			101.7		%		85-115	16-JUN-16
WG2328958-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-JUN-16
WG2328958-10 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-JUN-16
WG2328958-12 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-JUN-16
WG2328958-4 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-JUN-16
WG2328958-6 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-JUN-16
WG2328958-8 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-JUN-16
EC-PCT-VA	**Water**							
Batch R3485595								
WG2331112-19 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			106.1		%		90-110	20-JUN-16
WG2331112-16 MB								
Conductivity			<2.0		uS/cm		2	20-JUN-16
NH3-F-VA	**Water**							
Batch R3488054								
WG2333386-6 LCS								
Ammonia, Total (as N)			94.0		%		85-115	23-JUN-16
WG2333386-5 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	23-JUN-16
Batch R3488354								
WG2333745-2 LCS								
Ammonia, Total (as N)			95.3		%		85-115	23-JUN-16
WG2333745-1 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	23-JUN-16
NO2-L-IC-N-VA	**Water**							
Batch R3480857								
WG2328710-2 LCS								
Nitrite (as N)			104.3		%		90-110	16-JUN-16
WG2328710-21 LCS								
Nitrite (as N)			103.9		%		90-110	16-JUN-16
WG2328710-1 MB								

Quality Control Report

Test		Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-L-IC-N-VA		**Water**							
Batch	**R3480857**								
WG2328710-1	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	16-JUN-16
WG2328710-10	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	16-JUN-16
WG2328710-13	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	16-JUN-16
WG2328710-16	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	16-JUN-16
WG2328710-19	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	16-JUN-16
WG2328710-4	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	16-JUN-16
WG2328710-7	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	16-JUN-16
WG2328710-11	**MS**		**L1784062-1**						
Nitrite (as N)				105.1		%		75-125	16-JUN-16
NO3-L-IC-N-VA		**Water**							
Batch	**R3480857**								
WG2328710-2	**LCS**								
Nitrate (as N)				105.7		%		90-110	16-JUN-16
WG2328710-21	**LCS**								
Nitrate (as N)				105.7		%		90-110	16-JUN-16
WG2328710-1	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	16-JUN-16
WG2328710-10	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	16-JUN-16
WG2328710-13	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	16-JUN-16
WG2328710-16	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	16-JUN-16
WG2328710-19	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	16-JUN-16
WG2328710-4	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	16-JUN-16
WG2328710-7	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	16-JUN-16
WG2328710-11	**MS**		**L1784062-1**						
Nitrate (as N)				106.7		%		75-125	16-JUN-16

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
P-T-PRES-COL-VA	**Water**							
Batch R3486076								
WG2331613-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			95.7		%		80-120	21-JUN-16
WG2331613-1 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	21-JUN-16
P-TD-COL-VA	**Water**							
Batch R3482830								
WG2329538-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total Dissolved			107.7		%		80-120	17-JUN-16
WG2329538-1 MB								
Phosphorus (P)-Total Dissolved			<0.0020		mg/L		0.002	17-JUN-16
PH-PCT-VA	**Water**							
Batch R3485595								
WG2331112-17 CRM		**VA-PH7-BUF**						
pH			7.00		pH		6.9-7.1	20-JUN-16
PO4-DO-COL-VA	**Water**							
Batch R3480494								
WG2328631-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			89.6		%		80-120	16-JUN-16
WG2328631-6 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			81.7		%		80-120	16-JUN-16
WG2328631-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	16-JUN-16
WG2328631-5 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	16-JUN-16
WG2328631-8 MS		**L1784062-2**						
Orthophosphate-Dissolved (as P)			93.4		%		70-130	16-JUN-16
TDS-VA	**Water**							
Batch R3486760								
WG2331795-8 LCS								
Total Dissolved Solids			101.3		%		85-115	21-JUN-16
WG2331795-7 MB								
Total Dissolved Solids			<10		mg/L		10	21-JUN-16
TSS-LOW-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
TSS-LOW-VA	**Water**							
Batch R3486833								
WG2332401-2 LCS								
Total Suspended Solids			97.8		%		85-115	21-JUN-16
WG2332401-1 MB								
Total Suspended Solids			<1.0		mg/L		1	21-JUN-16
TURBIDITY-VA	**Water**							
Batch R3481026								
WG2328992-2 CRM		**VA-FORM-40**						
Turbidity			98.3		%		85-115	16-JUN-16
WG2328992-5 CRM		**VA-FORM-40**						
Turbidity			103.5		%		85-115	16-JUN-16
WG2328992-8 CRM		**VA-FORM-40**						
Turbidity			99.8		%		85-115	16-JUN-16
WG2328992-9 DUP		**L1784062-2**						
Turbidity		0.14	0.14		NTU	2.9	15	16-JUN-16
WG2328992-1 MB								
Turbidity			<0.10		NTU		0.1	16-JUN-16
WG2328992-4 MB								
Turbidity			<0.10		NTU		0.1	16-JUN-16
WG2328992-7 MB								
Turbidity			<0.10		NTU		0.1	16-JUN-16

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	14-JUN-16 10:50	20-JUN-16 09:27	0.25	143	hours	EHTR-FM
	2	14-JUN-16 10:50	20-JUN-16 09:27	0.25	143	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1784062 were received on 15-JUN-16 17:25.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Short Holding Time
(A) Rush Processing

BR164134
June

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2022

Report To		Reporting		Service Requested
Company:	ECOFISH RESEARCH LTD	Distribution:	☐Fax ☐Mail ☑Email	⦿ Regular (Standard Turnaround Times - Business Days) - R
Contact:	Kevin Ganshorn	☐Criteria on Report (select from Guidelines below)		O Priority (3 Days) - surcharge will apply - P
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5	Report Type:	☑Excel ☑Digital	O Priority (2 Days) - surcharge will apply - P2
		Report Format:	CROSSTAB_ALSQC	O Emergency (1-2 day) – surcharge will apply - E
		Report Email(s):	kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com	O Same Day or Weekend Emergency - surcharge will apply - E2
				O Specify date required - X
Phone: 250-334-3042	Fax: 250-334-3097			

Invoice To	☑Email ☐Mail		
Company:	ECOFISH RESEARCH LTD	EDD Format:	ECF100
Contact:	Accounts Payable	EDD Email(s):	kganshorn@ecofishresearch.com bbennett@ecofishresearch.com tkasubuchi@ecofishresearch.com
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5	Project Info	
		Job #:	1230 JHT-MON8
		PO/AFE:	1230-16.03.05
Email:	accountspayable@ecofishresearch.com	LSD:	
Phone:	250-334-3042	Quote #:	
Lab Work Order # (lab use only)		ALS Contact: Ariel Tang, B.Sc.	Sampler: Leah Hull

Analysis Requests — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Nitrate in Water by IC (Low Level)	Nitrite in Water by IC (Low Level)	Total Dissolved Solids by Gravimetric	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)
	SAM-WQA			14-June-2016	10:50	Water	3	R	R	R	R	R	R	R	R	R	R	R
	SAM-WQB			〃	10:50	Water	3	R	R	R	R	R	R	R	R	R	R	R

L1784062-COFC

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐Yes ☒No
If yes, please use an authorized drinking water COC

Is the water sampled intended to be potable for human consumption? ☐Yes ☒No

Guidelines

SAMPLE CONDITION (lab use only)
☐Frozen ☐Cold ☐Ambient ☐Cooling Initiated

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Leah Hull	Date:	Time:	Received by: JC	Date: 15 JUN	Time: 17:25	Temperature: 3 °C	Verified by:	Date:	Time:	Observations: ☐Yes If Yes add SIF

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 13-JUL-16
Report Date: 21-JUL-16 13:53 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1798005

Project P.O. #: 1230-16.03.05
Job Reference: 1230 JHT-MON8
C of C Numbers: OL-2024
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1798005-1	L1798005-2			
	Description	Water	Water			
	Sampled Date	12-JUL-16	12-JUL-16			
	Sampled Time	10:07	10:07			
	Client ID	SAM-WQA	SAM-WQB			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	36.9	37.0			
	pH (pH)	7.46	7.49			
	Total Suspended Solids (mg/L)	<1.0	<1.0			
	Total Dissolved Solids (mg/L)	32	30			
	Turbidity (NTU)	0.14	0.14			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	17.6	18.1			
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050			
	Nitrate (as N) (mg/L)	0.0236	0.0235			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010			
	Phosphorus (P)-Total (mg/L)	<0.0020	0.0035			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

OL-2024

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5
Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3504301								
WG2348413-29 CRM		**VA-ALKL-CONTROL**						
Alkalinity, Total (as CaCO3)			96.9		%		85-115	15-JUL-16
WG2348413-28 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	15-JUL-16
WG2348413-31 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	15-JUL-16
WG2348413-33 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	15-JUL-16
WG2348413-35 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	15-JUL-16
EC-PCT-VA	**Water**							
Batch R3506932								
WG2349822-9 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			97.1		%		90-110	19-JUL-16
WG2349822-6 MB								
Conductivity			<2.0		uS/cm		2	19-JUL-16
NH3-F-VA	**Water**							
Batch R3507469								
WG2350696-6 LCS								
Ammonia, Total (as N)			97.8		%		85-115	19-JUL-16
WG2350696-5 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	19-JUL-16
NO2-L-IC-N-VA	**Water**							
Batch R3505723								
WG2347260-17 LCS								
Nitrite (as N)			99.1		%		90-110	14-JUL-16
WG2347260-2 LCS								
Nitrite (as N)			98.8		%		90-110	14-JUL-16
WG2347260-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
WG2347260-11 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
WG2347260-14 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
WG2347260-16 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
WG2347260-3 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-L-IC-N-VA	**Water**							
Batch R3505723								
WG2347260-5 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
WG2347260-8 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
NO3-L-IC-N-VA	**Water**							
Batch R3505723								
WG2347260-17 LCS								
Nitrate (as N)			101.6		%		90-110	14-JUL-16
WG2347260-2 LCS								
Nitrate (as N)			101.2		%		90-110	14-JUL-16
WG2347260-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-11 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-14 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-16 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-3 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-5 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-8 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
P-T-PRES-COL-VA	**Water**							
Batch R3504068								
WG2347251-10 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			111.1		%		80-120	15-JUL-16
WG2347251-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			100.1		%		80-120	15-JUL-16
WG2347251-1 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	15-JUL-16
WG2347251-9 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	15-JUL-16
PH-PCT-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PH-PCT-VA	**Water**							
Batch R3506932								
WG2349822-7 CRM		**VA-PH7-BUF**						
pH			7.01		pH		6.9-7.1	19-JUL-16
PO4-DO-COL-VA	**Water**							
Batch R3503053								
WG2347163-10 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			91.9		%		80-120	14-JUL-16
WG2347163-14 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			92.7		%		80-120	14-JUL-16
WG2347163-18 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			87.4		%		80-120	14-JUL-16
WG2347163-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			93.1		%		80-120	13-JUL-16
WG2347163-22 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			95.4		%		80-120	14-JUL-16
WG2347163-26 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			88.9		%		80-120	14-JUL-16
WG2347163-6 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			95.4		%		80-120	14-JUL-16
WG2347163-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	13-JUL-16
WG2347163-13 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	14-JUL-16
WG2347163-17 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	14-JUL-16
WG2347163-21 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	14-JUL-16
WG2347163-25 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	14-JUL-16
WG2347163-5 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	14-JUL-16
WG2347163-9 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	14-JUL-16
TDS-VA	**Water**							
Batch R3503882								
WG2347076-5 LCS								
Total Dissolved Solids			94.9		%		85-115	13-JUL-16
WG2347076-4 MB								

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
TDS-VA	**Water**							
Batch R3503882								
WG2347076-4 MB								
Total Dissolved Solids			<10		mg/L		10	13-JUL-16
TSS-LOW-VA	**Water**							
Batch R3504408								
WG2348052-6 LCS								
Total Suspended Solids			95.9		%		85-115	14-JUL-16
WG2348052-5 MB								
Total Suspended Solids			<1.0		mg/L		1	14-JUL-16
TURBIDITY-VA	**Water**							
Batch R3503488								
WG2347359-11 CRM		**VA-FORM-40**						
Turbidity			105.3		%		85-115	14-JUL-16
WG2347359-14 CRM		**VA-FORM-40**						
Turbidity			104.8		%		85-115	14-JUL-16
WG2347359-2 CRM		**VA-FORM-40**						
Turbidity			103.0		%		85-115	14-JUL-16
WG2347359-5 CRM		**VA-FORM-40**						
Turbidity			104.5		%		85-115	14-JUL-16
WG2347359-8 CRM		**VA-FORM-40**						
Turbidity			106.8		%		85-115	14-JUL-16
WG2347359-1 MB								
Turbidity			<0.10		NTU		0.1	14-JUL-16
WG2347359-10 MB								
Turbidity			<0.10		NTU		0.1	14-JUL-16
WG2347359-13 MB								
Turbidity			<0.10		NTU		0.1	14-JUL-16
WG2347359-4 MB								
Turbidity			<0.10		NTU		0.1	14-JUL-16
WG2347359-7 MB								
Turbidity			<0.10		NTU		0.1	14-JUL-16

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	12-JUL-16 10:07	19-JUL-16 07:26	0.25	165	hours	EHTR-FM
	2	12-JUL-16 10:07	19-JUL-16 07:26	0.25	165	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1798005 were received on 13-JUL-16 17:45.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

L1798005-COFC

BR164138

July

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2024

Report To	
Company:	ECOFISH RESEARCH LTD
Contact:	Kevin Ganshorn
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Phone:	250-334-3042
Fax:	250-334-3097
Invoice To	☑ Email ☐ Mail
Company:	ECOFISH RESEARCH LTD
Contact:	Accounts Payable
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Email:	accountspayable@ecofishresearch.com
Phone:	250-334-3042
Lab Work Order # (lab use only)	

Reporting	
Distribution:	☐ Fax ☐ Mail ☑ Email
☐ Criteria on Report (select from Guidelines below)	
Report Type:	☑ Excel ☑ Digital
Report Format:	CROSSTAB_ALSQC
Report Email(s):	kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com
EDD Format:	ECF100
EDD Email(s):	kganshorn@ecofishresearch.com bbennett@ecofishresearch.com tkasubuchi@ecofishresearch.com
Project Info	
Job #:	1230 JHT-MON8
PO/AFE:	1230-16.03.05
LSD:	
Quote #:	
ALS Contact:	Ariel Tang, B.Sc.
Sampler:	Leah Hull

Service Requested
- ⦿ Regular (Standard Turnaround Times - Business Days) - R
- ○ Priority (3 Days) - surcharge will apply - P
- ○ Priority (2 Days) - surcharge will apply - P2
- ○ Emergency (1-2 day) – surcharge will apply - E
- ○ Same Day or Weekend Emergency - surcharge will apply - E2
- ○ Specify date required - X

Analysis Requests — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Nitrate in Water by IC (Low Level)	Nitrite in Water by IC (Low Level)	Total Dissolved Solids by Gravimetric	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)		
	SAM-WQA			~~May-06-2016~~ 12-July-2016	~~12:00 PM~~ 10:07	WATER	3	R	R	R	R	R	R	R	R	R	R	R		
	SAM-WQB			~~May-06-2016~~ 12-July-2016	~~12:00 PM~~ 10:07	WATER	3	R	R	R	R	R	R	R	R	R	R	R		

Short Holding Time

(A) *Rush Processing*

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐ Yes ☒ No

If yes, please use an authorized drinking water COC

Is the water sampled intended to be potable for human consumption? ☐ Yes ☒ No

Guidelines

SAMPLE CONDITION (lab use only)

☐ Frozen ☐ Cold ☐ Ambient ☐ Cooling Initiated

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Leah Hull	Date: 13-July 2016	Time: 14:00	Received by: Shayan	Date: July 13	Time: 1745	Temperature: 6 °C	Verified by:	Date:	Time:	Observations: ☐ Yes If Yes add SIF

