Columbia River Project Water Use Plan

Middle Columbia River Juvenile Habitat Use Assessment (Year 5 of 6)

Reference: CLBMON#17

Columbia River Water Use Plan Monitoring Program: Middle Columbia River Juvenile Fish Habitat Use

Study Period: 2012-2013

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Middle Columbia River
Juvenile Fish Habitat Use

Final

CLBMON-17

Year 5 (2012) of 6

April 2013

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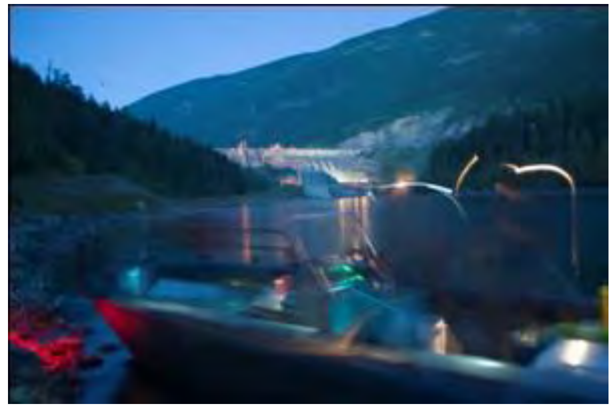

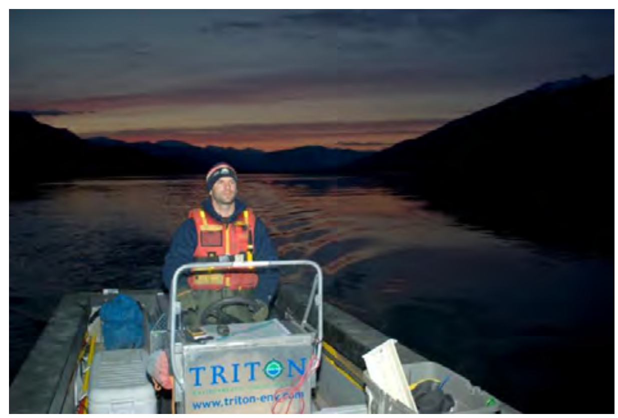

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Executive Summary

The Middle Columbia River, located downstream of the Revelstoke Dam, forms the upstream end of the Arrow Lakes Reservoir. The Middle Columbia River is affected by flows from the Revelstoke Dam at its upstream end, and by fluctuating reservoir elevations at the downstream end from water impounded behind the Hugh Keenleyside Dam at the city of Castlegar. The impacts of the operation of the Revelstoke Dam and Arrow Lakes Reservoir on fish and fish habitat in the Middle Columbia River were recognized in the Columbia River Water Use Plan. Implementation of a minimum flow release of 142 m^3/s from the Revelstoke Dam was proposed with the objective of improving habitat conditions for fish, in general, within the Middle Columbia. The Middle Columbia River Juvenile Fish Habitat Use project (CLBMON-17) was initiated in order to determine if this objective was met for juvenile life stages.

Year 1 of the program (2008) included an initial habitat assessment and the development of a stratified random sampling plan that resulted in the identification of 60 sites including 55 representative river sites located throughout the study area, as well as in five tributary sites. All river sites were sampled at night using a boat electrofisher with an anode pole, while tributary sites were typically sampled using a backpack electrofisher. Data on water depth, velocities, substrates, slope, temperature, pH, and discharge were collected at each site. Fish sampling focused on juveniles within the study area and the total number of all species captured, as well as lengths and weights of up to 30 randomly selected individuals from each species, were recorded. Three sampling Trips have been completed annually since 2008: Trip 1 in the spring (May/June), Trip 2 in the summer (June/July), and Trip 3 in the fall (September). Years 1 to 3 (2008–2010) of the study represent the baseline conditions (i.e., before implementation of minimum base flows), while Years 4 to 6 (2011–2013) form the after-implementation data set.

This report summarizes Year 5 of sampling, which was the second year following the implementation of the minimum base flow. In total 2,899 fishes were captured and observed in 2012, compared to 6,504 fishes in 2011, 10,474 in 2010, 7,763 in 2009, and

3,977 in 2008. The 2012 total was the lowest since the inception of the program. This was likely due mainly to the high reservoir levels during the summer trip, which was the highest for all years of the program. In total, 16 species were captured during the three sampling trips in 2012, (compared to 15 in 2011, 16 in 2010 and 2009 and 17 in 2008). Morphometric analysis was expanded in 2012, as per the amended Term of Reference (BC Hydro 2010), to include additional species: Kokanee, Redside Shiner, Largescale Sucker and, in the case CPUE analysis, all Sculpins (condition factor analysis included Prickly Sculpin only). Together, juveniles of these species accounted for the majority of all juveniles caught and observed. The length, weight, and condition factor of Rainbow Trout, Bull Trout and Mountain Whitefish in 2012 were similar to those in 2011 and to the three years of baseline data, which suggests that the rearing environment was relatively constant. Condition factors of the additional species will be compared among previous years in the Year 6 Synthesis report. The results of the three years of baseline data showed that, in general, fish usage tended to be higher and more consistent in the lower Reaches, where conditions were less variable, than in the upper Reaches which experienced greater fluctuations in discharge. This trend was observed in 2012 and in 2011 – the first two years of post-minimum flow.

Statistical analysis of CPUE in 2012 for the most abundant species was limited to comparisons between Reaches within and between trips. For the spring and summer there were no significant differences between the Reaches (tributaries included). In the fall trip, Reach 3 had significantly higher CPUE than Reach 4 and the tributaries. CPUE for Reach 3 significantly increased from the summer trip to the fall trip. CPUE for Reach 4 significantly decreased from the spring trip to the summer trip and again from the summer trip to the fall trip. Comparisons of Year 1 to Year 6 CPUEs will be included in the Year 6 Synthesis report in 2014.

CLBMON #17 STATUS of OBJECTIVES, MANAGEMENT QUESTIONS and HYPOTHESES after Year 5

Objectives	Management Questions	Management Hypotheses	Year 5 (2012) Status
To provide information on Juvenile fishes' use of the Middle Columbia River and on the suitability of these habitats to meet critical life history requirements.	What are the seasonal abundances and distribution of juvenile life stages of fishes in the Middle Columbia River? How do juvenile fishes use the mainstem habitats in the Middle Columbia River?	Ho1: Juveniles do not use mainstem habitats in the absence of minimum flow releases. Ho2: Juveniles do not use mainstem habitats during 142 m3/s minimum flow releases.	Juvenile fish make use of the mainstem for rearing and presumably for overwintering. Juvenile fish continued to make use of the mainstem following the implementation of minimum flows.
To assess the effects of the implementation of the 142 m3/s minimum flow and REV5 on the recruitment of juvenile life stages of fishes of the Middle Columbia**.**	What factors affect recruitment of juvenile life stages in the Middle Columbia River? Do operational strategies for Revelstoke Dam and Arrow Lake Reservoir influence the availability of juvenile fishes' preferred habitats? Do current operational strategies affect availability of the food base for juvenile fish life stages? Do predators influence fish recruitment and habitat use in the Middle Columbia River?	Ho3: The provision of a minimum flow does not affect the average abundance of juvenile life stages in mainstem habitats	Analysis has been expanded to include CPUE of juveniles of the most abundant species instead of just Rainbow Trout, Bull Trout and Mountain Whitefish. Effects of minimum base flow will be fully assessed following Year 6. Total catch in Year 4 (first year post minimum flow) was the second highest of the 5 years sampled, while Year 5 was the second lowest. As a result it is unclear at this time what effect if any the minimum flows are having on juvenile fish in the study area. Changes to availability of food will be addressed in Year 6 following review of CLBMON 15 (Ecological Productivity) results. Effects of predators will be addressed in Year 6 following review of CLBMON 16 and 18 results.

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1.0 INTRODUCTION

The Middle Columbia River, located downstream of the Revelstoke Dam, forms the upstream end of the Arrow Lakes Reservoir (ALR). The ALR is formed by the Hugh Keenleyside Dam in Castlegar, B.C. Water levels in the Middle Columbia River fluctuate daily based on discharge from the Revelstoke Dam. The ALR fills through spring, reaches full-pool in June or July, remains high throughout the summer, and is drawn down through late fall and the winter. As the ALR fills, the study system changes from riverine to predominantly lacustrine as the floodplain of the Middle Columbia River becomes inundated, typically upstream of the city of Revelstoke. This inundation reduces the length of the river by approximately 50 km. When the reservoir reaches full-pool, the ALR "backwaters" to the base of the Revelstoke Dam (BC Hydro 2010) resulting in lacustrine conditions downstream of that point. Complex flood control treaties and water storage agreements with the United States and downstream facilities drive the operation of the reservoir. The general operating regime provided here is a very simplistic overview. The Revelstoke Dam is a peaking facility, with discharge tied to energy demand. This can result in widely fluctuating discharges that typically remain high during the day when power demand is greatest, and are reduced during the night when demand drops. The dam historically housed four turbines; an additional turbine (known as Rev 5) came online in December 2010. The pre-Rev 5 discharge from the facility ranged from a minimum of 0 m^3/s to a maximum of approximately 1,700 m^3/s (BC Hydro 2010). The addition of the fifth generating unit increases the projected maximum discharge from the facility to approximately 2,125 m^3/s, with an established minimum base flow of 142 m^3/s (BC Hydro 2010).

Past fisheries studies on the Middle Columbia River have shown that the mainstem river habitats are used primarily by sub adult and adult life stages of fishes, with very few juvenile life stages present (RL&L 1994; Golder Associates Ltd. 2005). These findings could suggest that mainstem habitats within the Middle Columbia are either unsuitable for juvenile fishes, that localized recruitment is limited, or that sufficient, preferable habitat exists elsewhere. However, it should be noted that those studies did not specifically focus on capturing juveniles or on sampling juvenile habitats and as a result sampling bias may exist.

The impacts of the operations of the Revelstoke Dam and ALR on fishes and fish habitat in the Middle Columbia River were recognized in the Columbia River Water Use Plan. Implementation of a minimum flow release of 142 m^3/s from the Revelstoke Dam was proposed with the objective of improving habitat conditions for fishes, in general, within the Middle Columbia (BC Hydro 2005). In particular, in order to determine if this objective was met for juvenile life stages, baseline data on the relative abundance, distribution, and habitat use of juvenile life stages were necessary. The six-year monitoring program associated with this project (CLBMON-17 Middle Columbia River Juvenile Fish Habitat Use) consists of three years of pre- and three years of post-minimum flow surveys. The overall management objectives for the project are, as stated in the Terms of Reference (BC Hydro 2010):

1. *To provide information on juvenile fishes' use of the Middle Columbia River and on the suitability of these habitats to meet critical life history requirements (e.g., rearing) of these fish populations.*

2. *To assess the effects of the implementation of the 142 m^3/s minimum flow and Rev 5 on the recruitment of juvenile life stages of fishes of the Middle Columbia.*

The management hypotheses, as stated in the Terms of Reference (BC Hydro 2010), for the project are:

1. *H_{o1}: Juvenile life stages do not use mainstem habitats in the absence of minimum flow releases.*

2. *H_{o2}: Juvenile life stages do not use mainstem habitats during 142 m^3/s minimum flow releases.*

3. *H_{o3}: The provision of a minimum flow does not affect the average abundance of juvenile life stages in mainstem habitats.*

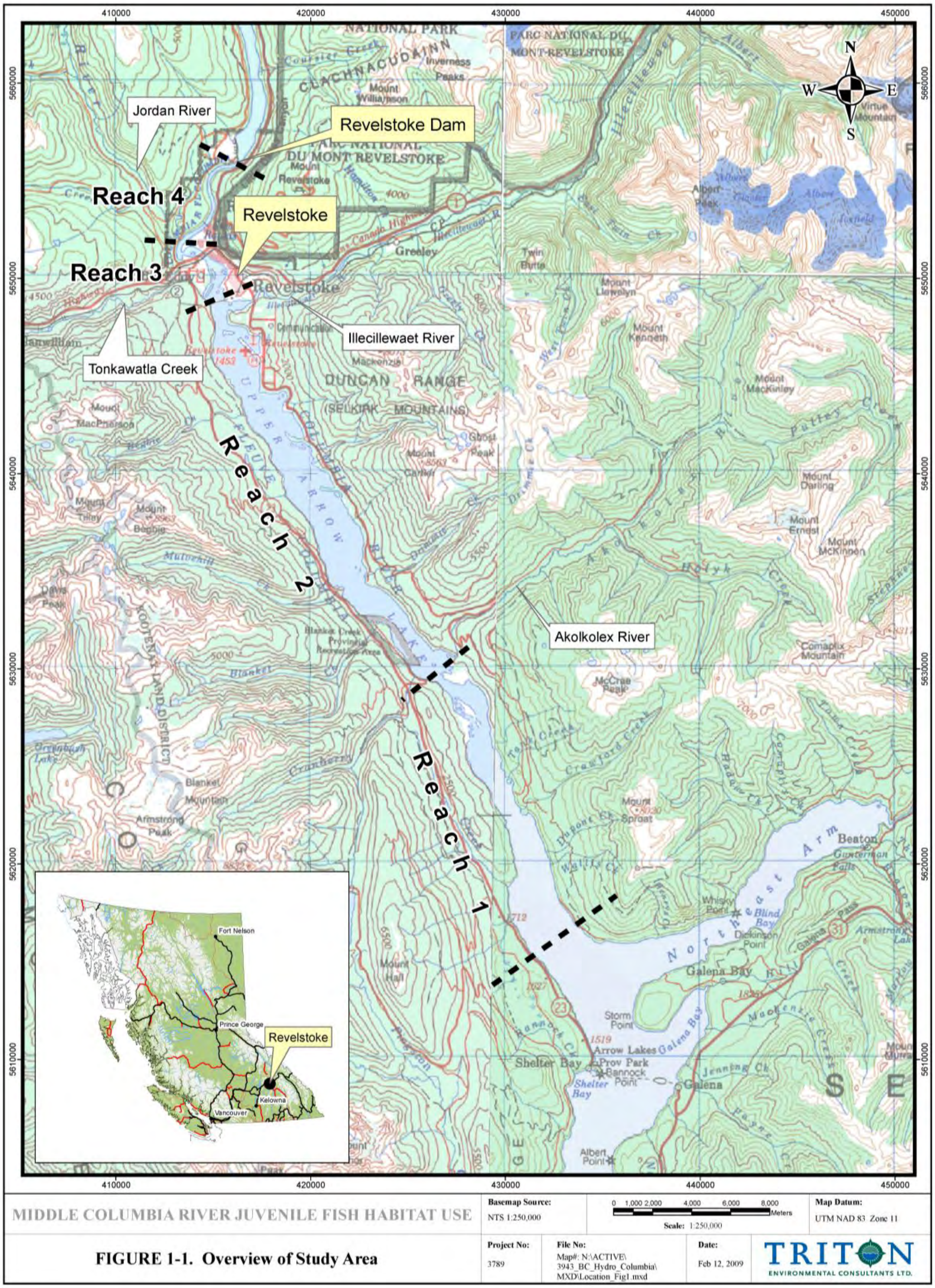
The Juvenile Fish Habitat Use study was designed to monitor the relative abundance and seasonal distribution of juvenile fishes, to determine the range of habitats available within the study area that are used by the juvenile life stages of key fish species, and to assess changes in habitat use by juvenile life stages in response to implementation of a minimum flow release from Revelstoke Dam. The specific management questions to be addressed by CLBMON-17 are as follows (BC Hydro, 2010):

1. *What are the seasonal abundances and distribution of juvenile life stages of fishes in the Middle Columbia River?*
2. *How do juvenile fishes use the mainstem habitats in the Middle Columbia River?*
3. *What factors affect recruitment of juvenile life stages in the Middle Columbia River?*
    a. *Do operational strategies for Revelstoke Dam and Arrow Lake Reservoir influence the availability of juvenile fishes' preferred habitats?*
    b. *Do current operational strategies affect availability of the food base for juvenile fish life stages?*
    c. *Do predators influence fish recruitment and habitat use in the Middle Columbia River?*

The study area includes the Middle Columbia River from Revelstoke Dam downstream to the Beaton Arm of the Arrow Lakes (Figure 1-1), as well as selected tributaries within this section of river. However, the focus of the study is on the riverine reaches (Reaches 3 and 4) located closer to the dam (BC Hydro 2010).

It should be noted that the original Terms of Reference for the project (those that applied to Years 1 – 3 of the project; BC Hydro [2007]) identified three key species as the focus of the study. These "target species" were Rainbow Trout, Bull Trout, and Mountain Whitefish. As a result, the data analysis and reporting for those years focused primarily on those three species. The Terms of Reference were revised in 2010 for Years 4-6 and the focus on those key species was removed in favour of a more general summary of all species in the study area. This report primarily focuses on the Year 5 (2012) sampling results with comparison to previous years where possible. However, due to the change in the terms of reference following Year 3, many of the comparisons with previous years (for example for species beyond the original "target species") have been deferred to the Year 6 report which as identified in the Terms of Reference will be the synthesis report which includes results from all six years of the study.

Figure 1-1: Overview of study area



2.0 METHODS

Year 5 of the Middle Columbia River Juvenile Fish Habitat Use project involved seasonal sampling for fishes and associated data entry and reporting. The study area (Figure 1-1) was divided into four sections (corresponding to Reaches) with the Revelstoke Dam at the upstream end (Reach 4) and Beaton Arm at the downstream end (Reach 1). The focus of the study was on the riverine sections, which included Reaches 3 and 4 (Illecillewaet River to Revelstoke Dam).

In 2011 BC Hydro developed a naming convention for sample sites in all BC Hydro studies on the Middle Columbia River. Each site label includes the river kilometre as measured from the U.S./Canada border, the side of the river where the site is located (left or right when facing downstream), the project ID (MON-17 for this project), and the sampling technique (boat electrofishing: ES; backpack electrofishing: EF). For example, the former site 1 has been relabelled 236.5/R/MON17/ES. The application of this naming convention was in 2012, but the site labels used in Years 1–3 have been maintained in the report, while both the old and new labels are reported in the database and are displayed on the maps for ease of comparison. Appendix 1b provides a summary of the sites with both old and new labels.

2.1 HABITAT INVENTORY

2.1.1 INITIAL SAMPLING DESIGN

Year 1 of the program (2008 field season) included an initial habitat assessment (April 17-20, 2008) of the entire 50-km long study area between the Revelstoke Dam and Beaton Flats (Figure 2-1). A stratified random sampling plan was used that resulted in the identification of 56 sites located throughout the study area based on the proportion of shoreline habitats within each of the 12 habitat categories. Habitat categories were based on bank slope (steep or low) and substrate (sand, gravel, cobble, boulder, rip-rap, bedrock). Five tributary sites were also included in the sampling plan to help determine the relative use of tributaries by juvenile fishes compared to mainstem habitats.

The 61 sites that were originally identified (56 riverine sites plus 5 tributary sites) have been sampled annually during three periods: spring (May), summer (June/July), and fall (September). Given that the focus of the study was on the Reaches that remain riverine (i.e., flowing) throughout most of the year, 65 per cent of the sites (*n* = 39) were located in Reaches 3 and 4, while 27 per cent (*n* = 17) were located in Reaches 1 and 2. The remaining 8 per cent (*n* = 5) were located in tributaries. A detailed summary of the habitat inventory and initial site selection is provided in Triton (2009). A summary of the sites sampled by reach and habitat class is provided in Table 2-1.

2.1.2 MODIFIED SAMPLING DESIGN

Following the May sampling in 2008, it was discovered that seven of the original sites (sites 40, 42, 43, 45, 49, 50, and 53) in Reaches 1 and 2 would most likely not be able to be sampled during the summer and fall Trips because they would be inundated by the ALR. Therefore, these sites were dropped from summer and fall sampling (Trips 2 and 3), and seven additional sites were added to Reach 4 to increase the number of riverine sites sampled at high reservoir elevations (riverine sites being most relevant to the management questions). The seven new sites were referred to as “Biased 1 to 7” since they were not selected using the stratified random methodology. In addition, two other sites (sites 46 and 47) in Reach 2 also had to be moved due to a change in accessibility from steep angle, fine-dominated habitat to steep angle, bedrock-dominated habitat. Since Trip 2 in 2008 the seven Biased sites have been sampled during all three sampling Trips to increase overall sampling effort. Thus, the maximum number of riverine sites that can be sampled during any Trip is 63 (56 original sites plus 7 Biased).

Figure 2-1: Habitat inventory map for Reaches 3 and 4

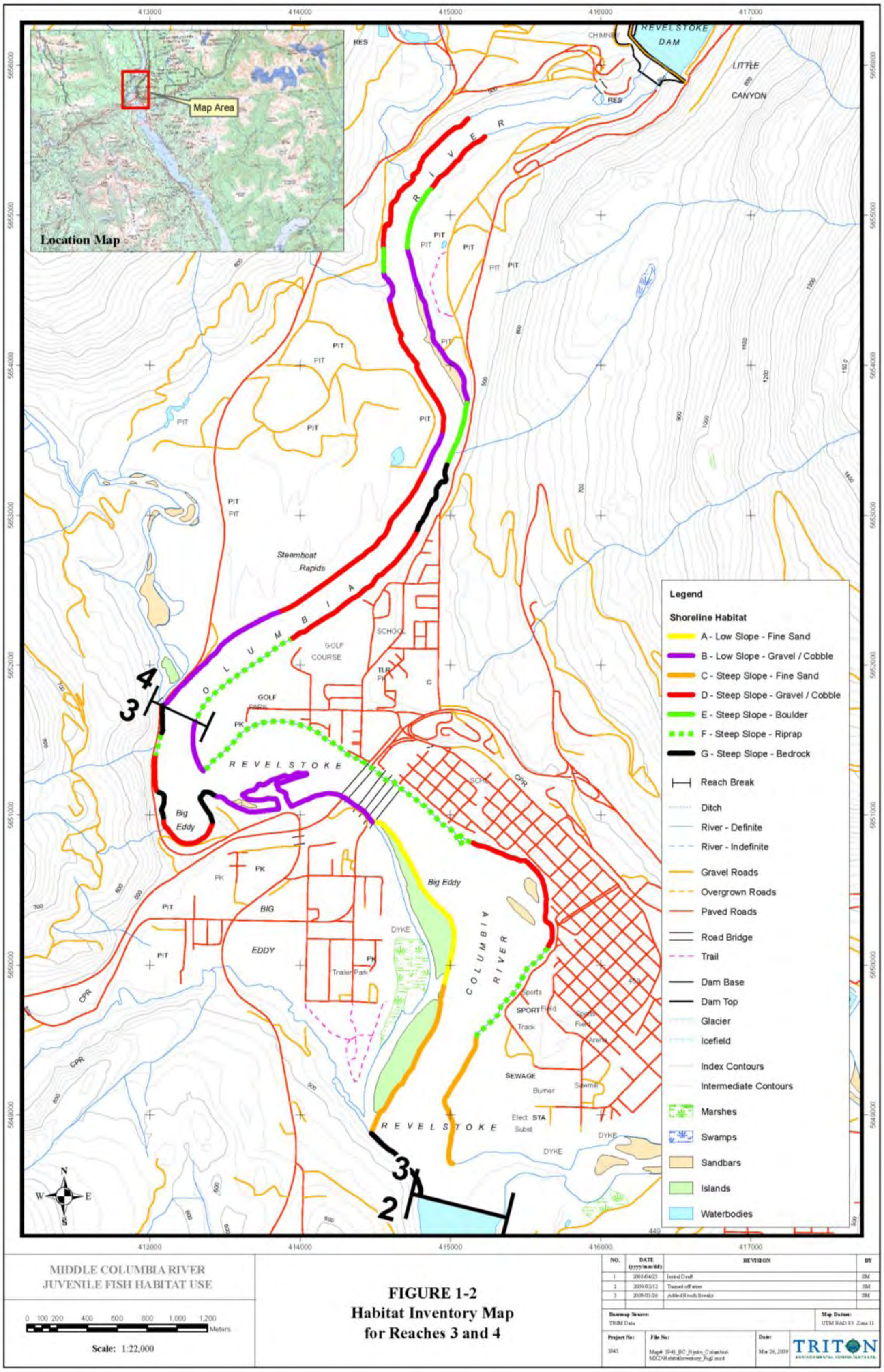


Table 2-1: Habitat summary and 2012 sample sites by reach

Habitat Class	Reach 1	Reach 2	Reach 3	Reach 4	Total
Low angle - Fines	2	3	2	0	7
Low angle – Gravel/Cobble	0	1	4	5 + 2 Biased	12
Steep angle – Fines	2	1	4	0	7
Steep angle – Gravel/Cobble	0	2	5	7 + 3 Biased	17
Steep angle – Boulder	0	0	0	2 + 1 Biased	3
Steep angle – Rip-rap	0	0	5	2+1 Biased	8
Steep angle – Bedrock	1	5	1	2	9
Total	**5**	**12**	**21**	**25**	**63**
Tributaries	0	2	2	1	5
Total	**5**	**14**	**23**	**26**	**68**[A]

2012 Sites Sampled[B]	Reach 1	Reach 2	Reach 3	Reach 4[C]	Total
Spring Trip (May)	5	12	19	14	55
Summer Trip (July)	3	6	21	24	59
Summer Trip (September)	5	10	21	25	65

[A] Includes the 61 originally proposed sites along with 7 biased sites. The spring trip is the only trip where it is possible to sample all 68 sites. High ALR elevations during the summer and fall trips typically reduce the total that can be sampled by up to seven sites which become inundated.
[B] Including tributary sites
[C] Includes Biased sites – the seven sites added in Reach 4 to compensate for the seven sites that are typically flooded (high reservoir elevation) in Reaches 1 and 2 during the summer trip.

The number of sites sampled in the Middle Columbia River during the spring and summer trips in 2012 was less than the 61 sites identified during the initial study design. This was due to mechanical issues (spring trip) and adverse sampling conditions (summer trip). Three of the seven Biased sites were sampled during the spring trip and all were sampled during the summer and fall trips in 2012. During the spring trip eleven sites were not sampled due to equipment failure (Reach 4: sites 4 to 10 and Biased 1 to 4). During Trip 2, in addition to the seven sites that typically cannot be sampled at high ALR elevation, one additional site (Reach 1 site 56) was also inundated. Further, one site (Reach 4: site 10) was not sampled due to unsafe sampling conditions (i.e., high water velocity due to high discharge from the dam). During Trip 3 two sites were not sampled due to increased ALR elevations (Reach 2: sites 49 and 50) and two tributary sites were not sampled due to presence of spawning Kokanee (Drimmie "upstream" and Tonkawatla "upstream"). It should be noted that during the summer months when the ALR is at or near its peak, which coincides with Trip 2, there are seven sites that are flooded and not sampled. This brings the maximum number of sampling sites down to 61 from 68.

2.1.3 TRIBUTARY SAMPLING

Tributaries were sampled to compare species composition and abundance with mainstem sites. Five tributary sample sites were dispersed throughout the study area (one in Reach 4, two in Reach 3, two in Reach 2) to assess juvenile fishes' use of tributary habitats and the relative importance of those habitats to juvenile fish production. Tributaries were selected based on the criteria of size — large enough to safely sample at night (e.g., absence of dense riparian vegetation overhanging the wetted channel)—and accessibility for sampling at the confluence (i.e., within the portion inundated by the ALR) as well as upstream of the zone of influence of the ALR (identified by the presence of mature, riparian vegetation).

At each site, one 50-m long site was sampled at the confluence (within the zone influenced by the reservoir), and one 50-m long site was sampled upstream in a section above the reservoir high water level. Selected tributaries included the Jordan River, Tonkawatla Creek, Illecillewaet River, Begbie Creek, and Drimmie Creek (see Appendix 1a for site locations). Data on habitat parameters (substrate, gradient, morphology, and cover) were collected at these sites.

2.2 SEASONAL FIELD SURVEYS

Sampling trips in 2012 were completed in May, July, and September, consistent with the timing of sampling in 2008 - 2011. The only exception was that the summer trips in 2009 were completed in June prior to the ALR backwatering into Reach 3, whereas in 2008, 2010, 2011 and 2012 they were completed in July after the ALR had backwatered into Reach 4.

Table 2-2. Timing of sampling and average reservoir elevation (m) for sampling Trips 1, 2 and 3 in 2008, 2009, 2010, 2011, and 2012.

	Year 1 (2008)		Year 2 (2009)		Year 3 (2010)		Year 4 (2011)		Year 5 (2012)	
Sampling Trip	Date	Reservoir Elevation (m)	Date	Reservoir Elevation (m)	Date	Reservoir Elevation (m)	Date	Reservoir Elevation (m)	Date	Reservoir Elevation (m)
Spring	May 14-22	431.6	May 26-June 3	432.8	May 25 -June 1	434.6	May 26-June 3	433.1	May 28-June 5	433.0
Summer	July 21-29	439.3	June 20-30	437.1	July 24-Aug 1	437.9	July 19-27	439.3	July 9-18	440.4
Fall	Sept 9-18	438.2	Sept 8-17	435.5	Aug 30-Sept 7	436.0	Sept 13-20	437.0	Sept 10-19	435.1

During each trip, habitat, fish abundance and distribution data were collected. Following 2008, it was noted that depending on the time of night when sampling was completed, habitat conditions (e.g., bank slope and substrate type) at a given site could change substantially depending on water level. To reduce this potential variability, sampling in Reaches 3 and 4 targeted the daily minimum discharge in subsequent years. This was based on the rationale that sampling during the period of minimum base flows would help ensure that physical conditions (e.g., site depth and velocity) were comparable between years. Due to their distance from the dam and the influence of the reservoir on Reaches 1 and 2, it was not considered necessary to sample those reaches during the period of minimum dam discharge.

2.2.1 HABITAT DATA

Data on substrate composition, slope, water velocity, water depth, water temperature, conductivity, and turbidity were collected at each site during the three sampling trips to facilitate habitat grouping and comparison of results. Substrate composition was assessed by visual observations according to the categories defined by Kaufmann and Robison (1993): fines (< 2 mm), gravels (2–64 mm), cobbles (64–256 mm), boulders (256–4,000 mm), or bedrock (> 4,000 mm). D_{95}, the diameter of bed material larger than 95 per cent of the total substrate, was measured with a folding ruler where substrate could be easily accessed or by visual estimate in deeper waters. Slope was measured using a handheld clinometer (per cent slope), and sites were classified as low angle (< 10 per cent) or steep angle (> 10 per cent).

Water velocity was measured at 40 per cent of the water depth using a velocity sensor (Swoffer Instruments, Seattle, Washington), and depths were measured using a graduated rod or, where depth was greater than approximately 2.5 m, a handheld digital sonar device. Water temperature and conductivity were measured at the surface using a handheld digital meter (Hanna Combo Meter HI98129). Turbidity was visually assessed as *clear*, *lightly turbid*, *moderately turbid*, or *turbid* as per the Reconnaissance Fish and Fish Habitat Inventory standards (BC Fisheries 2001), where:

- turbid water is muddy and brown, and visibility is restricted to a few centimetres;
- moderately turbid water is muddy with increased visibility in shallow areas;
- lightly turbid water allows features in shallow areas to be distinguished, and has limited visibility in deeper pools (up to 1.5 m); and
- clear water has excellent visibility except in very deep areas.

Site coordinates were documented with a Garmin GPSmap 60CSx GPS. Navigation between sites was assisted by use of a Trimble Juno ST handheld unit, which displayed real-time location onto navigational charts for the study area.