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 18-AUG-16
Report Date: 25-AUG-16 16:16 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1815481
Project P.O. #: 1230-16.03.05
Job Reference: 1230 JHT-MON8
C of C Numbers: OL-2026
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1815481-1	L1815481-2			
	Description	Water	Water			
	Sampled Date	16-AUG-16	16-AUG-16			
	Sampled Time	10:45	10:45			
	Client ID	SAM-WQA	SAM-WQB			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	50.4	50.1			
	pH (pH)	7.32	7.34			
	Total Suspended Solids (mg/L)	<1.0	1.4			
	Total Dissolved Solids (mg/L)	36	28			
	Turbidity (NTU)	0.13	0.12			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	21.3	21.6			
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050			
	Nitrate (as N) (mg/L)	0.0824	0.0814			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010			
	Phosphorus (P)-Total (mg/L)	<0.0020	0.0020			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

OL-2026

GLOSSARY OF REPORT TERMS
Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3532104								
WG2373809-2 LCS								
Alkalinity, Total (as CaCO3)			106.6		%		85-115	23-AUG-16
WG2373809-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	23-AUG-16
WG2373809-6 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	23-AUG-16
WG2373809-8 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	23-AUG-16
EC-PCT-VA	**Water**							
Batch R3530913								
WG2372520-9 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			105.9		%		90-110	22-AUG-16
WG2372520-6 MB								
Conductivity			<2.0		uS/cm		2	22-AUG-16
NH3-F-VA	**Water**							
Batch R3533269								
WG2374311-10 LCS								
Ammonia, Total (as N)			99.1		%		85-115	25-AUG-16
WG2374311-9 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	25-AUG-16
NO2-L-IC-N-VA	**Water**							
Batch R3531974								
WG2371161-2 LCS								
Nitrite (as N)			99.3		%		90-110	19-AUG-16
WG2371161-24 LCS								
Nitrite (as N)			98.6		%		90-110	19-AUG-16
WG2371161-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	19-AUG-16
WG2371161-10 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	19-AUG-16
WG2371161-13 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	19-AUG-16
WG2371161-16 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	19-AUG-16
WG2371161-19 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	19-AUG-16
WG2371161-22 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	19-AUG-16

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-L-IC-N-VA	**Water**							
Batch R3531974								
WG2371161-4 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	19-AUG-16
WG2371161-7 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	19-AUG-16
NO3-L-IC-N-VA	**Water**							
Batch R3531974								
WG2371161-2 LCS								
Nitrate (as N)			100.1		%		90-110	19-AUG-16
WG2371161-24 LCS								
Nitrate (as N)			100.0		%		90-110	19-AUG-16
WG2371161-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	19-AUG-16
WG2371161-10 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	19-AUG-16
WG2371161-13 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	19-AUG-16
WG2371161-16 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	19-AUG-16
WG2371161-19 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	19-AUG-16
WG2371161-22 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	19-AUG-16
WG2371161-4 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	19-AUG-16
WG2371161-7 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	19-AUG-16
P-T-PRES-COL-VA	**Water**							
Batch R3530186								
WG2372031-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			97.5		%		80-120	21-AUG-16
WG2372031-1 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	21-AUG-16
PH-PCT-VA	**Water**							
Batch R3530913								
WG2372520-7 CRM		**VA-PH7-BUF**						
pH			7.00		pH		6.9-7.1	22-AUG-16
PO4-DO-COL-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PO4-DO-COL-VA	**Water**							
Batch R3528840								
WG2370916-10 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			80.0		%		80-120	18-AUG-16
WG2370916-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			94.9		%		80-120	18-AUG-16
WG2370916-6 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			86.0		%		80-120	18-AUG-16
WG2370916-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	18-AUG-16
WG2370916-5 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	18-AUG-16
WG2370916-9 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	18-AUG-16
TDS-VA	**Water**							
Batch R3531197								
WG2372218-5 LCS								
Total Dissolved Solids			96.5		%		85-115	21-AUG-16
WG2372218-4 MB								
Total Dissolved Solids			<10		mg/L		10	21-AUG-16
TSS-LOW-VA	**Water**							
Batch R3531199								
WG2372343-2 LCS								
Total Suspended Solids			109.1		%		85-115	21-AUG-16
WG2372343-1 MB								
Total Suspended Solids			<1.0		mg/L		1	21-AUG-16
TURBIDITY-VA	**Water**							
Batch R3529271								
WG2371230-2 CRM		**VA-FORM-40**						
Turbidity			102.3		%		85-115	19-AUG-16
WG2371230-5 CRM		**VA-FORM-40**						
Turbidity			103.5		%		85-115	19-AUG-16
WG2371230-1 MB								
Turbidity			<0.10		NTU		0.1	19-AUG-16
WG2371230-4 MB								
Turbidity			<0.10		NTU		0.1	19-AUG-16

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	16-AUG-16 10:45	22-AUG-16 09:22	0.25	143	hours	EHTR-FM
	2	16-AUG-16 10:45	22-AUG-16 09:22	0.25	143	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1815481 were received on 18-AUG-16 10:45.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

BR164140
August

Chain of Custody / Analytical Request Form

Canada Toll Free : 1 800 668 9878
www.alsglobal.com

ALS Environmental

Report To	
Company:	ECOFISH RESEARCH LTD
Contact:	Kevin Ganshorn
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Phone:	250-334-3042 — Fax: 250-334-3097
Invoice To	☑Email ☐Mail
Company:	ECOFISH RESEARCH LTD
Contact:	Accounts Payable
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Email:	accountspayable@ecofishresearch.com
Phone:	250-334-3042
Lab Work Order # (lab use only)	

Reporting	
Distribution:	☐Fax ☐Mail ☑Email
☐Criteria on Report (select from Guidelines below)	
Report Type:	☑Excel ☑Digital
Report Format:	CROSSTAB_ALSQC
Report Email(s):	kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com
EDD Format:	ECF100
EDD Email(s):	kganshorn@ecofishresearch.com bbennett@ecofishresearch.com tkasubuchi@ecofishresearch.com
Project Info	
Job #:	1230 JHT-MON8
PO/AFE:	1230-16.03.05
LSD:	
Quote #:	
ALS Contact: Ariel Tang, B.Sc.	Sampler: LEAH HULL

Service Requested

- ⊙ Regular (Standard Turnaround Times - Business Days) - R
- O Priority (3 Days) - surcharge will apply - P
- O Priority (2 Days) - surcharge will apply - P2
- O Emergency (1-2 day) – surcharge will apply - E
- O Same Day or Weekend Emergency - surcharge will apply - E2
- O Specify date required - X

Analysis Requests — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Nitrate in Water by IC (Low Level)	Nitrite in Water by IC (Low Level)	Total Dissolved Solids by Gravimetric	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)
	SAM-WQA			16-Aug-2016	10:45	WATER	3	R	R	R	R	R	R	R	R	R	R	R
	SAM-WQB			〃	10:45	WATER	3	R	R	R	R	R	R	R	R	R	R	R

L1815481-COFC

Short Holding Time
Rush Processing

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐Yes ☒No

If yes, please use an authorized drinking water COC

Is the water sampled intended to be potable for human consumption? ☐Yes ☒No

Guidelines

SAMPLE CONDITION (lab use only)

☐Frozen ☐Cold ☐Ambient ☐Cooling Initiated

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Leah Hull	Date: 17-Aug-2016	Time: 16:00	Received by: HMC	Date: Aug18/16	Time: 10:45	Temperature: 6 °C	Verified by:	Date:	Time:	Observations: ☐Yes If Yes add SIF

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 14-SEP-16
Report Date: 26-SEP-16 18:42 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1828878

Project P.O. #: 1230-16.03.05
Job Reference: 1230-16.03.05
C of C Numbers: BR164142 September
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1828878-1	L1828878-2			
	Description	Water	Water			
	Sampled Date	13-SEP-16	13-SEP-16			
	Sampled Time	12:17	12:17			
	Client ID	SAM-WQA	SAM-WQB			
WATER						
Physical Tests	Conductivity (uS/cm)	48.4	47.8			
	pH (pH)	7.82	7.65			
	Total Suspended Solids (mg/L)	<1.0	<1.0			
	Total Dissolved Solids (mg/L)	34	34			
	Turbidity (NTU)	0.20	0.15			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	20.5	20.3			
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050			
	Nitrate (as N) (mg/L)	0.0405	0.0402			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010			
	Phosphorus (P)-Total (mg/L)	<0.0020	0.0023			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

ALS Test Code	Matrix	Test Description	Method Reference**
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

ALS Test Code	Matrix	Test Description	Method Reference**
NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

ALS Test Code	Matrix	Test Description	Method Reference**
PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

ALS Test Code	Matrix	Test Description	Method Reference**
TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

ALS Test Code	Matrix	Test Description	Method Reference**
TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

ALS Test Code	Matrix	Test Description	Method Reference**
TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

ALS Test Code	Matrix	Test Description	Method Reference**
TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

BR164142 September

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5
Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3550047								
WG2390494-2 LCS								
Alkalinity, Total (as CaCO3)			107.7		%		85-115	16-SEP-16
WG2390494-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-SEP-16
WG2390494-4 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-SEP-16
WG2390494-6 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-SEP-16
WG2390494-8 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-SEP-16
EC-PCT-VA	**Water**							
Batch R3555966								
WG2394829-19 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			100.6		%		90-110	23-SEP-16
WG2394829-16 MB								
Conductivity			<2.0		uS/cm		2	23-SEP-16
NH3-F-VA	**Water**							
Batch R3555717								
WG2395817-2 LCS								
Ammonia, Total (as N)			103.1		%		85-115	23-SEP-16
WG2395817-1 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	23-SEP-16
NO2-L-IC-N-VA	**Water**							
Batch R3551703								
WG2389035-2 LCS								
Nitrite (as N)			102.6		%		90-110	15-SEP-16
WG2389035-21 LCS								
Nitrite (as N)			102.3		%		90-110	15-SEP-16
WG2389035-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16
WG2389035-10 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16
WG2389035-13 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16
WG2389035-16 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16
WG2389035-19 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-L-IC-N-VA	**Water**							
Batch R3551703								
WG2389035-4 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16
WG2389035-7 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16
NO3-L-IC-N-VA	**Water**							
Batch R3551703								
WG2389035-2 LCS								
Nitrate (as N)			100.5		%		90-110	15-SEP-16
WG2389035-21 LCS								
Nitrate (as N)			100.5		%		90-110	15-SEP-16
WG2389035-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-10 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-13 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-16 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-19 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-4 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-7 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
P-T-PRES-COL-VA	**Water**							
Batch R3549730								
WG2389902-6 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			105.8		%		80-120	16-SEP-16
WG2389902-5 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	16-SEP-16
PH-PCT-VA	**Water**							
Batch R3555966								
WG2394829-17 CRM		**VA-PH7-BUF**						
pH			7.02		pH		6.9-7.1	23-SEP-16
PO4-DO-COL-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PO4-DO-COL-VA	**Water**							
Batch R3548483								
WG2388903-10 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			99.8		%		80-120	15-SEP-16
WG2388903-14 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			96.9		%		80-120	15-SEP-16
WG2388903-18 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			94.1		%		80-120	15-SEP-16
WG2388903-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			96.5		%		80-120	15-SEP-16
WG2388903-22 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			93.8		%		80-120	15-SEP-16
WG2388903-26 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			88.1		%		80-120	15-SEP-16
WG2388903-30 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			99.7		%		80-120	15-SEP-16
WG2388903-34 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			99.4		%		80-120	15-SEP-16
WG2388903-6 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			94.7		%		80-120	15-SEP-16
WG2388903-35 DUP		**L1828878-1**						
Orthophosphate-Dissolved (as P)		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	15-SEP-16
WG2388903-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-13 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-17 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-21 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-25 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-29 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-33 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-5 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-9 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-36 MS		**L1828878-2**						

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PO4-DO-COL-VA	**Water**							
Batch R3548483								
WG2388903-36 MS		**L1828878-2**						
Orthophosphate-Dissolved (as P)			93.7		%		70-130	15-SEP-16
TDS-VA	**Water**							
Batch R3553153								
WG2392005-2 LCS								
Total Dissolved Solids			101.6		%		85-115	19-SEP-16
WG2392005-1 MB								
Total Dissolved Solids			<10		mg/L		10	19-SEP-16
TSS-LOW-VA	**Water**							
Batch R3552725								
WG2392080-2 LCS								
Total Suspended Solids			100.1		%		85-115	19-SEP-16
WG2392080-1 MB								
Total Suspended Solids			<1.0		mg/L		1	19-SEP-16
TURBIDITY-VA	**Water**							
Batch R3548474								
WG2388918-2 CRM		**VA-FORM-40**						
Turbidity			102.8		%		85-115	15-SEP-16
WG2388918-5 CRM		**VA-FORM-40**						
Turbidity			103.3		%		85-115	15-SEP-16
WG2388918-8 CRM		**VA-FORM-40**						
Turbidity			103.5		%		85-115	15-SEP-16
WG2388918-1 MB								
Turbidity			<0.10		NTU		0.1	15-SEP-16
WG2388918-4 MB								
Turbidity			<0.10		NTU		0.1	15-SEP-16
WG2388918-7 MB								
Turbidity			<0.10		NTU		0.1	15-SEP-16

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	13-SEP-16 12:17	23-SEP-16 12:45	0.25	240	hours	EHTR-FM
	2	13-SEP-16 12:17	23-SEP-16 12:45	0.25	240	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR: Exceeded ALS recommended hold time prior to sample receipt.
EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT: Exceeded ALS recommended hold time prior to analysis.
Rec. HT: ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1828878 were received on 14-SEP-16 19:00.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

Short Holding Time
Rush Processing B

BR164142
September

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2028

Report To

Company:	ECOFISH RESEARCH LTD
Contact:	Kevin Ganshorn
Address:	Suite 906 - 595 Howe Street Vancouver, BC Canada, V6C 2T5
Phone:	604-608-6180
Fax:	

Invoice To ☑Email ☐Mail

Company:	ECOFISH RESEARCH LTD
Contact:	Accounts Payable
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Email:	accountspayable@ecofishresearch.com
Phone:	250-334-3042

Reporting

Distribution:	☐Fax ☐Mail ☑Email
☐Ciriteria on Report (select from Guidelines below)	
Report Type:	☑Excel ☑Digital
Report Format:	CROSSTAB_ALSQC
Report Email(s):	kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com
EDD Format:	ECF100
EDD Email(s):	kganshorn@ecofishresearch.com bbennett@ecofishresearch.com tkasubuchi@ecofishresearch.com

Project Info

Job #:	1230 JHT-MON8
PO/AFE:	1230-16.03.05
LSD:	
Quote #:	

Service Requested

- ⦿ Regular (Standard Turnaround Times - Business Days) - R
- O Priority (3 Days) - surcharge will apply - P
- O Priority (2 Days) - surcharge will apply - P2
- O Emergency (1-2 day) – surcharge will apply - E
- O Same Day or Weekend Emergency - surcharge will apply - E2
- O Specify date required - X

Lab Work Order # (lab use only)

ALS Contact: Ariel Tang, B.Sc. Sampler: Leah Hull

Analysis Requests — Please indicate below Filtered, Preserved or both(F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Nitrate in Water by IC (Low Level)	Nitrite in Water by IC (Low Level)	Total Dissolved Solids by Gravimetric	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)
	SAM-WQA			13-Sept 2016	12:17	Water	3	R	R	R	R	R	R	R	R	R	R	R
	SAM-WQB			〃	〃	Water	3	R	R	R	R	R	R	R	R	R	R	R

L1828878-COFC

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐Yes ☑No
If yes, please use an authorized drinking water COC
Is the water sampled intended to be potable for human consumption? ☐Yes ☑No

Guidelines

SAMPLE CONDITION (lab use only)
☐Frozen ☐Cold ☐Ambient ☐Cooling Initiated

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Leah Hull	Date: 14-Sept 2016	Time: 16:00	Received by: [signature]	Date: Sept 14	Time: 7pm	Temperature: 4 °C	Verified by:	Date:	Time:	Observations: ☐Yes If Yes add SIF

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 12-OCT-16
Report Date: 19-OCT-16 17:28 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1842269

Project P.O. #: 1230-16.03.05
Job Reference: 1230 JHT-MON8
C of C Numbers: OL-2030
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1842269-1	L1842269-2			
	Description	Water	Water			
	Sampled Date	11-OCT-16	11-OCT-16			
	Sampled Time	09:40	09:40			
	Client ID	SAM-WQA	SAM-WQB			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	48.0	46.4			
	pH (pH)	7.70	7.63			
	Total Suspended Solids (mg/L)	1.2	<1.0			
	Total Dissolved Solids (mg/L)	39	34			
	Turbidity (NTU)	0.44	0.40			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	20.3	20.1			
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050			
	Nitrate (as N) (mg/L)	0.0324	0.0329			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010			
	Phosphorus (P)-Total (mg/L)	0.0030	0.0030			

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Reference Information

Chain of Custody Numbers:

OL-2030

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5
Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3571410								
WG2410640-2 LCS								
Alkalinity, Total (as CaCO3)			104.0		%		85-115	14-OCT-16
WG2410640-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	14-OCT-16
WG2410640-4 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	14-OCT-16
WG2410640-6 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	14-OCT-16
WG2410640-8 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	14-OCT-16
EC-PCT-VA	**Water**							
Batch R3570741								
WG2409242-29 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			105.0		%		90-110	13-OCT-16
WG2409242-26 MB								
Conductivity			<2.0		uS/cm		2	13-OCT-16
NH3-F-VA	**Water**							
Batch R3573258								
WG2412375-7 DUP		**L1842269-2**						
Ammonia, Total (as N)		<0.0050	<0.0050	RPD-NA	mg/L	N/A	20	17-OCT-16
WG2412375-6 LCS								
Ammonia, Total (as N)			106.1		%		85-115	17-OCT-16
WG2412375-5 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	17-OCT-16
WG2412375-8 MS		**L1842269-2**						
Ammonia, Total (as N)			86.2		%		75-125	17-OCT-16
NO2-L-IC-N-VA	**Water**							
Batch R3570340								
WG2409160-15 DUP		**L1842269-2**						
Nitrite (as N)		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	12-OCT-16
WG2409160-18 LCS								
Nitrite (as N)			101.4		%		90-110	12-OCT-16
WG2409160-2 LCS								
Nitrite (as N)			100.9		%		90-110	12-OCT-16
WG2409160-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	12-OCT-16
WG2409160-10 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	12-OCT-16

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-L-IC-N-VA	**Water**							
Batch R3570340								
WG2409160-13 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	12-OCT-16
WG2409160-16 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	12-OCT-16
WG2409160-4 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	12-OCT-16
WG2409160-7 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	12-OCT-16
NO3-L-IC-N-VA	**Water**							
Batch R3570340								
WG2409160-15 DUP		**L1842269-2**						
Nitrate (as N)		0.0329	0.0328		mg/L	0.2	20	12-OCT-16
WG2409160-18 LCS								
Nitrate (as N)			103.4		%		90-110	12-OCT-16
WG2409160-2 LCS								
Nitrate (as N)			103.2		%		90-110	12-OCT-16
WG2409160-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	12-OCT-16
WG2409160-10 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	12-OCT-16
WG2409160-13 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	12-OCT-16
WG2409160-16 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	12-OCT-16
WG2409160-4 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	12-OCT-16
WG2409160-7 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	12-OCT-16
P-T-PRES-COL-VA	**Water**							
Batch R3570211								
WG2409392-6 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			115.2		%		80-120	13-OCT-16
WG2409392-5 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	13-OCT-16
WG2409392-8 MS		**L1842269-1**						
Phosphorus (P)-Total			92.5		%		70-130	13-OCT-16
PH-PCT-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PH-PCT-VA	**Water**							
Batch R3570741								
WG2409242-27 CRM		**VA-PH7-BUF**						
pH			7.02		pH		6.9-7.1	13-OCT-16
PO4-DO-COL-VA	**Water**							
Batch R3569661								
WG2409310-10 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			94.3		%		80-120	13-OCT-16
WG2409310-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			99.3		%		80-120	13-OCT-16
WG2409310-6 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			98.9		%		80-120	13-OCT-16
WG2409310-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	13-OCT-16
WG2409310-5 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	13-OCT-16
WG2409310-9 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	13-OCT-16
WG2409310-8 MS		**L1842269-1**						
Orthophosphate-Dissolved (as P)			97.7		%		70-130	13-OCT-16
TDS-VA	**Water**							
Batch R3571737								
WG2410243-5 LCS								
Total Dissolved Solids			101.7		%		85-115	14-OCT-16
WG2410243-4 MB								
Total Dissolved Solids			<10		mg/L		10	14-OCT-16
TSS-LOW-VA	**Water**							
Batch R3571851								
WG2410698-2 LCS								
Total Suspended Solids			97.3		%		85-115	14-OCT-16
WG2410698-4 LCS								
Total Suspended Solids			89.8		%		85-115	14-OCT-16
WG2410698-1 MB								
Total Suspended Solids			<1.0		mg/L		1	14-OCT-16
WG2410698-3 MB								
Total Suspended Solids			<1.0		mg/L		1	14-OCT-16
TURBIDITY-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
TURBIDITY-VA	**Water**							
Batch R3570045								
WG2409531-2 CRM		**VA-FORM-40**						
Turbidity			103.8		%		85-115	13-OCT-16
WG2409531-5 CRM		**VA-FORM-40**						
Turbidity			104.0		%		85-115	13-OCT-16
WG2409531-1 MB								
Turbidity			<0.10		NTU		0.1	13-OCT-16
WG2409531-4 MB								
Turbidity			<0.10		NTU		0.1	13-OCT-16

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	11-OCT-16 09:40	13-OCT-16 07:31	0.25	46	hours	EHTR-FM
	2	11-OCT-16 09:40	13-OCT-16 07:31	0.25	46	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1842269 were received on 12-OCT-16 11:20.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

L1842269-COFC

BR164144
October

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2030

Report To

Company:	ECOFISH RESEARCH LTD
Contact:	Kevin Ganshorn
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Phone:	250-334-3042
Fax:	250-334-3097

Invoice To ☑Email ☐Mail

Company:	ECOFISH RESEARCH LTD
Contact:	Accounts Payable
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Email:	accountspayable@ecofishresearch.com
Phone:	250-334-3042

Lab Work Order # (lab use only)

Reporting

Distribution:	☐Fax ☐Mail ☑Email
☐Criteria on Report (select from Guidelines below)	
Report Type:	☑Excel ☑Digital
Report Format:	CROSSTAB_ALSQC
Report Email(s):	kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com
EDD Format:	ECF100
EDD Email(s):	kganshorn@ecofishresearch.com bbennett@ecofishresearch.com tkasubuchi@ecofishresearch.com

Project Info

Job #:	1230 JHT-MON8
PO/AFE:	1230-16.03.05
LSD:	
Quote #:	
ALS Contact:	Ariel Tang, B.Sc.
Sampler:	Leah Hull

Service Requested

- ⊙ Regular (Standard Turnaround Times - Business Days) - R
- ○ Priority (3 Days) - surcharge will apply - P
- ○ Priority (2 Days) - surcharge will apply - P2
- ○ Emergency (1-2 day) – surcharge will apply - E
- ○ Same Day or Weekend Emergency - surcharge will apply - E2
- ○ Specify date required - X

Analysis Requests

Please indicate below Filtered, Preserved or both(F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Nitrate in Water by IC (Low Level)	Nitrite in Water by IC (Low Level)	Total Dissolved Solids by Gravimetric	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)
	SAM-WQA			11-Oct-2016	9:40	Water	3	R	R	R	R	R	R	R	R	R	R	R
	SAM-WQB			11-Oct-2016	9:40	Water	3	R	R	R	R	R	R	R	R	R	R	R

Short Holding Time
Rush Processing

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐Yes ☒No

If yes, please use an authorized drinking water COC

Is the water sampled intended to be potable for human consumption? ☐Yes ☒No

Guidelines

SAMPLE CONDITION (lab use only)

☐Frozen ☐Cold ☐Ambient ☐Cooling Initiated

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations:
Leah Hull	11-Oct 2016	17:00	HMC	Oct12/16	11:20Am	4 °C				☐Yes If Yes add SIF

Appendix B. ALS Laboratory Water Quality Results and QA/QC for the Quinsam River, 2016.

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 18-MAY-16
Report Date: 27-MAY-16 17:03 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1770930

Project P.O. #: 1230-16.03.02
Job Reference: 1230 JHT-MON8
C of C Numbers: OL-2019
Legal Site Desc:

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1770930-1	L1770930-2	L1770930-3	L1770930-4
	Description	Water	Water	Water	Water
	Sampled Date	18-MAY-16	18-MAY-16	18-MAY-16	18-MAY-16
	Sampled Time	10:58	10:58	10:58	10:58
	Client ID	QUN-FIELD BLANK	QUN-TRIP BLANK	QUN-WQA	QUN-WQB
Grouping	**Analyte**				
WATER					
Physical Tests	Conductivity (uS/cm)	<2.0	<2.0	131	132
	pH (pH)	5.62	5.58	7.80	7.86
	Total Suspended Solids (mg/L)	<1.0	<1.0	<1.0	<1.0
	Total Dissolved Solids (mg/L)	<10	<10	85	85
	Turbidity (NTU)	<0.10	<0.10	0.59	0.38
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	<2.0	<2.0	35.1	35.6
	Ammonia, Total (as N) (mg/L)	<0.0050	0.0059 RRV	<0.0050	<0.0050
	Nitrate (as N) (mg/L)	<0.0050	<0.0050	0.0161	0.0164
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Total (mg/L)	<0.0020	<0.0020	0.0039	0.0030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Nitrite (as N)	DLDS	L1770930-1, -2, -3, -4
Duplicate	Nitrate (as N)	DLDS	L1770930-1, -2, -3, -4

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
RRV	Reported Result Verified By Repeat Analysis

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

Reference Information

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

OL-2019

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5
Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3464898								
WG2314464-2 CRM		**VA-ALKL-CONTROL**						
Alkalinity, Total (as CaCO3)			105.7		%		85-115	25-MAY-16
WG2314464-5 CRM		**VA-ALKM-CONTROL**						
Alkalinity, Total (as CaCO3)			112.6		%		85-115	25-MAY-16
WG2314464-8 CRM		**VA-ALKH-CONTROL**						
Alkalinity, Total (as CaCO3)			109.1		%		85-115	25-MAY-16
WG2314464-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-10 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-12 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-14 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-16 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-18 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-20 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-4 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
WG2314464-7 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	25-MAY-16
EC-PCT-VA	**Water**							
Batch R3465514								
WG2314095-14 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			100.8		%		90-110	25-MAY-16
WG2314095-9 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			100.2		%		90-110	25-MAY-16
WG2314095-11 MB								
Conductivity			<2.0		uS/cm		2	25-MAY-16
WG2314095-6 MB								
Conductivity			<2.0		uS/cm		2	25-MAY-16
NH3-F-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NH3-F-VA	**Water**							
Batch R3466430								
WG2315768-2 LCS								
Ammonia, Total (as N)			102.8		%		85-115	27-MAY-16
WG2315768-6 LCS								
Ammonia, Total (as N)			101.1		%		85-115	27-MAY-16
WG2315768-1 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	27-MAY-16
WG2315768-5 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	27-MAY-16
NO2-L-IC-N-VA	**Water**							
Batch R3463447								
WG2312952-3 DUP		**L1770930-3**						
Nitrite (as N)		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	21-MAY-16
WG2312952-2 LCS								
Nitrite (as N)			97.6		%		90-110	21-MAY-16
WG2312952-21 LCS								
Nitrite (as N)			96.3		%		90-110	21-MAY-16
WG2312952-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	21-MAY-16
WG2312952-10 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	21-MAY-16
WG2312952-13 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	21-MAY-16
WG2312952-16 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	21-MAY-16
WG2312952-19 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	21-MAY-16
WG2312952-4 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	21-MAY-16
WG2312952-7 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	21-MAY-16
NO3-L-IC-N-VA	**Water**							
Batch R3463447								
WG2312952-3 DUP		**L1770930-3**						
Nitrate (as N)		0.0161	0.0157		mg/L	2.5	20	21-MAY-16
WG2312952-2 LCS								
Nitrate (as N)			98.0		%		90-110	21-MAY-16
WG2312952-21 LCS								
Nitrate (as N)			98.2		%		90-110	21-MAY-16

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-L-IC-N-VA	**Water**							
Batch R3463447								
WG2312952-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	21-MAY-16
WG2312952-10 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	21-MAY-16
WG2312952-13 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	21-MAY-16
WG2312952-16 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	21-MAY-16
WG2312952-19 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	21-MAY-16
WG2312952-4 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	21-MAY-16
WG2312952-7 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	21-MAY-16
P-T-PRES-COL-VA	**Water**							
Batch R3464041								
WG2313218-6 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			105.9		%		80-120	25-MAY-16
WG2313218-5 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	25-MAY-16
PH-PCT-VA	**Water**							
Batch R3465514								
WG2314095-12 CRM		**VA-PH7-BUF**						
pH			7.00		pH		6.9-7.1	25-MAY-16
WG2314095-7 CRM		**VA-PH7-BUF**						
pH			7.00		pH		6.9-7.1	25-MAY-16
TDS-VA	**Water**							
Batch R3465723								
WG2314479-2 LCS								
Total Dissolved Solids			99.9		%		85-115	25-MAY-16
WG2314479-1 MB								
Total Dissolved Solids			<10		mg/L		10	25-MAY-16
TSS-LOW-VA	**Water**							
Batch R3465608								
WG2314538-2 LCS								
Total Suspended Solids			98.3		%		85-115	25-MAY-16
WG2314538-1 MB								

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
TSS-LOW-VA	**Water**							
Batch R3465608								
WG2314538-1 MB								
Total Suspended Solids			<1.0		mg/L		1	25-MAY-16
TURBIDITY-VA	**Water**							
Batch R3462113								
WG2312493-11 CRM		**VA-FORM-40**						
Turbidity			99.3		%		85-115	20-MAY-16
WG2312493-8 CRM		**VA-FORM-40**						
Turbidity			98.8		%		85-115	20-MAY-16
WG2312493-10 MB								
Turbidity			<0.10		NTU		0.1	20-MAY-16
WG2312493-7 MB								
Turbidity			<0.10		NTU		0.1	20-MAY-16

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	18-MAY-16 10:58	25-MAY-16 09:35	0.25	167	hours	EHTR-FM
	2	18-MAY-16 10:58	25-MAY-16 09:35	0.25	167	hours	EHTR-FM
	3	18-MAY-16 10:58	25-MAY-16 09:35	0.25	167	hours	EHTR-FM
	4	18-MAY-16 10:58	25-MAY-16 09:35	0.25	167	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR: Exceeded ALS recommended hold time prior to sample receipt.
EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT: Exceeded ALS recommended hold time prior to analysis.
Rec. HT: ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1770930 were received on 18-MAY-16 17:55.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