2.2.2 FISH SAMPLING

A Smith-Root Generator Powered Pulsator (5.0 GPP) electrofisher based out of a 6.1 m Ali-Craft aluminium river boat was used to sample fish. The electrofisher was set at a frequency of 60 Hz direct current, with an amperage target of 1.0–1.5 A, typically obtained by using the high output setting (100–1,000 volts) at 60–80 per cent output.

Electrofishing involved manoeuvring the boat in an upstream direction, approximately 3 m from shore. Two crew members were positioned on the railed platform at the bow of the boat, with one crew member operating a 2.7 m anode wand (similar to those used with backpack electrofishers). The use of a wand allowed the electrical pulse to be directed to specific locations, with the current controlled by the person observing the fish. A second crew member with a dip net on a 2.7 m fibreglass pole would then retrieve the stunned fishes and place them in a 150 L aerated cooler. A third crew member manoeuvred the boat along the shoreline. Sampling was conducted at night, with halogen bow lights and a pivoting halogen light bar on the boat used to illuminate the water between the boat and the shoreline.

A Smith-Root 12B backpack electrofisher was used to sample the majority of tributary sites and the occasional mainstem sites that were too shallow to sample by boat. Backpack electrofisher voltage settings varied according to site conditions and tributary conductivity, but the frequency was set to 60 Hz, similar to the boat-based electrofisher. Captured fishes were processed after the completion of each site. Clove oil was added to the water to anesthetize the fish (2 ml per 5 L of water). Length (fork or total length to the nearest mm) and weight (to the nearest 0.1 g) were collected from a random subsample of up to 30 fish from each of the species encountered. Total numbers of each species captured were also recorded to calculate catch-per-unit-effort (CPUE; fish per second of electrofishing). Once recovered, fishes were returned to their site of capture.

2.3 DATA ENTRY AND ANALYSES

Field data were entered into an MS ACCESS database developed specifically for the project. A front-end data entry tool was developed to facilitate the data entry process and ensure that all required data were entered. Fulton's condition factor (Ricker 1975), a measure of relative condition, robustness, or well-being of fish, was calculated for juvenile salmonid fishes. The coefficient of condition for salmonids, (K), was calculated using Equation (1). For non-salmonid species, Ricker proposed a modified version of Fulton's K equation to more accurately portray health condition. Ricker proposed replacing the cube-power, associated with length variable, with the slope value of the $\log_{10}$ length-weight regression curve for the species being measured. He referred to this as Relative Condition factor K′ (Equation 2):

$$K = 10^5 W/L^3 \quad (1)$$

where:

K = coefficient of condition; often referred to as the “K-value”
W = weight of fish (g)
L = fork length of fish (mm)
10^5 = scaling constant

$$K' = 10^5 W/L^b \quad (2)$$

where:

K′ = coefficient of relative condition
W = weight of fish (g)
L = fork length of fish (mm)
b = slope value of $\log_{10}$ length-weight regression curve for species in question
10^5 = scaling constant

Weight–length regressions were completed for seven most abundant fish species. Data were analyzed after being logarithmically transformed. Logarithmic transformation accounts for more of the variation in weight and minimizes overall model error (Pope and Kruse 2007). Based on the least-squares regression model, Equation (3) was used because it generally describes the weight–length relationship of most fishes:

$$\log_{10}(W) = a + b(\log_{10} L) \quad (3)$$

where:

W = weight of fish (g)
L = fork length of fish (mm)
a = y-intercept ($\log_{10}$ scaling)
b = slope of the line

Weight–length scatterplots with a best-fit trend line for non-transformed data were produced for ease of visually determining length and weight characteristics.

In 2012, species diversity and evenness indices were calculated from the collected data. To quantify diversity and to describe the assemblage structure of the study’s juvenile fish community the Shannon (Shannon-Wiener) Index was used. This index is one of the most widely used indices in aquatic systems (Washington 1984 as cited in; Pope and Kruse 2007) taking into account species richness (the number of different species present), relative abundance (the number of each species caught) and evenness (the degree of similarity between the abundances of different species). Equation (4) uses richness and relative abundance as variables to calculate the diversity index (H') value and Equation (5) uses richness and H' to calculate Shannon's index of evenness (J').

$$H' = -\sum_{i=1}^{s}(p_i)(\log_e p_i) \qquad (4)$$

where:

s = number of species

p_i = proportion of the total sample represented by the *i*th species

To describe evenness Pielou's evenness index (J'), which corresponds directly with the Shannon Diversity index, was used (Pope and Kruse 2007). Values range from 0 to 1. The higher the value, the greater the degree of similarity between the abundances of different species in the community is.

$$J' = \frac{H'}{H'_{max}} = \frac{H'}{\log_e s} \qquad (5)$$

where:

$H'_{max} = \log_e s$ = maximum possible value of Shannon's index

e = constant = 2.718

s = number of species

2.3.1 STATISTICAL ANALYSES

The dependent variable used in the 2012 data analyses was CPUE of juvenile fishes of the seven most abundant species in the study area. In previous years, Rainbow Trout, Bull Trout and Mountain Whitefish were target species. In 2012 four additional species were added to the analyses based on abundance: Kokanee, Prickly Sculpin, Redside Shiner and Largescale Sucker. Together these seven species comprised 57 per cent of the total number of fishes captured and observed. The remaining species that were captured and observed accounted for 3.7 per cent of the total while the remaining 39.3 per cent were comprised of individuals of the genus *Cottus* that were observed but not captured and therefore not identified to species. CPUE of juvenile fishes was chosen because it provides a more accurate estimate of relative abundance at each site compared to total count since it factors in the sampling effort (electrofishing seconds).

Comparisons of CPUE between Reaches, habitat types, and sampling trip were completed using parametric statistics (ANOVA) with a post-hoc Tukey test for individual comparisons. All statistical analyses were completed using R (ver. 2.15.2; R Core Team, 2012), and significance was set at alpha = 0.05.

2.4 DATA QA/QC

A systematic QA/QC consisted of running various queries of the database and looking for outliers (e.g., water velocities greater than 3 m/second). Length versus weight plots and condition factors were used to identify outliers in the individual fish data. After systematic data queries were completed, the fish summary fields for all site cards were reviewed for accuracy because these fields are critical to the study design and interpretation of results. Additional QA/QC functions were completed using GIS software to map site locations to ensure that UTMs corresponded to the correct Reach and position on the river or reservoir.

2.5 REPORTING

Fish species codes used in this report and in the associated database follow those in the *Fish Collection Methods and Standards* (BC Ministry of Environment, Lands and Parks 1997), and are summarized in Table 2-3.

Table 2-3: Fish species codes used for CLBMON-17

Common Name	Code	Family	Scientific Name
Bull Trout	BT	Salmonidae	*Salvelinus confluentus*
Eastern Brook Trout	EB	Salmonidae	*Salvelinus fontinalis*
Burbot	BB	Gadidae	*Lota lota*
Common Carp	CP	Cyprinidae	*Cyprinus carpio*

Common Name	Code	Family	Scientific Name
Kokanee	KO	Salmonidae	*Oncorhynchus nerka*
Largescale Sucker	CSU	Catostomidae	*Catostomus macrocheilus*
Longnose Sucker	LSU	Catostomidae	*Catostomus catostomus*
Mountain Whitefish	MW	Salmonidae	*Prosopium williamsoni*
Northern Pikeminnow	NSC	Cyprinidae	*Ptychocheilus oregonensis*
Peamouth Chub	PCC	Cyprinidae	*Mylocheilus caurinus*
Prickly Sculpin	CAS	Cottidae	*Cottus asper*
Pygmy Whitefish	PW	Salmonidae	*Prosopium coulteri*
Rainbow Trout	RB	Salmonidae	*Oncorhynchus mykiss*
Redside Shiner	RSC	Cyprinidae	*Richardsonius balteatus*
Slimy Sculpin	CCG	Cottidae	*Cottus cognatus*
Tench	TC	Cyprinidae	*Tinca tinca*
Yellow Perch	YP	Percidae	*Perca flavescens*

Other abbreviations used refer to substrate composition (Table 2-4).

Table 2-4: Substrate types, size classes, and abbreviations (Kaufmann and Robison 1993)

Substrate Type	Size (mm)	Abbreviation
Fines	< 2	F
Gravels	2 – 64	G
Cobbles	64 – 256	C
Boulders	256 – 4,000	B
Bedrock	> 4,000	R
Rip-rap	N/A	RR

3.0 RESULTS

3.1 PHYSICAL CONDITIONS

3.1.1 WATER TEMPERATURE

Across the three trips, surface water temperatures were generally warmer in the more-lacustrine reaches (Reach 1 and 2) than the more-riverine reaches (Reaches 3 and 4). Tributary temperatures were cooler than mainstem temperatures in the spring and fall but higher during the summer trip. For the three trips the mean temperature ranges across all reaches including tributaries was 1.1 °C (spring), 2.6 °C (summer) and 1.1 °C (fall).

Surface water temperatures at the sites sampled during the spring trip ranged from a low of 4.4°C in the Jordan River (Reach 3) to a high of 8.0°C in Tonkawatla Creek tributary (Table 3-1). Electrofishing at temperatures near 5 °C was limited to one occurrence and not intensive in nature. Reach 1 had the highest mean temperature (7.0°C), while Reach 3 had the lowest (5.6°C). Mean temperatures in Reaches 2, 3, and 4 were cooler than in 2009 and 2010 but were warmer than in 2008 and 2011. Reach 1 mean temperatures were cooler than in all previous years except 2008. Mean temperature at the tributary sites (5.9°C) was similar to that in 2011 (6.3°C) but was approximately 1°C cooler than in 2008, 2009, and 2010.

Surface water temperatures at sites sampled during the summer trip ranged from a low of 7.2°C in Drimmie Creek - *upstream* site to a high of 13.1°C at the Drimmie Creek - *downstream* site (inundated by ALR) (Table 3-1). Mean reach temperatures all increased from May with Reach 1 the warmest (10.8°C). Mean temperatures for Reaches 1, 2, and 3 were warmer than in 2009, but cooler than in 2008, 2010, and 2011. Mean temperatures for Reach 4 were cooler than in 2008, 2009, 2010, and 2011. Mean temperature at the tributary sites (10.5°C) was cooler than 2008 and 2010 but warmer than 2009 and 2011.

Surface water temperatures at sites sampled in during the fall trip ranged from a low of 8.0°C Begbie Creek (*upstream* and *downstream* sampling locations) to a high of 12.4°C at the Drimmie Creek - *downstream* site (inundated by ALR) (Table 3-1). Mean temperature in each Reach was higher than in May and July with the exception of the tributaries, which was cooler than in July. Reach 1 had the highest mean temperature (11.1°C), while the tributaries had the lowest (10.0°C). Mean temperature in Reach 1 was cooler than in 2008, 2009, and 2010 but warmer than 2011. Mean water temperatures for Reach 2 were cooler than all previous sampling years while in Reach 4 mean temperatures were warmer than all other sampling years. In Reach 3, mean temperatures were cooler in 2012 than in 2010, warmer than 2009 and 2011, but the same as 2008. Mean water temperature at the tributary sites in 2012 (10.0°C) was consistent with 2008, 2010, and 2011 but a degree cooler than in 2009.

Table 3-1: Minimum, maximum, mean, and standard deviation (SD) of surface water temperature recorded at electrofishing sites by month and river Reach, Middle Columbia River, 2012. Means for 2008, 2009, 2010, and 2011 are presented for comparison.

Trip	Reach	Temperature (°C)								
		Min	Max	Mean	SD	*N*	2008 Mean	2009 Mean	2010 Mean	2011 Mean
Spring	Reach 1	6.5	7.1	**7.0**	0.27	5	5.4	8.6	8.6	7.2
	Reach 2	6.1	6.9	**6.6**	0.37	12	5.4	6.9	10.0	6.5
	Reach 3	5.3	5.9	**5.6**	0.19	19	5.0	7.0	7.0	5.2
	Reach 4	5.6	6.9	**5.9**	0.55	14	4.9	6.2	7.8	4.7
	Tribs.	4.4	8	**5.9**	1.08	10	6.6	7.4	7.5	6.3
Summer	Reach 1	10.8	10.8	**10.8**	0.00	3	12.4	9.0	18.2	11.9
	Reach 2	9.3	10.4	**9.7**	0.57	6	12.4	8.1	11.5	10.3
	Reach 3	8.5	9.3	**8.8**	0.33	21	10.2	7.4	11.1	9.2
	Reach 4	7.8	9.4	**8.2**	0.64	24	10.3	8.9	10.3	9.5
	Tribs.	7.2	13.1	**10.5**	1.78	10	12.2	8.2	13.2	10.1
Fall	Reach 1	10.9	11.1	**11.1**	0.09	5	11.4	12.4	12.6	10.1
	Reach 2	10.9	11.0	**10.9**	0.05	10	11.4	12.0	13.1	11.0
	Reach 3	10.1	11.3	**11.0**	0.32	21	11.0	10.6	11.3	9.8
	Reach 4	10.5	11.1	**10.9**	0.28	25	10.5	10.7	10.2	9.6
	Tribs.	8.0	12.4	**10.0**	1.48	8	10.0	11.3	10.7	10.4

3.1.2 RIVER DISCHARGE

River discharge varied during each day of sampling as well as between the different months of sampling (Figure 3-1). Discharge tended to peak daily during the mid-morning or late afternoon, with low discharge usually in the early morning hours (12:00 a.m. – 4:00 a.m.). Daily discharges tended to be lower on weekends than on weekdays. Over the three sampling periods, mean daily discharge was lower during the May trip (845 m^3/s) than in the July and September trips (1244 m^3/s and 1034 m^3/s, respectively).

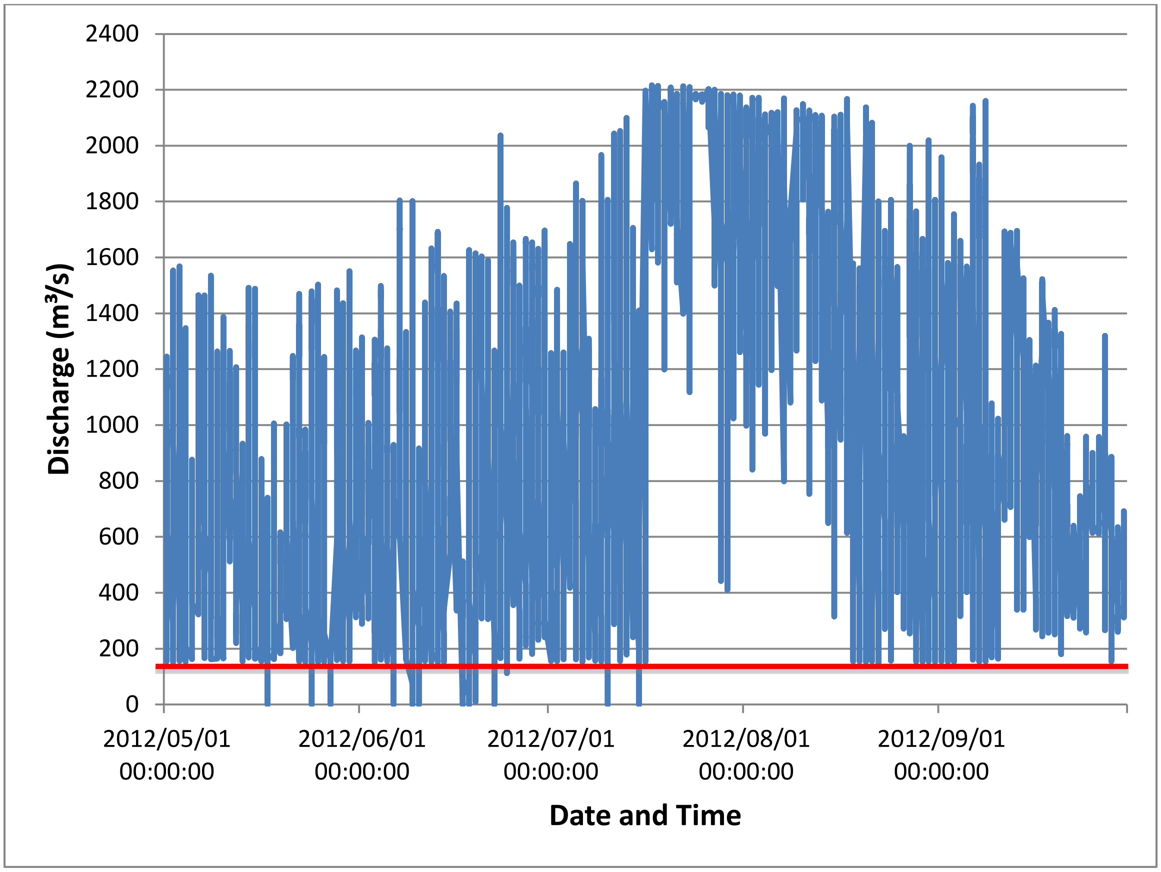


Figure 3-1: Hourly discharge from Revelstoke Dam from May 1, 2012 to September 30, 2012. The red line indicates the minimum flow (142 m^3/s)

Discharge from the Revelstoke Dam followed a highly variable and unpredictable pattern throughout the year. During the spring sampling (May 28–June 5), river discharge ranged from a high of 1,551 m^3/s at 6:00 p.m. on May 30 to a low of 153 m^3/s at 7:00 a.m. on June 3 (Figure 3-2a). During the summer sampling Trip (July 9–18), river discharge ranged from a high of 2,216 m^3/s at 2:00 p.m. on July 17 to a low of 0 m^3/s at 5:00 a.m. on July 10 and at 7:00 a.m. on July 15 (Figure 3-2b). During the fall sampling (September 10-19), river discharge ranged from a high of 1,695 m^3/s at 9:00 p.m. on September 13 to a low of 164 m^3/s at 1:00 a.m. on September 10 (Figure 3-2c). Figure 3-2 shows that all three sampling periods occurred during similar daily flow patterns.

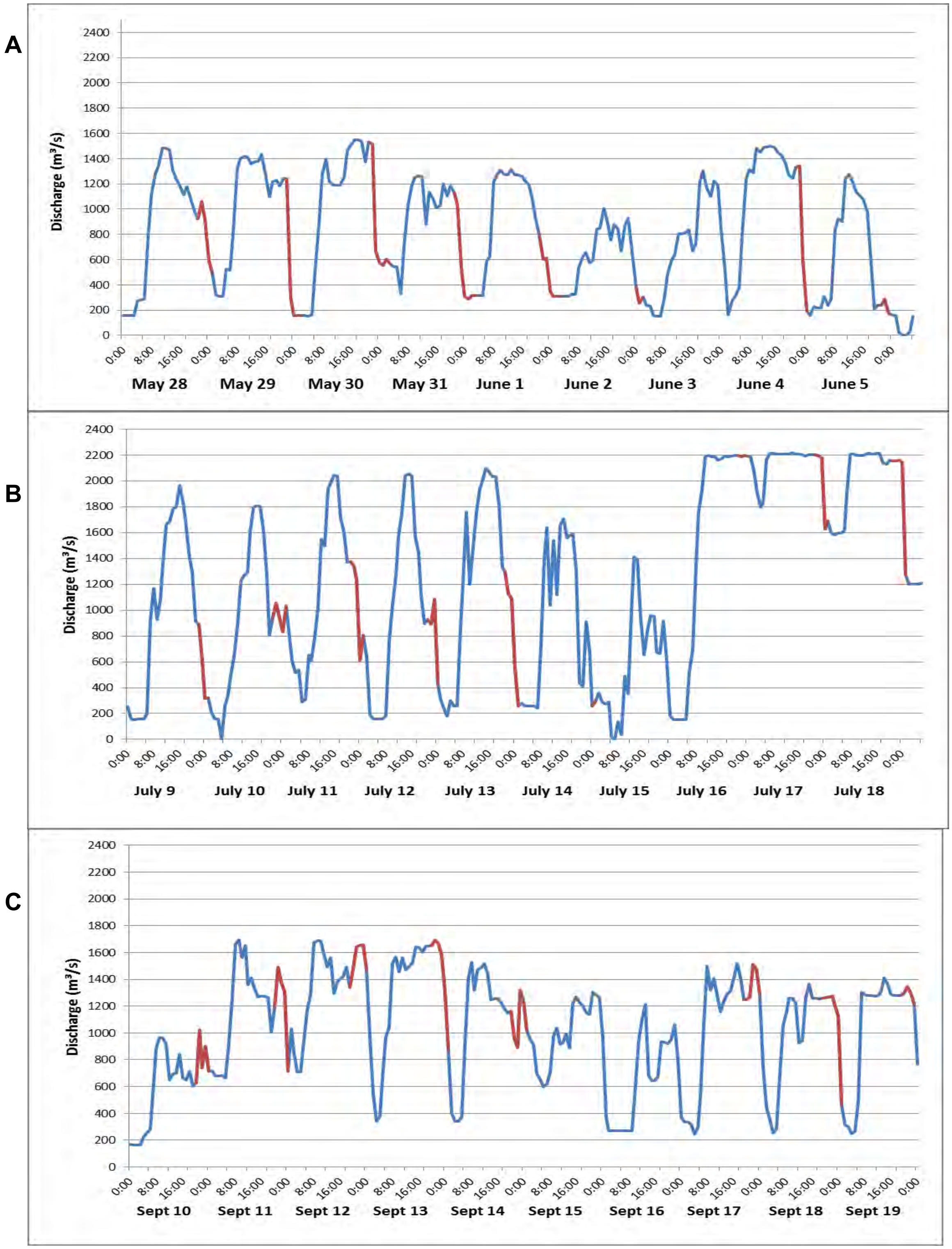


Figure 3-2: Discharge (hourly means) for the Columbia River at the Revelstoke Dam during the three sampling periods of (a) May 28–June 5, (b) July 9–18, and (c) September 10–19, 2012. The red lines indicate the daily sampling periods.

3.1.3 TURBIDITY

In general, the tributary sites were more turbid than the mainstem sites, particularly during the spring and summer (May and July) sampling trips, due to increased runoff in those systems. Water clarity was assessed as *clear* at most sites during the May (68 per cent), and September (99 per cent) sampling trips and as low at most sites during the July (77 per cent) sampling trip. During the May sampling, thirteen sites had low turbidity, five sites had moderate turbidity and one site was turbid. Most of these were in Reaches 1 and 2 and the sites with the greatest turbidity were tributary sites. During the July sampling, clear sites were limited to sites 1-7 and Biased 1-3. All sites with moderate turbidity were tributary sites. During the September sampling, only the downstream Drimmie Creek site had low turbidity.

3.2 SPECIES ASSEMBLAGE, DIVERSITY AND EVENNESS

In total, 16 species were captured in the Middle Columbia River during the three sampling trips in 2012 (Figure 3-4). This is one less than in 2011 and 2010, and one more than 2008. One invasive species was encountered during the 2012 sampling: Yellow Perch (*Perca flavescens*). Brook Trout (*Salvelinus fontinalis*), a non-native species introduced in B.C. in the 1920s (McPhail 2007), was also encountered. Species richness was relatively constant between sampling events in the various reaches and tributaries. In Reaches 1 and 2, twelve species were captured in May, eight in July, and twelve in September (Figure 3-4). In Reaches 3 and 4, ten species were captured in May, eleven in July, and thirteen in September. At the tributary sites, six species were captured in May, eight in July, and ten in September (Figure 3-5).

Common Carp and Pygmy Whitefish were not encountered in any of the reaches or tributaries during any of the sampling trips in 2012. Species that were not encountered in Reaches 1 and 2 during any of the sampling events include Longnose Sucker, Tench, and Brook Trout. These species have been historically caught in these reaches in previous years (2011). However, historic abundances of these species has been low during any particular trip (i.e, less than 5). Species that were not encountered in the tributaries during any of the sampling events included Burbot, Northern Pikeminnow, Yellow Perch, Tench, and Brook Trout. The absence of these species in tributaries was not surprising. They have usually been caught in the mainstem rather than tributaries.

Comparison of sampling results between riverine (spring trip) and predominantly lacustrine conditions (summer and fall trips) showed a transition from Redside Shiners being most abundant in Reaches 1 and 2 in the spring to Mountain Whitefish in summer and back to Redside Shiners in the fall. In Reaches 3 and 4, Prickly Sculpin was most abundant during the spring and fall, while in the summer, Mountain Whitefish were dominant, along with Kokanee and Largescale Sucker. At the tributary sites, Rainbow Trout were dominant in the spring, but Largescale Sucker (adults) were dominant in the summer and sculpins were dominant in the fall.

The following are some additional observations:

- Kokanee numbers increased in all reaches in September compared to May and July as a result of spawners making their way to tributaries. However overall Kokanee numbers in 2012 were the second lowest observed in the five years of the study (2008 = 173; **2012 = 178**, 2010 = 631; 2011 = 780; 2009 = 954).
- Tench numbers in 2012 were lower than in 2011, but still exceeded those in 2008, 2009, and 2010. Five Tench were encountered at five different sites in 2012 compared to eleven captured in 2011, four in 2008, and one in both 2009 and 2010.
- No Common Carp were captured in 2012, the same as 2008, while one was captured in 2011 and 2010, and 11 were captured in 2009.
- White Sturgeon, though known to occur in the study area, were not captured or observed during any of the sampling periods.
- General trends observed at tributary sites in 2012 were that in Trip 1, more fish were caught at the upstream site for Tonkawatla Creek, Begbie Creek, and Jordan River, but at the downstream site for Illecillewaet River and Drimmie Creek. In Trip 2, more fish were caught at the downstream site for Tonkawatla Creek, Begbie Creek, and Jordan River, but at the upstream site

for Illecillewaet River and Drimmie Creek. In Trip 3, sampling could not be completed at the upstream sites of Drimmie Creek and Tonkawatla Creek due to the presence of spawning Kokanee. At the Jordan River and Illecillewaet River, more fish were captured at the downstream site than the upstream site, while at Begbie Creek, more fish were captured at the upstream site than the downstream site.

In 2012, species diversity and evenness were included in the analysis. Species diversity is one of many descriptors of the assemblage structure of different species within a community and is useful when comparing to similar communities or the same community through time. However, the relationship between diversity and the productivity of a system or stability of a population, for example, is unclear (Pope and Kruse 2007). Species diversity analysis included:

1. Species richness: the number of different species captured during each trip,
2. Relative abundance: the number of individuals per species caught and
3. Evenness: the degree of similarity between the relative abundance of different species caught

Using Equations (4) and (5) (Section 2.3) diversity and evenness were calculated for each Reach for all sampling Trips (Figure 3-3).

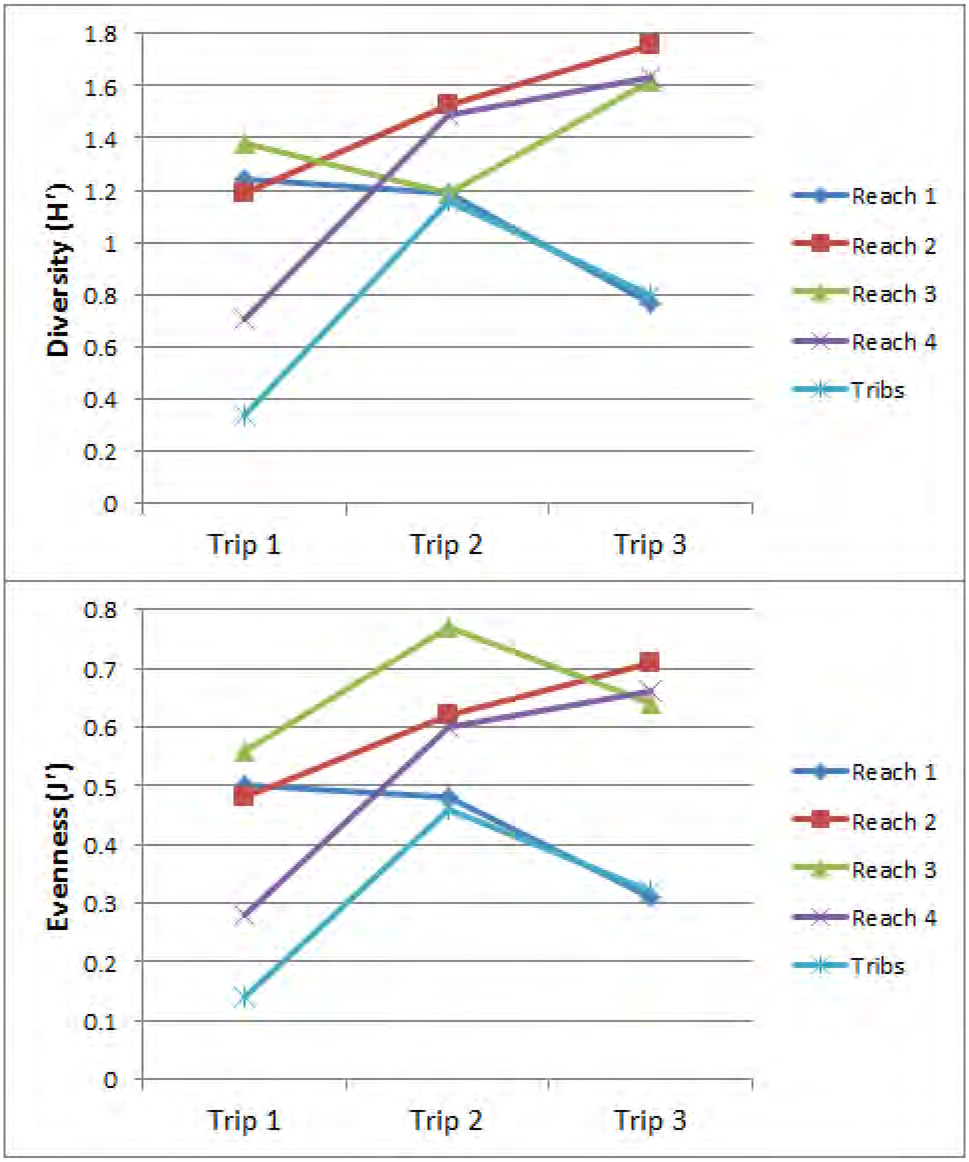


Figure 3-3. Species Diversity and Evenness trends for Year 5 (2012) of CLBMON-17.

Diversity and evenness values for Year 5 were highest in Reach 3 and lowest in the tributaries during the spring. During the summer and fall trips diversity was highest in Reach 2 and lowest in the tributaries (summer) and Reach 1 (fall). Evenness during the summer trip was highest in Reach 3 and lowest in the tributaries while during the fall trip evenness was highest in Reach 2 and lowest in Reach 1.

In Reach 1 diversity and evenness decreased over the three trips, while the opposite trend was observed in Reaches 2 and 4. This suggests that while habitats in Reach 1 became less suitable for several species as it transitioned from riverine (spring) to lacustrine (summer and fall), the opposite occurred in Reaches 2 and 4. Reach 3 had the lowest diversity in Trip 2 which could be related to the high discharge experienced during that trip, potentially making habitats less favourable for some species. Alternatively Reach 3 had the highest evenness in Trip 2 suggesting the species that were present were found in similar abundances. Lastly, tributaries had the highest diversity and evenness in Trip 2 which could suggest increased usage of tributary habitats when mainstem conditions are less favourable.

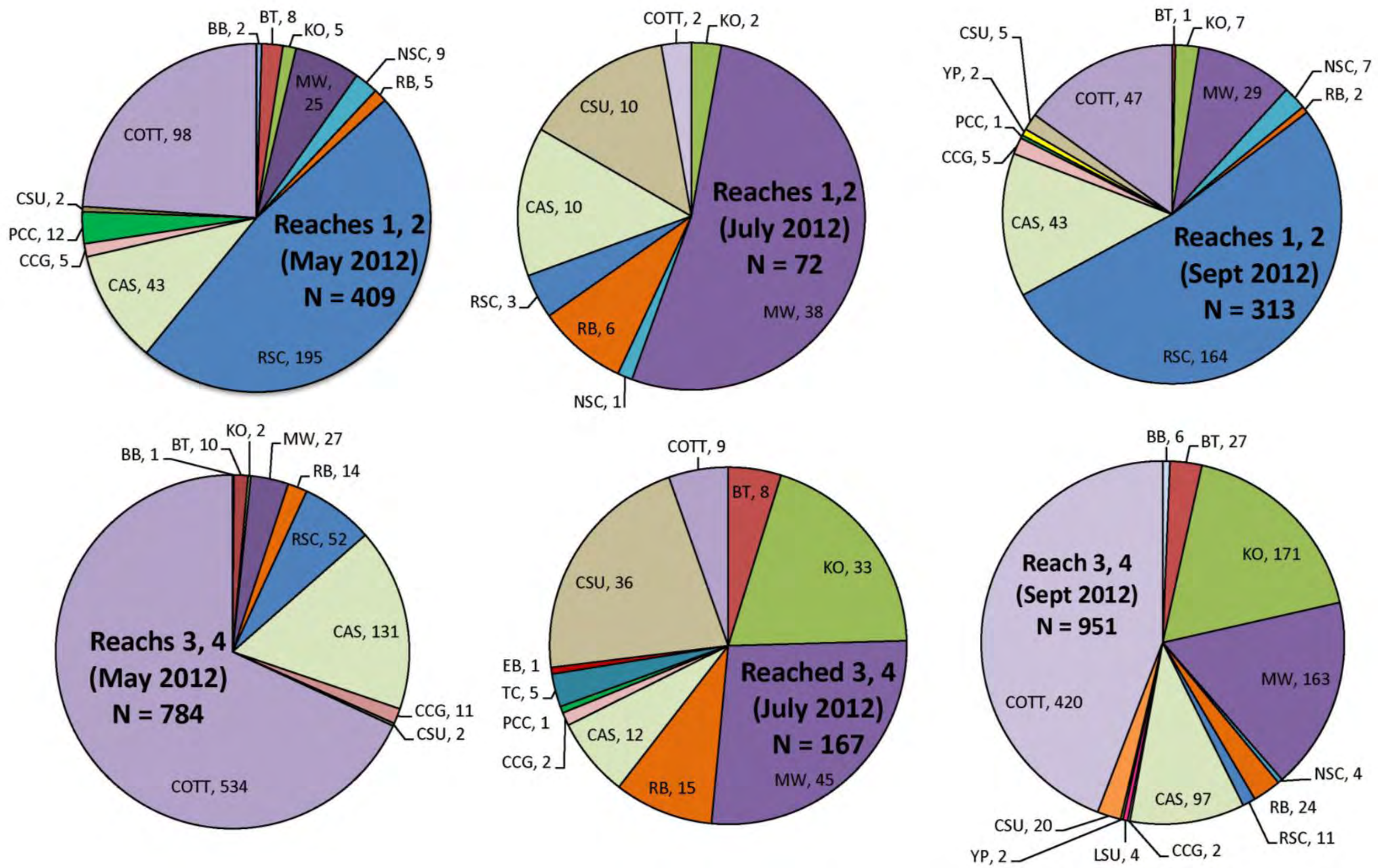


Figure 3-4: Species composition by reach and sampling season (2012). Refer to Table 2-2 for fish species codes. The COTT group is the combination of Prickly, Slimy, and unidentified Sculpin. Reaches 1 and 2 are lacustrine; 3 and 4 are riverine.

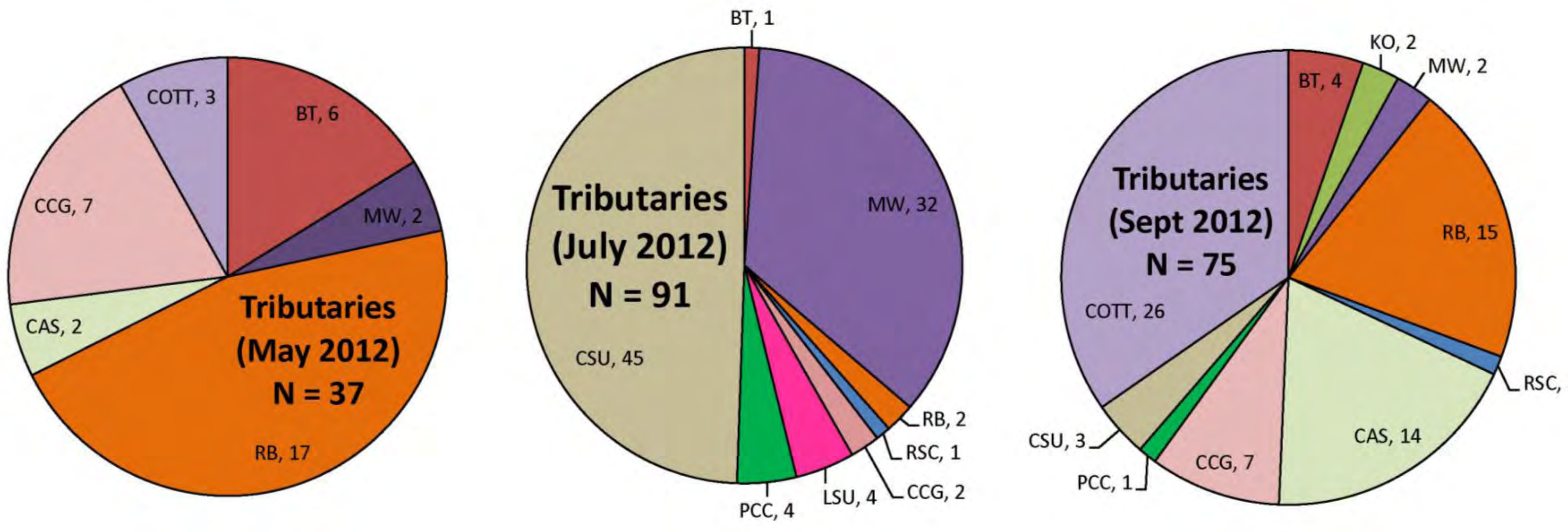


Figure 3-5: Species composition in tributary sites during the three sampling events in 2012. Refer to Table 2-2 for fish species codes. The COTT group is the combination of Prickly, Slimy, and unidentified Sculpin.

3.2.1 SPRING TRIP (MAY/JUNE)

Sampling in Reaches 1 and 2, which are considered to be controls with respect to the influence of dam discharge, resulted in the capture of a total of 409 individuals representing 11 species (Figure 3-4). Redside Shiners were the most abundant species (48 per cent relative abundance), followed by Sculpins (36 per cent) and Mountain Whitefish (6 per cent). The Sculpin specimens included both Prickly Sculpins (11 per cent) and Slimy Sculpins (1 per cent); the remaining 24 per cent were visual observations that were not identified to species. Sampling in Reaches 3 and 4, which are most influenced by dam operation, resulted in the capture of 784 individuals of nine species. Sculpins were the most abundant (86 per cent relative abundance), followed by Redside Shiners (7 per cent). The sculpin specimens included both Prickly Sculpins (17 per cent) and Slimy Sculpins (1 per cent); the remaining 68 per cent were visual observations that were not identified to species. Sampling in the tributaries resulted in the capture of 37 individuals of five species (Figure 3-5). Rainbow Trout were most abundant (46 per cent; all juveniles), followed by Sculpins (32 per cent). The Sculpin specimens included both Prickly Sculpins (5 per cent) and Slimy Sculpins (19 per cent); the remaining 8 per cent were visual observations that were not identified to species.

There were no significant differences in mean number of fishes per site between the reaches in the spring trip (ANOVA: $F = 2.16$, df = 4, $p = 0.085$; Table 3-2). The greatest catch ($n = 96$) was at site 51 in Reach 2 with Redside Shiners being the most abundant ($n = 76$). Fish were not captured at four sites: site Biased 6 in Reach 4, sites 20 and 24 in Reach 3, and the Drimmie Creek "upstream" site.

3.2.2 SUMMER TRIP (JULY)

Sampling in reaches 1 and 2 resulted in the capture of 72 individuals of seven species (Figure 3-3). Mountain Whitefish were the dominant species (53 per cent relative abundance), followed by Sculpins (17 per cent), and Largescale Sucker (14 per cent). Sculpin specimens included Prickly Sculpin (14 per cent); the remaining 3 per cent were visual observations that were not identified to species. Sampling in Reaches 3 and 4 resulted in the capture of 167 individuals of 10 species. Mountain Whitefish were the dominant species (27 per cent relative abundance) followed by Largescale Sucker (22 per cent), Kokanee (20 per cent), and Sculpins (13 per cent). Sculpin specimens consisted of Prickly Sculpin (7 per cent), Slimy Sculpin (1 per cent), and visual observation (5 per cent) that were not identified to species. Sampling in the tributaries in July resulted in the capture of 91 individuals of eight species. Largescale Sucker were the dominant species (49 per cent relative abundance) followed by Mountain Whitefish (35 per cent) (Figure 3-5).

The mean number of fishes captured was significantly higher in Reach 2 than in Reach 4 (ANOVA: $F = 5.46$, df = 4, $p = 0.0008$; Tukey: $p = 0.048$). As well, the mean number of fishes captured was significantly higher in the tributaries than in Reach 4 (ANOVA: $F = 5.46$, df = 4, $p = 0.0008$; Tukey: $p = 0.001$). No other significant differences were detected (Table 3-3). The greatest number of fishes ($n = 20$) was captured at the Drimmie Creek "downstream" site (backwatered from the reservoir), with Largescale Sucker and Mountain Whitefish being the most abundant species ($n = 9$ each). Fish were not captured at nine sites: sites Biased 3, 4, and 6, and sites 8, 12, 13 and 18 in Reach 4, site 52 in Reach 1 and the Jordan River "downstream" site.

3.2.3 FALL TRIP (SEPTEMBER)

Sampling in Reaches 1 and 2 resulted in the capture of 313 individuals of 11 species (Figure 3-4). Redside Shiners were the dominant species (52 per cent relative abundance), followed by Sculpins (30 per cent relative abundance) and Mountain Whitefish (9 per cent). Sculpins consisted of Prickly Sculpin (14 per cent) and Slimy Sculpin (2 per cent); the remaining 37 per cent were visual observations that were not identified to species. Sampling in Reaches 3 and 4 resulted in the capture of 951 individuals representing 12 species. Sculpins were the dominant species (55 per cent relative abundance), followed by Kokanee (18 per cent) and Mountain Whitefish (17 per cent). Sculpins consisted of Prickly Sculpin (10 per cent), Slimy Sculpin (0.2 per cent), and visual observations (44 per cent) that were not identified to species. Sampling in the tributaries resulted in the capture of 75 individuals of nine species (Figure 3-5). Sculpins were the most abundant (63 per cent relative abundance) followed by Rainbow Trout (20 per cent). Sculpin specimens consisted of Prickly Sculpin (19 per cent), Slimy Sculpin (9 per cent), and visual observations (35 per cent) which were not identified to species.

In the fall, the mean number of fishes captured was significantly higher in Reach 3 than in both Reach 4 (ANOVA: $F = 4.04$, df = 4, $p = 0.006$; Tukey: $p = 0.007$) and the tributaries (ANOVA: $F = 4.04$, df = 4, $p = 0.006$; Tukey: $p = 0.038$). No other significant differences were detected (Table 3-3). The greatest number of fishes captured per site in September was at site 33 in Reach 3 ($n = 82$), and the catch was comprised primarily of Sculpins ($n = 69$). Fish were not captured at two sites: site 2 in Reach 4 and site 24 in Reach 3.

Table 3-2: Mean, maximum, and minimum number of fishes caught per site by Reach, May/June 2012.

	Significance[1]	Mean	Max	Min	SD	Number of Sites
Reach 1	A	33.4	91	11	32.9	5
Reach 2	A	20.2	96	3	26.8	12
Reach 3	A	18.3	69	0	20.9	19
Reach 4	A	31.1	95	0	32.4	14
Tributaries	A	3.7	11	0	3.4	10

[1] Reaches with different letters were significantly different from one another. Pair-wise comparisons completed using the Tukey test.

Table 3-3: Mean, maximum, and minimum number of fishes caught per site for sites sampled in July 2012, by Reach

	Significance[1]	Mean	Max	Min	SD	Number of Sites
Reach 1	A/B	8.0	18	0	9.2	3
Reach 2	A	8.0	13	3	3.7	6
Reach 3	A/B	5.2	17	1	4.3	21
Reach 4	B	2.4	9	0	2.6	24
Tributaries	A	9.1	20	0	6.0	10

[1] Reaches with different letters were significantly different from one another. Pair-wise comparisons completed using a Tukey test.

Table 3-4: Mean, maximum, and minimum number of fishes caught per site for sites sampled in September 2012, by Reach

	Significance[1]	Mean	Max	Min	SD	Number of Sites
Reach 1	A/B	24.2	78	2	31.9	5
Reach 2	A/B	19.2	34	6	10.0	10
Reach 3	A	30.0	82	0	21.8	21
Reach 4	B	12.8	42	0	10.3	25
Tributaries	B	9.4	17	1	5.9	8

[1] Reaches with different letters were significantly different from one another. Pair-wise comparisons completed using a Tukey test.

3.2.4 RELATIVE ABUNDANCE BETWEEN TRIPS

There was no significant difference in the mean number of fishes per site between any of the three trips in Reach 1 (ANOVA: $F = 0.70$, df = 2, $p = 0.517$) or Reach 2 (ANOVA: $F = 0.92$, df = 2, $p = 0.411$). A significant difference was observed in Reach 3 (ANOVA: $F = 10.6$, df = 2, $p < 0.001$) with the spring and fall trips being significantly greater than the summer trip (Tukey: p = 0.05 and p < 0.001, respectively). No difference was detected between spring and fall (Tukey: p = 0.10). A significant difference was also observed in Reach 4 (ANOVA: $F = 13.4$, df = 2, $p < 0.001$) with the number of fish per site in the spring trip being significantly greater than both the summer and fall trips (Tukey: p < 0.001 and p = 0.004, respectively). No difference was detected between the summer and fall trips (Tukey; p =0.08). Lastly, a slightly significant difference in mean number of fish per site was detected at the tributary sites between trips (ANOVA: $F = 3.63$, df = 2, $p = 0.041$) but none of the individual comparisons were found to be significant. Both the summer and fall trips were greater than the spring trip and the difference was near significant (Tukey: p = 0.070 for both).

3.3 MORPHOMETRICS

Length and weight data for all captured fishes are provided in the project database (Attachment 1). Summaries for Rainbow Trout, Bull Trout, Mountain Whitefish, Kokanee, Prickly Sculpin, Redside Shiner and Largescale Suckers are provided the subsequent sections. Comparison of results between years of the study will be completed for the Year 6 Synthesis Report.

3.3.1 RAINBOW TROUT

In 2012, data on length and weight were collected from 61 Rainbow Trout, which ranged in length from 67 to 280 mm. The majority of Rainbow Trout captured were considered juveniles (n = 54, 89 per cent). Figure 3-6 shows the length weight regression for Rainbow Trout captured in the Middle Columbia River mainstem in 2012. The regression lines for the 2008–2010 data (red-dashed line) and the combined 2011-2012 data (solid black line) show that length-weight relationship in 2012 was similar to that of 2008-2010 and 2011. This suggests relatively consistent growing conditions for Rainbow Trout in the system since 2008.

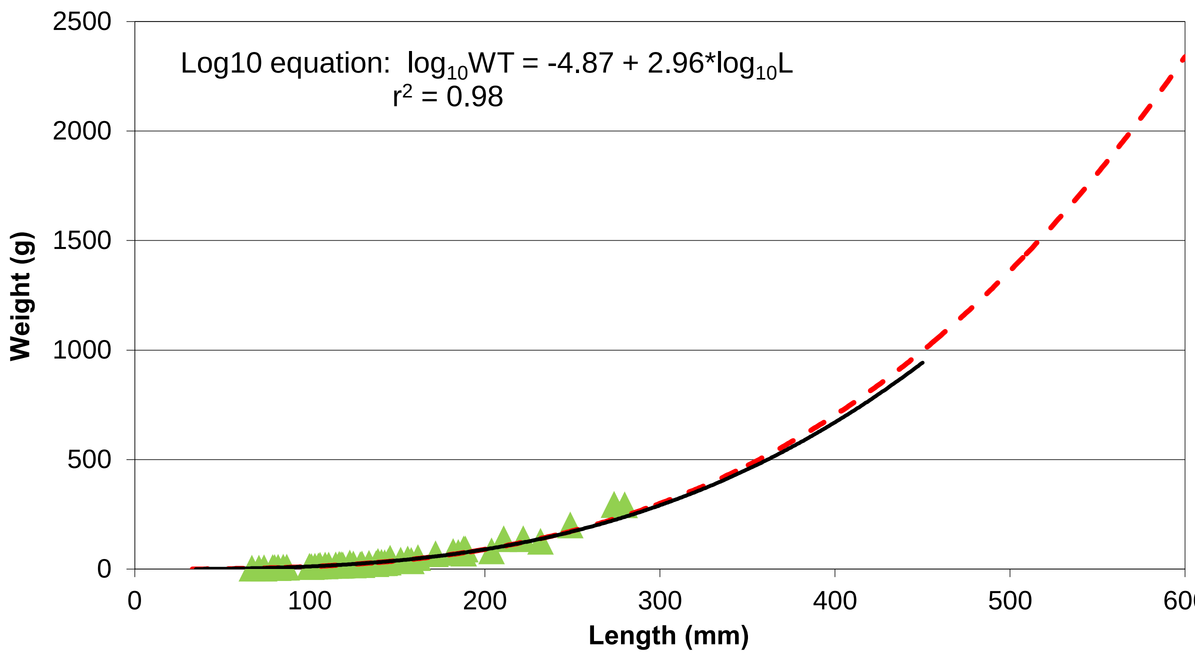


Figure 3-6: Weight–length regression for Rainbow Trout captured during the 2012 field program (*N* = 61). The combined 2008–2010 weight–length regression line (red dashed line) and 2011-2012 regression line (solid black line) are shown for comparison.

Condition factors for juvenile Rainbow Trout captured in 2012 in the mainstem ranged from 0.93 to 1.56, with an overall mean of 1.18 (SD = 0.15, n = 54) for the three sampling trips (Table 3-5). For tributary sites, condition factors for captured juvenile Rainbow Trout ranged from 0.78 to 1.34, with a mean of 1.15 (SD = 0.13, n = 35) for the three sampling trips. Barnham and Baxter (1998) proposed a grading scale for fish condition factor in which a value of 1.2 suggests “a fair fish, acceptable to many anglers”, whereas a value of 1.4 suggests "a good, well-proportioned fish". Values less than 1.0 are considered "poor" and are characterized by long, skinny bodies. Based on this scale, collectively, juvenile Rainbow Trout condition in the Middle Columbia River is considered to be fair to good, suggesting that the fish are well-proportioned in terms of length and weight. Across the three sampling trips, condition factor of juvenile Rainbow Trout tended to be higher in the tributaries and those Reaches closest to the dam (Reaches 3 and 4; Figure 3-7). This may suggest that rearing habitat value is higher in these areas.

Table 3-5. Summary of Condition Factor (K) for Juvenile Rainbow Trout for the three 2012 sampling Trips (Trip 1 = May, Trip 2 = July, Trip 3 = September).

		Spring Trip	Summer Trip	Fall Trip
Reach 1	Mean	1.05	1.13	1.05
	Min	0.94	1.13	1.05
	Max	1.18	1.13	1.05
	SD	0.17	n/a	n/a
	n	3	1	1
Reach 2	Mean	1.00	1.31	1.17
	Min	1.00	1.13	1.17
	Max	1.00	1.56	1.17
	SD	n/a	0.18	n/a
	n	1	5	1
Reach 3	Mean	1.10	1.26	1.19
	Min	0.93	1.03	0.96
	Max	1.39	1.40	1.43
	SD	0.14	0.12	0.15
	n	11	11	16
Reach 4	Mean	1.28	1.07	1.26
	Min	1.28	1.07	1.19
	Max	1.28	1.07	1.33
	SD	n/a	n/a	0.10
	n	1	1	2
Tributaries	Mean	1.15	1.32	1.15
	Min	0.88	1.32	0.78
	Max	1.26	1.32	1.34
	SD	0.12	n/a	0.15
	n	18	1	16

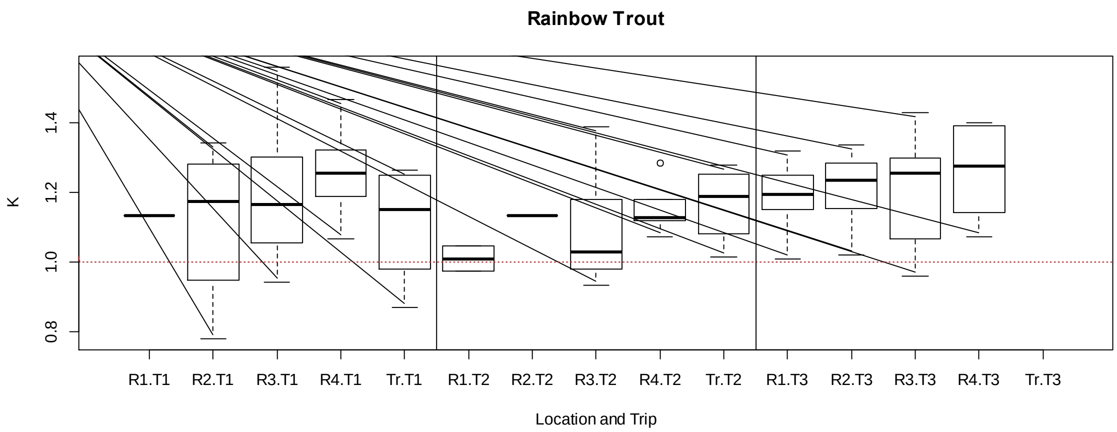


Figure 3-7. Boxplot of condition factor (K) of juvenile Rainbow Trout captured in the Middle Columbia River by Reach (R1-4; "tr" = tributary sites) in 2012 for each of the three sampling trips (T1 = May, T2 = July, T3 = September).

3.3.2 BULL TROUT

In 2012, data on length and weight were collected from 46 Bull Trout, which length from 117 to 650 mm. Half of the individuals (n = 23) were considered juveniles.

Figure 3-8 shows the weight to length regression for Bull Trout captured in the Middle Columbia River mainstem in 2012. The regression lines for the 2008–2010 data (red-dashed line) and 2011-2012 data (solid black line) show that length-weight relationship in 2012 was similar to that of 2008-2010, and 2011. This suggests relatively consistent growing conditions for Bull Trout in the system since 2008.

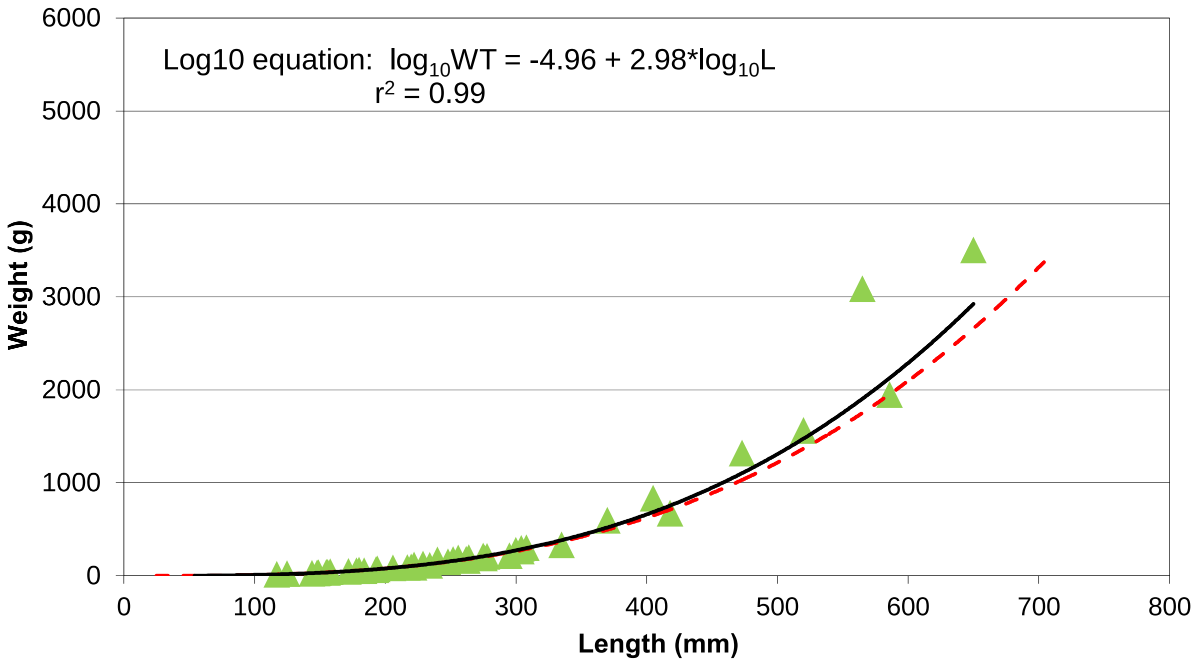


Figure 3-8: Weight–length regression for Bull Trout captured during the 2012 field program (*N* = 46). The combined 2008–2010 weight–length regression line (red dashed line) and 2011-2012 regression line (solid black line) are shown for comparison.

Condition factors for juvenile Bull Trout captured in 2012 in the mainstem ranged from 0.85 to 1.24, with an overall mean of 0.98 (SD = 0.17, n = 23) for the three sampling Trips (Table 3-6). For tributary sites, condition factors for captured juvenile Bull Trout ranged from 0.85 to 1.17, with a mean of 0.96 (SD = 0.15, n = 8) for the three sampling Trips. Individuals captured in 2012 were therefore considered to be of fair condition, suggesting that the fish are adequately-proportioned in terms of length and weight. Across the three sampling trips, condition factors of juvenile Bull Trout tended to be similar across all reaches and the tributary sites (Figure 3-9). This suggests similar rearing conditions across the study area.

Table 3-6. Summary of Condition Factor (K) for juvenile Bull Trout for the three 2012 sampling Trips (Trip 1 = May, Trip 2 = July, Trip 3 = September).

		Spring Trip	Summer Trip	Fall Trip
Reach 1	Mean	0.95	NFC[A]	NFC[A]
	Min	0.89		
	Max	1.01		
	SD	0.08		
	n	2		
Reach 2	Mean	0.97	NFC[A]	NFC[A]
	Min	0.88		
	Max	1.05		
	SD	0.08		
	n	5		
Reach 3	Mean	1.04	0.85	0.97
	Min	0.89	0.85	0.88
	Max	1.20	0.85	1.05
	SD	0.13	n/a	0.12
	n	4	1	2
Reach 4	Mean	0.97	0.98	0.99
	Min	0.92	0.98	0.86
	Max	1.03	0.98	1.24
	SD	0.08	n/a	0.13
	n	2	1	6
Tributaries	Mean	0.90	1.07	1.17
	Min	0.85	1.07	0.96
	Max	0.95	1.07	1.07
	SD	0.04	n/a	0.15
	n	5	1	2

[A]NFC – No Juvenile Fish Caught

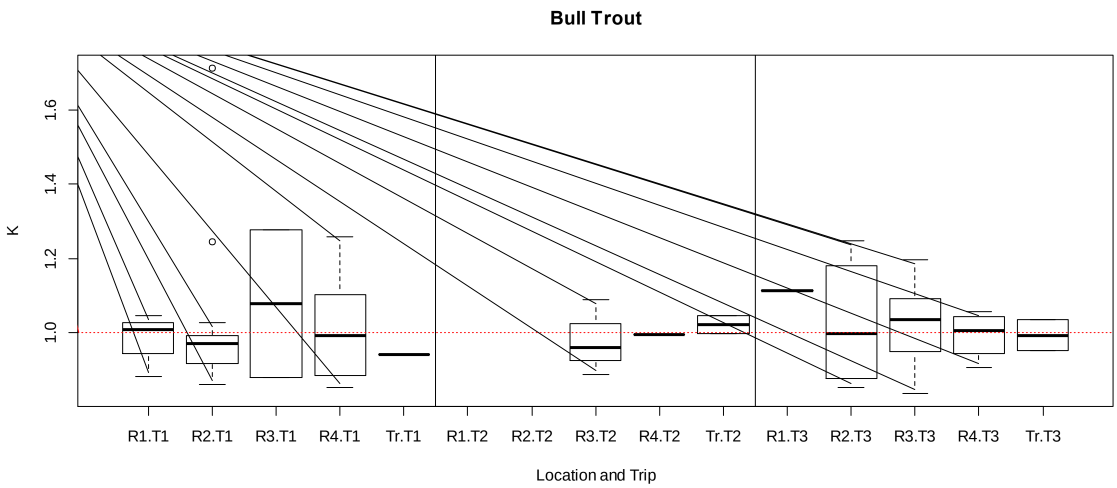


Figure 3-9. Boxplot of condition factor (K) of juvenile Bull Trout captured in the Middle Columbia River by Reach (R1-4; "tr" = tributary sites) in 2012 for each of the three sampling trips (T1 = May, T2 = July, T3 = September).

3.3.3 MOUNTAIN WHITEFISH

In 2012, data on length and weight were collected from 275 Mountain Whitefish, which ranged in length from 48 to 413 mm. Approximately half of the individuals captured in 2012 were considered juveniles (n = 141; 51per cent). Figure 3-10 shows the weight to length regression for Mountain Whitefish captured in the Middle Columbia River mainstem in 2012. The regression lines for the 2008–2010 data (red-dashed line) and 2011-2012 data (solid black line) show that length-weight relationship in 2012 was similar to that of 2008-2010, and 2011. This suggests relatively consistent growing conditions for Mountain Whitefish in the system since 2008.