BR164126

Short Holding Time

Rush Processing

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2019

Report To		**Reporting**		**Service Requested**
Company:	ECOFISH RESEARCH LTD	Distribution:	☐Fax ☐Mail ☑Email	⦿ Regular (Standard Turnaround Times - Business Days) - R
Contact:	Kevin Ganshorn	☐ Criteria on Report (select from Guidelines below)		○ Priority (3 Days) - surcharge will apply - P
Address:	Suite F, 450 - 8th Street, Courtenay, BC, Canada, V9N 1N5	Report Type:	☑Excel ☑Digital	○ Priority (2 Days) - surcharge will apply - P2
		Report Format:	CROSSTAB_ALSQC	○ Emergency (1-2 day) – surcharge will apply - E
		Report Email(s):	kganshorn@ecofishresearch.com, Tkasubuchi@ecofishresearch.com	○ Same Day or Weekend Emergency - surcharge will apply - E2
Phone:	250-334-3042 Fax: 250-334-3097			○ Specify date required - X
Invoice To	☑Email ☐Mail	EDD Format:	ECF100	
Company:	ECOFISH RESEARCH LTD	EDD Email(s):	kganshorn@ecofishresearch.com, bbennett@ecofishresearch.com, tkasubuchi@ecofishresearch.com	
Contact:	Accounts Payable	**Project Info**		
Address:	Suite F, 450 - 8th Street, Courtenay, BC, Canada, V9N 1N5	Job #:	1230 JHT-MON8	
		PO/AFE:	1230-16,03,02	
Email:	accountspayable@ecofishresearch.com	LSD:		
Phone:	250-334-3042	Quote #:		
Lab Work Order # (lab use only)	L1770930	ALS Contact: Ariel Tang, B.Sc.	Sampler: Leah Hull	

Analysis Requests — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Nitrate in Water by IC (Low Level)	Nitrite in Water by IC (Low Level)	Total Dissolved Solids by Gravimetric	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)
	QUN-FIELD BLANK			18-May-2016	10:58	Water	3	R	R	R	R	R	R	R	R	R	R	R
	QUN-TRIP BLANK			↓	↓	Water	3	R	R	R	R	R	R	R	R	R	R	R
	QUN-WQA			↓	↓	Water	3	R	R	R	R	R	R	R	R	R	R	R
	QUN-WQB			↓	↓	Water	3	R	R	R	R	R	R	R	R	R	R	R

L1770930-COFC

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐Yes ☒No

If yes, please use an authorized drinking water COC

Is the water sampled intended to be potable for human consumption? ☐Yes ☒No

Guidelines

SAMPLE CONDITION (lab use only)

☐Frozen ☐Cold ☐Ambient ☐Cooling Initiated

SHIPMENT RELEASE (client use)			**SHIPMENT RECEPTION (lab use only)**				**SHIPMENT VERIFICATION (lab use only)**			
Released by: Leah Hull	Date: 18-May 2016	Time: 14:30	Received by: JC	Date: 18 May	Time: 17:55	Temperature: 6 °C	Verified by:	Date:	Time:	Observations: ☐Yes If Yes add SIF

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 15-JUN-16
Report Date: 24-JUN-16 12:26 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1784287

Project P.O. #: 1230-16.03.02
Job Reference: 1230-16.03.02
C of C Numbers: OL-2021
Legal Site Desc:

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1784287-1	L1784287-2			
	Description	Water	Water			
	Sampled Date	15-JUN-16	15-JUN-16			
	Sampled Time	09:47	09:47			
	Client ID	QUN-WQA	QUN-WQB			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	131	130			
	pH (pH)	7.77	7.78			
	Total Suspended Solids (mg/L)	<1.0	<1.0			
	Total Dissolved Solids (mg/L)	88	86			
	Turbidity (NTU)	0.44	0.46			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	34.7	33.9			
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050			
	Nitrate (as N) (mg/L)	0.0160	0.0144			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Orthophosphate-Dissolved (as P) (mg/L)	0.0017	0.0012			
	Phosphorus (P)-Total (mg/L)	0.0039	0.0027			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Nitrite (as N)	DLDS	L1784287-1, -2

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

Reference Information

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

OL-2021

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3486303								
WG2332161-2 CRM		**VA-ALKL-CONTROL**						
Alkalinity, Total (as CaCO3)			100.9		%		85-115	21-JUN-16
WG2332161-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	21-JUN-16
WG2332161-4 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	21-JUN-16
WG2332161-6 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	21-JUN-16
WG2332161-8 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	21-JUN-16
EC-PCT-VA	**Water**							
Batch R3485595								
WG2331112-19 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			106.1		%		90-110	20-JUN-16
WG2331112-16 MB								
Conductivity			<2.0		uS/cm		2	20-JUN-16
NH3-F-VA	**Water**							
Batch R3488354								
WG2333745-2 LCS								
Ammonia, Total (as N)			95.3		%		85-115	23-JUN-16
WG2333745-1 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	23-JUN-16
NO2-L-IC-N-VA	**Water**							
Batch R3488023								
WG2330426-2 LCS								
Nitrite (as N)			99.9		%		90-110	18-JUN-16
WG2330426-21 LCS								
Nitrite (as N)			99.3		%		90-110	18-JUN-16
WG2330426-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	18-JUN-16
WG2330426-10 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	18-JUN-16
WG2330426-13 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	18-JUN-16
WG2330426-16 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	18-JUN-16
WG2330426-19 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	18-JUN-16

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-L-IC-N-VA	**Water**							
Batch R3488023								
WG2330426-4 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	18-JUN-16
WG2330426-7 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	18-JUN-16
NO3-L-IC-N-VA	**Water**							
Batch R3488023								
WG2330426-2 LCS								
Nitrate (as N)			101.1		%		90-110	18-JUN-16
WG2330426-21 LCS								
Nitrate (as N)			101.2		%		90-110	18-JUN-16
WG2330426-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	18-JUN-16
WG2330426-10 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	18-JUN-16
WG2330426-13 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	18-JUN-16
WG2330426-16 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	18-JUN-16
WG2330426-19 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	18-JUN-16
WG2330426-4 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	18-JUN-16
WG2330426-7 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	18-JUN-16
P-T-PRES-COL-VA	**Water**							
Batch R3486076								
WG2331613-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			95.7		%		80-120	21-JUN-16
WG2331613-1 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	21-JUN-16
PH-PCT-VA	**Water**							
Batch R3485595								
WG2331112-17 CRM		**VA-PH7-BUF**						
pH			7.00		pH		6.9-7.1	20-JUN-16
PO4-DO-COL-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PO4-DO-COL-VA	**Water**							
Batch R3481353								
WG2329446-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			99.9		%		80-120	17-JUN-16
WG2329446-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	17-JUN-16
TDS-VA	**Water**							
Batch R3486760								
WG2331795-8 LCS								
Total Dissolved Solids			101.3		%		85-115	21-JUN-16
WG2331795-7 MB								
Total Dissolved Solids			<10		mg/L		10	21-JUN-16
TSS-LOW-VA	**Water**							
Batch R3486833								
WG2332401-2 LCS								
Total Suspended Solids			97.8		%		85-115	21-JUN-16
WG2332401-1 MB								
Total Suspended Solids			<1.0		mg/L		1	21-JUN-16
TURBIDITY-VA	**Water**							
Batch R3482975								
WG2330045-2 CRM		**VA-FORM-40**						
Turbidity			102.3		%		85-115	17-JUN-16
WG2330045-1 MB								
Turbidity			<0.10		NTU		0.1	17-JUN-16

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	15-JUN-16 09:47	20-JUN-16 09:27	0.25	120	hours	EHTR-FM
	2	15-JUN-16 09:47	20-JUN-16 09:27	0.25	120	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR: Exceeded ALS recommended hold time prior to sample receipt.
EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT: Exceeded ALS recommended hold time prior to analysis.
Rec. HT: ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1784287 were received on 15-JUN-16 17:25.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

S‑ort Holding Time

BR164133
June

ALS Envir — Rush Processing

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2021

Report To

Company:	ECOFISH RESEARCH LTD
Contact:	Kevin Ganshorn
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Phone:	250-334-3042
Fax:	250-334-3097

Invoice To ☑Email ☐Mail

Company:	ECOFISH RESEARCH LTD
Contact:	Accounts Payable
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Email:	accountspayable@ecofishresearch.com
Phone:	250-334-3042

Lab Work Order # (lab use only):

Reporting

Distribution:	☐Fax ☐Mail ☑Email
☐Criteria on Report (select from Guidelines below)	
Report Type:	☑Excel ☑Digital
Report Format:	CROSSTAB_ALSQC
Report Email(s):	kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com
EDD Format:	ECF100
EDD Email(s):	kganshorn@ecofishresearch.com bbennett@ecofishresearch.com tkasubuchi@ecofishresearch.com

Project Info

Job #:	1230 JHT-MON8
PO/AFE:	1230-16.03.02
LSD:	
Quote #:	
ALS Contact:	Ariel Tang, B.Sc.
Sampler:	Leah Hull

Service Requested

- ⦿ Regular (Standard Turnaround Times - Business Days) - R
- ○ Priority (3 Days) - surcharge will apply - P
- ○ Priority (2 Days) - surcharge will apply - P2
- ○ Emergency (1-2 day) – surcharge will apply - E
- ○ Same Day or Weekend Emergency - surcharge will apply - E2
- ○ Specify date required - X

Analysis Requests — Please indicate below Filtered, Preserved or both(F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Nitrate in Water by IC (Low Level)	Nitrite in Water by IC (Low Level)	Total Dissolved Solids by Gravimetric	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)
	QUN-WQA			15-June-2016	9:47	Water	3	R	R	R	R	R	R	R	R	R	R	R
	QUN-WQB			"	9:47	Water	3	R	R	R	R	R	R	R	R	R	R	R

L1784287-COFC

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐Yes ☒No

If yes, please use an authorized drinking water COC

Is the water sampled intended to be potable for human consumption? ☐Yes ☒No

Guidelines

SAMPLE CONDITION (lab use only)

☐Frozen ☐Cold ☐Ambient ☐Cooling Initiated

SHIPMENT RELEASE (client use)

Released by:	Date:	Time:
Leah Hull	15-June 2016	13:00

SHIPMENT RECEPTION (lab use only)

Received by:	Date:	Time:	Temperature:
K.	15 Jun	1725	6 °C

SHIPMENT VERIFICATION (lab use only)

Verified by:	Date:	Time:	Observations:
			☐Yes If Yes add SIF

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 13-JUL-16
Report Date: 21-JUL-16 12:46 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1798004

Project P.O. #: 1230-16.03.02
Job Reference: 1230 JHT-MON8
C of C Numbers: OL-2023
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1798004-1	L1798004-2			
	Description	Water	Water			
	Sampled Date	13-JUL-16	13-JUL-16			
	Sampled Time	10:05	10:05			
	Client ID	QUN-WQA	QUN-WQB			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	111	109			
	pH (pH)	7.67	7.68			
	Total Suspended Solids (mg/L)	1.5	1.0			
	Total Dissolved Solids (mg/L)	72	67			
	Turbidity (NTU)	1.14	1.19			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	36.5	36.7			
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050			
	Nitrate (as N) (mg/L)	0.0171	0.0163			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010			
	Phosphorus (P)-Total (mg/L)	0.0042	0.0049			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

OL-2023

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5
Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3504301								
WG2348413-29 CRM		**VA-ALKL-CONTROL**						
Alkalinity, Total (as CaCO3)			96.9		%		85-115	15-JUL-16
WG2348413-28 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	15-JUL-16
WG2348413-31 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	15-JUL-16
WG2348413-33 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	15-JUL-16
WG2348413-35 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	15-JUL-16
EC-PCT-VA	**Water**							
Batch R3506932								
WG2349822-4 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			98.7		%		90-110	19-JUL-16
WG2349822-1 MB								
Conductivity			<2.0		uS/cm		2	19-JUL-16
NH3-F-VA	**Water**							
Batch R3507469								
WG2350696-6 LCS								
Ammonia, Total (as N)			97.8		%		85-115	19-JUL-16
WG2350696-5 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	19-JUL-16
Batch R3507908								
WG2350731-6 LCS								
Ammonia, Total (as N)			99.2		%		85-115	20-JUL-16
WG2350731-5 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	20-JUL-16
NO2-L-IC-N-VA	**Water**							
Batch R3505723								
WG2347260-17 LCS								
Nitrite (as N)			99.1		%		90-110	14-JUL-16
WG2347260-2 LCS								
Nitrite (as N)			98.8		%		90-110	14-JUL-16
WG2347260-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
WG2347260-11 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
WG2347260-14 MB								

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-L-IC-N-VA	**Water**							
Batch R3505723								
WG2347260-14 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
WG2347260-16 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
WG2347260-3 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
WG2347260-5 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
WG2347260-8 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	14-JUL-16
WG2347260-15 MS		**L1798004-2**						
Nitrite (as N)			97.9		%		75-125	14-JUL-16
NO3-L-IC-N-VA	**Water**							
Batch R3505723								
WG2347260-17 LCS								
Nitrate (as N)			101.6		%		90-110	14-JUL-16
WG2347260-2 LCS								
Nitrate (as N)			101.2		%		90-110	14-JUL-16
WG2347260-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-11 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-14 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-16 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-3 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-5 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-8 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	14-JUL-16
WG2347260-15 MS		**L1798004-2**						
Nitrate (as N)			101.1		%		75-125	14-JUL-16
P-T-PRES-COL-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
P-T-PRES-COL-VA	**Water**							
Batch R3504068								
WG2347251-10 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			111.1		%		80-120	15-JUL-16
WG2347251-9 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	15-JUL-16
PH-PCT-VA	**Water**							
Batch R3506932								
WG2349822-2 CRM		**VA-PH7-BUF**						
pH			7.00		pH		6.9-7.1	19-JUL-16
PO4-DO-COL-VA	**Water**							
Batch R3503053								
WG2347163-10 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			91.9		%		80-120	14-JUL-16
WG2347163-14 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			92.7		%		80-120	14-JUL-16
WG2347163-18 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			87.4		%		80-120	14-JUL-16
WG2347163-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			93.1		%		80-120	13-JUL-16
WG2347163-22 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			95.4		%		80-120	14-JUL-16
WG2347163-26 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			88.9		%		80-120	14-JUL-16
WG2347163-6 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			95.4		%		80-120	14-JUL-16
WG2347163-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	13-JUL-16
WG2347163-13 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	14-JUL-16
WG2347163-17 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	14-JUL-16
WG2347163-21 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	14-JUL-16
WG2347163-25 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	14-JUL-16
WG2347163-5 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	14-JUL-16
WG2347163-9 MB								

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PO4-DO-COL-VA	**Water**							
Batch R3503053								
WG2347163-9 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	14-JUL-16
TDS-VA	**Water**							
Batch R3505925								
WG2349185-2 LCS								
Total Dissolved Solids			95.2		%		85-115	17-JUL-16
WG2349185-1 MB								
Total Dissolved Solids			<10		mg/L		10	17-JUL-16
TSS-LOW-VA	**Water**							
Batch R3505886								
WG2348996-4 LCS								
Total Suspended Solids			100.3		%		85-115	16-JUL-16
WG2348996-3 MB								
Total Suspended Solids			<1.0		mg/L		1	16-JUL-16
TURBIDITY-VA	**Water**							
Batch R3503488								
WG2347359-11 CRM		**VA-FORM-40**						
Turbidity			105.3		%		85-115	14-JUL-16
WG2347359-14 CRM		**VA-FORM-40**						
Turbidity			104.8		%		85-115	14-JUL-16
WG2347359-2 CRM		**VA-FORM-40**						
Turbidity			103.0		%		85-115	14-JUL-16
WG2347359-5 CRM		**VA-FORM-40**						
Turbidity			104.5		%		85-115	14-JUL-16
WG2347359-8 CRM		**VA-FORM-40**						
Turbidity			106.8		%		85-115	14-JUL-16
WG2347359-1 MB								
Turbidity			<0.10		NTU		0.1	14-JUL-16
WG2347359-10 MB								
Turbidity			<0.10		NTU		0.1	14-JUL-16
WG2347359-13 MB								
Turbidity			<0.10		NTU		0.1	14-JUL-16
WG2347359-4 MB								
Turbidity			<0.10		NTU		0.1	14-JUL-16
WG2347359-7 MB								
Turbidity			<0.10		NTU		0.1	14-JUL-16