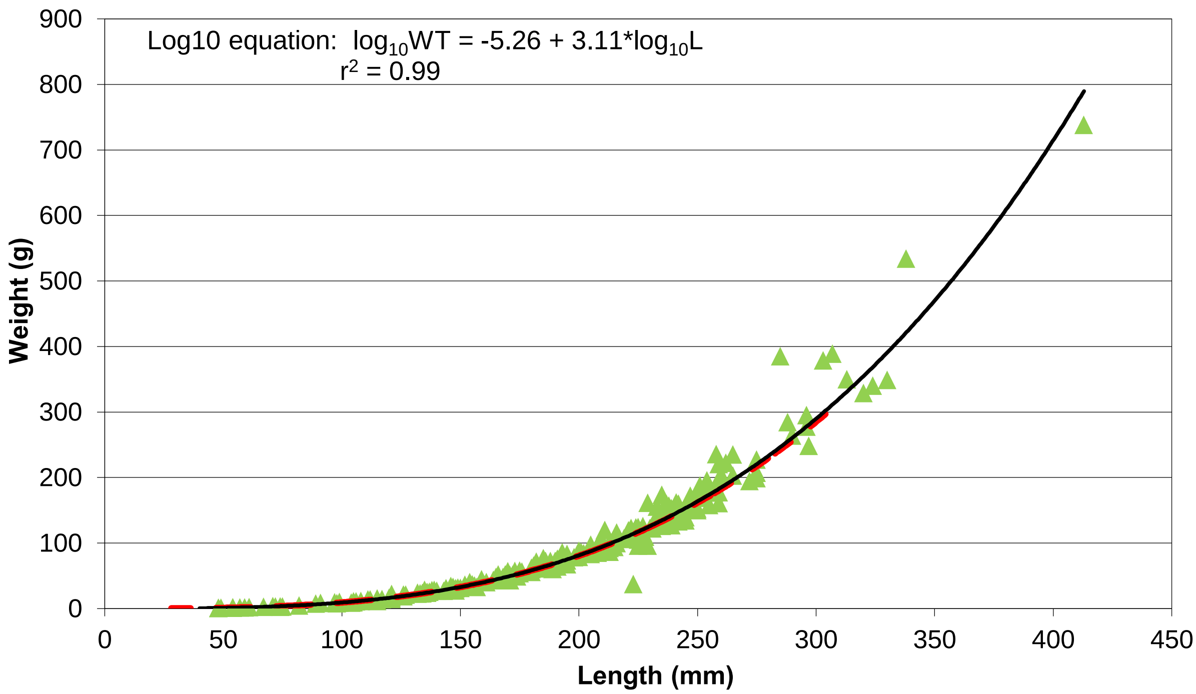


Figure 3-10: Weight–length regression for Mountain Whitefish captured during the 2012 field program (*N* = 275). The combined 2008–2010 weight–length regression line (red dashed line) and 2011-2012 regression line (solid black line) are shown for comparison.

Condition factors for juvenile Mountain Whitefish captured in 2012 in the mainstem ranged from 0.69 to 1.26, with an overall mean of 0.98 (SD = 0.16, n = 143) for the three sampling Trips (Table 3-7). For tributary sites, condition factors for captured juvenile Mountain Whitefish ranged from 1.01 to 1.17, with a mean of 1.08 (SD = 0.17, n = 11) for the three sampling Trips. Individuals captured in 2012 were therefore considered to be of fair to good condition, suggesting that the fish are well-proportioned in terms of length and weight. Eight of the eleven juvenile Whitefish were caught during Trip 2 at the Drimmie Creek upstream site, which marked the elevation limit of the ALR during that Trip.

For all three sampling trips, condition factor of juvenile Mountain Whitefish tended to be higher in Reaches 3 and 4 compared to Reaches 1 and 2 (Figure 3-11). As well, the majority of captures were within Reaches 3 and 4 (n = 94) compared to Reaches 1 and 2 (n = 48). No juveniles were captured in tributaries during Trips 1 and 3.

Table 3-7. Summary of Condition Factor (K) for juvenile Mountain Whitefish for the three 2012 sampling Trips (Trip 1 = May, Trip 2 = July, Trip 3 = September).

		Spring Trip	Summer Trip	Fall Trip
Reach 1	Mean	0.88	1.08	1.03
	Min	0.69	0.98	0.91
	Max	1.10	1.26	1.19
	SD	0.12	0.10	0.12
	n	11	7	5
Reach 2	Mean	0.92	0.94	0.89
	Min	0.76	0.94	0.78
	Max	1.05	0.94	1.06
	SD	0.11	n/a	0.09
	n	8	1	16
Reach 3	Mean	0.91	1.02	1.00
	Min	0.84	0.92	0.83
	Max	1.06	1.18	1.13
	SD	0.07	0.10	0.07
	n	8	6	47
Reach 4	Mean	0.92	1.04	1.05
	Min	0.92	0.92	0.96
	Max	0.92	1.21	1.16
	SD	n/a	0.08	0.06
	n	1	12	21
Tributaries	Mean		1.08	
	Min		1.01	
	Max	NFC[A]	1.17	NFC[A]
	SD		0.05	
	n		11	

[A]NFC – No Juvenile Fish Caught

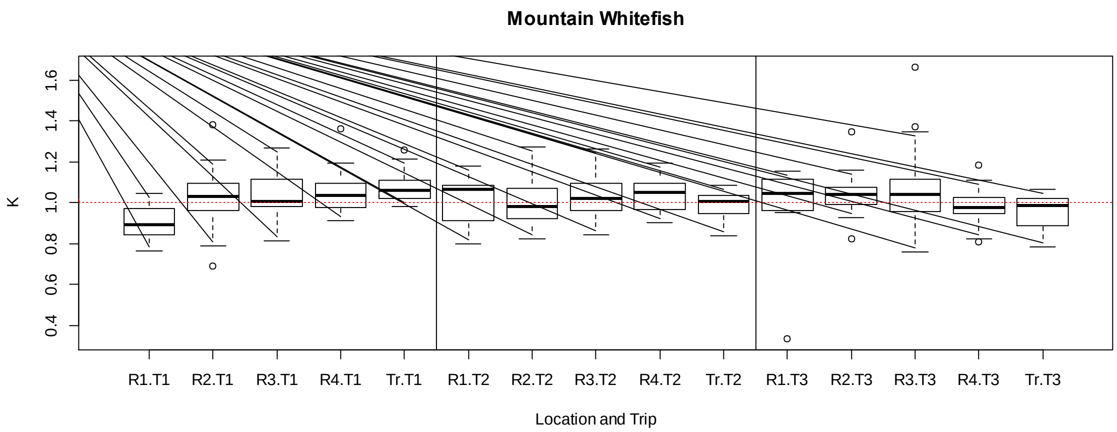


Figure 3-11. Boxplot of condition factor (K) of juvenile Mountain Whitefish captured in the Middle Columbia River by Reach (R1-4; "tr" = tributary sites) in 2012 for each of the three sampling trips (T1 = May, T2 = July, T3 = September).

3.3.4 KOKANEE

In 2012, data on length and weight were collected from 181 Kokanee, which ranged in length from 28 to 296 mm. The majority of Kokanee captured in 2012 were considered juveniles (n = 125; 69per cent). Figure 3-12 shows the weight to length regression for Kokanee captured in the Middle Columbia River mainstem in 2012. The regression lines for the 2008–2010 data (red-dashed line) and 2011-2012 data (solid black line) show that length-weight relationship in 2012 was similar to that of 2008-2010, and 2011. This suggests relatively consistent growing conditions for Kokanee in the system since 2008.

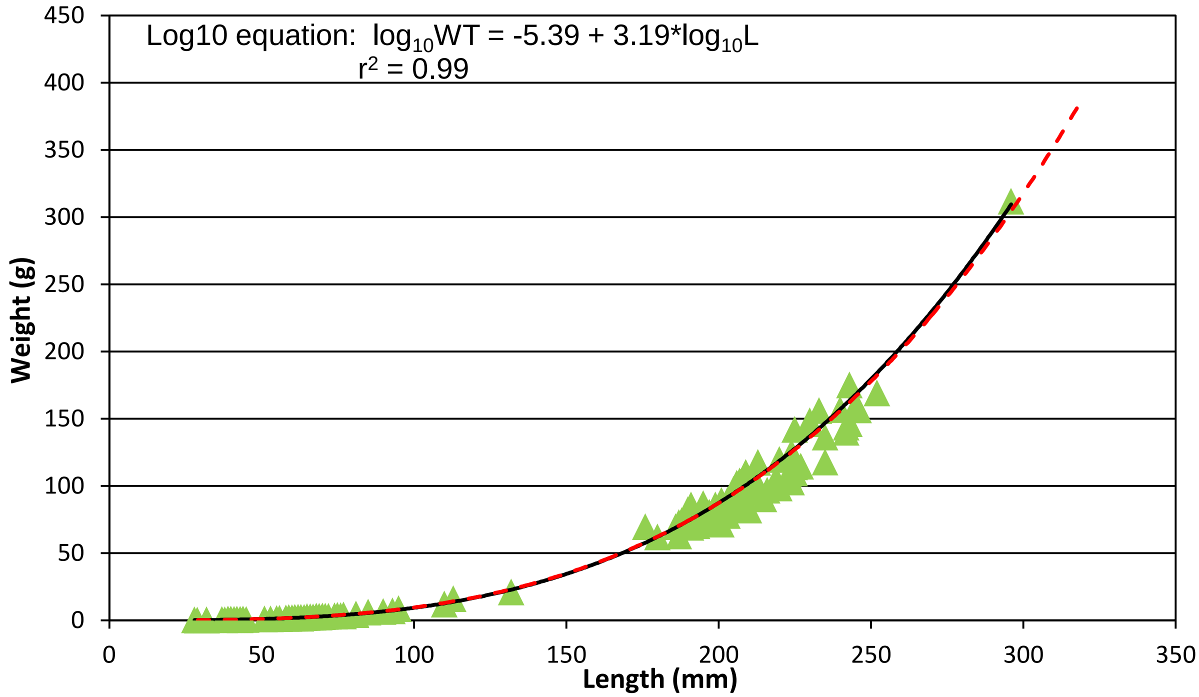


Figure 3-12. Weight–length regression for Kokanee captured during the 2012 field program (N = 181). The combined 2008–2010 weight–length regression line (red dashed line) and 2011-2012 regression line (solid black line) are shown for comparison.

Condition factors for juvenile Kokanee captured in 2012 in the mainstem ranged from 0.45 to 1.46, with an overall mean of 0.90 (SD = 0.15, n = 125) for the three sampling Trips (Table 3-8). Individuals captured in 2012 were therefore considered to be of fair to good condition, suggesting that the fish are well-proportioned in terms of length and weight. No juvenile Kokanee were captured in tributaries in 2012 during the three sampling trips although adult spawners were present in Drimmie Creek and Tonkawatla Creek in Trip 3 at the "upstream" sites. Due to the presence of spawners these sites were not sampled. The majority of juvenile Kokanee were caught in the fall trip (n = 93) compared to the summer (n = 26) and spring (n = 5). For all three sampling Trips, condition factor of juvenile Kokanee appeared to be similar across the mainstem reaches (Figure 3-13).

Table 3-8. Summary of Condition Factor (K) for juvenile Kokanee for the three 2012 sampling Trips (Trip 1 = May, Trip 2 = July, Trip 3 = September).

		Spring Trip	Summer Trip	Fall Trip
Reach 1	Mean	0.83	NFC[A]	NFC[A]
	Min	0.77		
	Max	0.86		
	SD	0.04		
	n	4		
Reach 2	Mean	1.02	0.93	0.84
	Min	1.02	0.93	0.72
	Max	1.02	0.93	0.99
	SD	n/a	n/a	0.09
	n	1	1	7
Reach 3	Mean	NFC[A]	0.92	0.90
	Min		0.45	0.65
	Max		1.46	1.20
	SD		0.23	0.13
	n		23	63
Reach 4	Mean	NFC[A]	0.86	0.90
	Min		0.82	0.72
	Max		0.90	1.28
	SD		0.06	0.15
	n		2	24
Tributaries	Mean	NFC[A]	NFC[A]	NFC[A]
	Min			
	Max			
	SD			
	n			

[A]NFC – No Juvenile Fish Caught

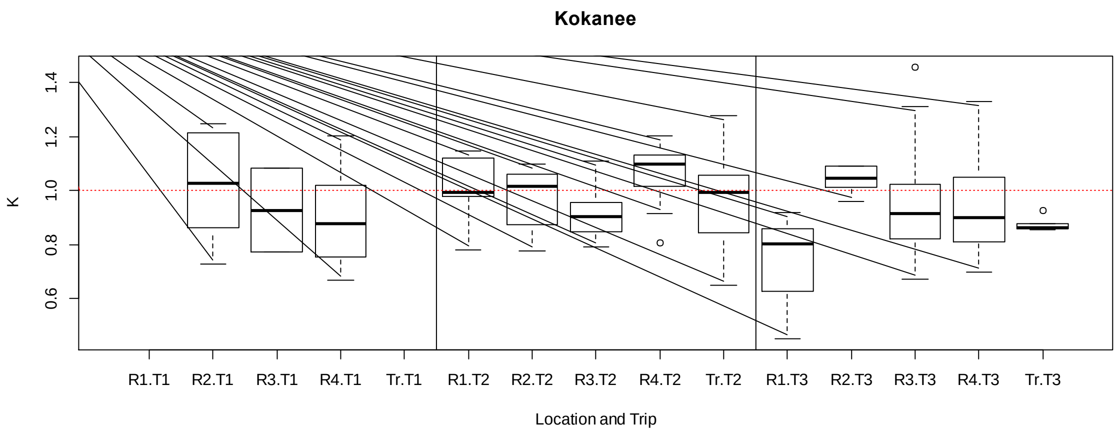


Figure 3-13. Boxplot of condition factor (K) of juvenile Kokanee captured in the Middle Columbia River by Reach (R1-4; "tr" = tributary sites) in 2012 for each of the three sampling trips (T1 = May, T2 = July, T3 = September).

3.3.5 PRICKLY SCULPIN

In 2012, data on length and weight were collected from 339 Prickly Sculpins, which ranged in length from 28 to 145 mm. The majority of individuals captured in 2012 were considered adults (n = 311; 92per cent). Figure 3-14 shows the weight to length regression for Prickly Sculpins captured in the Middle Columbia River mainstem in 2012. The regression lines for the 2008–2010 data (red-dashed line) and 2011-2012 data (solid black line) show that length-weight relationship in 2012 was similar to that of 2008-2010, and 2011. This suggests relatively consistent growing conditions for Prickly Sculpin in the system since 2008.

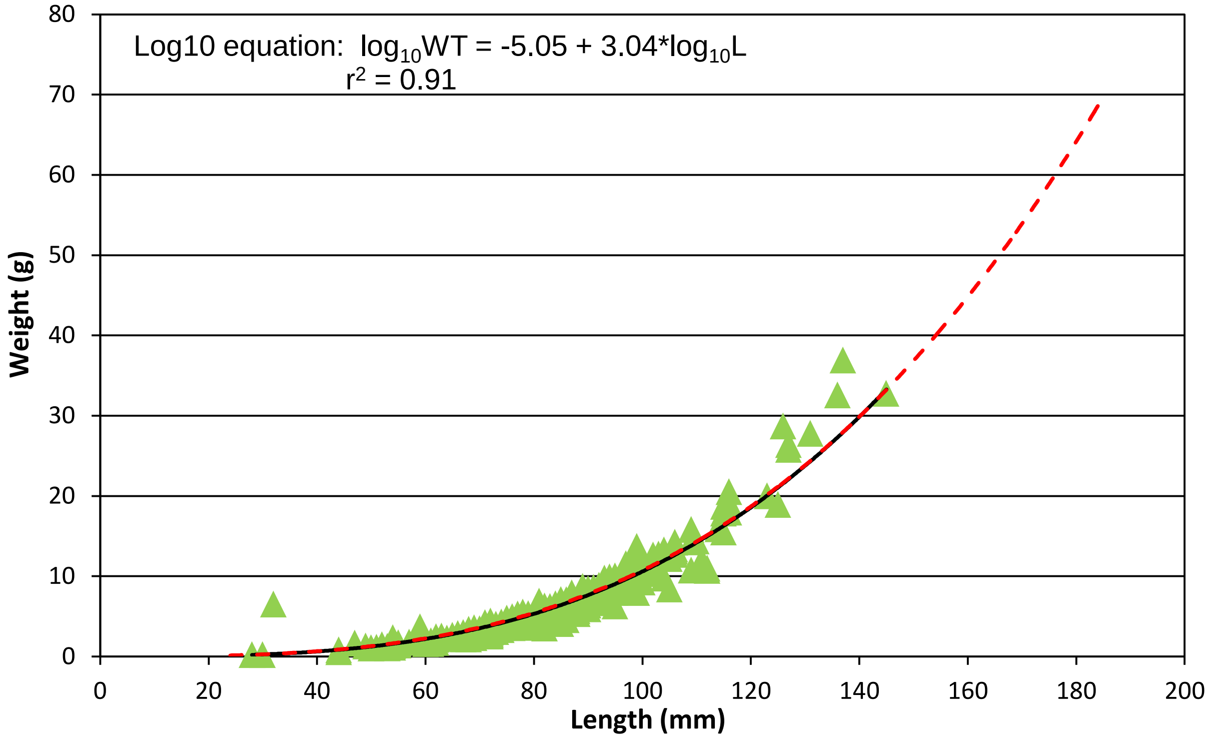


Figure 3-14. Weight–length regression for Prickly Sculpins captured during the 2012 field program (N = 359). The combined 2008–2010 weight–length regression line (red dashed line) and 2011-2012 regression line (solid black line) are shown for comparison.

Relative condition factor (K′) for juvenile Prickly Sculpin captured in 2012 in the mainstem ranged from 0.60 to 1.53, with an overall mean of 0.85 (SD = 0.24, n = 28) for the three sampling trips (Table 3-9). No juvenile Prickly Sculpins were captured in Reach 1 during any of the trips in 2012 and or at the tributaries during Trips 2. Across all three sampling trips, condition factors of juvenile Prickly Sculpin were similar between the reaches.

Table 3-9. Summary of Condition Factor (K) for juvenile Prickly Sculpin for the three 2012 sampling Trips (Trip 1 = May, Trip 2 = July, Trip 3 = September).

		Spring Trip	Summer Trip	Fall Trip
Reach 1	Mean Min Max SD n	NFC[A]	NFC[A]	NFC[A]
Reach 2	Mean	0.65	0.79	1.05
	Min	0.59	0.55	0.73
	Max	0.74	1.36	1.36
	SD	0.08	0.23	0.45
	n	3	9	2
Reach 3	Mean	0.92	0.86	0.72
	Min	0.61	0.83	0.72
	Max	1.53	0.90	0.72
	SD	0.32	0.06	n/a
	n	8	2	1
Reach 4	Mean	0.75	0.79	1.06
	Min	0.60	0.79	0.74
	Max	0.89	0.79	1.38
	SD	0.09	n/a	0.45
	n	7	1	2
Tributaries	Mean	1.15	NFC[A]	0.69
	Min	1.15		0.50
	Max	1.15		0.88
	SD	n/a		0.27
	n	1		2

[A]NFC – No Juvenile Fish Caught

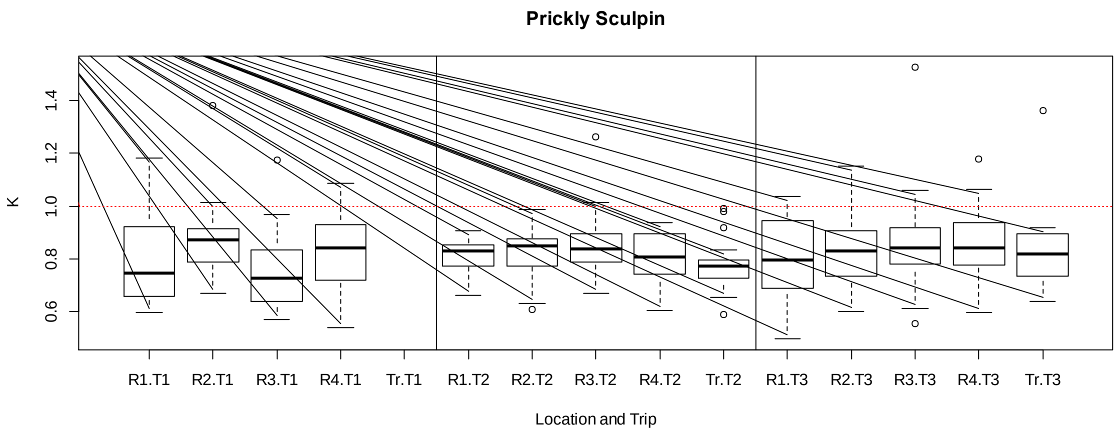


Figure 3-15. Boxplot of condition factor (K) of juvenile Prickly Sculpin captured in the Middle Columbia River by Reach (R1-4; "tr" = tributary sites) in 2012 for each of the three sampling Trips (T1 = May, T2 = July, T3 = September).

3.3.6 Redside Shiner

In 2012, data on length and weight were collected from 217 Redside Shiners, which ranged in length from 45 to 115 mm. The majority of individuals captured in 2012 were adults (n = 180; 83per cent). Figure 3-16 shows the weight to length regression for Redside Shiners captured in the Middle Columbia River mainstem in 2012. The regression lines for the 2008–2010 data (red-dashed line) and 2011-2012 data (solid black line) show that length-weight relationship in 2012 was similar to that of 2008-2010, and 2011. This suggests relatively consistent growing conditions for Redside Shiners in the system since 2008.

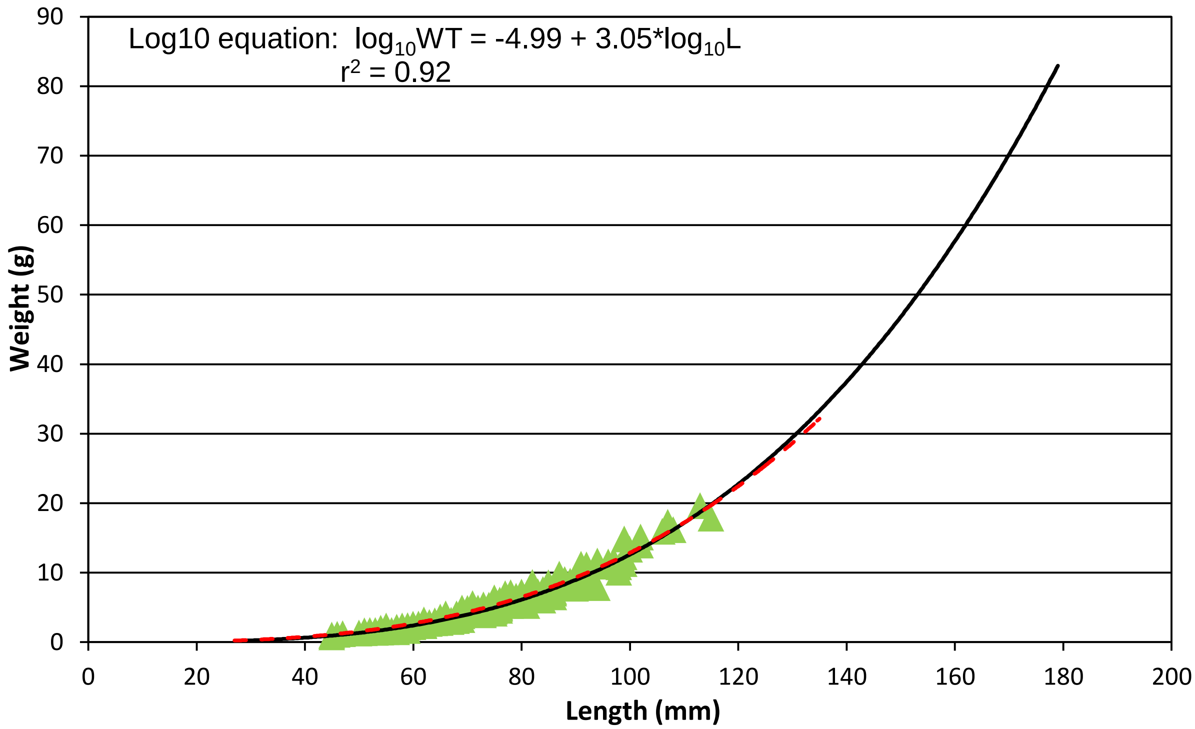


Figure 3-16. Weight–length regression for Redside Shiners captured during the 2012 field program (N = 217). The combined 2008–2010 weight–length regression line (red dashed line) and 2011-2012 regression line (solid black line) are shown for comparison.

Relative condition factors for juvenile Redside Shiners captured in 2012 in the mainstem ranged from 0.66 to 1.16, with an overall mean of 0.89 (SD = 0.12, n = 37) for the three sampling trips (Table 3-10). No juvenile Redside Shiners were captured in Reach 4 during any of the trips, Reach 1 or 3 during Trip 2, or in the tributaries during Trips 1 and 3. Mean condition factors of juvenile Redside Shiners were similar between the reaches and tended to increase from Trip 1 to 3.

Table 3-10. Summary of Relative Condition Factor (K') for juvenile Redside Shiner for the three annual sampling Trips (Trip 1 = May, Trip 2 = July, Trip 3 = September).

		Spring Trip	Summer Trip	Fall Trip
Reach 1	Mean	0.85	NFC[A]	1.02
	Min	0.66		1.02
	Max	0.98		1.02
	SD	0.09		n/a
	n	10		1
Reach 2	Mean	0.82	1.09	1.01
	Min	0.70	1.09	0.93
	Max	0.97	1.09	1.16
	SD	0.12	n/a	0.09
	n	5	1	6
Reach 3	Mean	0.87	NFC[A]	1.10
	Min	0.67		1.10
	Max	0.99		1.10
	SD	0.09		n/a
	n	14		1
Reach 4	Mean	NFC[A]	NFC[A]	NFC[A]
	Min			
	Max			
	SD			
	n			
Tributaries	Mean	NFC[A]	0.71	NFC[A]
	Min		0.71	
	Max		0.70	
	SD		n/a	
	n		1	

[A]NFC – No Juvenile Fish Caught

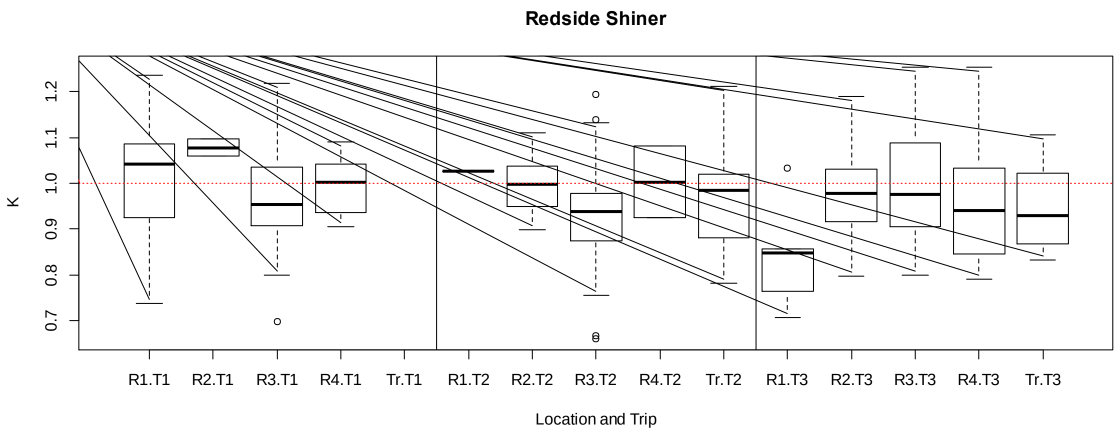


Figure 3-17. Boxplot of relative condition factor (K’) of juvenile Redside Shiner captured in the Middle Columbia River by Reach (R1-4; “tr” = tributary sites) in 2012 for each of the three sampling Trips (T1 = May, T2 = July, T3 = September).

3.3.7 LARGESCALE SUCKER

In 2012, data on length and weight were collected from 59 Largescale Suckers, which ranged in length from 126 to 505 mm. The majority of individuals captured in 2012 were adults (n = 56; 95per cent). Figure 3-18 shows the weight to length regression for Largescale Suckers captured in the Middle Columbia River mainstem in 2012. The regression lines for the 2008–2010 data (red-dashed line) and 2011-2012 data (solid black line) show that length-weight relationship in 2012 was similar to that of 2008-2010, and 2011. This suggests relatively consistent growing conditions for Largescale Suckers in the system since 2008.

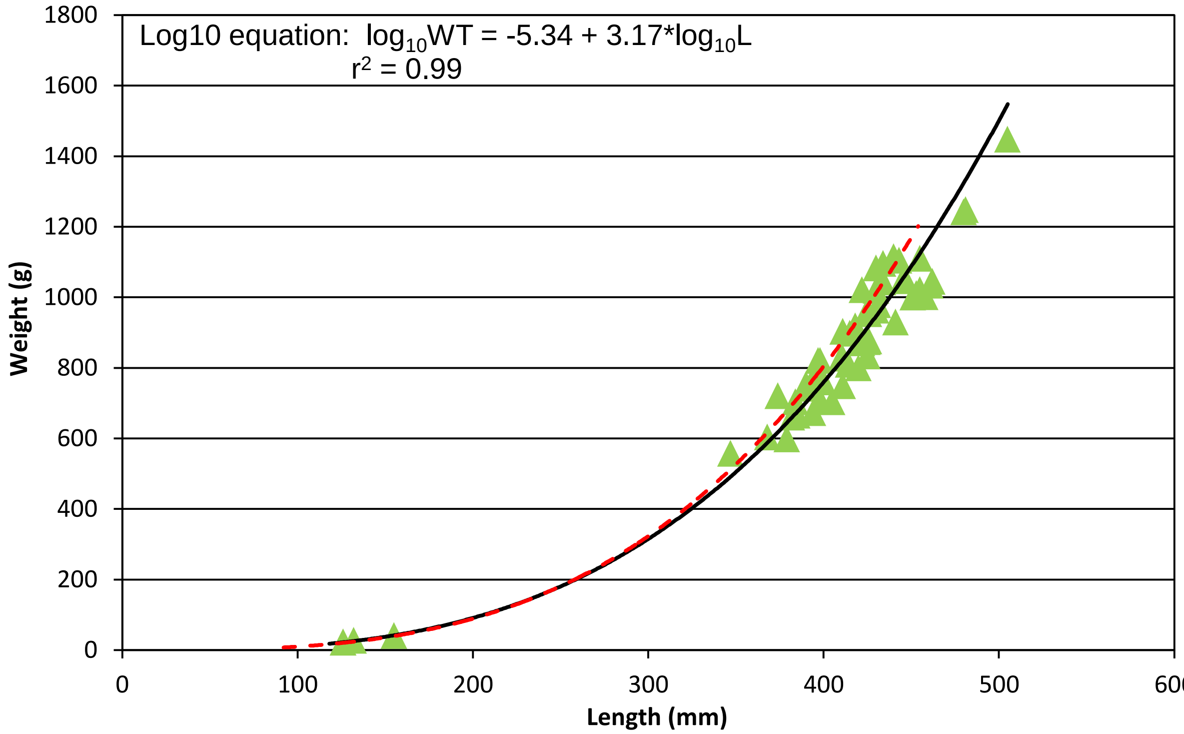


Figure 3-18. Weight–length regression for Largescale Suckers captured during the 2012 field program (N = 59). The combined 2008–2010 weight–length regression line (red dashed line) and 2011-2012 regression line (solid black line) are shown for comparison.

Relative condition factor (K′) for juvenile Largescale Suckers captured in 2012 in the mainstem ranged from 0.49 to 0.53, with an overall mean of 0.51 (SD = 0.02, n = 3) for the three sampling Trips (Table 3-11). Juvenile Largescale Suckers were captured in Reaches 1 (Trip 1), Reach 2 (Trip 3) and 4 (Trip 3) only. The low number of juveniles captured suggests that preferred habitat may not be abundant. However Porter and Rosenfeld (1999) (as cited in McPhail 2007) found, in the Nazko River, that juvenile sucker preferred shallow (0.25 – 0.5 m), low water velocity (0 – 0.1 m/s) habitats over sandy/silt substrates which, in the study area, is represented by several sites Reaches 1 and 2 at. It’s possible that the study program simply doesn’t have enough sites characterized by this type of habitat to facilitate capture of large numbers of juvenile Largescale Sucker.

Table 3-11. Summary of Condition Factor (K) for juvenile Largescale Sucker for the three annual sampling Trips (Trip 1 = May, Trip 2 = July, Trip 3 = September).

		Spring Trip	Summer Trip	Fall Trip
Reach 1	Mean	0.49	NFC[A]	NFC[A]
	Min	0.49		
	Max	0.49		
	SD	n/a		
	n	1		
Reach 2	Mean	NFC[A]	NFC[A]	0.53
	Min			0.53
	Max			0.53
	SD			n/a
	n			1
Reach 3	Mean	NFC[A]	NFC[A]	NFC[A]
	Min			
	Max			
	SD			
	n			
Reach 4	Mean	NFC[A]	NFC[A]	0.50
	Min			0.50
	Max			0.50
	SD			n/a
	n			1
Tributaries	Mean	NFC[A]	NFC[A]	NFC[A]
	Min			
	Max			
	SD			
	n			

[A]NFC – No Juvenile Fish Caught

3.4 CATCH-PER-UNIT-EFFORT

Unlike the annual reports for Years 1 – 4 of CLBMON 17 which used catch-per-unit-effort (CPUE) of juveniles of the three target species (Rainbow Trout, Bull Trout, Mountain Whitefish), Year 5 focuses on CPUE of juveniles of the most abundant species

(Rainbow Trout, Bull Trout, Mountain Whitefish, Kokanee, Sculpins[1], Redside Shiner and Largescale Suckers). As a result of these changes, no comparison with the results of previous years is included in this report. However, as outlined in the Terms of Reference (BC Hydro, 2010) the synthesis report, completed following Year 6, will include analysis of data from all years of the study.

3.4.1 SPRING TRIP (MAY/JUNE)

A total of 393 juvenile fishes of the seven most abundant species were captured during the spring sampling trip in 2012 (367 from the mainstem reaches and 27 from the tributaries; Table 3-12). Mean CPUE per site was not statistically different between any mainstem reaches or tributaries (ANOVA: $F = 1.52$, df = 4, $p = 0.21$). In the mainstem CPUE ranged from a low of 0 (at 10 sites spanning Reaches 2, 3 and 4) to 0.15 fish/second of electrofishing at site 15 in Reach 4. CPUE ranged from 0 at Drimmie Creek "upstream" to 0.052 fish/second of electrofishing at Tonkawatla Creek "upstream".

Table 3-12. Mean, maximum, and minimum CPUE of juvenile fishes captured per site by reach, May 2012.

	Significance[1]	Mean	Max	Min	SD	Number of Fish	Number of Sites[2]
Reach 1	A	0.044	0.125	0.010	0.046	64	5
Reach 2	A	0.013	0.074	0	0.021	45	12
Reach 3	A	0.020	0.075	0	0.023	118	19
Reach 4	A	0.033	0.15	0	0.05	140	14
Tributaries	A	0.014	0.052	0	0.015	27	10

[1] Reaches with different letters were significantly different from one another. Pair-wise comparisons completed using the Tukey test.
[2] Tributary sites included two, 50 m sites (termed "upstream" and "downstream").

3.4.2 SUMMER TRIP (JULY)

A total of 99 juvenile fishes of the seven most abundant species were captured during the spring sampling trip in 2012 (82 from the mainstem reaches and 17 from the tributaries; Table 3-13). Mean CPUE per site was not statistically different between any mainstem reaches or tributaries (ANOVA: $F = 0.91$, df = 4, $p = 0.46$). In the mainstem CPUE ranged from a low of 0 (at 23 sites spanning Reaches 1, 3 and 4) to 0.027 fish/second of

[1] CPUE data for all Sculpin species was combined to maximize the size of the data set. This included Prickly Sculpins, Slimy Sculpins and "Sculpin General" – those that were not able to be captured but were positively identified as belonging to the *Cottus* genus.

electrofishing at site 55 in Reach 1. For tributaries CPUE ranged from 0 at Tonkawatla Creek "upstream" to 0.023 fish/second of electrofishing at Begbie Creek "downstream".

Table 3-13. Mean, maximum, and minimum CPUE of juvenile fishes captured per site by reach, July 2012.

	Significance[1]	Mean	Max	Min	SD	Number of Fish	Number of Sites[2]
Reach 1	A	0.009	0.027	0	0.016	9	3
Reach 2	A	0.005	0.008	0.003	0.002	10	6
Reach 3	A	0.006	0.020	0	0.008	44	21
Reach 4	A	0.003	0.016	0	0.004	19	24
Tributaries	A	0.009	0.044	0	0.014	17	10

[1] Reaches with different letters were significantly different from one another. Pair-wise comparisons completed using the Tukey test.
[2] Tributary sites included two, 50 m sites (termed "upstream" and "downstream").

3.4.3 FALL TRIP (SEPTEMBER)

A total of 368 juvenile fishes of the seven most abundant species were captured during the spring sampling trip in 2012 (348 from the mainstem reaches and 20 from the tributaries; Table 3-14). Mean CPUE per site in Reach 3 was significantly greater than in Reach 4 (ANOVA: $F = 4.74$, df = 4, $p = 0.002$; Tukey: $p = 0.0010$) and the tributaries (ANOVA: $F = 4.74$, df = 4, $p = 0.02$; Tukey: $p = 0.049$). In the mainstem CPUE ranged from a low of 0 (at 11 sites spanning Reaches 1, 3 and 4) to 0.10 fish/second of electrofishing at site 27 in Reach 1. For tributaries CPUE ranged from 0 at Drimmie Creek "downstream" and Jordan River "downstream" to 0.053 fish/second of electrofishing at Begbie Creek "upstream".

Table 3-14. Mean, maximum, and minimum CPUE of juvenile fish captured per site by reach, September 2012.

	Significance[1]	Mean	Max	Min	SD	Number of Fish	Number of Sites[2]
Reach 1	A/B	0.023	0.056	0	0.022	27	5
Reach 2	A/B	0.019	0.042	0.0030	0.016	47	10
Reach 3	A	0.032	0.098	0	0.027	217	21
Reach 4	B	0.009	0.029	0	0.010	57	25

Tributaries	B	0.011	0.053	0	0.017	20	10

[1] Reaches with different letters were significantly different from one another. Pair-wise comparisons completed using the Tukey test.
[2] Tributary sites included two, 50 m sites (termed "upstream" and "downstream").

3.4.4 CPUE between Trips

There were no significant differences in mean CPUE per site in Reaches 1 and 2 as well as the tributaries between the three sampling trips (p = 0.38, p = 0.26, p = 0.77, respectively). For Reach 3, CPUE was significantly higher in the fall compared to the summer trip (ANOVA: $F = 7.88$, df = 2, $p = 0.0009$; Tukey: $p = 0.0006$). For Reach 4 CPUE was significantly higher in spring than in summer (ANOVA: $F = 8.49$, df = 2, $p = 0.0006$; Tukey: $p = 0.005$) and fall (ANOVA: $F = 8.49$, df = 2, $p = 0.0006$; Tukey: $p = 0.0005$). No other significant differences between Reaches over the three Trips were detected ($p > 0.05$).

3.4.5 Before-After-Control-Impact

Before-After-Control-Impact (BACI) is a standard study design for environmental impact assessments to determine if a change has occurred and to estimate the magnitude of the effects (Stewart-Oaten and Bence 2001). The BACI builds upon a basic before-after comparison by including control sites, where presumably no effect of the impact will be felt. Inclusion of the control sites allows for the temporal variation that naturally occurs to be measured. This can then be accounted for in the total change that occurs at the non-control sites (termed "impact" sites), and the residual can be used to quantify the environmental impact.

For the current study, data from Years 1–3 (2008–2010) will form the "before" data set, while data from Years 4–6 (2011–2013) will form the "after" data set. Data from Reaches 1 and 2 are the "controls", while data from Reaches 3 and 4 are the "impacts". The dependent variable that will be used for this analysis will be CPUE of juveniles fish captured in the study area. Due to the change in the focus of the study from three target species in Years 1-3 to all species in Years 4-6, the CPUE from Years 1-3 will be recalculated before this comparison can be completed. This is beyond the scope of the annual technical reports and will be completed for the Year 6 synthesis report.

3.5 HABITAT SUITABILITY FOR JUVENILES

Mainstem sites with the highest CPUE of juveniles of Rainbow Trout, Bull Trout, and Mountain Whitefish for 2008–2012 area summarized in Table 3-15. In addition, sites with the highest CPUE of juvenile Kokanee, Sculpins (*Cottus Sp*.), Redside Shiner and Largescale Sucker from Year 5 are also included. The habitat characteristics of each site (substrate, slope, discharge, depth, and velocity at 0, 1.5, and 3 m from shore) were used to make inferences about the habitat preferences of each species within the study area. The sites included in Table 3-15 in 2012 were the top 3 to 6 highest CPUE sites and constituted at least 33 per cent of the total catch for each species each year (100 per cent for Largescale Suckers in 2012).

Sites with the highest juvenile Bull Trout CPUE in 2012 tended to be steep and dominated by coarse substrates (gravel/cobble: 4 site; bedrock: 1 site). Mean depths in 2012 ranged from 0 m to 2.57 m, which was shallower than in 2011 (0 m to 2.90 m), deeper than in 2008 to 2010 (0 m to 1.49 m in 2008; 0 m to 1.37 m in 2009; 0 m to 1.59 m in 2010). This can be attributed to the one bedrock-dominated site (site 44) which is deeper than the sites where Bull Trout CPUE was highest in years 2008 to 2010. Velocities in 2012 ranged from 0 m/s at the shoreline to 0.39 m/s at 3 m from shore, which was higher than in all previous years. As in 2011, none of the sites had high CPUE in more than one Trip in 2012, which suggests there was a lack of site fidelity and opportunistic habitat use. Bull Trout are piscivorous and habitat used is often influenced by the presence of other fish species (McPhail, 2007). There was only one site in 2012 where more than one Bull Trout juvenile were captured compared to 15 sites in 2011 , 24 sites in 2010, 13 sites in 2009, and four sites in 2008.

The majority of the top Rainbow Trout ranked sites in 2012 (3 of 5 sites) were steep rip-rap sights, while the remaining two were dominated by bedrock. This is consistent with previous years. Mean depths in 2012 ranged from 0 m at the shore to 2.69 m at 3 m from shore. Depths at each station from shore (0 m, 1.5 m, and 3 m) were similar compared to previous years. Similarly, mean velocities were comparable to those of previous years. Two of the five top ranked sites in 2012 (sites 34 and 35) have, except for 2009, consistently been in the top –five ranked sites for CPUE in each year of the study regardless of Trip. Both of these sites consist of steep, rip-rap substrates (D_{95} 100 to 200 cm). These results suggest possible site fidelity and that juvenile Rainbow Trout in the study area show an affinity for coarse substrates (i.e., rip-rap and bedrock). This is consistent with observations in other systems such the Skagit river (Washington), where juvenile Rainbow Trout were found to be more abundant along banks with boulder-size rip-rap (~25.6 cm) than along natural banks (Beamer and Henderson, 1998 as cited in Quigley and Harper, 2004).

The CPUE of juvenile Mountain Whitefish at the highest ranked sites in 2012 was less than all previous years of the study (Table 3-15). Habitat conditions in 2012 at the highest ranked sites were represented by four of the seven habitat classes (rip-rap, steep fines, steep gravel/cobble and low gravel/cobble). This was consistent with previous years with Mountain Whitefish in the study area showing an apparent affinity for steeper-slopped sites. The only exception to this was Biased 1 in 2012, site 19 in 2011 and site 27 in 2009, which were all low-gradient gravel and cobble shorelines. Depths in 2012 ranged from 0 m to 1.29 m and velocities ranged from 0 m/s to 0.26 m/s which was deeper and faster than the majority of previous years. Literature review suggests Mountain Whitefish make use of a wide range of habitats which is consistent with observations from the Middle Columbia. McPhail (2007) suggests adults favour shallower habitats in the spring (i.e. < 1.0 m) and deeper habitats (i.e. > 1 m) in the summer and fall with coarse substrates are preferred over fines. Juveniles are more likely to be found in glides and runs, as opposed to riffles and backwaters, with larger substrates and moderate currents (0.25 – 0.60 m/s) (McPhail, 2007). Lastly, young-of-year tend to be found in shallow water (<0.5 m) with fine gravel or sand substrates (McPhail, 2007).

The CPUE of juvenile Kokanee at the highest ranked sites in 2012 ranged from 0.026 to 0.098 fish/second of electrofishing (Table 3-15). Site 27 (Reach 3) CPUE was the highest compared to all other sites across the reaches through the three trips with nearly five times the CPUE of the next highest site (site 4, Reach 4). Site 27 consisted of gravel-cobble substrates with shallow (0 m to 0.26 m) depths and slow velocities (0 m/s to 0.05 m/s). The other top ranked sites were deeper and faster than site 27.

The CPUE of juvenile Sculpins at the four highest-ranked sites in 2012 ranged from 0.06 to 0.15 fish/second of electrofishing (Table 3-15). All four sites were located in Reaches 3 (site 33, Trips 1 and 3) and 4 (site 15 and Biased 7) with the top four sites accounting for 33 per cent of the total juvenile Sculpin catch. Depths at these four sites ranged from 0 m at the shoreline to 1.53 m at 3 m from shore while velocities ranged from 0 m/s at the shoreline to 0.48 m/s at 3 m from shore. Substrates at these sites consisted of steep gravel/cobble and rip-rap. Between the highest ranked sites, the majority of Sculpin were caught at those sites where water velocities were faster (sites 15 and Biased 7 in Reach 4). This is typical of Sculpin in the Columbia River. R.L. & L Environmental Services Ltd (1995a) found that Sculpins in the Columbia River below Keenleyside Dam were associated with boulder substrates and average water velocities of 0.34 m/s (McPhail, 2007).

The CPUE of juvenile Redside Shiners at the four highest-ranked sites in 2012 ranged from 0.04 to 0.10 fish/second of electrofishing (Table 3-15). Additionally, site 55 was represented twice – Trip 1 and 3. The four highest-ranked capture sites were located in Reaches 1 (site 55), 2 (site 51) and 3 (site 32) and represented 77 per cent of the total juvenile Redside Shiner catch. Depths at these four sites ranged from 0 m at the shoreline to 2.04 m at 3 m from shore and velocities ranged from 0 m/s at the shoreline to 0.13 m/s at 3 m from shore. Most fish were caught at sites with low to no velocities. Three of the top four sites had steep bedrock substrates with the fourth consisting of steep gravel/cobble substrates. The majority of Redside Shiners captured were associated with deep, bedrock-dominated sites with near zero water velocities which is consistent with reviewed literature (McPhail, 2007).

The CPUE of juvenile Largescale Sucker in 2012 was the lowest of the seven target species and ranged from 0.0029 to 0.0033 fish/second of electrofishing (Table 3-15). Only four juveniles were captured in 2012 over four sites in Reach 1 (sites 52 and 55, Trip 1), Reach 2 (site 51, Trip 3) and Reach 4 (site 9, Trip 3). Depths ranged from 0 m at the shore to 2.33 m at 3 m from shore while water velocities ranged from 0 m/s to 0.18 m/s. Three of the four individuals captured were associated with steep bedrock substrates while the fourth was captured over steep gravel/cobble substrates. Literature on the habitat preferences of juvenile Largescale Sucker British Columbia is limited but juveniles seem to prefer relatively shallow (< 0.5 m), slow-water (<0.1 m/s) areas over gravel/fines substrates (McPhail, 2007).

3.5.1 TRIBUTARIES

Juvenile Rainbow Trout captured in tributaries in 2012 accounted for 37% of the total juvenile Rainbow Trout catch. This was the higher than all previous years: (2011 and 2010: 27% ; 2009: 34% and 2008: 26%). Additionally, nearly one-quarter of all juvenile Rainbow Trout captured in 2012 were located at two tributary sites: Begbie "upstream" site (n=12, Trip 3) and Tonkawatla "upstream" site (n=9, Trip 1). Juvenile Bull Trout captured in tributaries in 2012 accounted for 32 per cent of the total juvenile Bull Trout catch. This was higher than all previous years: 2011: 18%, 2010: 15%, 2009: 29% and 2008: 28%. Juvenile Mountain Whitefish captured in tributaries in 2012 accounted for 8% of the total catch. This was the median value compared to previous years' proportions with 2011 and 2008 having lower catch proportions (4% and 7%) and 2008 and 2010 having higher proportions caught in the tributaries (18% and 16%). In general, habitat conditions in the tributaries are considered favourable for both Rainbow Trout and Bull Trout, both of which are strongly associated with higher velocity, steeper, riffle-pool habitats found in several of the tributaries (McPhail, 2007). Alternatively Mountain Whitefish, which tend to prefer deeper water, were less abundant in the tributaries than in the mainstem.

No juvenile Kokanee or Largescale Sucker were captured or observed during the 2012 field season in the five sampled tributaries. However, sampling was not carried out in two "upstream" tributary sites during Trip 3 due to the presence of spawning adult Kokanee. This result was not unexpected as rearing juvenile Kokanee typically prefer off-shore, lacustrine habitat over fluvial habitat (McPhail, 2007). Juvenile Sculpin captured in tributaries accounted for just 1.5 percent of the total catch of Sculpin species in 2012. The number of sites where all the individuals were captured, in turn, represented only 14 percent of the total number of sites sampled in 2012. Juvenile Redside Shiner captured in tributary sites in 2012 represented just 1% (n=1) of the total juvenile Redside Shiner catch (n=103) with Begbie "downstream", during the summer Trip, being the site where the individual was collected. Additionally, during the summer, the downstream Begbie site was classed as reservoir morphology as the elevation of the ALR was near its peak as opposed to riffle-pool as in the spring and fall Trips.

Habitat preferences of juveniles of the target species are summarized in Table 3-16.

Table 3-15: Habitat characteristics of sites with the highest catch-per-unit-effort (CPUE) of juveniles of the seven most abundant species for 2008 – 2012.

Year	Site	Trip	CPUE	Habitat[1]	Discharge (m^3/s)	Mean Depth (m) at station from shore: 0 m	1.5 m	3 m	Mean Vel. (m/s) at station from shore: 0 m	1.5 m	3 m
Bull Trout											
2008	22	2	0.010	Steep G/C	463	0.08	0.59	0.93	0	0	0
	Bias 3	2	0.007	Steep G/C	264	0	0.43	0.83	0	0	0.03
	19	2	0.004	Low G/C	539	0.07	0.43	0.57	0	0.01	0.09
	21	3	0.005	Bedrock	757	0.67	1.18	1.49	0.20	0.25	0.38
2009	31	2	0.013	Steep Fine	403	0	0.41	0.70	0	0.08	0.13
	23	2	0.007	Steep G/C	16	0	0.50	1.15	0	0	0
	36	2	0.007	Steep Fine	16	0	0.63	1.00	0	0	0
	27	3	0.006	Low G/C	13	0	0.50	0.55	0	0	0.02
	38	2	0.006	Steep Fine	16	0	0.93	1.37	0	0	0
	39	2	0.006	Steep Fine	16	0	0.62	1.00	0	0	0
2010	28	1	0.015	Steep Fine	19	0	0.42	0.58	0	0.13	0.21
	Bias 7	3	0.014	Bedrock	420	0	0.90	1.59	0	0.18	0.27
	22	1	0.014	Steep G/C	318	0	0.43	0.83	0	0.04	0.07
	22	2	0.012	Steep G/C	95	0	0.38	0.71	0	0	0
2011	47	1	0.012	Bedrock	154	0	1.12	2.01	0	0.03	0
	8	3	0.009	Steep B	598	0	0.47	0.88	0	0.10	0.20
	26	1	0.008	Rip-rap	1284	0	0.80	1.37	0	0.10	0.24
	28	1	0.008	Steep Fine	159	0	0.43	0.62	0	0.12	0.12
	10	3	0.008	Bedrock	604	0	1.72	2.90	0	0.18	0.27
2012	44	1	0.0060	Bedrock	603	0	0.72	2.57	0	0.14	0.19
	23	1	0.0045	Steep G/C	1058	0	0.57	1.00	0	0.07	0.12
	3	3	0.0041	Steep G/C	1268	0	0.55	1.06	0	0.21	0.39
	42	1	0.0040	Steep G/C	230	0	0.35	0.59	0	0.01	0.01
	Biased 5	2	0.0036	Steep G/C	1629	0	0.31	0.62	0	0.01	0.08
Rainbow Trout											
2008	35	2	0.015	Rip-rap	267	0.12	1.28	> 2	0	0	0
	34	1	0.013	Rip-rap	1217	0	1.04	1.86	0	0.06	0.14
	44	3	0.009	Bedrock	636	0	0.88	1.65	0	0	0
	26	2	0.009	Rip-rap	585	0	0.43	1.27	0	0	0
	29	3	0.009	Rip-rap	596	0	0.57	1.20	0	0.06	0.09
	35	3	0.009	Rip-rap	9	0.12	0.93	2.00	0	0.01	0.01
2009	55	1	0.019	Bedrock	998	0	0.76	1.51	0	0	0
	48	2	0.017	Steep G/C	785	0.03	0.87	1.20	0	0	0
	55	2	0.015	Bedrock	272	0	0.60	1.07	0	0	0
	67	1	0.013	Rip-rap	330	0.02	1.19	1.70	0	0.07	0.11
	30	2	0.009	Rip-rap	979	0	0.83	1.57	0	0.06	0.09
	47	2	0.009	Bedrock	16	0	1.33	1.87	0	0	0
2010	35	3	0.056	Rip-rap	338	0	1.01	2.20	0	0.10	0.18
	47	2	0.042	Bedrock	441	0.03	0.91	1.90	0	0	0
	29	2	0.034	Rip-rap	336	0	0.31	0.99	0	0.01	0.19
	34	2	0.034	Rip-rap	338	0	0.84	1.65	0	0.02	0.05

Year	Site	Trip	CPUE	Habitat[1]	Discharge (m^3/s)	Mean Depth (m) at station from shore: 0 m	1.5 m	3 m	Mean Vel. (m/s) at station from shore: 0 m	1.5 m	3 m
2011	35	2	0.035	Rip-rap	459	0	0.76	2.04	0	0.01	0.03
	35	1	0.031	Rip-rap	154	0	0.74	1.80	0	0.10	0.21
	30	1	0.025	Rip-rap	153	0	0.79	1.46	0	0.17	0.34
	44	2	0.024	Bedrock	1275	0.03	0.99	1.92	0	0	0
	47	2	0.024	Bedrock	1569	0	0.93	1.81	0	0.02	0.02
	34	2	0.021	Rip-rap	427	0	0.89	1.48	0	0	0
2012	34	3	0.017	Rip-rap	1318	0	0.63	1.40	0	0.15	0.18
	35	2	0.011	Rip-rap	434	0	0.57	2.69	0	0	0
	26	3	0.011	Rip-rap	715	0	0.78	1.48	0	0.01	0.10
	55	1	0.010	Bedrock	671	0	0.65	2.04	0	0.03	0.02
	21	1	0.008	Bedrock	920	0	1.17	1.50	0	0.34	0.70
Mountain Whitefish											
2008	42	1	0.058	Steep G/C	1571	0	0.33	0.55	0	0.02	0.24
	10	2	0.020	Bedrock	268	0.65	4.00	> 2	0.02	0.18	0.34
	11	3	0.027	Bedrock	813	0	0.50	1.28	0	0.03	0.19
	22	1	0.032	Steep G/C	261	0	0.42	0.85	0	0.05	0.07
	55	1	0.030	Bedrock	1527	0	0.75	> 2	0	0.03	0.06
2009	27	3	0.155	Low G/C	13	0	0.50	0.55	0	0	0.02
	45	3	0.144	Steep G/C	13	0	0.56	0.89	0	0	0.01
	23	2	0.117	Steep G/C	16	0	0.50	1.15	0	0	0
2010	43	3	0.157	Steep Fine	961	0	0.61	0.87	0	0	0
	Bias 5	3	0.105	Steep G/C	23	0	0.30	0.42	0	0.02	0.10
	31	3	0.072	Steep Fine	981	0	0.22	0.49	0	0.15	0.21
	10	3	0.064	Bedrock	23	0	0.77	1.58	0	0.02	0.07
2011	56	1	0.159	Steep Fine	250	0	0.53	0.85	0	0	0
	19	2	0.151	Low G/C	313	0	0.31	0.46	0	0.04	0.05
	20	3	0.101	Steep G/C	323	0.11	0.30	0.45	0.03	0.02	0.08
	53	1	0.100	Steep Fine	1225	0	0.33	0.48	0	0	0.01
2012	30	3	0.048	Rip-rap	961	0	0.37	0.97	0	0.01	0.26
	53	3	0.034	Steep Fine	1650	0.41	0.61	0.77	0.01	0.01	0.01
	20	3	0.030	Steep G/C	741	0.27	0.51	0.70	0.12	0.20	0.20
	43	3	0.028	Steep Fine	1668	0.19	0.69	1.01	0	0.01	0.14
	29	3	0.027	Rip-rap	961	0	0.56	0.88	0	0.08	0.23
	Biased 1	3	0.025	Low G/C	1268	0	0.40	1.29	0	0.06	0.05
Kokanee											
2012	27	3	0.098	Low G/C	1281	0	0.15	0.26	0	0.02	0.05
	4	3	0.027	Steep B	1268	0	0.63	1.64	0	0.33	0.65
	37	3	0.026	Steep Fine	1478	0	0.58	0.94	0	0.16	0.25
Sculpins											
2012	15	1	0.15	Steep G/C	312	0	0.69	1.18	0	0.30	0.48
	Biased 7	1	0.11	Rip-rap	317	0	0.63	1.53	0	0	0.25
	33	3	0.07	Steep G/C	891	0	0.52	1.42	0	0.20	0.37
	33	1	0.06	Steep G/C	155	0	0.77	1.29	0	0.25	0.41
Redside Shiner											
2012	55	1	0.10	Bedrock	671	0	0.65	2.04	0	0.01	0.02
	51	1	0.07	Bedrock	557	0	0.84	1.47	0	0	0
	55	3	0.05	Bedrock	1642	0	0.73	1.63	0	0	0
	32	1	0.04	Steep G/C	155	0	0.63	1.24	0	0.09	0.13

Year	Site	Trip	CPUE	Habitat[1]	Discharge (m^3/s)	Mean Depth (m) at station from shore: 0 m	1.5 m	3 m	Mean Vel. (m/s) at station from shore: 0 m	1.5 m	3 m
Largescale Sucker											
2012	51	3	0.0033	Bedrock	1659	0	0.78	1.47	0	0	0
	55	1	0.0033	Bedrock	671	0	0.65	2.04	0	0.01	0.02
	9	3	0.0033	Steep G/C	1489	0	0.58	1.01	0	0.15	0.18
	52	1	0.0029	Bedrock	574	0	1.12	2.33	0	0.01	0.04

[1] G/C = Gravel/Cobble; B = Boulder

Table 3-16: Summary of velocity and substrate of sites with the highest density of the seven most abundant species based on the 2008–2012 sampling results[2]

Species	Preferred velocities	Preferred substrates
Bull Trout	0–0.38 m/s	Fines and Gravel/cobble
Rainbow Trout	0–0.34 m/s	Rip-rap
Mountain Whitefish	0– 0.34 m/s	Gravel/cobble
Kokanee	0 – 0.65 m/s	Gravel/cobble
Sculpins	0 – 0.48 m/s	Gravel/cobble
Redside Shiner	0 – 0.13 m/s	Bedrock
Largescale Sucker	0 – 0.18 m/s	Gravel/cobble and Bedrock

[2] For Kokanee, Sculpins, Redside Shiners and Largescale Suckers preferred velocities and substrates are for 2012 only. Comparisons to previous years will be included in the Year 6 Synthesis report in 2014.

4.0 DISCUSSION

4.1 TEMPERATURE AND DISCHARGE

The use of handheld meters to collect surface water temperatures was considered sufficient to document site conditions related to juvenile fish use and habitat in the Middle Columbia River. Recorded temperatures in 2012 were typically within the middle of the range of temperatures observed during the three years of baseline (i.e., neither the warmest nor coolest temperatures observed over the four years of sampling). The exception to this was the July sampling in Reach 4 and the September sampling in Reach 2, where mean temperatures were the coolest of the five years of sampling. The range in temperatures between all reaches within each trip likely was not a major variable in influencing recruitment of juvenile fishes in 2012. Within each trip, the difference in temperatures between all sampled reaches was not great: 1.1 °C (spring), 2.6 °C (summer) and 1.1 °C (fall) and were all within allowable ranges for the species present in the system (McPhail 2007).

Discharge from the Revelstoke Dam was highly variable during all three sampling trips, with high discharge typically occurring during the day and early evening, and daily low discharge occurring after midnight until approximately 6 am. In 2008, the first one or two hours of sampling after dark were typically completed during high flows, followed by two or three hours of sampling during rapidly decreasing discharge as the turbines at the Revelstoke Dam were shut down for the night. For the 2009, 2010, 2011 and 2012 programs, the sampling times for riverine sites (Reaches 3 and 4) were specifically targeted toward the minimum flow period. This was based on research completed on the Colorado River that showed catch rates of age-0 Rainbow Trout in near-shore areas were at least two to four times higher at daily minimum flows compared to daily maximum flows (Korman and Campana 2009). Assuming juvenile fishes in the Middle Columbia respond similarly to fluctuating flows, it was theorized that sampling riverine sites at low flow periods would result in increased catch rates.

Dam discharge and ALR elevation were both exceptionally high during the summer trip in 2012. This resulted in high velocity flows (especially in Reaches 4 and 3) and increased depths that resulted in flooding into the vegetation at many sites. One site (Site 10 Reach 4) could not be sampled due to high velocities and strong currents resulting in unsafe boating conditions so close to shore. The catch during Trip 2 was lower than in any of the four previous years of sampling, and this can likely be attributed to the adverse conditions. The higher water velocities and increased depth at sites that, in previous years, did not experience such flows, were higher/deeper than the preferred depths and velocities of juvenile fishes in the community. They would have likely moved in toward shore seeking velocity refuge and been amongst the flooded vegetation where electrofishing effort was not possible.

4.2 FISH SIZE

Electrofishing was effective at capturing juvenile life stages of most species and all life stages of most of the smaller fish species (e.g., Redside Shiners and Sculpins). Approximately 95 per cent percent of measured fishes from 2008 to 2012 were less than 250 mm (Figure 4-1). The majority of captured fishes were within the 51–100 mm size class. Except for Sculpins and Redside Shiners, these fishes were considered juveniles. For Sculpins and Redside Shiners, individuals longer than 60 mm FL were considered adults. Larger fishes typically evaded captured due to their burst speed and were frequently observed darting away from the boat. The majority of individuals of the seven most abundant species measured in 2012 were also less than 250 mm (Figure 4-2) with the size range of 51-100 mm being most commonly encountered.