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	13-JUL-16 10:05	19-JUL-16 07:26	0.25	141	hours	EHTR-FM
	2	13-JUL-16 10:05	19-JUL-16 07:26	0.25	141	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1798004 were received on 13-JUL-16 17:45.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

L1798004-COFC

BR164137
July

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2023

Report To		Reporting		Service Requested
Company:	ECOFISH RESEARCH LTD	Distribution:	☐Fax ☐Mail ☑Email	◉ Regular (Standard Turnaround Times - Business Days) - R
Contact:	Kevin Ganshorn	☐Criteria on Report (select from Guidelines below)		○ Priority (3 Days) - surcharge will apply - P
Address:	Suite 906 - 595 Howe Street Vancouver, BC Canada, V6C 2T5	Report Type:	☑Excel ☑Digital	○ Priority (2 Days) - surcharge will apply - P2
		Report Format:	CROSSTAB_ALSQC	○ Emergency (1-2 day) – surcharge will apply - E
		Report Email(s):	kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com	○ Same Day or Weekend Emergency - surcharge will apply - E2
				○ Specify date required - X
Phone:	604-608-6180 Fax:			
Invoice To	☑Email ☐Mail	EDD Format:	ECF100	
Company:	ECOFISH RESEARCH LTD	EDD Email(s):	kganshorn@ecofishresearch.com bbennett@ecofishresearch.com tkasubuchi@ecofishresearch.com	
Contact:	Accounts Payable			
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5	Project Info		
		Job #:	1230 JHT-MON8	
		PO/AFE:	1230-16.03.02	
Email:	accountspayable@ecofishresearch.com	LSD:		
Phone:	250-334-3042	Quote #:		
Lab Work Order # (lab use only)		ALS Contact: Ariel Tang, B.Sc.	Sampler: LEAH HULL	

Analysis Requests (Please indicate below Filtered, Preserved or both(F, P, F/P))

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Nitrate in Water by IC (Low Level)	Nitrite in Water by IC (Low Level)	Total Dissolved Solids by Gravimetric	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)
	QUN-WQA			13-July-2016	10:05	WATER	3	R	R	R	R	R	R	R	R	R	R	R
	QUN-WQB			"	"	WATER	3	R	R	R	R	R	R	R	R	R	R	R

Short Holding Time

(B) *Rush Processing*

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐Yes ☒No

If yes, please use an authorized drinking water COC

Is the water sampled intended to be potable for human consumption? ☐Yes ☒No

Guidelines

SAMPLE CONDITION (lab use only)

☐Frozen ☐Cold ☐Ambient ☐Cooling Initiated

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Leah Hull	Date: 13-July 2016	Time: 14:00	Received by: Shayan	Date: July.13	Time: 1745	Temperature: 6.4 °C	Verified by:	Date:	Time:	Observations: ☐Yes If Yes add SIF

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 18-AUG-16
Report Date: 25-AUG-16 16:19 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1815492

Project P.O. #: 1230-16.03.02
Job Reference: 1230 JHT-MON8
C of C Numbers: OL-2025
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1815492-1	L1815492-2			
	Description	Water	Water			
	Sampled Date	17-AUG-16	17-AUG-16			
	Sampled Time	10:45	10:45			
	Client ID	QUN-WQA	QUN-WQB			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	137	138			
	pH (pH)	7.50	7.51			
	Total Suspended Solids (mg/L)	1.1	<1.0			
	Total Dissolved Solids (mg/L)	86	88			
	Turbidity (NTU)	0.44	0.47			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	35.5	35.4			
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050			
	Nitrate (as N) (mg/L)	0.0241	0.0239			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010			
	Phosphorus (P)-Total (mg/L)	0.0030	0.0046			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

OL-2025

GLOSSARY OF REPORT TERMS
Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L1815492 Report Date: 25-AUG-16

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3532104								
WG2373809-2 LCS								
Alkalinity, Total (as CaCO3)			106.6		%		85-115	23-AUG-16
WG2373809-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	23-AUG-16
WG2373809-6 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	23-AUG-16
WG2373809-8 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	23-AUG-16
EC-PCT-VA	**Water**							
Batch R3530913								
WG2372520-9 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			105.9		%		90-110	22-AUG-16
WG2372520-6 MB								
Conductivity			<2.0		uS/cm		2	22-AUG-16
NH3-F-VA	**Water**							
Batch R3533269								
WG2374311-10 LCS								
Ammonia, Total (as N)			99.1		%		85-115	25-AUG-16
WG2374311-9 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	25-AUG-16
NO2-L-IC-N-VA	**Water**							
Batch R3532904								
WG2372055-12 LCS								
Nitrite (as N)			99.3		%		90-110	20-AUG-16
WG2372055-2 LCS								
Nitrite (as N)			98.7		%		90-110	20-AUG-16
WG2372055-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	20-AUG-16
WG2372055-10 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	20-AUG-16
WG2372055-4 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	20-AUG-16
WG2372055-7 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	20-AUG-16
NO3-L-IC-N-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-L-IC-N-VA	**Water**							
Batch R3532904								
WG2372055-12 LCS								
Nitrate (as N)			99.9		%		90-110	20-AUG-16
WG2372055-2 LCS								
Nitrate (as N)			99.6		%		90-110	20-AUG-16
WG2372055-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	20-AUG-16
WG2372055-10 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	20-AUG-16
WG2372055-4 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	20-AUG-16
WG2372055-7 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	20-AUG-16
P-T-PRES-COL-VA	**Water**							
Batch R3530186								
WG2372031-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			97.5		%		80-120	21-AUG-16
WG2372031-1 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	21-AUG-16
PH-PCT-VA	**Water**							
Batch R3530913								
WG2372520-7 CRM		**VA-PH7-BUF**						
pH			7.00		pH		6.9-7.1	22-AUG-16
PO4-DO-COL-VA	**Water**							
Batch R3528840								
WG2370916-10 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			80.0		%		80-120	18-AUG-16
WG2370916-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			94.9		%		80-120	18-AUG-16
WG2370916-6 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			86.0		%		80-120	18-AUG-16
WG2370916-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	18-AUG-16
WG2370916-5 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	18-AUG-16
WG2370916-9 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	18-AUG-16
TDS-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
TDS-VA	**Water**							
Batch R3532390								
WG2373168-2 LCS								
Total Dissolved Solids			99.8		%		85-115	22-AUG-16
WG2373168-1 MB								
Total Dissolved Solids			<10		mg/L		10	22-AUG-16
TSS-LOW-VA	**Water**							
Batch R3531199								
WG2372343-2 LCS								
Total Suspended Solids			109.1		%		85-115	21-AUG-16
WG2372343-1 MB								
Total Suspended Solids			<1.0		mg/L		1	21-AUG-16
TURBIDITY-VA	**Water**							
Batch R3529658								
WG2371627-11 CRM		**VA-FORM-40**						
Turbidity			102.8		%		85-115	19-AUG-16
WG2371627-14 CRM		**VA-FORM-40**						
Turbidity			102.5		%		85-115	19-AUG-16
WG2371627-2 CRM		**VA-FORM-40**						
Turbidity			103.5		%		85-115	19-AUG-16
WG2371627-5 CRM		**VA-FORM-40**						
Turbidity			102.8		%		85-115	19-AUG-16
WG2371627-8 CRM		**VA-FORM-40**						
Turbidity			103.5		%		85-115	19-AUG-16
WG2371627-1 MB								
Turbidity			<0.10		NTU		0.1	19-AUG-16
WG2371627-10 MB								
Turbidity			<0.10		NTU		0.1	19-AUG-16
WG2371627-13 MB								
Turbidity			<0.10		NTU		0.1	19-AUG-16
WG2371627-4 MB								
Turbidity			<0.10		NTU		0.1	19-AUG-16
WG2371627-7 MB								
Turbidity			<0.10		NTU		0.1	19-AUG-16

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	17-AUG-16 10:45	22-AUG-16 09:22	0.25	119	hours	EHTR-FM
	2	17-AUG-16 10:45	22-AUG-16 09:22	0.25	119	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR: Exceeded ALS recommended hold time prior to sample receipt.
EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT: Exceeded ALS recommended hold time prior to analysis.
Rec. HT: ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1815492 were received on 18-AUG-16 10:45.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

BR164139
August

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2025

Report To
Company: ECOFISH RESEARCH LTD
Contact: Kevin Ganshorn
Address: Suite F, 450 - 8th Street, Courtenay, BC, Canada, V9N 1N5
Phone: 250-334-3042 Fax: 250-334-3097

Invoice To ☑Email ☐Mail
Company: ECOFISH RESEARCH LTD
Contact: Accounts Payable
Address: Suite F, 450 - 8th Street, Courtenay, BC, Canada, V9N 1N5
Email: accountspayable@ecofishresearch.com
Phone: 250-334-3042

Lab Work Order # (lab use only)

Reporting
Distribution: ☐Fax ☐Mail ☑Email
☐Criteria on Report (select from Guidelines below)
Report Type: ☑Excel ☑Digital
Report Format: CROSSTAB_ALSQC
Report Email(s): kganshorn@ecofishresearch.com, tkasubuchi@ecofishresearch.com
EDD Format: ECF100
EDD Email(s): kganshorn@ecofishresearch.com, bbennett@ecofishresearch.com, tkasubuchi@ecofishresearch.com

Project Info
Job #: 1230 JHT-MON8
PO/AFE: 1230-16.03.02
LSD:
Quote #:

ALS Contact: Ariel Tang, B.Sc. Sampler: Leah Hull

Service Requested
◉ Regular (Standard Turnaround Times - Business Days) - R
○ Priority (3 Days) - surcharge will apply - P
○ Priority (2 Days) - surcharge will apply - P2
○ Emergency (1-2 day) – surcharge will apply - E
○ Same Day or Weekend Emergency - surcharge will apply - E2
○ Specify date required - X

Analysis Requests (Please indicate below Filtered, Preserved or both (F, P, F/P))

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Nitrate in Water by IC (Low Level)	Nitrite in Water by IC (Low Level)	Total Dissolved Solids by Gravimetric	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)
	QUN-WQA			17-Aug-2016	10:45	WATER	3	R	R	R	R	R	R	R	R	R	R	R
	QUN-WQB			"	10:45	WATER	3	R	R	R	R	R	R	R	R	R	R	R

L1815492-COFC

Short Holding Time
Rush Processing

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)
Are any sample taken from a regulated DW system? ☐Yes ☒No
If yes, please use an authorized drinking water COC
Is the water sampled intended to be potable for human consumption? ☐Yes ☒No

Guidelines

SAMPLE CONDITION (lab use only)
☐Frozen ☐Cold ☐Ambient ☐Cooling Initiated

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Leah Hull	Date: 17-Aug2016	Time: 17:30	Received by: HMC	Date: Aug18/16	Time: 10:45	Temperature: 6 °C	Verified by:	Date:	Time:	Observations: ☐Yes If Yes add SIF

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 14-SEP-16
Report Date: 26-SEP-16 18:49 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1828879

Project P.O. #: 1230-16.03.02
Job Reference: 1230 JHT-MON8
C of C Numbers: OL-2027
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1828879-1	L1828879-2			
	Description	Water	Water			
	Sampled Date	14-SEP-16	14-SEP-16			
	Sampled Time	11:30	11:30			
	Client ID	QUN-WQA	QUN-WQB			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	139	139			
	pH (pH)	7.70	7.72			
	Total Suspended Solids (mg/L)	<1.0	<1.0			
	Total Dissolved Solids (mg/L)	84	83			
	Turbidity (NTU)	0.45	0.46			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	35.1	35.4			
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050			
	Nitrate (as N) (mg/L)	0.0184	0.0185			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010			
	Phosphorus (P)-Total (mg/L)	0.0025	0.0027			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

OL-2027

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5
Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3550047								
WG2390494-2 LCS								
Alkalinity, Total (as CaCO3)			107.7		%		85-115	16-SEP-16
WG2390494-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-SEP-16
WG2390494-4 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-SEP-16
WG2390494-6 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-SEP-16
WG2390494-8 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	16-SEP-16
EC-PCT-VA	**Water**							
Batch R3555966								
WG2394829-19 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			100.6		%		90-110	23-SEP-16
WG2394829-16 MB								
Conductivity			<2.0		uS/cm		2	23-SEP-16
NH3-F-VA	**Water**							
Batch R3555717								
WG2395817-7 DUP		**L1828879-2**						
Ammonia, Total (as N)		<0.0050	<0.0050	RPD-NA	mg/L	N/A	20	23-SEP-16
WG2395817-6 LCS								
Ammonia, Total (as N)			104.6		%		85-115	23-SEP-16
WG2395817-5 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	23-SEP-16
WG2395817-8 MS		**L1828879-2**						
Ammonia, Total (as N)			101.6		%		75-125	23-SEP-16
NO2-L-IC-N-VA	**Water**							
Batch R3551703								
WG2389035-2 LCS								
Nitrite (as N)			102.6		%		90-110	15-SEP-16
WG2389035-21 LCS								
Nitrite (as N)			102.3		%		90-110	15-SEP-16
WG2389035-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16
WG2389035-10 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16
WG2389035-13 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-L-IC-N-VA	**Water**							
Batch R3551703								
WG2389035-16 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16
WG2389035-19 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16
WG2389035-4 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16
WG2389035-7 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	15-SEP-16
WG2389035-20 MS		**L1828879-1**						
Nitrite (as N)			102.8		%		75-125	15-SEP-16
NO3-L-IC-N-VA	**Water**							
Batch R3551703								
WG2389035-2 LCS								
Nitrate (as N)			100.5		%		90-110	15-SEP-16
WG2389035-21 LCS								
Nitrate (as N)			100.5		%		90-110	15-SEP-16
WG2389035-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-10 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-13 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-16 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-19 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-4 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-7 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	15-SEP-16
WG2389035-20 MS		**L1828879-1**						
Nitrate (as N)			100.9		%		75-125	15-SEP-16
P-T-PRES-COL-VA	**Water**							
Batch R3549730								
WG2389902-6 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			105.8		%		80-120	16-SEP-16
WG2389902-5 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	16-SEP-16

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PH-PCT-VA	**Water**							
Batch R3555966								
WG2394829-17 CRM		**VA-PH7-BUF**						
pH			7.02		pH		6.9-7.1	23-SEP-16
PO4-DO-COL-VA	**Water**							
Batch R3548483								
WG2388903-10 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			99.8		%		80-120	15-SEP-16
WG2388903-14 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			96.9		%		80-120	15-SEP-16
WG2388903-18 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			94.1		%		80-120	15-SEP-16
WG2388903-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			96.5		%		80-120	15-SEP-16
WG2388903-22 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			93.8		%		80-120	15-SEP-16
WG2388903-26 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			88.1		%		80-120	15-SEP-16
WG2388903-30 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			99.7		%		80-120	15-SEP-16
WG2388903-34 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			99.4		%		80-120	15-SEP-16
WG2388903-6 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			94.7		%		80-120	15-SEP-16
WG2388903-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-13 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-17 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-21 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-25 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-29 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-33 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
WG2388903-5 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PO4-DO-COL-VA	**Water**							
Batch R3548483								
WG2388903-9 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	15-SEP-16
TDS-VA	**Water**							
Batch R3553153								
WG2392005-2 LCS								
Total Dissolved Solids			101.6		%		85-115	19-SEP-16
WG2392005-1 MB								
Total Dissolved Solids			<10		mg/L		10	19-SEP-16
TSS-LOW-VA	**Water**							
Batch R3552725								
WG2392080-2 LCS								
Total Suspended Solids			100.1		%		85-115	19-SEP-16
WG2392080-1 MB								
Total Suspended Solids			<1.0		mg/L		1	19-SEP-16
TURBIDITY-VA	**Water**							
Batch R3548995								
WG2389437-2 CRM		**VA-FORM-40**						
Turbidity			102.3		%		85-115	15-SEP-16
WG2389437-5 CRM		**VA-FORM-40**						
Turbidity			102.5		%		85-115	15-SEP-16
WG2389437-1 MB								
Turbidity			<0.10		NTU		0.1	15-SEP-16
WG2389437-4 MB								
Turbidity			<0.10		NTU		0.1	15-SEP-16