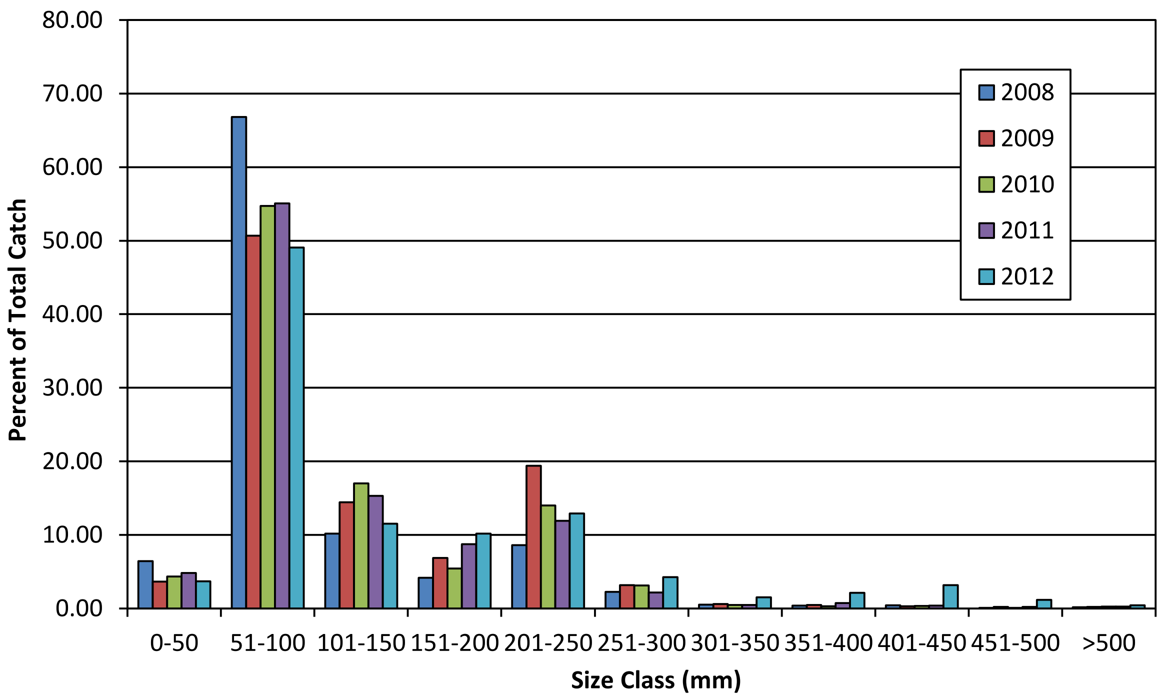


Figure 4-1: Length frequency histogram for fishes measured during the 2008–2012 field seasons (*n* = 1457 for the 2012 field season)

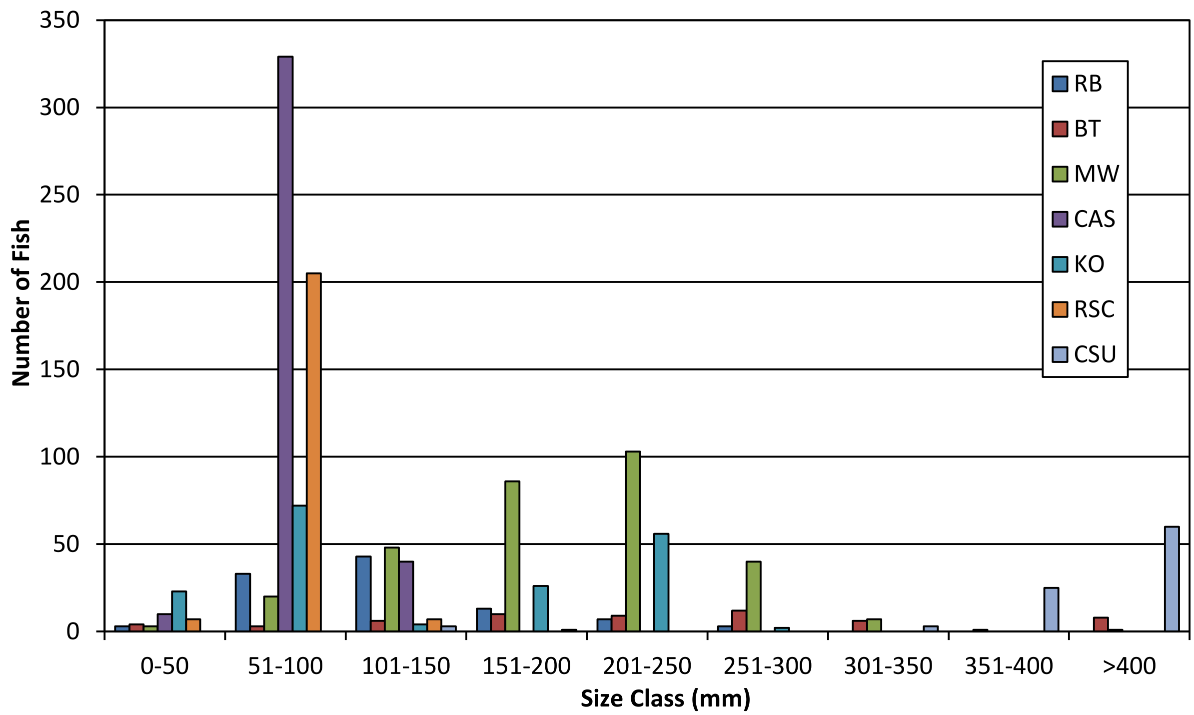


Figure 4-2: Length frequency histogram for most commonly encountered fish species (Rainbow Trout [RB], Bull Trout [BT], Mountain Whitefish [MW], Prickly Sculpin [CAS], Kokanee [KO], Redside Shiner [RSC], and Largescale Sucker [CSU]) measured during the 2012 field season (*N* = 1,342). Note: RB, BT, MW, KO and CSU individuals less than 250 mm were considered to be juveniles.

In general the methodology utilized is effective at capturing juveniles of the majority of the species present. In the case of Sculpins and Redside Shiners, juveniles are likely too small to be spotted and captured but use of other techniques such as Gee traps or netting would not be feasible at many of the sites due to habitat and variable flow conditions. Electrofishing is also a more efficient technique with netting and trapping requiring much more time per site or repeat visits to the same site both of which would reduce the overall sites that could be sampled. Lastly, for species such as Redside Shiners and Sculpins it is reasonable to expect juveniles to use similar habitats as larger individuals and therefore some inferences can be still be made regarding juvenile behaviours from the sampling results. Changes to the methodology to increase the catch of juvenile shiners and Sculpins are therefore not recommended for the final year of the study.

4.3 FISH DISTRIBUTION

Similar to Years 1–4, the focus of the data analyses for Year 5 was to compare fish abundances between river reaches and habitat units and confirm that the methodology would be able to address the overall goals of the project:

1. *To provide information on juvenile fishes' use of the Middle Columbia River and on the suitability of these habitats to meet critical life history requirement (e.g., rearing) of these fish populations.*
2. *To assess the effects of the implementation of the 142 m^3/s minimum flow and REV 5 on the recruitment of juvenile life stages of fishes of the Middle Columbia.*

Sampling in 2012 was completed in three discrete periods: May, July, and September. All reaches were considered "riverine" (containing flow) during the May sampling, whereas by July, all had become inundated by the ALR and were more lacustrine. By September, the ALR elevation had receded such that Reach 4 had returned to riverine conditions, while Reaches 1–3 remained inundated and largely lacustrine in nature (though water velocities were recorded as far downstream as site 47 in Reach 2). During both the May and September trips the highest densities of fish (fish/m of shoreline) were in Reaches 2 and 3. In July, when the ALR had backwatered throughout the study area Reach 4 had the highest density of fish. This suggests that during periods when the elevation of the ALR is at its highest, therefore mitigating some of the effects of high discharges from the dam, the majority of fishes may prefer the tempered flows of Reach 4 rather than the more-lacustrine nature of Reaches 3 to 1. It should be noted that the backwatering effect of the ALR into Reach 4 was greatest at low flows (i.e., flows in Reach 4 were slowest). At high flows, water velocities were lower. Similar results were observed in 2011 and 2010 with Reach 1 having the highest densities in spring and fall but Reach 3 being highest in July when the ALR was at high elevation. It should be noted that ALR elevation in July 2012 was higher than all previous July trips by approximately 1.1 m as measured at the Upper Arrow Lakes Reservoir monitoring station at Nakusp thus backwatering the Middle Columbia further than all previous years - well into Reach 4. However both years differed from 2009 during which Reaches 1 and 2 had the highest density in all three sampling periods. Additional data will be required to determine if there is a consistent seasonal trend in fish density within the study area. Lastly, the similarity between the

2008 – 2010 data and the 2011 and 2012 data suggests that changes to the flow regime associated with Rev-5 are not yet having an effect on the distribution of fish in the system.

The number of species encountered was consistent between Years 1–5 of the study, with 14 different species being captured in 2012, 15 in 2008, and 17 in each of 2009 to 2011. The highest species richness during the three sampling events in 2012 was 12 species in Reach 2 in September. Of the seven most abundant species, Rainbow Trout was the only species where juveniles were caught in every reach (including the tributaries) for every Trip (Table 3-5). Juvenile Bull Trout were captured in all reaches in all trips except Reaches 1 and 2 during Trips 2 and 3 (Table 3-6). Juvenile Mountain Whitefish were caught in all Reaches for all trips except the tributaries for Trips 1 and 3 (Table 3-7). For abundance and distribution of juveniles of the additional four most abundant species (Kokanee, Prickly Sculpin, Redside Shiner and Largescale Sucker) refer to Table 3-8 to Table 3-11.

4.3.1 HABITAT SUITABILITY FOR JUVENILES

Habitat Suitability Index (HSI) curves for Rainbow Trout, Bull Trout and Mountain Whitefish juveniles were reviewed to determine preferences for rearing depth and velocities. The HSI curves for Bull Trout and Rainbow Trout were from the Water Use Planning (WUP) process and were developed by Ron Ptolemy (Instream Flow Specialist, Ministry of Environment, Victoria, B.C., pers. comm.). However, these curves were developed for non-regulated systems, which could limit their application to systems such as the Middle Columbia which experiences highly variable flow regimes. According to these curves, velocities from 0 m/s to 1.0 m/s are suitable for both species, but Rainbow Trout prefer velocities ranging from 0.25 m/s to 0.50 m/s (HSI = 1.0), whereas Bull Trout prefer slightly faster waters with velocities ranging from 0.40 m/s to 0.69 m/s. Both species show a preference (HSI = 1.0) for depths greater than 0.3 m. HSI curves for Mountain Whitefish were not available from the WUP process but were developed for juvenile rearing depths and velocities for the South Saskatchewan River, Alberta (Addley et al. 2003). Based on those curves, juvenile Mountain Whitefish show a preference (HSI = 1.0) for velocities ranging from 0 m/s to 0.7 m/s and for depths greater than 0.3 m.

Juvenile Kokanee prefer lacustrine rearing habitat over fluvial rearing habitat thus they tend spend most of their time off-shore with periodic daytime movements towards the shore to forage (McPhail, 2007). This is consistent with data gathered for juvenile Kokanee in 2012. From observations gathered throughout the five years of this study, Prickly Sculpin seem to be relatively opportunistic species in terms of the habitat types with which they associate. Juveniles and adults have been caught and observed in low or zero velocity sites (e.g., reservoir) in Reaches 1 and 2 to higher water velocity sites found in Reaches 3 and 4. Prickly Sculpins have been caught and observed in both shallow water (<0.30 m) and deep water (>2.0 m) sites over fines, cobble/boulder, rip-rap and bedrock substrates. In contrast to Prickly Sculpins, throughout the previous years of this study, adult and juvenile Redside Shiners were caught and observed in mainly low velocity, deep water sites in Reaches 1 and 2 over boulder and bedrock substrates. Juvenile Largescale Suckers were not encountered often, though adults were. In 2012 only 4 juvenile Largescale Suckers were captured. Literature review found that Largescale Suckers are not well-studied in British Columbia. However, juvenile Largescale Suckers seem to be associated with slow water velocities (0 – 0.1 m/s) and fines-dominated substrates (Miura 1962 and Porter and Rosenfeld 1999 as cited in McPhail 2007). In 2012, three of four individuals were captured in the reservoir (Reaches 1 and 2).

Based on these criteria, it was expected that sites exhibiting similar substrate, depth, and velocity characteristics would have the highest catch rates of several of the seven most abundant species. However, while sites with the highest numbers of target species were generally within preferred depth ranges (greater than 0.3 m), their velocities tended to be lower than those from the HSI curves (Table 3-15). However, because conditions at each site are highly variable due to the Revelstoke Dam operation as well as ALR elevation, the depth and velocities measured at the sites during sampling do not necessarily reflect the conditions during most of the day. For example, a decrease in discharge from approximately 700 m^3/s to approximately 20 m^3/s at a site results in a 0.4 m/s–0.7 m/s decrease in velocity at that same site (Table 4-1). Therefore, certain sites will be within the typical HSI ranges for species but at other times will be outside that range. For that reason, definition of a Middle Columbia habitat suitability range based on velocities is not practical.

Table 4-1: Mean depth and velocities at representative sites based on discharges (2010 site data)

Site	Habitat	Discharge (m^3/s)	Depth (m) at station			Velocity (m/s) at station		
			0 m	1.5 m	3 m	0 m	1.5 m	3 m
15	Steep Gravel/Cobble	700	0	0.88	1.28	0	0.51	0.71
		735	0	0.85	1.21	0	0.47	0.55
		25	0	0.65	0.87	0	0.09	0.31
16	Steep Rip-Rap	721	0	0.85	1.17	0	0.60	0.78
		624	0	0.65	0.98	0	0.47	0.64
		16	0	0.55	0.93	0	0	0.05

At sites where Bull Trout were captured, the substrate tended to be steep and dominated by either gravel/cobble or fines. Alternatively, Rainbow Trout showed a stronger preference for coarser substrates, such as rip-rap and bedrock. The relatively stable depths and velocities at sites with steep, large diameter substrates over a range of discharges could potentially explain the higher densities of target species captured at those sites (Table 3-15). These habitats provide interstitial spaces for refuge areas for juvenile fish. Since there is both an energetic cost and increased risk of predation associated with moving from one habitat to another as flows change, it is reasonable to expect juveniles to focus on habitats that are more stable, which thus limits the need for daily migrations between habitats (Korman and Campana, 2009).

5.0 COMPARISON YEARS 4 AND 5 (POST-REV 5 AND MINIMUM FLOW) TO YEARS 1–3 (PRE-REV 5 AND MINIMUM FLOW) SUMMARY

The following sections provide a summary of the sampling conditions and results during the first two years of the post-Rev 5 flow regime compared to each of the three years of baseline data collection.

Physical Environment

Year 5 (2012) was the second year of sampling following the completion of Rev 5. The results (along with those of upcoming Year 6) are expected to address the second management objective for the project: "*To assess the effects of the implementation of the 142 m^3/s minimum flow and Rev 5 on the recruitment of juvenile life stages of fishes of the Middle Columbia.*". A review of the data on hourly-average discharge from the Revelstoke Dam from May 1 to September 30, 2012 (152 days) showed that during that period, discharge dropped below the 142 m^3/s threshold on 13 days (15 instances ranging from one hour to nine hours) or 9 per cent. This was less than in 2011 where discharge dropped below the 142 m^3/s threshold on 59 days (35 per cent of the time) and generally for periods of more than one hour. For comparison, discharge dropped below 142 m^3/s on 112 days (66 per cent of the time) during the same period in 2010 (pre minimum flow). As in 2011, sampling in 2012 did not occur at discharges below142 m^3/s; however, it is not known what effect, if any, the continuing drop in discharge below the threshold might have on identifying before/after trends in the data. Variation in discharge and in particular the frequency of occurrences of discharge below142 m^3/s will be included in the year 6 analysis.

Another factor that confounds the ability to assess the influence of the minimum base flow on juvenile recruitment is the influence of the ALR on the study area through backwater-effect. Specifically, when the ALR elevation is high (typically mid-June to early winter), its influence obscures any effect the minimum base flows might be having on the system as a result of the backwater effect. Therefore sampling during riverine conditions provides the best opportunity to assess the effect of the minimum base flow. However, river conditions in each of the three years of baseline data collection (2008–2010), as well as in the first two years after the implementation of minimum flows (2011 and 2012), have differed during at least one of the sampling trips each year due to changes in ALR elevation (Table 5-1). Trip 1 (May) was the only trip where conditions were consistent across the three years of baseline and the first two years of minimum flows, with all four reaches considered riverine with no influence of the ALR for the duration of the sampling. For Trip 2 (June/July), influence of the ALR was observed in all four Reaches in 2012 and 2010, in Reaches 1, 2, and 3 in 2008 and 2011 and only in

Reaches 1 and 2 in 2009. For Trip 3 (September), influence of the ALR was observed in Reaches 1, 2, and 3 in 2008 and 2011, but only in Reaches 1 and 2 in 2009, 2010 and 2012. Additional analysis of the influence of the ALR on juvenile fish will be included in Year 6.

Table 5-1: Summary of river conditions at each Reach during each of the three sampling events for 2008–2012 (R = Reach). Red border indicates start of minimum flows

Trip	Condition	2008	2009	2010	2011	2012
May/June	River Reservoir	R 1–4	R 1–4	R 1–4	R 1–4	R 1-4
June/July	River Reservoir	R 4 R 1–3	R 3–4 R 1–2	 R 1–4	R4 R 1–3	 R 1-4
September	River Reservoir	R 4 R 1–3	R 3–4 R 1–2	R 3–4 R 1–2	R 4 R 1–3	R 2-4 R 1-2[A]

[A] The influence of the reservoir reached part-way into Reach 2 in September 2012

The addition of a fifth generator at the Revelstoke Dam also increased the peak daily discharge of the facility by up to 20 per cent (from a maximum of 1,700 m^3/s to 2,125 m^3/s) (BC Hydro 2009). Therefore, if changes in juvenile fish habitat use are identified, it will be difficult to determine whether they are attributable to the minimum base flow or the increased maximum flow. Maximum discharge during the 2012 study period occurred periodically from June 7 to September 8 when daily peaks reached 2216 m^3/s. Discharge was greatest during Trip 2 when daily peak flows ranged from 1900 to 2216 m^3/s. Peak flows during Trips 1 and 3 ranged from approximately 1000 to 1600 m^3/s (Figure 3-2). The pre-Rev 5 maximum of 1700 m^3/s was surpassed on 56 days from June 7 to September 8 2012 (35 per cent of that span) for durations ranging from one hour to seventy-two hours (July 23 to 26, 2012). Except for this three-day period, flows typically dropped during the early morning hours. Discharge during the study period in 2012 was greater than that in 2011 where the pre-Rev 5 maximum of 1,700 m^3/s was exceeded on only 21 days (12 per cent of the time) and generally for periods of less than one hour. Further, the maximum discharge observed during that period was only 1,779 m^3/s.

Similar to 2011, recorded water temperatures in 2012 were typically within the middle of the range of temperatures observed during the three years of baseline data collection (i.e., neither the warmest nor coolest temperatures observed over the four years of sampling). The exception to this was the July trip sampling in Reach 4, where mean temperatures were the coolest of the five years of sampling. As well, temperatures during sampling in July tended to be cooler than that 2008, 2010 and 2011 but warmer than that in 2009. (Table 3-1).

Sampling Results

The number of species encountered in 2012 was one less than 2009 to 2011 but one more than 2008. The number of individuals captured and observed in 2012 was lower than all previous years of the program (Table 5-2). Most notably, the summer trip in 2012 had a much lower catch than previous years. Several factors likely contributed to this result: high ALR elevation and high discharge. The ALR elevation during summer the trip was higher than all previous summer trips (Table 2-2) resulting in significant backwatering throughout the reaches. Some of sample sites were backwatered into riparian vegetation thus limiting the ability to reach the shore to carry out electrofishing. As such, these sites were sampled in deeper-than-usual water. Additionally discharge from the dam was high during the summer trip and in particular from July 16 to 18 when sampling in Reaches 3 and 4 was completed discharge remained above 1200 m^3/s throughout (Figure 3-2). The increased depth and velocity at sample sites (compared to previous years of the study) decreased the efficiency of capture (deeper sampling sites offer increased potential of fishes escaping the electric field). As well, juvenile fishes would likely seek refuge from increased water velocity in the shallows in the flooded riparian where sampling was not possible. Numbers of fish were also lower in Trip 3 than in each of the previous years. The ALR elevation during that trip was the lowest observed (Table 2-2) but sampling conditions were considered good and therefore it is unclear what effect if any that might have had on fish numbers. Kokanee numbers in September 2012 (n = 178) were much lower than in 2009, 2010 and 2011 (954, 631, and 780 respectively) and only slightly higher than the 2008 numbers (n = 173). This trend was also noted by BC Hydro staff completing Kokanee enumeration overflights who noted very low spawner numbers (Karen Bray, BC Hydro, pers. comm.).

Table 5-2: Summary of sampling results for 2008–2012, all Reaches and tributaries combined

Year	Spring Trip		Summer Trip		Fall Trip		Total	
	# fish	# species	# fish	# species	# fish	# species	# fish	# species
2012	1230	12	330	14	1339	12	2899	16
2011	1877	15	1227	15	3400	17	6504	17
2010	2337	15	3782	16	4355	17	10474	17
2009	1406	12	1001	10	5356	11	7763	17
2008	454	14	1345	15	2178	15	3977	15

5.1 RECOMMENDATIONS

The remaining year of the study (Year 6) should use the same sites, sampling techniques, and procedures used in Years 1–5.

Trips should be completed during the same time of year, and reservoir elevation forecasts should be monitored to ensure sampling occurs while river conditions (i.e., river vs. reservoir) are similar to those of the baseline data set. In addition, habitat data (depth, velocity, substrate composition) should continue to be collected in order to identify any changes in physical habitat conditions that may help explain observed changes in fish distribution.

During trips when Reaches 3 and 4 are riverine, sampling should be conducted at daily minimum flows, which is the period where the effects of the minimum base flow will be most evident.

6.0 MANAGEMENT QUESTION SUMMARY

The following is a summary of the answers to the management questions following year 5 of the 6-year study:

1. *What are the seasonal abundances and distribution of juvenile life stages of fishes in the Middle Columbia River?*

- Seasonal abundances and distribution of juveniles species captured are reported in each of the annual reports. A synthesis report will be produced in year 6 (as per the Terms of Reference) that summarizes the data for each of the 6 years of study.

2. *How do juvenile fishes use the mainstem habitats in the Middle Columbia River?*

   - Juvenile habitat use in the Middle Columbia River is primarily associated with rearing (April to September). While it is assumed that overwintering also likely occurs due to the depths being suitable, this is beyond the scope of the study and therefore cannot be commented on further.

3. *What factors affect recruitment of juvenile life stages in the Middle Columbia River?*
   a. *Do operational strategies for Revelstoke Dam and Arrow Lake Reservoir influence the availability of juvenile fishes' preferred habitats?*

      - All of the habitats sampled in Years 1-4 of the study were accessible in Year 5. The minimum base flow and influence of the ALR does not limit habitat access.
      - Habitat characteristics of sites with high abundance of Rainbow Trout, Bull Trout, and Mountain Whitefish in Year 5 were similar to those of Years 1-4. This suggests that operational strategies have not influenced the availability of preferred habitats.

   b. *Do current operational strategies affect availability of the food base for juvenile fish life stages?*

      - Length, weight and condition factor data of Rainbow Trout, Bull Trout and Mountain Whitefish captured in Year 5 were comparable to that of fish captured in Years 1 – 4. This suggests growth conditions were consistent over the four years. The analyses will encompass the additional four species added in 2012 in the Year 6 report.
      - Data from CLBMON-15a (Physical Habitat Monitoring) and 15b (Ecological Productivity) will be reviewed and incorporated into the final (Year 6) report. It is expected that those studies will be able to provide additional insight into any changes to the food base that may have occurred in the system.

   c. *Do predators influence fish recruitment and habitat use in the Middle Columbia River?*
      - Adult piscivorous fish such as Bull Trout are present in the system and are known to prey on many species. However, it is unknown what influence predators have on fish recruitment and habitat use at this stage. Review of the results of CLBMON 16 (Fish Population Indexing) and CLBMON 18 (Adult Fish Habitat Use)

may provide additional insight into this question. This analysis will be incorporated into the year 6 synthesis report.

7.0 CLOSURE

This report was written by Damian Slivinski and Tori Waites (Triton – Kamloops) with statistical analysis completed by Jocelyn Garner (Triton – Kamloops). The draft report was reviewed by Greg Sykes (Triton – Kamloops).

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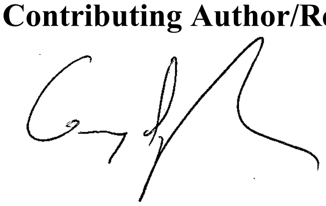

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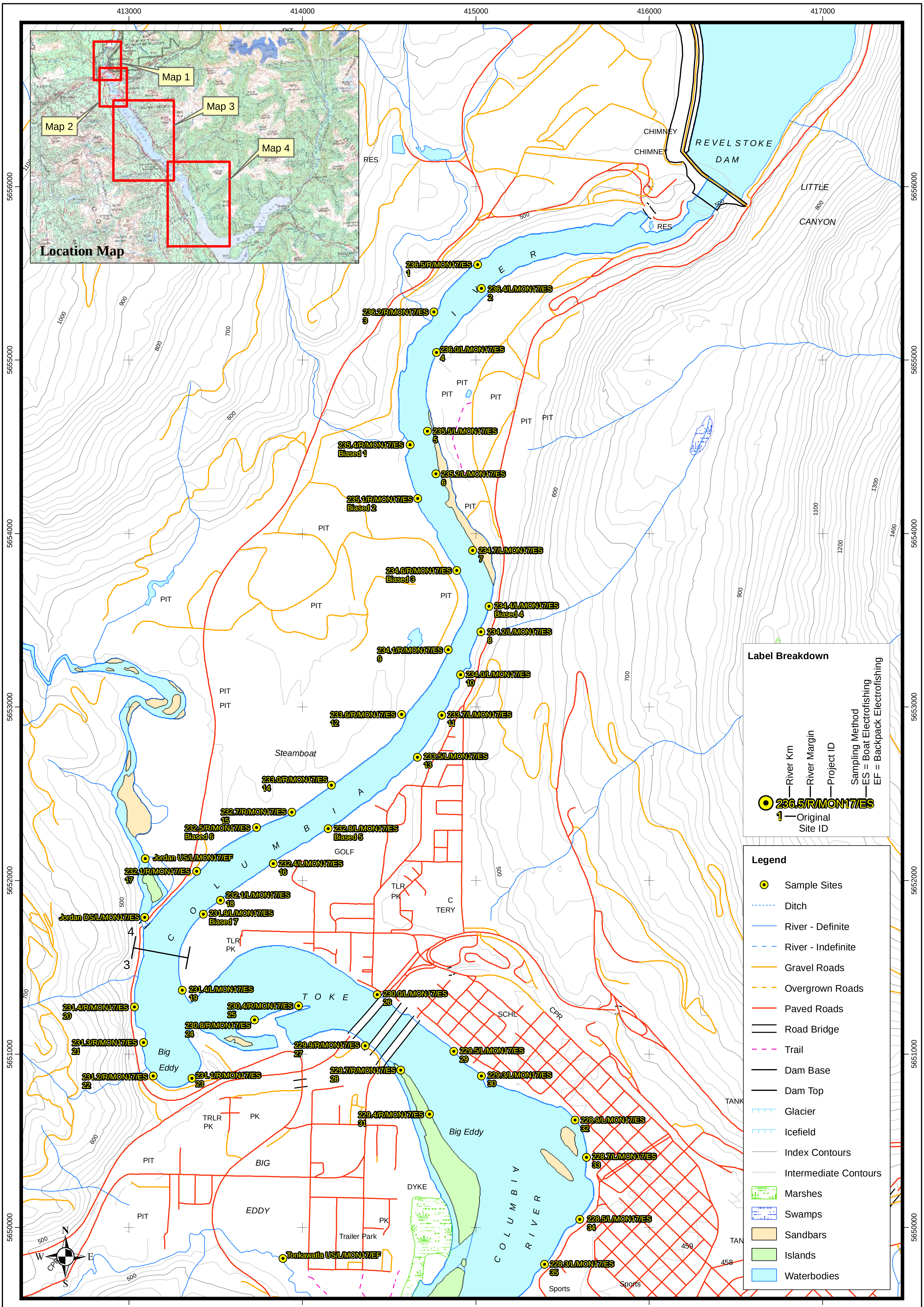
Appendix 1a

Site Location Maps



MIDDLE COLUMBIA RIVER
JUVENILE HABITAT USE

0 100 200 400 600 800 1,000 1,200 Meters

Scale: 1:20,000

TRIM Basemap
MAP 1

NO.	DATE (yyyy/mm/dd)	REVISION	BY
1	2008/04/23	Initial Draft	SM
2	2008/07/18	May 2008 Waypoints added	DW
3	2008/09/08	Updated with July High Reservoir Waypoints	DW
4	2009/02/12	Replaced sites with new data	SM

Basemap Source: TRIM Data

Map Datum: UTM NAD 83 Zone 11

Project No: 3943

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Date: Feb 1, 2012

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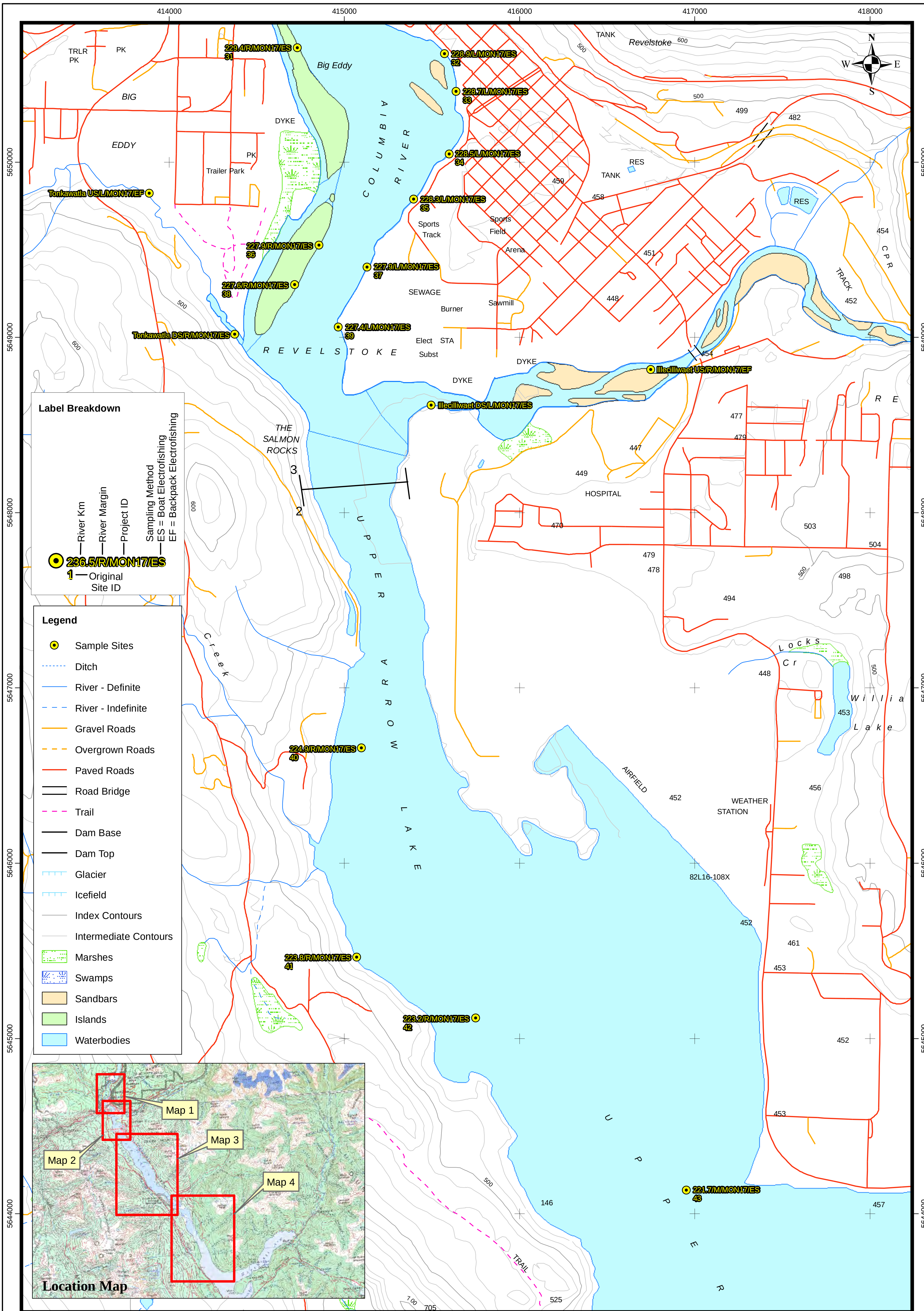