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	14-SEP-16 11:30	23-SEP-16 12:45	0.25	217	hours	EHTR-FM
	2	14-SEP-16 11:30	23-SEP-16 12:45	0.25	217	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1828879 were received on 14-SEP-16 19:00.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Short Holding Time
Rush Processing

BR164141
September

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2027

Report To	
Company:	ECOFISH RESEARCH LTD
Contact:	Kevin Ganshorn
Address:	Suite 906 - 595 Howe Street Vancouver, BC Canada, V6C 2T5
Phone:	604-608-6180 Fax:
Invoice To	☑Email ☐Mail
Company:	ECOFISH RESEARCH LTD
Contact:	Accounts Payable
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Email:	accountspayable@ecofishresearch.com
Phone:	250-334-3042
Lab Work Order # (lab use only)	

Reporting	
Distribution:	☐Fax ☐Mail ☑Email
☐Criteria on Report (select from Guidelines below)	
Report Type:	☑Excel ☑Digital
Report Format:	CROSSTAB_ALSQC
Report Email(s):	kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com
EDD Format:	ECF100
EDD Email(s):	kganshorn@ecofishresearch.com bbennett@ecofishresearch.com tkasubuchi@ecofishresearch.com
Project Info	
Job #:	1230 JHT-MON8
PO/AFE:	1230-16.03.02
LSD:	
Quote #:	
ALS Contact: Ariel Tang, B.Sc.	Sampler: Leah Hull

Service Requested
- ⦿ Regular (Standard Turnaround Times - Business Days) - R
- ○ Priority (3 Days) - surcharge will apply - P
- ○ Priority (2 Days) - surcharge will apply - P2
- ○ Emergency (1-2 day) – surcharge will apply - E
- ○ Same Day or Weekend Emergency - surcharge will apply - E2
- ○ Specify date required - X

Analysis Requests — Please indicate below Filtered, Preserved or both(F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Nitrate in Water by IC (Low Level)	Nitrite in Water by IC (Low Level)	Total Dissolved Solids by Gravimetric	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)
	QUN-WQA			14-Sept-2016	11:30	Water	3	R	R	R	R	R	R	R	R	R	R	R
	QUN-WQB			"	"	Water	3	R	R	R	R	R	R	R	R	R	R	R

L1828879-COFC

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐Yes ☒No

If yes, please use an authorized drinking water COC

Is the water sampled intended to be potable for human consumption? ☐Yes ☒No

Guidelines

SAMPLE CONDITION (lab use only)

☐Frozen ☐Cold ☐Ambient ☐Cooling Initiated

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Leah Hull	Date: 14-Sept 2016	Time: 16:00	Received by: Indy	Date: Sept. 14	Time: 7pm	Temperature: 4 °C	Verified by:	Date:	Time:	Observations: ☐Yes If Yes add SIF

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 12-OCT-16
Report Date: 20-OCT-16 17:27 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1842343

Project P.O. #: 1230-16.03.02
Job Reference: 1230 JHT-MON8
C of C Numbers: OL-2029
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1842343-1	L1842343-2			
	Description	Water	Water			
	Sampled Date	12-OCT-16	12-OCT-16			
	Sampled Time	11:40	11:40			
	Client ID	QUN-WQA	QUN-WQB			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	114	123			
	pH (pH)	7.71	7.69			
	Total Suspended Solids (mg/L)	<1.0	<1.0			
	Total Dissolved Solids (mg/L)	81	84			
	Turbidity (NTU)	0.72	0.72			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	30.8	30.4			
	Ammonia, Total (as N) (mg/L)	0.0092	0.0098			
	Nitrate (as N) (mg/L)	0.0390	0.0386			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010			
	Phosphorus (P)-Total (mg/L)	0.0054	0.0055			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

OL-2029

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L1842343 Report Date: 20-OCT-16

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5
Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3571410								
WG2410640-2 LCS								
Alkalinity, Total (as CaCO3)			104.0		%		85-115	14-OCT-16
WG2410640-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	14-OCT-16
WG2410640-4 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	14-OCT-16
WG2410640-6 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	14-OCT-16
WG2410640-8 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	14-OCT-16
EC-PCT-VA	**Water**							
Batch R3571865								
WG2409936-14 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			104.7		%		90-110	14-OCT-16
WG2409936-11 MB								
Conductivity			<2.0		uS/cm		2	14-OCT-16
Batch R3573414								
WG2411579-4 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			101.1		%		90-110	17-OCT-16
WG2411579-1 MB								
Conductivity			<2.0		uS/cm		2	17-OCT-16
NH3-F-VA	**Water**							
Batch R3574453								
WG2412555-11 DUP		**L1842343-1**						
Ammonia, Total (as N)		0.0092	0.0086		mg/L	6.3	20	18-OCT-16
WG2412555-10 LCS								
Ammonia, Total (as N)			100.7		%		85-115	18-OCT-16
WG2412555-9 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	18-OCT-16
WG2412555-12 MS		**L1842343-1**						
Ammonia, Total (as N)			96.6		%		75-125	18-OCT-16
NO2-L-IC-N-VA	**Water**							
Batch R3570315								
WG2409470-18 LCS								
Nitrite (as N)			97.3		%		90-110	13-OCT-16
WG2409470-2 LCS								
Nitrite (as N)			101.1		%		90-110	13-OCT-16
WG2409470-1 MB								

Quality Control Report

Test		Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-L-IC-N-VA		**Water**							
Batch	**R3570315**								
WG2409470-1	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	13-OCT-16
WG2409470-10	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	13-OCT-16
WG2409470-13	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	13-OCT-16
WG2409470-16	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	13-OCT-16
WG2409470-4	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	13-OCT-16
WG2409470-7	**MB**								
Nitrite (as N)				<0.0010		mg/L		0.001	13-OCT-16
NO3-L-IC-N-VA		**Water**							
Batch	**R3570315**								
WG2409470-18	**LCS**								
Nitrate (as N)				103.4		%		90-110	13-OCT-16
WG2409470-2	**LCS**								
Nitrate (as N)				103.2		%		90-110	13-OCT-16
WG2409470-1	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	13-OCT-16
WG2409470-10	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	13-OCT-16
WG2409470-13	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	13-OCT-16
WG2409470-16	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	13-OCT-16
WG2409470-4	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	13-OCT-16
WG2409470-7	**MB**								
Nitrate (as N)				<0.0050		mg/L		0.005	13-OCT-16
P-T-PRES-COL-VA		**Water**							
Batch	**R3570220**								
WG2409393-2	**CRM**		**VA-ERA-PO4**						
Phosphorus (P)-Total				104.3		%		80-120	13-OCT-16
WG2409393-1	**MB**								
Phosphorus (P)-Total				<0.0020		mg/L		0.002	13-OCT-16
PH-PCT-VA		**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PH-PCT-VA	**Water**							
Batch R3571865								
WG2409936-12 CRM		**VA-PH7-BUF**						
pH			7.03		pH		6.9-7.1	14-OCT-16
PO4-DO-COL-VA	**Water**							
Batch R3569661								
WG2409310-10 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			94.3		%		80-120	13-OCT-16
WG2409310-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			99.3		%		80-120	13-OCT-16
WG2409310-6 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			98.9		%		80-120	13-OCT-16
WG2409310-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	13-OCT-16
WG2409310-5 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	13-OCT-16
WG2409310-9 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	13-OCT-16
TDS-VA	**Water**							
Batch R3572611								
WG2411424-3 DUP		**L1842343-2**						
Total Dissolved Solids		84	79		mg/L	7.0	20	15-OCT-16
WG2411424-2 LCS								
Total Dissolved Solids			100.2		%		85-115	15-OCT-16
WG2411424-1 MB								
Total Dissolved Solids			<10		mg/L		10	15-OCT-16
TSS-LOW-VA	**Water**							
Batch R3571851								
WG2410698-4 LCS								
Total Suspended Solids			89.8		%		85-115	14-OCT-16
WG2410698-3 MB								
Total Suspended Solids			<1.0		mg/L		1	14-OCT-16
TURBIDITY-VA	**Water**							
Batch R3570045								
WG2409531-2 CRM		**VA-FORM-40**						
Turbidity			103.8		%		85-115	13-OCT-16
WG2409531-5 CRM		**VA-FORM-40**						
Turbidity			104.0		%		85-115	13-OCT-16
WG2409531-1 MB								

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
TURBIDITY-VA	**Water**							
Batch R3570045								
WG2409531-1 MB								
Turbidity			<0.10		NTU		0.1	13-OCT-16
WG2409531-4 MB								
Turbidity			<0.10		NTU		0.1	13-OCT-16

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	12-OCT-16 11:40	14-OCT-16 13:54	0.25	50	hours	EHTR-FM
	2	12-OCT-16 11:40	14-OCT-16 13:54	0.25	50	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1842343 were received on 12-OCT-16 18:10.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

L1842343-COFC

BR164143
October

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2029

Report To

Company: ECOFISH RESEARCH LTD
Contact: Kevin Ganshorn
Address: Suite F, 450 - 8th Street
Courtenay, BC
Canada, V9N 1N5
Phone: 250-334-3042 Fax: 250-334-3097

Invoice To ☑Email ☐Mail
Company: ECOFISH RESEARCH LTD
Contact: Accounts Payable
Address: Suite F, 450 - 8th Street
Courtenay, BC
Canada, V9N 1N5
Email: accountspayable@ecofishresearch.com
Phone: 250-334-3042

Lab Work Order # (lab use only)

Reporting

Distribution: ☐Fax ☐Mail ☑Email
☐Criteria on Report (select from Guidelines below)
Report Type: ☑Excel ☑Digital
Report Format: CROSSTAB_ALSQC
Report Email(s): kganshorn@ecofishresearch.com
tkasubuchi@ecofishresearch.com
EDD Format: ECF100
EDD Email(s): kganshorn@ecofishresearch.com
bbennett@ecofishresearch.com
tkasubuchi@ecofishresearch.com

Project Info

Job #: 1230 JHT-MON8
PO/AFE: 1230-16.03.02
LSD:
Quote #:
ALS Contact: Ariel Tang, B.Sc. Sampler: Leah Hull

Service Requested

- ◉ Regular (Standard Turnaround Times - Business Days) - R
- ○ Priority (3 Days) - surcharge will apply - P
- ○ Priority (2 Days) - surcharge will apply - P2
- ○ Emergency (1-2 day) – surcharge will apply - E
- ○ Same Day or Weekend Emergency - surcharge will apply - E2
- ○ Specify date required - X

Analysis Requests — Please indicate below Filtered, Preserved or both(F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Nitrate in Water by IC (Low Level)	Nitrite in Water by IC (Low Level)	Total Dissolved Solids by Gravimetric	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)			
	QUN-WQA			12-Oct-2016	11:40	Water	3	R	R	R	R	R	R	R	R	R	R	R			
	QUN-WQB			12-Oct-2016	11:40	Water	3	R	R	R	R	R	R	R	R	R	R	R			

Short Holding Time
Rush Processing

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐Yes ☒No
If yes, please use an authorized drinking water COC
Is the water sampled intended to be potable for human consumption? ☐Yes ☒No

Guidelines

SAMPLE CONDITION (lab use only)
☐Frozen ☐Cold ☐Ambient ☐Cooling Initiated

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Leah Hull	Date: 12-Oct 2016	Time: 16:00	Received by: SF	Date: Oct 12	Time: 6:10 pm	Temperature: 8° °C	Verified by:	Date:	Time:	Observations: ☐Yes If Yes add SIF

Appendix C. Water Quality Guidelines, Typical Parameter Values, Previous Results, and Quality Control Results Summary.

LIST OF TABLES

Table 1. Water quality guidelines for the protection of aquatic life in British Columbia for parameters with less complex guidelines.

Parameter	Unit	BC Guideline for the Protection of Aquatic Life[1]	Guideline Reference
Specific Conductivity	µS/cm	No provincial or federal guidelines	n/a
pH	pH units	When baseline values are between 6.5 and 9 there is no restriction on changes within this range (lethal effects observed below 4.5 and above 9.5)	McKean and Nagpal (1991)
Alkalinity	mg/L	No provincial or federal guidelines. However, waterbodies with <10 mg/L are highly sensitive to acidic inputs, 10 to 20 mg/L are moderatly sensitive to acidic inputs, > 20 mg/L have a low sensitivity to acidic inputs	n/a
Total Ammonia (N)	µg/L	Dependent on pH and temperature, too numerous to present, lowest maximum allowable concentration of 680 µg/L occurs at a pH of 9 and water temperature of 8ºC, lowest maximum average 30 day concentration of 102 µg/L occurs at a pH of 9 and water temperature of 20ºC	Nordin and Pommen (1986)
Nitrite (N)	µg/L	The lowest maximum allowable concentration occurs when chloride is ≤ 2 mg/L; instantaneous maximum allowable concentration is 60 µg/L and a maximum 30 day average of 20 µg/L is allowed when chloride is ≤ 2 mg/L	Nordin and Pommen (1986)
Nitrate (N)	µg/L	The 30 day average concentration to protect freshwater aquatic life is 3,000 µg/L[2] and the maximum concentration is 32,800 µg/L.	Meays (2009)
Orthophosphate	µg/L	No provincial or federal guidelines	n/a
Total Phosphate (P)	µg/L	Trigger ranges that would signify a change in the trophic classification: <4: ultra-oligotrophic, 4-10 oligotrophic, 10 -20 mesotrophic, 20-35 meso-eutrophic, 35-100 eutrophic, > 100 hyper-eutrophic	CCME (2004)

[1] Guideline for total phosphate is a federal guideline; provincial guidelines do not exist

[2] The 30-d average (chronic) concentration is based on 5 weekly samples collected within a 30-day period.

Table 2. Total suspended solids and turbidity guidelines for the protection of aquatic life in British Columbia.

Period	British Columbia[1] Suspended Sediment and Turbidity Guidelines for the Protection of Aquatic Life	
	Total Suspended Sediments (mg/L)	Turbidity (NTU)
Clear Flow Period (less than 25 mg/L or less than 8 NTU)	"Induced suspended sediment concentrations should not exceed background levels by more than 25 mg/L during any 24-hour period (hourly sampling preferred). For sediment inputs that last between 24 hours and 30 days (daily sampling preferred), the average suspended sediment concentration should not exceed background by more than 5 mg/L."	"Induced turbidity should not exceed background levels by more than 8 NTU during any 24-hour period (hourly sampling preferred). For sediment inputs that last between 24 hours and 30 days (daily sampling preferred) the mean turbidity should not exceed background by more than 2 NTU."
Turbid Flow Period (greater than or equal to 25 mg/L or greater than or equal to 8 NTU)	"Induced suspended sediment concentrations should not exceed background levels by more than 10 mg/L at any time when background levels are between 25 and 100 mg/L. When background exceeds 100 mg/L, suspended sediments should not be increased by more than 10% of the measured background level at any one time."	"Induced turbidity should not exceed background levels by more than 5 NTU at any time when background turbidity is between 8 and 50 NTU. When background exceeds 50 NTU, turbidity should not be increased by more than 10% of the measured background level at any one time."

[1] reproduced from Singleton (2001)

Table 3. Dissolved oxygen guidelines for the protection of aquatic life in British Columbia.

	BC Guidelines for the Protection of Aquatic Life[1]		
	Life Stages Other Than Buried Embryo/Alevin	Buried Embryo/Alevin[2]	Buried Embryo/Alevin[2]
Dissolved Oxygen Concentration	Water column mg/L O_2	Water column mg/L O_2	Interstitial Water mg/L O_2
Instantaneous minimum[3]	5	9	6
30-day mean[4]	8	11	8

[1] MOE (1997a) and MOE (1997b)

[2] For the buried embryo / alevin life stages these are in-stream concentrations from spawning to the point of yolk sac absorption or 30 days post-hatch for fish; the water column concentrations recommended to achieve interstitial dissolved oxygen values when the latter are unavailable. Interstitial oxygen measurements would supersede water column measurements in comparing to criteria.

[3] The instantaneous minimum level is to be maintained at all times.

[4] The mean is based on at least five approximately evenly spaced samples. If a diurnal cycle exists in the water body, measurements should be taken when oxygen levels are lowest (usually early morning).

Table 4. Total gas pressure guidelines for the protection of aquatic life in British Columbia.

Water Depth	Maximum Allowable ΔP (Total Gas Pressure - Barometric Pressure) for the Protection of Aquatic Life in BC[1]
> 1 m	76 mm Hg regardless of pO_2 levels
< 1 m	$\Delta P_{\text{initiation of swim bladder overinflation}}$ = 73.89 * water depth (m) + 0.15 * pO_2 where pO_2 = 157 mm Hg (i.e., sea level normoxic condition) In its most conservative form (assuming water column depth = 0 m), the BC guideline for waters less than 1 m deep is that the maximum allowable ΔP should not exceed 24 mm Hg

[1] Fidler and Miller (1994)

Table 5. Typical values for water quality parameters in British Columbia waters.

Parameter	Unit	Typical range in British Columbia streams and rivers	Reference
Specific Conductivity	µS/cm	The typical value in coastal BC streams is 100 µS/cm	RISC (1998)
pH	pH units	Natural fresh waters have a pH range from 4 to 10, lakes tend to have a pH ≥ 7.0 and coastal streams commonly have pH values of 5.5 to 6.5	RISC (1998)
Alkalinity	mg/L	Natural waters almost always have concentrations less than 500 mg/L, with waters in coastal BC typically ranging from 0 to 10 mg/L; waters in interior BC can have values greater than 100 mg/L	RISC (1998)
Total Suspended Solids	mg/L	In BC natural concentrations of suspended solids vary extensively from waterbody to waterbody and can have large variation within a day and among seasons	Singleton (1985) in Caux *et al.* (1997)
Turbidity	NTU	In BC natural concentrations of suspended solids vary extensively from waterbody to waterbody and can have large variation within a day and among seasons	Singleton (1985) in Caux *et al.* (1997)
Dissolved Oxygen	mg/L	In BC surface waters are generally well aerated and have DO concentrations > 10 mg/L	MOE (1997a)
Dissolved Oxygen	% saturation	In BC surface waters are generally well aerated and have DO concentrations close to equilibrium with the atmosphere (i.e., close to 100% saturation)	MOE (1997a)
ΔP (Total Gas Pressure - Barometric Pressure)	mm Hg	In BC, dissolved gas supersaturation is a natural feature of many waters with ΔP commonly being between 50 – 80 mm Hg. (We often see values between -10 and 60)	Fidler and Miller (1994)
Total Ammonia (N)	µg/L	<100 µg/L for waters not affected by waste discharges	Nordin and Pommen (1986)
Nitrite (N)	µg/L	Due to its unstable nature, nitrite concentrations are very low, typically present in surface waters at concentrations of <1 µg/L	RISC (1998)
Nitrate (N)	µg/L	In oligotrophic lakes and streams, nitrate concentrations are expected to be <100 µg/L; in most streams and lakes not impacted by anthropogenic activities, nitrate is typically <900 µg/L.	Nordin and Pommen (1986); CCME (2012)
Orthophosphate (P)	µg/L	Coastal BC streams typically have concentrations <1 µg/L	Slaney and Ward (1993); Ashley and Slaney (1997)
Total Phosphorus (P)	µg/L	Oligotrophic water bodies have total phosphorus concentrations that are between 4 to 10 µg/L while concentrations are typically between 10 to 20 µg/L in mesotrophic water bodies.	CCME (2004)

1. 2014 AND 2015 WATER QUALITY IN THE QUINSAM RIVER AND SALMON RIVER

Table 6. Quinsam River (QUN-WQ) general water quality variables measured in situ during Years 1 and 2, 2014 and 2015.

Year	Date	Specific Conductivity µS/cm				pH pH units				Air Temperature °C				Water Temperature °C			
		Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2014	23-May	95.6	95.6	95.6	0.0	7.38	7.38	7.39	0.01	-	-	-	-	12.8	12.8	12.8	0.0
	18-Jun	143.1	143.1	143.1	0.0	7.58	7.57	7.58	0.01	14	14	14	0	17.1	17.1	17.1	0.0
	22-Jul	148.1	148.1	148.1	0.0	7.36	7.36	7.36	0.00	16	16	16	0	17.7	17.7	17.7	0.0
	19-Aug	152.3	152.2	152.4	0.1	7.38	7.36	7.43	0.04	19	19	19	0	20.2	20.2	20.2	0.0
	24-Sep	109.9	109.9	109.9	0.0	7.30	7.23	7.36	0.07	14	14	14	0	16.1	16.1	16.1	0.0
	04-Nov	69.4	69.4	69.4	0.0	7.01	7.01	7.02	0.01	7	7	7	0	9.6	9.6	9.6	0.0
2015	12-May	144.4	144.4	144.5	0.1	7.68	7.68	7.68	0.00	14	14	14	0	14.2	14.2	14.2	0.0
	17-Jun	98.1	14.0	140.2	72.8	7.71	7.71	7.71	0.00	15	15	15	0	18.2	18.2	18.2	0.0
	23-Jul	190.7	190.7	190.7	0.0	7.49	7.49	7.49	0.00	17	17	17	0	17.0	17.0	17.0	0.0
	13-Aug	197.7	197.6	197.7	0.1	7.41	7.40	7.41	0.01	17	17	17	0	18.5	18.5	18.5	0.0
	16-Sep	185.7	185.7	185.7	0.0	7.50	7.50	7.50	0.00	12	12	12	0	14.1	14.1	14.1	0.0
	14-Oct	131.9	131.8	131.9	0.1	7.52	7.50	7.54	0.02	11	11	11	0	9.5	9.5	9.6	0.1

[1] Average of three replicates (n=3) on each date unless otherwise indicated.

Table 7. Quinsam River (QUN-WQ) dissolved gases measured in situ during Years 1 and 2, 2014 and 2015.

Year	Date	Oxygen Dissolved (In Situ) %				Oxygen Dissolved (In Situ) mg/L				Barometric Pressure mm Hg				TGP %				TGP mm Hg				ΔP mm Hg			
		Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2014	23-May	101.8	101.4	102.6	0.7	10.74	10.69	10.82	0.07	744	743	745	1	100	100	100	0	744	744	745	1	0	0	1	1
	18-Jun	91.3	90.9	91.9	0.5	8.84	8.80	8.87	0.04	748	748	749	1	101	101	101	0	755	753	757	2	7	5	8	2
	22-Jul	95.8	95.8	95.9	0.1	9.13	9.12	9.13	0.01	747	747	748	1	101	101	101	0	753	753	753	0	6	5	6	1
	19-Aug	77.9	77.7	78.3	0.3	7.01	6.99	7.03	0.02	745	744	745	1	99	99	99	0	735	735	735	0	-10	-10	-9	1
	24-Sep	91.7	90.1	92.7	1.4	8.78	8.53	8.91	0.21	753	752	753	1	98	98	98	0	739	739	740	1	-13	-14	-13	1
	04-Nov	88.5	88.4	88.5	0.1	9.95	9.94	9.96	0.01	761	761	762	1	99	99	99	0	755	755	755	0	-6	-7	-6	1
2015	12-May	96.2	96.2	96.3	0.1	9.89	9.88	9.89	0.01	741	741	741	0	-	-	-	-	-	-	-	-	-	-	-	-
	17-Jun	83.7	83.6	83.9	0.2	7.90	7.89	7.91	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	23-Jul	84.2	84.1	84.4	0.2	8.14	8.13	8.14	0.01	744	744	744	0	-	-	-	-	-	-	-	-	-	-	-	-
	13-Aug	84.2	84.1	84.4	0.2	7.89	7.88	7.91	0.02	746	746	746	0	-	-	-	-	-	-	-	-	-	-	-	-
	16-Sep	78.1	77.8	78.5	0.4	8.03	8.00	8.05	0.03	743	743	743	0	-	-	-	-	-	-	-	-	-	-	-	-
	14-Oct	87.0	86.8	87.3	0.3	9.88	9.87	9.89	0.01	754	754	754	0	-	-	-	-	-	-	-	-	-	-	-	-

[1] Average of three replicates (n=3) on each date unless otherwise indicated.

Blue shading indicates that the more conservative provincial guideline (DO instantaneous minimum of 9 mg/L) for the protection of buried embryo/alevin has not been achieved. Note that the guideline for life stages other than buried embryo/alevin is met (DO instantaneous minimum of 5 mg/L).

Table 8. Quinsam River (QUN-WQ) general water quality variables measured at ALS labs during Years 1 and 2, 2014 and 2015.

Year	Date	Site	Alkalinity, Total (as $CaCO_3$) mg/L				Specific Conductivity µS/cm				Total Dissolved Solids mg/L				Total Suspended Solids mg/L				Turbidity NTU				pH pH units			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2014	23-May	QUN-WQ	31.7	31.5	31.8	0.2	94.8	94.1	95.4	0.9	69	68	70	1	<1.0	<1.0	<1.0	0.0	0.59	0.52	0.65	0.09	7.77	7.77	7.77	0.00
		QUN-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.60	-	-	-
		QUN-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.64	-	-	-
	18-Jun	QUN-WQ	41.0	40.8	41.1	0.2	139.5	139.0	140.0	0.7	96	96	96	0	<1.0	<1.0	<1.0	0.0	0.42	0.40	0.44	0.03	7.87	7.87	7.87	0.00
		QUN-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.47	-	-	-
		QUN-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.45	-	-	-
	22-Jul	QUN-WQ	42.4	42.4	42.4	0.0	140.0	139.0	141.0	1.4	103	101	105	3	<1.0	<1.0	<1.0	0.0	0.46	0.44	0.47	0.02	7.73	7.65	7.81	0.11
		QUN-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.69	-	-	-
		QUN-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.76	-	-	-
	19-Aug	QUN-WQ	42.1	41.9	42.3	0.3	156.0	146.0	166.0	14.1	96	95	96	1	<1.0	<1.0	<1.0	0.0	0.70	0.47	0.93	0.33	7.81	7.57	8.05	0.34
		QUN-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.91	-	-	-
		QUN-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	6.17	-	-	-
	24-Sep	QUN-WQ	35.0	35.0	35.0	0.0	109.0	109.0	109.0	0.0	71	67	74	5	<1.0	<1.0	<1.0	0.0	0.56	0.50	0.62	0.08	7.55	7.52	7.58	0.04
		QUN-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.45	-	-	-
		QUN-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.41	-	-	-
	04-Nov	QUN-WQ	23.7	23.5	23.8	0.2	71.3	70.7	71.8	0.8	59	53	64	8	<1.0	<1.0	<1.0	0.0	0.74	0.71	0.77	0.04	7.61	7.59	7.63	0.03
		QUN-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.70	-	-	-
		QUN-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.75	-	-	-
2015	12-May	QUN-WQ	40.8	40.6	41.0	0.3	143.0	143.0	143.0	0.0	91	89	93	3	<1.0	<1.0	<1.0	0.0	0.38	0.37	0.39	0.01	7.79	7.78	7.80	0.01
		QUN-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.84	-	-	-
		QUN-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.80	-	-	-
	17-Jun	QUN-WQ	43.9	43.8	43.9	0.1	157.0	157.0	157.0	0.0	97	94	100	4	<1.0	<1.0	<1.0	0.0	0.41	0.40	0.42	0.01	7.91	7.90	7.92	0.01
		QUN-field blank	<2.0	-	-	-	3.2	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	6.22	-	-	-
		QUN-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.91	-	-	-
	23-Jul	QUN-WQ	52.9	51.7	54.0	1.6	206.0	206.0	206.0	0.0	120	120	120	0	<1.0	<1.0	<1.0	0.0	0.49	0.49	0.49	0.00	8.00	7.99	8.01	0.01
	13-Aug	QUN-WQ	48.8	48.0	49.6	1.1	175.0	173.0	177.0	2.8	124	120	127	5	<1.0	<1.0	<1.0	0.0	0.36	0.30	0.42	0.08	7.78	7.70	7.85	0.11
	16-Sep	QUN-WQ	46.2	46.0	46.3	0.2	178.0	177.0	179.0	1.4	145	116	173	40	<1.0	<1.0	<1.0	0.0	0.40	0.38	0.42	0.03	7.94	7.94	7.94	0.00
	14-Oct	QUN-WQ	34.0	33.9	34.1	0.1	130.0	129.0	131.0	1.4	94	92	96	3	<1.3	<1.0	1.6	0.4	0.47	0.40	0.53	0.09	7.55	7.52	7.58	0.04

[1] Average of two replicates (n=2) on each date unless otherwise indicated. For field and travel blanks n=1.

Parameters that have a concentration below the detection limit are assumed to have a concentration equal to the detection limit for calculation purposes.

Table 9. Quinsam River (QUN-WQ) low level nutrients measured at ALS labs during Years 1 and 2, 2014 and 2015.

Year	Date	Site	Ammonia, Total (as N) µg/L				Dissolved Orthophosphate (as P) µg/L				Nitrate (as N) µg/L				Nitrite (as N) µg/L				Total Phosphorus (P) µg/L			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2014	23-May	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	13.8	13.5	14.0	0.4	<1.0	<1.0	<1.0	0.0	3.9	3.8	3.9	0.1
		QUN-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		QUN-travel blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	18-Jun	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	29.7	29.2	30.1	0.6	<1.0	<1.0	<1.0	0.0	2.8	2.7	2.9	0.1
		QUN-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		QUN-travel blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	22-Jul	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	31.6	31.3	31.9	0.4	<1.0	<1.0	<1.0	0.0	2.9	2.6	3.2	0.4
		QUN-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		QUN-travel blank	27.1	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	19-Aug	QUN-WQ	<5.2	<5.0	5.3	0.2	<1.0	<1.0	<1.0	0.0	17.1	17.0	17.1	0.1	<1.0	<1.0	<1.0	0.0	4.8	4.6	5.0	0.3
		QUN-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		QUN-travel blank	38.7	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	24-Sep	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	21.2	20.7	21.6	0.6	<1.0	<1.0	<1.0	0.0	4.3	3.9	4.6	0.5
		QUN-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		QUN-travel blank	55.1	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	04-Nov	QUN-WQ	5.1	5.1	5.1	0.0	<1.0	<1.0	<1.0	0.0	24.6	24.0	25.1	0.8	<1.0	<1.0	<1.0	0.0	3.7	2.9	4.4	1.1
		QUN-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		QUN-travel blank	99.5	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
2015	12-May	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	23.0	22.9	23.1	0.1	<1.0	<1.0	<1.0	0.0	2.9	2.5	3.3	0.6
		QUN-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		QUN-travel blank	11.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	17-Jun	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	23.8	23.6	23.9	0.2	<1.0	<1.0	<1.0	0.0	<2.0	<2.0	<2.0	0.0
		QUN-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		QUN-travel blank	58.5	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	23-Jul	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	29.9	29.3	30.5	0.8	<1.0	<1.0	<1.0	0.0	<2.1	<2.0	2.1	0.1
	13-Aug	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	41.0	40.6	41.3	0.5	<1.0	<1.0	<1.0	0.0	<2.0	<2.0	<2.0	0.0
	16-Sep	QUN-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	14.0	13.9	14.1	0.1	<1.0	<1.0	<1.0	0.0	<2.2	<2.0	2.3	0.2
	14-Oct	QUN-WQ	9.0	8.8	9.2	0.3	<1.0	<1.0	<1.0	0.0	36.0	35.6	36.3	0.5	<1.0	<1.0	<1.0	0.0	4.6	4.4	4.8	0.3

[1] Average of two replicates (n=2) on each date unless otherwise indicated. For field and travel blanks n=1.