MIDDLE COLUMBIA RIVER JUVENILE HABITAT USE

0 100 200 400 600 800 1,000 1,200 Meters

Scale: 1:20,000

TRIM Basemap
MAP 2

NO.	DATE (yyyy/mm/dd)	REVISION	BY
1	2008/04/23	Initial Draft	SM
2	2008/07/18	May 2008 Waypoints added	DW
3	2008/09/08	Updated with July High Reservoir Waypoints	DW
4	2009/02/12	Replaced sites with new data	SM

Basemap Source: TRIM Data

Map Datum: UTM NAD 83 Zone 11

Project No: 3943

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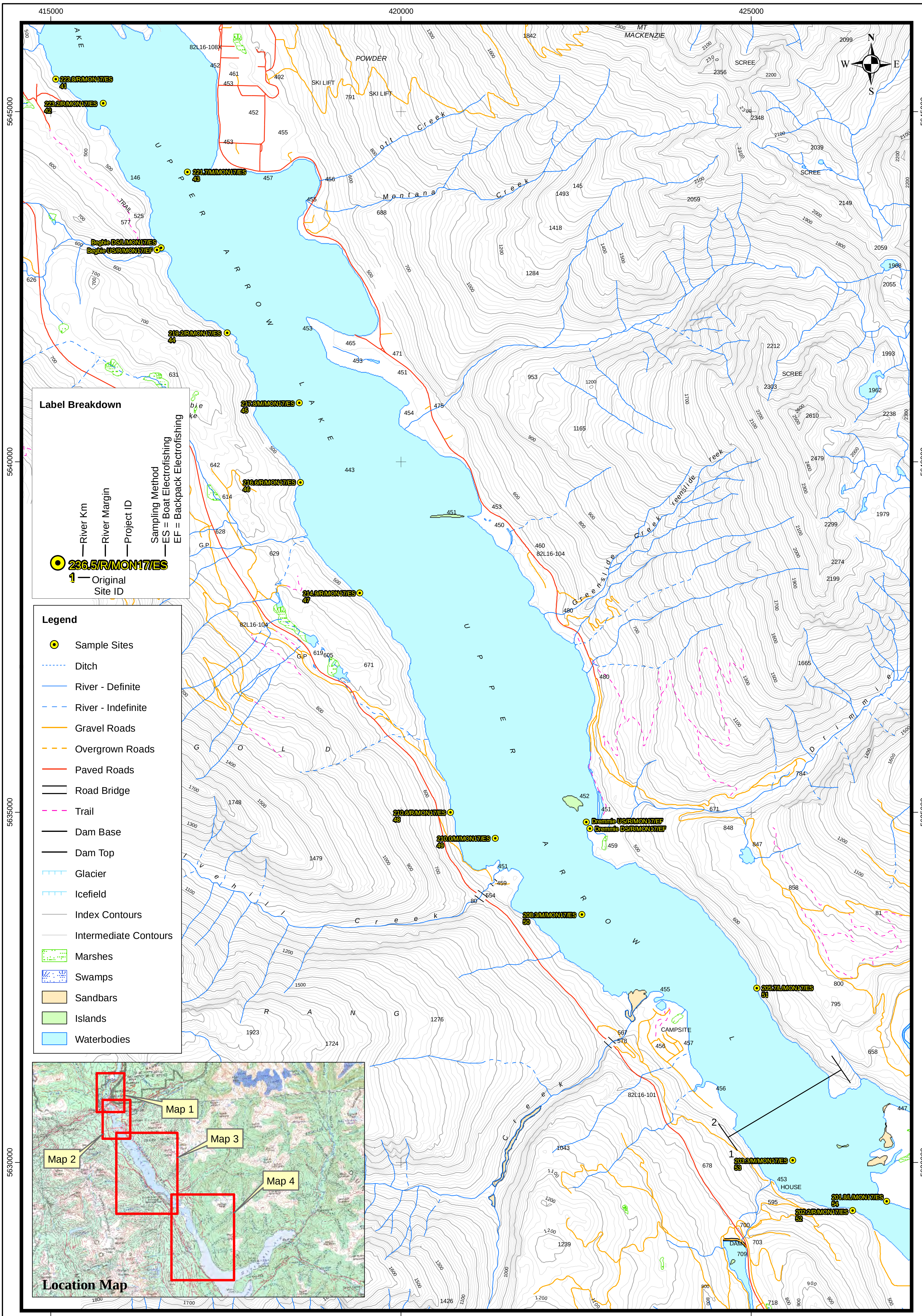

MIDDLE COLUMBIA RIVER
JUVENILE HABITAT USE

0 250 500 1,000 1,500 2,000 2,500 3,000 Meters

Scale: 1:50,000

TRIM Basemap
MAP 3

NO.	DATE (yyyy/mm/dd)	REVISION	BY
1	2008/04/23	Initial Draft	SM
2	2008/07/18	May 2008 Waypoints added	DW
3	2008/09/08	Updated with July High Reservoir Waypoints	DW
4	2009/02/12	Replaced sites with new data	SM

Basemap Source: TRIM Data

Map Datum: UTM NAD 83 Zone 11

Project No: 3943

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Date: Feb 1, 2012

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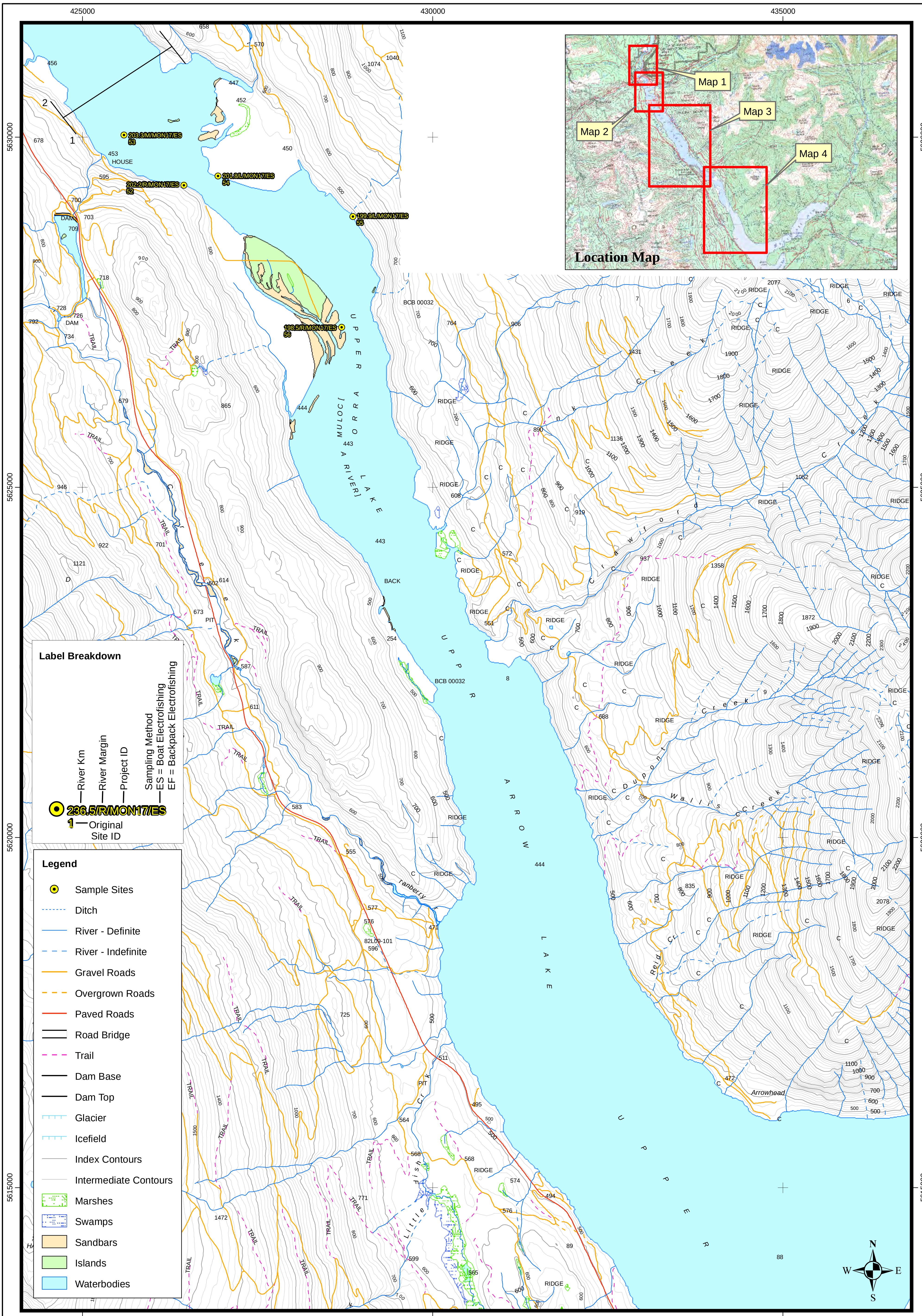

MIDDLE COLUMBIA RIVER
JUVENILE HABITAT USE

0 250 500 1,000 1,500 2,000 2,500 3,000 Meters

Scale: 1:50,000

TRIM Basemap
MAP 4

NO.	DATE (yyyy/mm/dd)	REVISION	BY
1	2008/04/23	Initial Draft	SM
2	2008/07/18	May 2008 Waypoints added	DW
3	2008/09/08	Updated with July High Reservoir Waypoints	DW
4	2009/02/12	Replaced sites with new data	SM

Basemap Source: TRIM Data

Map Datum: UTM NAD 83 Zone 11

Project No: 3943

File No: Map#: N:\ACTIVE\3943_BC_Hydro_Columbia\MXD\2012\Basemap4c_SM.mxd

Date: Feb 1, 2012

TRITON ENVIRONMENTAL CONSULTANTS LTD.

Appendix 1b

Site Label Summary

Original Site Label	Reach	UTM Zone	Easting	Northing	River km	2012 Site Label
1	4	11	415011	5655550	236Km 520m	236.5/R/MON17/ES
2	4	11	415033	5655414	236Km 440m	236.4/L/MON17/ES
3	4	11	414759	5655278	236Km 160m	236.2/R/MON17/ES
4	4	11	414774	5655044	235Km 980m	236.0/L/MON17/ES
5	4	11	414721	5654590	235Km 460m	235.5/L/MON17/ES
6	4	11	414771	5654345	235Km 200m	235.2/L/MON17/ES
7	4	11	414983	5653903	234Km 700m	234.7/L/MON17/ES
8	4	11	415029	5653434	234Km 240m	234.2/L/MON17/ES
9	4	11	414842	5653330	234Km 60m	234.1/R/MON17/ES
10	4	11	414913	5653186	233Km 980m	234.0/L/MON17/ES
11	4	11	414804	5652953	233Km 720m	233.7/L/MON17/ES
12	4	11	414572	5652958	233Km 600m	233.6/R/MON17/ES
13	4	11	414664	5652711	233Km 460m	233.5/L/MON17/ES
14	4	11	414168	5652550	232Km 980m	233.0/R/MON17/ES
15	4	11	413940	5652395	232Km 700m	232.7/R/MON17/ES
16	4	11	413832	5652098	232Km 440m	232.4/L/MON17/ES
17	4	11	413391	5652054	232Km 80m	232.1/R/MON17/ES
18	4	11	413528	5651887	232Km 60m	232.1/L/MON17/ES
19	3	11	413308	5651369	231Km 380m	231.4/L/MON17/ES
20	3	11	413031	5651272	231Km 320m	231.4/R/MON17/ES
21	3	11	413084	5651067	231Km 260m	231.3/R/MON17/ES
22	3	11	413140	5650874	231Km 220m	231.2/R/MON17/ES
23	3	11	413363	5650860	231Km 140m	231.1/R/MON17/ES

Original Site Label	Reach	UTM Zone	Easting	Northing	River km	2012 Site Label
24	3	11	413725	5651198	230Km 820m	230.8/R/MON17/ES
25	3	11	413978	5651279	230Km 440m	230.4/R/MON17/ES
26	3	11	414432	5651342	230Km 40m	230.0/L/MON17/ES
27	3	11	414363	5651049	229Km 900m	229.9/R/MON17/ES
28	3	11	414568	5650908	229Km 660m	229.7/R/MON17/ES
29	3	11	414874	5651016	229Km 500m	229.5/L/MON17/ES
30	3	11	415033	5650874	229Km 300m	229.3/L/MON17/ES
31	3	11	414733	5650653	229Km 360m	229.4/R/MON17/ES
32	3	11	415573	5650619	228Km 880m	228.9/L/MON17/ES
33	3	11	415639	5650404	228Km 740m	228.7/L/MON17/ES
34	3	11	415600	5650047	228Km 480m	228.5/L/MON17/ES
35	3	11	415397	5649789	228Km 280m	228.3/L/MON17/ES
36	3	11	414857	5649527	227Km 860m	227.9/R/MON17/ES
37	3	11	415131	5649401	227Km 860m	227.9/L/MON17/ES
38	3	11	414717	5649302	227Km 600m	227.6/R/MON17/ES
39	3	11	414966	5649060	227Km 420m	227.4/L/MON17/ES
40	2	11	415098	5646658	224Km 940m	224.9/R/MON17/ES
41	2	11	415071	5645464	223Km 820m	223.8/R/MON17/ES
42	2	11	415750	5645118	223Km 220m	223.2/R/MON17/ES
43	2	11	416952	5644136	221Km 700m	221.7/M/MON17/ES
44	2	11	417518	5641842	219Km 220m	219.2/R/MON17/ES
45	2	11	418549	5640843	217Km 760m	217.8/M/MON17/ES
46	2	11	418566	5639705	216Km 600m	216.6/R/MON17/ES

Original Site Label	Reach	UTM Zone	Easting	Northing	River km	2012 Site Label
47	2	11	419413	5638130	214Km 900m	214.9/R/MON17/ES
48	2	11	420707	5634996	210Km 620m	210.6/R/MON17/ES
49	2	11	421348	5634623	210Km 0m	210.0/M/MON17/ES
50	2	11	422583	5633535	208Km 320m	208.3/M/MON17/ES
51	2	11	425079	5632489	205Km 680m	205.7/L/MON17/ES
52	1	11	426448	5629314	202Km 180m	202.2/R/MON17/ES
53	1	11	425593	5630028	203Km 280m	203.3/M/MON17/ES
54	1	11	426935	5629443	201Km 800m	201.8/L/MON17/ES
55	1	11	428860	5628865	199Km 880m	199.9/L/MON17/ES
56	1	11	428700	5627286	198Km 500m	198.5/R/MON17/ES
Biased 1	4	11	414622	5654512	235Km 400m	235.4/R/MON17/ES
Biased 2	4	11	414666	5654202	235Km 100m	235.1/R/MON17/ES
Biased 3	4	11	414891	5653788	234Km 640m	234.6/R/MON17/ES
Biased 4	4	11	415077	5653582	234Km 400m	234.4/L/MON17/ES
Biased 5	4	11	414149	5652299	232Km 820m	232.8/L/MON17/ES
Biased 6	4	11	413737	5652306	232Km 460m	232.5/R/MON17/ES
Biased 7	4	11	413429	5651806	231Km 920m	231.9/L/MON17/ES
Begbie Creek D/S	2	11	416576	5643056	220Km 660m	Begbie Creek D/S
Begbie Creek U/S	2	11	416517	5643027	220Km 640m	Begbie Creek U/S
DrImmie Creek D/S	2	11	422646	5634859	209Km 80m	DrImmie US/R/MON17/EF
DrImmie Creek U/S	2	11	422696	5634766	209Km 0m	DrImmie DS/R/MON17/EF
Illecillewaet D/S	2	11	415497	5648614	226Km 740m	Illecilliwaet DS/L/MON17/ES

Original Site Label	Reach	UTM Zone	Easting	Northing	River km	2012 Site Label
Illecillewaet U/S	2	11	416749	5648818	226Km 620m	Illecilliwaet US/R/MON17/EF
Jordan River D/S	3	11	413091	5651788	231Km 720m	Jordan DS/L/MON17/ES
Jordan River U/S	3	11	413095	5652126	231Km 940m	Jordan US/L/MON17/ES
Tonkawatla Creek D/S	3	11	414376	5649018	227Km 380m	Tonkawatla DS/R/MON17/ES
Tonkawatla Creek U/S	3	11	413888	5649823	227Km 700m	Tonkawatla US/L/MON17/EF

Appendix 2a

Representative Site Photographs

Comparison of high discharge (2008 site inventory) and low discharge conditions (5:00 - 5:30 AM on June 2, 2010)

Plate 1a. Typical steep slope site with gravel and cobble substrates (Site 1, Reach 4). High flow.

Plate 1b. Typical steep slope site with gravel and cobble substrates (Site 1, Reach 4). Low flow.

Plate 2a. Typical steep slope site with gravel and cobble substrates (Site 2, Reach 4). High flow.

Plate 2b. Typical steep slope site with gravel and cobble substrates (Site 2, Reach 4). Low flow.

Plate 3a. Typical steep slope site with gravel and cobble substrates (Site 3, Reach 4). High flow.

Plate 3b. Typical steep slope site with gravel and cobble substrates (Site 3, Reach 4). Low flow

Plate 3a. Typical steep slope site with boulder substrates (Site 4, Reach 4). High flow.

Plate 3b. Typical steep slope site with boulder substrates (Site 4, Reach 4). Low flow.

Plate 2a. Typical shallow slope site with gravel and cobble substrates (Site 6, Reach 4). High flow.

Plate 2b. Typical shallow slope site with gravel and cobble substrates (Site 6, Reach 4). Low flow.

Plate 2a. Typical shallow slope site with gravel substrates (Bias 1, Reach 4). High flow.

Plate 2b. Typical shallow slope site with gravel substrates (Bias 1, Reach 4). Low flow.

Appendix 2b

Representative Fish Photographs (2008-2010)

Plate 9. Bull trout.

Plate 10. Rainbow trout.

Plate 11. Mountain whitefish.

Plate 12. Burbot.

Plate 13. Kokanee.

Plate 14. Eastern brook trout.

Plate 15. Tench.

Plate 16. Yellow perch.

Plate 17. Common carp.

Appendix 3

Site Summary Information

Appendix 3a. Site summary information for the May 2012 sampling trip.

		UTM 11			Start	End	Site	Site	Max Site	Water			Dominant	Sub-Dominant	
Site	Reach	Easting	Northing	Date	Time	Time	Length (m)	Width (m)	Depth (m)	Temp (°C)	Turbidity	Morphology	Substrate	Substrate	$D_{95\ (cm)}$
1	4	415081	5655321	05-Jun-12	21:30	21:42	100	3	3	6.9	C	LC	Gravel	Cobble	40
2	4	415107	5655190	05-Jun-12	21:50	22:00	100	3	1.5	6.9	C	LC	Cobble	Boulder	40
3	4	414845	5655062	05-Jun-12	22:29	22:37	100	3	0.9	6.9	C	LC	Gravel	Cobble	25
11	4	414882	5652751	31-May-12	21:40	21:46	100	3	3	5.6	C	LC	Bed Rock	Boulder	500
12	4	414671	5652730	31-May-12	22:02	22:14	100	3	1.5	5.6	C	RIVER	Boulder	Cobble	50
13	4	414744	5652521	31-May-12	22:20	22:27	100	3	1.2	5.6	C	RIVER	Cobble	Boulder	20
14	4	414253	5652338	31-May-12	22:49	22:57	100	3	2	5.6	C	RIVER	Cobble	Gravel	20
15	4	414024	5652179	31-May-12	23:38	23:46	100	3	1.2	5.6	C	LC	Boulder	Cobble	30
16	4	413917	5651897	01-Jun-12	0:20	0:30	100	3	1.5	5.6	C	LC	Riprap	N/A	100
17	4	413576	5651807	01-Jun-12	1:10	1:17	100	3	0.5	5.6	C	RIVER	Gravel	N/A	5
18	4	413602	5651678	01-Jun-12	1:26	1:37	100	3	1	5.6	C	RIVER	Riprap	N/A	50
19	3	413309	5651145	28-May-12	23:35	23:44	100	3	1	5.8	C	RP	Gravel	Cobble	-
20	3	413113	5651042	28-May-12	22:57	23:04	100	3	1	5.8	C	RIVER	Boulder	Cobble	400
21	3	413164	5650858	28-May-12	22:35	22:47	100	3	2	5.28	C	RP	Bed Rock	Gravel	600
22	3	413224	5650667	28-May-12	22:08	22:18	100	3	1.5	5.8	C	RIVER	Gravel	Fines	15
23	3	413447	5650634	28-May-12	21:50	21:59	100	3	2	5.8	C	RIVER	Gravel	Fines	12
24	3	413725	5651198	29-May-12	0:19	0:25	100	3	1.1	5.82	C	RP	Cobble	Gravel	12
25	3	414076	5651176	29-May-12	0:05	0:12	100	3	0.9	5.8	C	RP	Cobble	Gravel	10
26	3	414510	5651129	29-May-12	0:37	0:49	100	3	2	5.82	C	RP	Riprap	N/A	100
27	3	414526	5650899	02-Jun-12	0:55	1:07	100	3	0.5	5.6	C	LC	Gravel	Cobble	15
28	3	414640	5650702	02-Jun-12	0:34	0:48	100	3	0.5	5.9	C	LC	Gravel	Fines	20

Site	Reach	UTM 11		Date	Start Time	End Time	Site Length (m)	Site Width (m)	Max Site Depth (m)	Water Temp (°C)	Turbidity	Morphology	Dominant Substrate	Sub-Dominant Substrate	$D_{95\ (cm)}$
		Easting	Northing												
31	3	414878	5650505	30-May-12	2:00	2:10	100	3	1	5.5	C	RP	Gravel	Cobble	30
32	3	415652	5650408	30-May-12	0:31	0:41	100	3	2	5.4	C	LC	Gravel	Cobble	12
33	3	415718	5650201	30-May-12	0:09	0:16	100	3	2	5.5	C	LC	Gravel	Cobble	10
34	3	415671	5649841	29-May-12	23:23	23:34	100	3	3	5.5	C	LC	Riprap	Gravel	150
35	3	415476	5649586	29-May-12	23:07	23:15	100	3	2	5.5	C	LC	Riprap	N/A	200
36	3	415000	5649312	31-May-12	1:25	1:36	100	3	1.5	5.5	C	LC	Fines	N/A	0
37	3	415216	5649208	29-May-12	22:41	22:50	100	3	2	5.5	L	LC	Fines	Gravel	10
38	3	414839	5649092	30-May-12	1:05	1:15	100	3	1.5	5.4	C	LC	Cobble	Fines	30
39	3	415037	5648848	29-May-12	22:15	22:25	100	3	2	5.5	C	RP	Gravel	Cobble	10
40	2	415203	5646428	05-Jun-12	1:54	2:02	100	3	1.2	6.8	C	LC	Gravel	Cobble	10
41	2	415161	5642252	05-Jun-12	1:33	1:39	100	3	1.5	6.8	L	LC	Gravel	Cobble	12
42	2	415827	5644907	05-Jun-12	1:05	1:15	100	3	1	6.8	L	LC	Gravel	Fines	5
43	2	417033	5643926	05-Jun-12	0:35	0:44	100	3	1.5	6.8	C	LC	Fines	N/A	1
44	2	417606	5641636	04-Jun-12	22:47	22:56	100	3	3	6.1	C	LC	Boulder	Bed Rock	150
45	2	418630	5640636	04-Jun-12	22:28	22:35	100	3	0.6	6.1	C	LC	Gravel	Fines	5
46	2	418718	5639418	04-Jun-12	22:10	22:17	100	3	1.4	6.1	C	LC	Fines	N/A	0
47	2	419488	5637905	04-Jun-12	21:40	21:52	100	3	2	6.1	C	LG CHANNEL	Boulder	Bed Rock	200
48	2	420807	5634786	31-May-12	2:08	2:18	100	3	3	6.9	L	LC	Bed Rock	Gravel	400
49	2	421435	5634416	31-May-12	1:40	1:47	100	3	1.5	6.9	L	LC	Fines	N/A	0
50	2	422660	5633339	31-May-12	1:00	1:06	100	3	0.5	6.9	L	LC	Fines	Gravel	4

Site	Reach	UTM 11		Date	Start Time	End Time	Site Length (m)	Site Width (m)	Max Site Depth (m)	Water Temp (°C)	Turbidity	Morphology	Dominant Substrate	Sub-Dominant Substrate	D_{95} (cm)
		Easting	Northing												
51	2	425149	5632277	31-May-12	0:29	0:40	100	3	2	6.9	L	LC	Boulder	Bed Rock	200
52	1	426541	5629118	30-May-12	23:02	23:11	100	3	4	7.1	L	LC	Boulder	Bed Rock	300
53	1	425662	5629819	30-May-12	23:50	23:59	100	3	0.9	7.1	L	LC	Gravel	Fines	5
54	1	426771	5629309	30-May-12	22:47	22:54	100	3	0.9	7.1	L	LC	Fines	Gravel	15
55	1	428933	5628645	30-May-12	22:09	22:17	100	3	4	7.1	L	LC	Boulder	Bed Rock	100
56	1	428853	5626966	30-May-12	21:40	21:50	100	3	-	6.5	L	LC	Fines	N/A	0
Bias 5	4	414220	5652098	31-May-12	23:07	23:17	100	3	0.6	5.6	C	LC	Boulder	Cobble	30
Bias 6	4	413876	5652035	01-Jun-12	0:52	-	100	3	-	5.6	C	LC	Gravel	Cobble	10
Bias 7	4	413506	5651599	01-Jun-12	1:56	-	100	3	-	5.6	C	RIVER	Riprap	N/A	50
Begbie U/S	2	416604	5642814	04-Jun-12	23:30	23:40	50	3	1	6.1	C	RIFFLE	Boulder	Cobble	60
Begbie D/S	2	416658	5642814	04-Jun-12	23:17	23:27	50	3	0.4	6.1	C	RIFFLE	Gravel	Cobble	50
Drimmie U/S	2	422748	5634592	01-Jun-12	21:34	21:42	50	3	0.6	5.5	C	RP	Gravel	Fines	20
Drimmie D/S	2	422489	5634819	01-Jun-12	21:55	22:03	50	3	0.8	5.5	L	RP	Gravel	Fines	10
Illecillewaet U/S	2	416891	5648613	01-Jun-12	22:42	22:53	50	3	1	6.1	M	RP	Gravel	Fines	15
Illecillewaet D/S	2	415606	5648413	29-May-12	21:30	21:37	50	3	-	6.9	M	GLIDE	Gravel	Fines	12
Jordan U/S	3	413164	5651934	02-Jun-12	0:02	0:13	30	3	0.5	4.4	M	RP	Cobble	Gravel	20
Jordan D/S	3	413173	5651584	01-Jun-12	2:30	2:43	50	3	2.5	4.4	M	RP	Riprap	N/A	100
Tonkawatla U/S	3	413967	5649621	01-Jun-12	23:20	23:33	50	3	1.2	6.4	M	RP	Fines	Gravel	10
Tonkawatla D/S	3	414466	5648810	29-May-12	21:55	22:00	50	3	1.6	8	T	GLIDE	Fines	N/A	100

Appendix 3b. Site summary information for the July 2012 sampling trip.