Parameters that have a concentration below the detection limit are assumed to have a concentration equal to the detection limit for calculation purposes.

Table 10. Salmon River (SAM-WQ) general water quality variables measured in situ during Years 1 and 2, 2014 and 2015.

Year	Date	Specific Conductivity µS/cm				pH pH units				Air Temperature °C				Water Temperature °C			
		Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2014	21-May	28.2	28.2	28.2	0.0	6.91	6.91	6.91	0.00	-	-	-	-	9.1	9.1	9.1	0.0
	17-Jun	37.1	37.1	37.1	0.0	7.21	7.17	7.23	0.03	12	12	12	0	12.2	12.1	12.2	0.1
	23-Jul	46.7	46.7	46.7	0.0	7.03	7.03	7.03	0.00	14	14	14	0	15.5	15.5	15.5	0.0
	18-Aug	54.1	54.1	54.1	0.0	7.14	7.12	7.16	0.02	16	16	16	0	17.2	17.2	17.2	0.0
	23-Sep	54.7	54.7	54.8	0.1	7.22	7.21	7.23	0.01	17	17	17	0	14.6	14.6	14.6	0.0
	03-Nov	35.5	35.5	35.6	0.1	6.85	6.83	6.87	0.02	8	-	-	-	8.2	8.2	8.2	0.0
2015	13-May	41.5	41.5	41.5	0.0	7.36	7.34	7.39	0.03	11	11	11	0	10.8	10.8	10.8	0.0
	16-Jun	41.1	41.1	41.2	0.1	7.87	7.86	7.88	0.01	17	17	17	0	14.5	14.5	14.6	0.1
	22-Jul	52.6	52.6	52.6	0.0	7.60	7.58	7.62	0.02	16	16	16	0	16.5	16.5	16.5	0.0
	12-Aug	47.8	47.7	47.8	0.1	7.32	7.32	7.32	0.00	15	15	15	0	16.3	16.3	16.3	0.0
	17-Sep	47.4	47.4	47.4	0.0	7.09	7.08	7.09	0.01	11	11	11	0	11.2	11.2	11.2	0.0
	15-Oct	41.5	41.5	41.6	0.1	7.38	7.37	7.40	0.02	9	9	9	0	9.0	9.0	9.0	0.0

[1] Average of three replicates (n=3) on each date unless otherwise indicated.

Table 11. Salmon River (SAM-WQ) dissolved gases measured in situ during Years 1 and 2, 2014 and 2015.

Year	Quarter	Dissolved Oxygen %				Dissolved Oxygen mg/L				Barometric Pressure mm Hg				TGP %				TGP mm Hg				ΔP mm Hg			
		Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2014	21-May	102.6	102.6	102.6	0.0	11.68	11.67	11.68	0.01	748	748	748	0	102	102	102	0	761	761	761	0	13	13	13	0
	17-Jun	99.3	99.1	99.7	0.3	10.73	10.68	10.76	0.04	749	749	749	0	101	101	102	1	758	755	761	3	9	6	12	3
	23-Jul	101.8	101.8	101.9	0.1	10.20	10.20	10.20	0.00	747	747	747	0	101	101	101	0	755	755	755	0	8	8	8	0
	18-Aug	98.9	98.0	100.6	1.4	9.56	9.43	9.73	0.15	750	750	750	0	101	101	102	1	761	757	764	4	11	7	14	4
	23-Sep	88.2	87.1	88.8	0.9	8.80	8.71	8.86	0.08	760	760	760	0	98	98	99	1	749	748	751	2	-11	-12	-9	2
	03-Nov	95.7	95.1	96.5	0.7	11.08	11.02	11.18	0.09	763	762	763	1	100	100	100	0	763	761	764	2	0	-2	1	2
2015	13-May	93.7	93.7	93.8	0.1	10.38	10.37	10.39	0.01	742	742	742	0	-	-	-	-	-	-	-	-	-	-	-	-
	16-Jun	81.5	81.3	81.8	0.3	8.31	8.27	8.34	0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	22-Jul	96.1	96.1	96.2	0.1	9.40	9.38	9.42	0.02	744	744	744	0	-	-	-	-	-	-	-	-	-	-	-	-
	12-Aug	92.0	91.9	92.1	0.1	9.02	8.98	9.06	0.04	747	747	747	0	-	-	-	-	-	-	-	-	-	-	-	-
	17-Sep	82.8	82.4	83.3	0.5	9.08	9.04	9.14	0.05	746	746	746	0	-	-	-	-	-	-	-	-	-	-	-	-
	15-Oct	99.1	98.9	99.3	0.2	11.46	11.44	11.48	0.02	750	750	750	0	-	-	-	-	-	-	-	-	-	-	-	-

[1] Average of three replicates (n=3) on each date unless otherwise indicated. A single data listed under Avg. indicates n=1.

Blue shading indicates that the more conservative provincial guideline (DO instantaneous minimum of 9 mg/L) for the protection of buried embryo/alevin has not been achieved. Note that the guideline for life stages other than buried embryo/alevin is met (DO instantaneous minimum of 5 mg/L).

Table 12. Salmon River (SAM-WQ) general water quality variables measured at ALS labs during Years 1 and 2, 2014 and 2015.

Year	Date	Date	Alkalinity, Total (as CaCO3) mg/L				Specific Conductivity µS/cm				Total Dissolved Solids mg/L				Total Suspended Solids mg/L				Turbidity NTU				pH pH units			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2014	21-May	SAM-WQ	12.3	12.2	12.3	0.1	27.2	27.0	27.3	0.2	32	31	32	1	<1.0	<1.0	<1.0	0.0	0.30	0.22	0.38	0.11	7.38	7.35	7.40	0.04
		SAM-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.60	-	-	-
		SAM-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.54	-	-	-
	17-Jun	SAM-WQ	17.6	17.3	17.8	0.4	40.5	37.5	43.5	4.2	33	31	34	2	<1.0	<1.0	<1.0	0.0	0.22	0.17	0.26	0.06	7.57	7.55	7.59	0.03
		SAM-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.44	-	-	-
		SAM-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.48	-	-	-
	23-Jul	SAM-WQ	21.0	20.7	21.2	0.4	46.5	46.4	46.6	0.1	38	38	38	0	<1.0	<1.0	<1.0	0.0	0.92	0.71	1.12	0.29	7.58	7.53	7.62	0.06
		SAM-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.50	-	-	-
		SAM-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.47	-	-	-
	18-Aug	SAM-WQ	23.8	23.6	23.9	0.2	56.3	55.3	57.3	1.4	49	43	55	8	<4.6	<1.0	8.1	5.0	0.22	0.20	0.23	0.02	7.79	7.76	7.82	0.04
		SAM-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	6.50	-	-	-
		SAM-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	6.05	-	-	-
	23-Sep	SAM-WQ	23.9	23.8	23.9	0.1	53.1	52.8	53.4	0.4	46	41	51	7	<1.0	<1.0	<1.0	0.0	0.26	0.23	0.28	0.04	7.65	7.48	7.82	0.24
		SAM-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.28	-	-	-
		SAM-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	6.03	-	-	-
	03-Nov	SAM-WQ	16.6	16.5	16.6	0.1	37.2	36.7	37.7	0.7	53	37	69	23	<1.0	<1.0	<1.0	0.0	0.33	0.32	0.34	0.01	7.61	7.56	7.65	0.06
		SAM-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.75	-	-	-
		SAM-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.73	-	-	-
2015	13-May	SAM-WQ	15.8	15.3	16.2	0.6	33.5	33.3	33.6	0.2	25	23	27	3	<1.0	<1.0	<1.0	0.0	0.16	0.14	0.17	0.02	7.38	7.33	7.42	0.06
		SAM-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.50	-	-	-
		SAM-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	6.77	-	-	-
	16-Jun	SAM-WQ	21.6	20.8	22.4	1.1	47.8	47.7	47.8	0.1	32	31	33	1	<1.0	<1.0	<1.0	0.0	0.11	0.11	0.11	0.00	7.66	7.65	7.66	0.01
		SAM-field blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	6.32	-	-	-
		SAM-travel blank	<2.0	-	-	-	<2.0	-	-	-	<10	-	-	-	<1.0	-	-	-	<0.10	-	-	-	6.22	-	-	-
	22-Jul	SAM-WQ	23.1	22.6	23.5	0.6	59.9	55.0	64.8	6.9	32	31	32	1	<1.0	<1.0	<1.0	0.0	0.13	0.12	0.13	0.01	7.69	7.68	7.70	0.01
	12-Aug	SAM-WQ	22.6	21.7	23.4	1.2	51.4	51.2	51.6	0.3	47	45	48	2	<1.0	<1.0	<1.0	0.0	0.16	0.14	0.18	0.03	7.85	7.81	7.88	0.05
	17-Sep	SAM-WQ	20.4	20.4	20.4	0.0	47.2	47.1	47.3	0.1	32	32	32	0	<1.0	<1.0	<1.0	0.0	0.18	0.16	0.19	0.02	7.72	7.70	7.74	0.03
	15-Oct	SAM-WQ	18.2	18.1	18.2	0.1	40.7	40.6	40.8	0.1	37	36	37	1	<1.0	<1.0	<1.0	0.0	0.36	0.24	0.48	0.17	7.43	7.43	7.43	0.00

[1] Average of two replicates (n=2) on each date unless otherwise indicated. For field and travel blanks n=1.

Parameters that have a concentration below the detection limit are assumed to have a concentration equal to the detection limit for calculation purposes.

Table 13. Salmon River (SAM-WQ) low level nutrients measured at ALS labs during Years 1 and 2, 2014 and 2015.

Year	Date	Site	Ammonia, Total (as N) µg/L				Dissolved Orthophosphate (as P) µg/L				Nitrate (as N) µg/L				Nitrite (as N) µg/L				Total Phosphorus (P) µg/L			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2014	21-May	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	8.8	8.4	9.1	0.5	<1.0	<1.0	<1.0	0.0	3.2	3.1	3.2	0.1
		SAM-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		SAM-travel blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	17-Jun	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	15.5	15.2	15.7	0.4	<1.0	<1.0	<1.0	0.0	<2.1	<2.0	2.1	0.1
		SAM-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		SAM-travel blank	60.8	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	23-Jul	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	8.5	8.5	8.5	0.0	<1.0	<1.0	<1.0	0.0	2.4	2.2	2.5	0.2
		SAM-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		SAM-travel blank	50.2	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	18-Aug	SAM-WQ	5.8	5.5	6.0	0.4	<1.1	<1.0	1.1	0.1	27.6	27.4	27.7	0.2	<1.0	<1.0	<1.0	0.0	<3.8	<2.0	5.6	2.5
		SAM-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		SAM-travel blank	88.5	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	23-Sep	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	71.6	70.8	72.4	1.1	<1.0	<1.0	<1.0	0.0	<2.3	<2.0	2.5	0.4
		SAM-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		SAM-travel blank	81.6	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	03-Nov	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	26.1	25.6	26.5	0.6	<1.0	<1.0	<1.0	0.0	<2.0	<2.0	<2.0	0.0
		SAM-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		SAM-travel blank	87.7	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
2015	13-May	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	12.2	12.1	12.3	0.1	<1.0	<1.0	<1.0	0.0	<2.0	<2.0	<2.0	0.0
		SAM-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		SAM-travel blank	18.8	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	16-Jun	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	52.8	52.8	52.8	0.0	<1.0	<1.0	<1.0	0.0	<2.0	<2.0	<2.0	0.0
		SAM-field blank	<5.0	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
		SAM-travel blank	43.6	-	-	-	<1.0	-	-	-	<5.0	-	-	-	<1.0	-	-	-	<2.0	-	-	-
	22-Jul	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	25.0	24.6	25.4	0.6	<1.0	<1.0	<1.0	0.0	<2.0	<2.0	<2.0	0.0
	12-Aug	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	96.6	95.9	97.3	1.0	<1.0	<1.0	<1.0	0.0	<2.0	<2.0	<2.0	0.0
	17-Sep	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	40.0	39.9	40.0	0.1	<1.0	<1.0	<1.0	0.0	<2.0	<2.0	<2.0	0.0
	15-Oct	SAM-WQ	<5.0	<5.0	<5.0	0.0	<1.0	<1.0	<1.0	0.0	20.1	20.0	20.1	0.1	<1.0	<1.0	<1.0	0.0	<2.0	<2.0	<2.0	0.0

[1] Average of two replicates (n=2) on each date unless otherwise indicated. For field and travel blanks n=1.

Parameters that have a concentration below the detection limit are assumed to have a concentration equal to the detection limit for calculation purposes.

2. QUALITY CONTROL/QUALITY ASSURANCE

Table 14. Hold time exceedances for water samples analyzed by ALS Environmental.

Description	Site	Sampling Date	Recommended Hold Time (days)	Actual Hold Time (days)
Physical Tests				
Total Suspended Solids	SAM-WQ	17-May-16	7	8
Anions and Nutrients				
Nitrite in Water by Ion Chromatography	QUN-WQ	19-Aug-14	3	8
Total Dissolved P in Water by Colour	SAM-WQ	17-Jun-14	3	6

All samples for all sites and sample dates exceeded the recommended hold time for pH of 0.25 hours; however, laboratory measurements of pH are still considered more accurate than field measurements.

Table 15. Results of Field Blank and Trip Blanks for water samples analysed by ALS Environmental.

Year	Quarter	Site	Alkalinity, Total (as CaCO3) mg/L				Ammonia, Total (as N) mg/L				Conductivity (lab) µS/cm				Dissolved Orthophosphate (as P) mg/L				Nitrate (as N) mg/L				Nitrite (as N) mg/L			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2016	17-May	SAM-FIELD BLAN	<2.0	-	-	-	<0.0050	-	-	-	<2.0	-	-	-	<0.0010	-	-	-	<0.0050	-	-	-	<0.0010	-	-	-
		SAM-TRIP BLAN	<2.0	-	-	-	0.0121	-	-	-	<2.0	-	-	-	<0.0010	-	-	-	<0.0050	-	-	-	<0.0010	-	-	-
	18-May	QUN-FIELD BLANK	<2.0	-	-	-	<0.0050	-	-	-	<2.0	-	-	-	<0.0010	-	-	-	<0.0050	-	-	-	<0.0010	-	-	-
		QUN-TRIP BLANK	<2.0	-	-	-	0.0059	-	-	-	<2.0	-	-	-	<0.0010	-	-	-	<0.0050	-	-	-	<0.0010	-	-	-

[1] Average of three replicates (n=3) on each date unless otherwise indicated. A single data listed under Avg. indicates n=1.

Parameters that have a concentration below the detection limit are assumed to have a concentration equal to the detection limit for calculation purposes.

Table 15. Continued.

Year	Quarter	Site	Total Dissolved Solids mg/L				Total Phosphorus (P) mg/L				Total Suspended Solids mg/L				Turbidity (lab) NTU				pH (lab) pH units			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2016	17-May	SAM-FIELD BLAN	<10	-	-	-	<0.0020	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.70	-	-	-
		SAM-TRIP BLAN	<10	-	-	-	<0.0020	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.74	-	-	-
	18-May	QUN-FIELD BLANK	<10	-	-	-	<0.0020	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.62	-	-	-
		QUN-TRIP BLANK	<10	-	-	-	<0.0020	-	-	-	<1.0	-	-	-	<0.10	-	-	-	5.58	-	-	-

[1] Average of three replicates (n=3) on each date unless otherwise indicated. A single data listed under Avg. indicates n=1.

Parameters that have a concentration below the detection limit are assumed to have a concentration equal to the detection limit for calculation purposes.

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