Site	Reach	UTM 11		Date	Start Time	End Time	Site Length (m)	Site Width (m)	Max Site Depth (m)	Water Temp (°C)	Turbidity	Morphology	Dominant Substrate	Sub-Dominant Substrate	$D_{95\ (cm)}$
		Easting	Northing												
1	4	415069	5655350	16-Jul-12	21:34	21:41	100	3	2	7.8	C	GLIDE	Cobble	Boulder	40
2	4	415127	5655184	16-Jul-12	21:48	21:54	100	3	3	7.8	C	GLIDE	Boulder	Cobble	60
3	4	414831	5655074	16-Jul-12	22:09	22:15	100	3	2	7.8	C	GLIDE	Gravel	Fines	30
4	4	414853	5654831	16-Jul-12	22:31	22:40	100	3	3.5	7.8	C	GLIDE	Boulder	Cobble	60
5	4	414824	5654389	16-Jul-12	22:53	23:00	100	3	2	7.8	C	GLIDE	Fines	Gravel	10
6	4	414878	5654134	16-Jul-12	23:54	0:00	100	3	2	7.8	C	GLIDE	Cobble	Fines	27
7	4	415105	5653686	17-Jul-12	0:56	1:04	100	3	2	7.8	C	GLIDE	Cobble	Gravel	70
8	4	415093	5653227	17-Jul-12	21:46	21:50	100	3	4	8	L	GLIDE	Boulder	Cobble	100
9	4	414923	5653124	17-Jul-12	21:56	22:03	100	3	5	8	L	GLIDE	Cobble	Boulder	100
11	4	414882	5652756	17-Jul-12	22:17	22:23	100	3	4.5	8	L	GLIDE	Boulder	Cobble	400
12	4	414670	5652727	17-Jul-12	22:31	22:37	100	3	4	8	L	GLIDE	Cobble	Boulder	100
13	4	414749	5652522	17-Jul-12	22:45	22:50	100	3	3	8	L	GLIDE	Cobble	Gravel	80
14	4	414268	5652357	17-Jul-12	23:01	23:06	100	3	4	7.9	L	GLIDE	Gravel	Cobble	70
15	4	414023	5652178	18-Jul-12	0:01	0:07	100	3	4	7.9	L	GLIDE	Cobble	Boulder	70
16	4	413921	5651892	18-Jul-12	22:12	22:18	100	3	4.5	9.4	L	GLIDE	Riprap	N/A	100
17	4	413489	5651852	18-Jul-12	22:31	22:37	100	3	3	9.4	L	GLIDE	Gravel	Cobble	30
18	4	413583	5651666	18-Jul-12	22:46	22:53	100	3	4.2	9.4	L	GLIDE	Riprap	N/A	45
19	3	413392	5651155	13-Jul-12	22:00	22:09	100	3	2	8.7	L	GLIDE	Fines	Gravel	6
20	3	413113	5651042	09-Jul-12	22:10	22:23	100	3	2.6	9.3	L	RESERVOIR	Boulder	Fines	40
21	3	413164	5650858	09-Jul-12	22:42	22:55	100	3	3.2	9.3	L	RESERVOIR	Boulder	Fines	400
22	3	413224	5650669	09-Jul-12	23:00	23:10	100	3	3	9.3	L	RESERVOIR	Boulder	Fines	40

Site	Reach	UTM 11		Date	Start Time	End Time	Site Length (m)	Site Width (m)	Max Site Depth (m)	Water Temp (°C)	Turbidity	Morphology	Dominant Substrate	Sub-Dominant Substrate	$D_{95\ (cm)}$
		Easting	Northing												
23	3	413442	5650634	09-Jul-12	23:30	23:40	100	3	3.5	9.3	L	RESERVOIR	Gravel	Fines	10
24	3	413799	5650989	09-Jul-12	23:55	0:05	100	3	3	9.3	L	RESERVOIR	Fines	Cobble	15
25	3	414107	5651068	10-Jul-12	0:24	0:34	100	3	2.4	9.3	L	RESERVOIR	Fines	Gravel	10
26	3	414511	5651128	13-Jul-12	23:58	0:07	100	3	3	8.7	L	RESERVOIR	Riprap	N/A	100
27	3	414471	5650832	13-Jul-12	23:37	23:47	100	3	3	8.7	L	RESERVOIR	Fines	N/A	0
28	3	414653	5650698	13-Jul-12	23:25	23:32	100	3	4	8.7	L	RESERVOIR	Fines	N/A	0
29	3	414941	5650817	13-Jul-12	22:20	22:27	100	3	4	8.7	L	RESERVOIR	Boulder	Cobble	40
30	3	415106	5650674	13-Jul-12	22:33	22:42	100	3	3	8.7	L	RESERVOIR	Riprap	N/A	100
31	3	414816	5650453	13-Jul-12	23:10	23:20	100	3	4	8.7	L	RESERVOIR	Fines	N/A	0
32	3	415642	5650420	14-Jul-12	0:15	0:23	100	3	4	8.7	L	RESERVOIR	Fines	Gravel	6
33	3	415718	5650201	14-Jul-12	0:29	0:38	100	3	5	8.7	L	RESERVOIR	Fines	Gravel	6
34	3	415673	5649842	13-Jul-12	0:05	0:15	100	3	4	8.5	L	RESERVOIR	Gravel	Riprap	100
35	3	415478	5649580	12-Jul-12	23:51	23:59	100	3	3.6	8.5	L	RESERVOIR	Riprap	N/A	100
36	3	414940	5649318	12-Jul-12	23:05	23:11	100	3	2.2	8.5	L	RESERVOIR	Fines	N/A	0
37	3	415214	5649202	12-Jul-12	23:40	23:46	100	3	2.2	8.5	L	RESERVOIR	Fines	N/A	0
38	3	414805	5649091	12-Jul-12	22:55	23:00	100	3	1.9	8.5	L	RESERVOIR	Fines	N/A	0
39	3	415037	5648848	12-Jul-12	23:17	23:24	100	3	3.1	8.5	L	RESERVOIR	Gravel	Fines	4
41	2	415148	5645258	11-Jul-12	23:40	23:50	100	3	4.5	9.3	L	RESERVOIR	Cobble	Boulder	45
44	2	417604	5641630	11-Jul-12	22:35	22:45	100	3	4	9.3	L	RESERVOIR	Bed Rock	Boulder	400
46	2	418650	5639500	11-Jul-12	22:05	22:15	100	3	3	9.3	L	RESERVOIR	Bed Rock	Boulder	100
47	2	419500	5637904	11-Jul-12	21:45	21:54	100	3	3.1	9.3	L	RESERVOIR	Bed Rock	Boulder	400

Site	Reach	UTM 11		Date	Start Time	End Time	Site Length (m)	Site Width (m)	Max Site Depth (m)	Water Temp (°C)	Turbidity	Morphology	Dominant Substrate	Sub-Dominant Substrate	D_{95} (cm)
		Easting	Northing												
48	2	420789	5634793	10-Jul-12	23:50	0:00	100	3	2.6	10.4	L	RESERVOIR	Bed Rock	Boulder	400
51	2	425145	5632275	10-Jul-12	23:13	23:23	100	3	4	10.4	L	RESERVOIR	Bed Rock	N/A	400
52	1	426535	5629120	10-Jul-12	22:33	22:40	100	3	3.1	10.8	L	RESERVOIR	Bed Rock	N/A	400
54	1	427011	5629236	10-Jul-12	22:20	22:30	100	3	2.5	10.8	L	RESERVOIR	Gravel	Fines	5
55	1	428920	5628644	10-Jul-12	21:47	21:56	100	3	6	10.8	L	RESERVOIR	Bed Rock	Boulder	400
Bias 1	4	414640	5654341	16-Jul-12	23:24	23:30	100	3	3	7.8	C	GLIDE	Gravel	Cobble	6
Bias 2	4	414750	5653989	17-Jul-12	0:18	0:25	100	3	4	7.8	C	GLIDE	Cobble	Gravel	30
Bias 3	4	414976	5653573	17-Jul-12	0:44	0:49	100	3	4	7.8	C	GLIDE	Boulder	Cobble	100
Bias 4	4	415154	5653376	17-Jul-12	21:34	21:39	100	3	4	8	L	GLIDE	Boulder	Cobble	100
Bias 5	4	414241	5652086	17-Jul-12	23:43	23:49	100	3	0.7	7.9	L	GLIDE	Riprap	N/A	50
Bias 6	4	413834	5652098	18-Jul-12	21:59	22:04	100	3	3.5	9.4	L	GLIDE	Cobble	Gravel	30
Bias 7	4	413510	5651604	18-Jul-12	23:00	23:04	100	3	4.5	9.4	L	GLIDE	Riprap	N/A	100
Begbie D/S	2	416660	5642850	11-Jul-12	22:56	23:02	50	3	2.5	9.2	L	GLIDE	Gravel	Cobble	20
Begbie U/S	2	416598	5642820	11-Jul-12	23:05	23:13	50	3	2	9.5	-	RP	Gravel	Cobble	30
Drimmie D/S	2	422731	5634636	11-Jul-12	0:45	0:50	56	3	3	13.1	M	RESERVOIR	Gravel	Fines	5
Drimmie U/S	2	422771	5634559	11-Jul-12	0:53	0:59	50	3	1.4	7.2	M	GLIDE	Gravel	N/A	5
Illicillewaet D/S	2	415606	5648413	12-Jul-12	21:44	21:49	50	3	4	10.5	M	GLIDE	Fines	N/A	0
Illicillewaet U/S	2	416894	5648616	12-Jul-12	21:30	21:35	50	3	4	10.5	M	GLIDE	Cobble	Gravel	25
Jordan D/S	3	413182	5651599	13-Jul-12	21:43	21:48	50	3	3	10.2	M	GLIDE	Riprap	Boulder	100
Jordan U/S	3	413174	5651919	13-Jul-12	21:30	21:35	50	3	2	10.2	M	GLIDE	Cobble	Gravel	26
Tonkawatla D/S	3	414463	5648810	12-Jul-12	22:12	22:17	50	3	3	12.5	M	RESERVOIR	Fines	N/A	0

Site	Reach	UTM 11		Date	Start Time	End Time	Site Length (m)	Site Width (m)	Max Site Depth (m)	Water Temp (°C)	Turbidity	Morphology	Dominant Substrate	Sub-Dominant Substrate	D_{95} (cm)
		Easting	Northing												
Tonkawatla U/S	3	414185	5649341	12-Jul-12	22:24	22:29	50	3	3.1	12.5	M	GLIDE	Fines	Gravel	3

Appendix 3c. Site summary information for the September 2012 sampling trip.

Site	Reach	UTM 11 Easting	UTM 11 Northing	Date	Start Time	End Time	Site Length (m)	Site Width (m)	Max Site Depth (m)	Water Temp (°C)	Turbidity	Morphology	Dominant Substrate	Sub-Dominant Substrate	$D_{95\ (cm)}$
1	4	415000	5655555	18-Sep-12	19:40	19:51	100	3	1.6	11.1	C	GLIDE	Gravel	Cobble	75
2	4	415041	5655399	18-Sep-12	20:01	20:05	100	3	1.8	11.1	C	GLIDE	Cobble	Boulder	60
3	4	414755	5655271	18-Sep-12	20:12	20:17	100	3	1.5	11.1	C	GLIDE	Cobble	Gravel	60
4	4	414777	5655044	18-Sep-12	20:40	20:46	100	3	1.9	11.1	C	GLIDE	Cobble	Boulder	70
5	4	414721	5654618	18-Sep-12	21:32	21:37	100	3	1.3	11.1	C	GLIDE	Gravel	Cobble	100
6	4	418814	5654212	18-Sep-12	21:48	21:53	100	3	1.7	11.1	C	GLIDE	Gravel	Cobble	25
7	4	414978	5653928	18-Sep-12	22:50	22:55	100	3	1.2	11.1	C	GLIDE	Gravel	Cobble	20
8	4	415026	5653434	18-Sep-12	23:56	0:02	100	3	2	11.1	C	GLIDE	Boulder	Cobble	100
9	4	414842	5653335	11-Sep-12	20:10	20:17	100	3	1.5	10.5	C	GLIDE	Cobble	Boulder	30
10	4	414915	5653194	11-Sep-12	20:30	20:35	100	3	3	10.5	C	GLIDE	Bed Rock	N/A	400
11	4	414804	5652970	11-Sep-12	21:10	21:18	100	3	2	10.5	C	GLIDE	Bed Rock	Cobble	400
12	4	414591	5652927	11-Sep-12	21:26	21:35	100	3	2	10.5	C	GLIDE	Cobble	Boulder	50
13	4	414670	5652735	11-Sep-12	21:50	21:59	100	3	1.1	10.5	C	GLIDE	Cobble	Boulder	60
14	4	414179	5652558	11-Sep-12	22:15	22:20	100	3	2	10.5	C	GLIDE	Cobble	Gravel	40
15	4	413939	5652394	11-Sep-12	23:13	23:20	100	3	2.6	10.6	C	GLIDE	Boulder	Cobble	60
16	4	413832	5652103	19-Sep-12	20:32	20:36	100	3	2	11.1	C	GLIDE	Riprap	N/A	80
17	4	413428	5652053	19-Sep-12	21:05	21:10	100	3	1.2	11.1	C	GLIDE	Cobble	Gravel	25
18	4	413497	5651870	19-Sep-12	21:16	21:21	100	3	3	11.1	C	GLIDE	Riprap	N/A	100
19	3	413250	5651302	10-Sep-12	22:16	22:26	100	3	0.9	10.9	C	GLIDE	Cobble	N/A	30
20	3	413034	5651256	10-Sep-12	21:47	21:55	100	3	1.5	10.6	C	GLIDE	Cobble	Fines	100
21	3	413083	5651067	10-Sep-12	21:20	21:30	100	3	3	10.6	C	GLIDE/RIFFLE	Bed Rock	Boulder	200

Site	Reach	UTM 11		Date	Start Time	End Time	Site Length (m)	Site Width (m)	Max Site Depth (m)	Water Temp (°C)	Turbidity	Morphology	Dominant Substrate	Sub-Dominant Substrate	D_{95} (cm)
		Easting	Northing												
22	3	413146	5650868	10-Sep-12	20:50	20:59	100	3	-	10.6	C	GLIDE	Gravel	Fines	100
23	3	413363	5650855	10-Sep-12	20:15	20:30	100	3	1	10.6	C	GLIDE	Fines	Gravel	30
24	3	413698	5651256	10-Sep-12	23:05	23:10	100	3	1.2	10.9	C	GLIDE	Cobble	Gravel	30
25	3	414064	5651347	10-Sep-12	22:48	22:53	100	3	-	10.9	C	GLIDE	Cobble	Boulder	30
26	3	414428	5651334	10-Sep-12	23:21	23:28	100	3	2	10.8	C	GLIDE	Riprap	Riprap	100
27	3	414397	5651041	17-Sep-12	23:05	23:20	100	3	0.5	10.08	C	GLIDE	Gravel	Cobble	20
28	3	414582	5650905	14-Sep-12	21:20	21:26	100	3	2.2	11.2	C	GLIDE	Cobble	Gravel	40
29	3	414877	5651007	14-Sep-12	20:15	20:23	100	3	0.9	11.2	C	GLIDE	Riprap	N/A	80
30	3	415015	5650886	14-Sep-12	20:31	20:38	100	3	1.2	11.2	C	GLIDE	Gravel	Fines	90
31	3	414753	5650689	14-Sep-12	21:05	21:11	100	3	1.2	11.2	C	GLIDE	Gravel	Cobble	30
32	3	415566	5650622	14-Sep-12	22:15	22:20	100	3	1.4	11.1	C	GLIDE	Gravel	Cobble	25
33	3	415637	5650418	14-Sep-12	22:01	22:06	100	3	1.5	11.1	C	GLIDE	Gravel	Cobble	25
34	3	415600	5650061	14-Sep-12	22:51	22:57	100	3	3	11.1	C	GLIDE	Gravel	Cobble	100
35	3	415403	5649798	14-Sep-12	23:18	23:23	100	3	3	11.1	C	GLIDE	Riprap	N/A	150
36	3	414863	5649529	17-Sep-12	21:10	21:16	100	3	2	11.3	C	GLIDE	Gravel	Fines	10
37	3	415132	5649408	17-Sep-12	22:15	22:21	100	3	2	11.3	C	GLIDE	Fines	Gravel	60
38	3	414724	5649310	17-Sep-12	20:37	20:42	100	3	1.9	11.3	C	GLIDE	Fines	Gravel	1
39	3	414944	5649064	17-Sep-12	21:41	21:46	100	3	2.5	11.3	C	GLIDE	Cobble	Gravel	25
40	2	415115	5646636	12-Sep-12	19:50	19:58	100	3	2	11	C	GLIDE	Fines	Gravel	10
41	2	415071	5645467	13-Sep-12	20:11	20:21	100	3	1.7	11	C	GLIDE	Fines	Gravel	12
42	2	415762	5645110	13-Sep-12	20:48	21:03	100	3	1.2	11	C	GLIDE	Fines	Gravel	5

		UTM 11			Start	End	Site	Site	Max Site	Water			Dominant	Sub-Dominant	
Site	Reach	Easting	Northing	Date	Time	Time	Length (m)	Width (m)	Depth (m)	Temp (°C)	Turbidity	Morphology	Substrate	Substrate	$D_{95\ (cm)}$
43	2	416957	5644137	13-Sep-12	21:19	21:32	100	3	1.6	11	C	GLIDE	Fines	N/A	0
44	2	417526	5641840	12-Sep-12	23:04	23:20	100	3	5	10.9	C	GLIDE	Bed Rock	Boulder	400
45	2	418563	5640843	13-Sep-12	23:29	23:39	100	3	0.9	10.9	C	GLIDE	Fines	N/A	0
46	2	418641	5639595	13-Sep-12	23:57	0:08	100	3	1.5	10.9	C	GLIDE	Fines	N/A	0
47	2	419412	5638111	14-Sep-12	0:25	0:35	100	3	3.5	10.9	C	GLIDE	Boulder	Bed Rock	400
48	2	420723	5634991	12-Sep-12	23:20	23:32	100	3	4	10.9	C	RESERVOIR	Bed Rock	Cobble	400
51	2	425069	5632491	12-Sep-12	22:06	22:18	100	3	3	10.9	C	RESERVOIR	Bed Rock	Boulder	400
52	1	426458	5629328	12-Sep-12	20:59	21:08	100	3	3.2	11.1	C	RESERVOIR	Boulder	Bed Rock	200
53	1	425619	5629980	12-Sep-12	21:30	21:38	100	3	1.2	10.9	C	RESERVOIR	Fines	N/A	0
54	1	426703	5629527	12-Sep-12	20:45	20:53	100	3	0.7	11.1	C	RESERVOIR	Fines	Gravel	3
55	1	428848	5628868	12-Sep-12	20:11	20:23	100	3	3	11.1	C	RESERVOIR	Bed Rock	Gravel	400
56	1	428772	5627172	12-Sep-12	19:47	19:57	100	3	1	11.1	C	RESERVOIR	Fines	N/A	0
Bias 1	4	414619	5654508	18-Sep-12	20:58	21:04	100	3	2	11.1	C	GLIDE	Cobble	Boulder	100
Bias 2	4	414660	5654206	18-Sep-12	22:36	22:40	100	3	1.5	11.1	C	GLIDE	Cobble	Gravel	65
Bias 3	4	414892	5653788	18-Sep-12	23:08	23:13	100	3	1.7	11.1	C	GLIDE	Cobble	Boulder	100
Bias 4	4	415080	5653572	18-Sep-12	23:40	23:46	100	3	1.8	11.1	C	GLIDE	Boulder	Cobble	100
Bias 5	4	414167	5652310	11-Sep-12	22:58	23:02	100	3	1.1	10.6	C	GLIDE	Riprap	N/A	100
Bias 6	4	413840	5652324	11-Sep-12	23:45	23:50	100	3	1.4	10.6	C	GLIDE	Cobble	Boulder	70
Bias 7	4	413428	5651809	19-Sep-12	21:45	21:50	100	3	2	11.1	C	GLIDE	Riprap	N/A	100
Begbie D/S	2	416581	5643051	13-Sep-12	21:59	22:08	50	3	-	8	C	RIFFLE	Gravel	Cobble	27
Begbie U/S	2	416517	5643024	13-Sep-12	22:10	22:20	50	3	0.7	8	C	RIFFLE	Cobble	Gravel	60

Site	Reach	UTM 11		Date	Start Time	End Time	Site Length (m)	Site Width (m)	Max Site Depth (m)	Water Temp (°C)	Turbidity	Morphology	Dominant Substrate	Sub-Dominant Substrate	D_{95} (cm)
		Easting	Northing												
Drimmie D/S	2	422413	5635041	12-Sep-12	22:40	22:48	50	3	2.2	12.4	L	RESERVOIR	Fines	Gravel	8
Illecillewaet D/S	2	415527	5648621	17-Sep-12	19:43	19:49	100	3	0.9	10.2	C	GLIDE	Gravel	Cobble	60
Illecillewaet U/S	2	416797	5648815	17-Sep-12	23:53	0:00	50	3	0.8	9.7	C	GLIDE	Cobble	Gravel	15
Jordan D/S	3	413089	5651788	19-Sep-12	20:14	20:18	50	3	2.6	10.8	C	GLIDE	Riprap	N/A	100
Jordan U/S	3	413095	5652118	19-Sep-12	19:45	19:57	50	3	0.5	10.8	C	GLIDE	Boulder	Cobble	25
Tonkawatla D/S	3	414386	5649021	17-Sep-12	20:09	20:12	50	3	1.6	10.4	C	GLIDE	Fines	N/A	100

Appendix 4

Habitat Summary Information

Appendix 4a. Habitat summary information for the May sampling trip. Mid-site data has been omitted from table for clarity. Depth and velocity data are provided for stations at the shoreline (0 m), and 1.5 and 3.0 meters from the shoreline.

			Downstream End of Site												Upstream End of Site											
			Depth (m)			Velocity (m/s)			Substrate Composition						Depth (m)			Velocity (m/s)			Substrate Composition					
Site	**Reach**	**Date**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**
1	4	05-Jun-12	0	0.44	0.75	0	0.48	0.89	0	60	30	10	0	0	0	0.45	0.86	0	0.27	0.39	0	40	40	20	0	0
2	4	05-Jun-12	0	0.60	0.96	0	0.01	0.28	0	20	40	40	0	0	0	0.37	0.64	0	0	0.03	5	50	25	20	0	0
3	4	05-Jun-12	0	0.60	0.91	0	0.01	0.08	0	60	20	20	0	0	0	0.45	0.77	0	0.17	0.28	10	40	40	10	0	0
11	4	31-May-12	0	0.70	1.05	0	0.35	0.68	0	20	20	60	0	0	0	0.26	0.67	0	0	0.01	0	10	10	50	30	0
12	4	31-May-12	0	0.93	1.45	0	0.29	0.47	0	20	30	50	0	0	0	0.41	0.73	0	0.05	0.23	0	20	30	50	0	0
13	4	31-May-12	0	0.44	0.67	0	0.34	0.54	0	20	60	20	0	0	0	0.51	0.85	0	0.37	0.44	0	10	80	10	0	0
14	4	31-May-12	0	0.76	1.15	0	0.46	0.45	0	30	50	20	0	0	0	0.92	1.39	0	0.48	0.74	0	50	30	20	0	0
15	4	31-May-12	0	0.69	1.15	0	0.30	0.55	0	20	20	60	0	0	0	0.73	1.15	0	0.29	0.40	0	10	20	70	0	0
16	4	01-Jun-12	0	0.92	1.55	0	0.26	0.31	0	0	0	0	0	100	0	0.55	0.74	0	0.13	0.49	0	0	0	0	0	100
17	4	01-Jun-12	0	0.24	0.48	0	0.08	0.19	0	100	0	0	0	0	0.30	0.54	0.67	0.30	0.35	0.30	0	100	0	0	0	0
18	4	01-Jun-12	0	0.55	1.13	0	0.13	0.34	0	0	0	0	0	100	0	0.64	1.39	0	0.04	0.14	0	0	0	0	0	100
19	3	28-May-12	0.30	0.40	0.60	0.10	0.35	0.40	0	100	0	0	0	0	0.30	0.50	0.70	0.10	0.33	0.45	0	100	0	0	0	0
20	3	28-May-12	0	0.40	0.50	0	0	0	0	10	20	40	0	20	0	0.40	0.45	0	0.40	0.50	20	20	20	40	0	0
21	3	28-May-12	0	0.60	1.10	0	0.20	0.20	0	0	20	20	20	0	0	0.90	1.41	0	0.10	0.30	0	0	10	10	80	0
22	3	28-May-12	0	0.35	0.60	0	0.05	0.05	30	60	10	0	0	0	0	0.40	0.95	0	0.55	0.65	0	80	10	10	0	0
23	3	28-May-12	0	0.60	1.00	0	0.10	0.24	30	50	20	0	0	0	0	0.65	1.05	0	0.01	0.05	90	10	0	0	0	0
24	3	29-May-12	0.40	0.50	1.15	0.43	0.50	0.50	0	30	70	0	0	0	0.40	0.55	1.00	0.50	0.55	0.70	0	30	70	0	0	0
25	3	29-May-12	0.30	0.50	0.80	0.40	0.45	0.50	0	30	70	0	0	0	0.30	0.60	0.90	0.30	0.30	0.40	0	30	70	0	0	0
26	3	29-May-12	0	0.80	1.40	0	0.40	0.51	0	0	0	0	0	100	0	0.50	1.60	0	0.40	0.50	0	0	0	0	0	100
27	3	02-Jun-12	0	0.10	0.27	0	0	0.13	0	90	10	0	0	0	0	0.12	0.22	0	0	0.01	0	100	0	0	0	0
28	3	02-Jun-12	0	0.39	0.50	0	0.08	0.02	20	60	10	10	0	0	0	0.35	0.40	0	0	0	80	20	0	0	0	0
31	3	30-May-12	0.75	0.75	0.90	0.86	0.80	0.74	0	30	50	20	0	0	0	0.35	0.57	0	0.85	0.81	0	60	30	10	0	0
32	3	30-May-12	0	0.74	1.45	0	0.18	0.16	0	80	20	0	0	0	0	0.60	0.77	0	0	0.11	20	70	10	0	0	0
33	3	30-May-12	0	0.95	1.47	0	0.29	0.39	0	70	30	0	0	0	0	0.65	1.26	0	0.25	0.40	0	60	40	0	0	0
34	3	29-May-12	0	1.20	2.95	0	0.08	0.50	0	10	0	0	0	90	0	0.74	1.14	0	0.01	0.08	0	50	30	20	0	0
35	3	29-May-12	0	0.41	1.60	0	0	0.02	0	0	0	0	0	100	0	0.61	2.50	0	0	0.09	0	0	0	0	0	100

			Downstream End of Site												**Upstream End of Site**											
			Depth (m)			**Velocity (m/s)**			**Substrate Composition**						**Depth (m)**			**Velocity (m/s)**			**Substrate Composition**					
Site	**Reach**	**Date**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**
36	3	31-May-12	0.87	0.95	1.00	0.11	0.11	0.09	100	0	0	0	0	0	0	0.35	0.50	0	0	0	100	0	0	0	0	0
37	3	29-May-12	0	0.40	0.42	0	0.03	0.14	100	0	0	0	0	0	0	0.41	0.66	0	0	0	30	60	10	0	0	0
38	3	30-May-12	0.97	1.00	1.05	0.34	0.30	0.32	20	10	60	10	0	0	0	0.47	0.58	0	0	0	90	5	5	0	0	0
39	3	29-May-12	0	0.33	0.63	0	0.26	0.66	20	60	20	0	0	0	0	0.66	1.06	0	0.18	0.06	10	30	60	0	0	0
40	2	05-Jun-12	0	0.52	0.88	0	0.17	0.30	0	95	5	0	0	0	0	0.56	1.06	0	0.23	0.36	0	95	5	0	0	0
41	2	05-Jun-12	0	0.62	1.10	0	0	0.01	0	70	30	0	0	0	0	0.69	1.22	0	0	0.07	0	60	40	0	0	0
42	2	05-Jun-12	0	0.45	0.70	0	0.01	0.01	80	20	0	0	0	0	0	0.26	0.41	0	0	0	10	90	0	0	0	0
43	2	05-Jun-12	0	0.44	0.65	0	0	0	100	0	0	0	0	0	0	0.86	1.44	0	0.14	0.32	100	0	0	0	0	0
44	2	04-Jun-12	0	0.38	3.00	0	0.25	0.17	0	0	0	90	10	0	0	0.82	1.70	0	0	0.11	0	0	0	90	10	0
45	2	04-Jun-12	0	0.23	0.56	0	0.09	0.16	10	90	0	0	0	0	0	0.17	0.39	0	0.08	0.09	5	95	0	0	0	0
46	2	04-Jun-12	0	1.21	1.46	0	0.05	0.02	100	0	0	0	0	0	0	0.16	0.42	0	0	0.02	100	0	0	0	0	0
47	2	04-Jun-12	0	1.22	1.85	0	0.10	0.31	0	0	0	70	30	0	0	0.64	1.35	0	0.08	0.07	0	0	0	70	30	0
48	2	31-May-12	0	0.77	1.55	0	0	0	0	80	15	5	0	0	0	3.00	5.20	0	0	0	0	5	0	0	95	0
49	2	31-May-12	0	0.72	1.16	0	0.08	0.20	100	0	0	0	0	0	0	0.23	0.33	0	0.01	0.01	100	0	0	0	0	0
50	2	31-May-12	0	0.26	0.36	0	0	0.06	100	0	0	0	0	0	0	0.32	0.45	0	0	0	95	5	0	0	0	0
51	2	31-May-12	0	0.92	1.50	0	0	0	0	0	10	70	20	0	0	0.87	1.45	0	0	0	0	0	10	30	60	0
52	1	30-May-12	0	1.02	2.05	0	0.04	0.02	0	0	5	5	90	0	0	0.98	2.70	0	0	0.08	0	0	0	95	5	0
53	1	30-May-12	0	0.27	0.41	0	0.06	0.14	5	95	0	0	0	0	0	0.30	0.44	0	0.01	0.04	5	95	0	0	0	0
54	1	30-May-12	0	0.35	0.66	0	0.01	0.01	90	5	5	0	0	0	0	0.37	0.95	0	0.13	0.39	95	5	0	0	0	0
55	1	30-May-12	0	0.50	0.98	0	0.03	0.04	20	30	10	20	20	0	0	0.70	3.50	0	0	0.01	0	5	5	80	10	0
56	1	30-May-12	0	1.06	1.46	0	0.03	0.03	100	0	0	0	0	0	0	0.28	0.70	0	0.13	0.03	100	0	0	0	0	0
Bias 5	4	31-May-12	0.30	0.55	0.55	0.11	0.20	0.20	0	10	30	60	0	0	0	0.34	0.57	0	0	0	0	0	10	90	0	0
Bias 6	4	01-Jun-12	0.80	0.86	0.96	0.87	0.91	0.78	0	85	15	0	0	0	0.80	0.99	0.97	0.75	0.84	0.95	0	90	10	0	0	0
Bias 7	4	01-Jun-12	0	0.52	1.29	0	0	0.01	0	0	0	0	0	100	0	0.84	1.20	0	0.50	0.74	0	0	0	0	0	100
Begbie D/S	2	04-Jun-12	0	0.22	0.22	0	0.76	1.15	20	50	20	10	0	0	0	0.47	0.52	0	0.57	1.57	5	75	15	5	0	0
Begbie U/S	2	04-Jun-12	0	0.34	0.61	0	0.11	1.69	5	30	30	35	0	0	0	0.32	0.85	0	0.22	1.09	0	25	25	50	0	0

			Downstream End of Site												Upstream End of Site											
			Depth (m)			Velocity (m/s)			Substrate Composition						Depth (m)			Velocity (m/s)			Substrate Composition					
Site	**Reach**	**Date**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**
Drimmie D/S	2	01-Jun-12	0	0.15	0.20	0	0.70	0.98	5	95	0	0	0	0	0	0.50	0.65	0	0.49	0.77	65	5	0	0	0	30
Drimmie U/S	2	01-Jun-12	0	0.25	0.39	0	0.73	1.03	15	80	5	0	0	0	0	0.25	0.29	0	0.89	0.92	15	80	5	0	0	0
Illecillewaet D/S	2	29-May-12	0	0.47	0.75	0	0.36	0.86	90	10	0	0	0	0	0	0.80	0.98	0	0.95	0.96	0	80	20	0	0	0
Illecillewaet U/S	2	01-Jun-12	0	0.55	0.75	0	0.35	0.45	30	60	10	0	0	0	0	0.75	0.97	0	0.42	0.53	20	60	20	0	0	0
Jordan D/S	3	01-Jun-12	0	1.05	1.32	0	0.70	1.15	0	0	0	0	0	100	0	1.00	1.52	0	1.35	1.60	0	0	0	0	0	100
Jordan U/S	3	02-Jun-12	0	0.20	0.41	0	0.31	1.06	0	20	70	10	0	0	0	0.21	0.35	0	0.13	0.35	10	30	60	0	0	0
Tonkawatla D/S	3	29-May-12	0	1.05	1.35	0	0.12	0.14	100	0	0	0	0	0	0	1.15	1.50	0	0.11	0.32	95	0	0	5	0	0
Tonkawatla U/S	3	01-Jun-12	0	0.95	1.25	0	0.51	0.65	60	40	0	0	0	0	0	0.30	0.45	0	0.62	0.77	60	40	0	0	0	0

F = fines G = gravel C = cobble B = boulder R = bedrock RR = riprap

Appendix 4b. Habitat summary information for the July sampling trip. Mid-site data has been omitted from table for clarity. Depth and velocity data are provided for stations at the shoreline (0 m), and 1.5 and 3.0 from the shoreline.

			Downstream End of Site														Upstream End of Site												
			Depth (m)			Velocity (m/s)			Substrate Composition						Depth (m)			Velocity (m/s)			Substrate Composition					
Site	**Reach**	**Date**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**
1	4	16-Jul-12	0	1.06	1.50	0	0.10	0.42	0	0	70	10	0	0	0	0.70	1.50	0	0.80	0.95	0	0	40	40	0	0
2	4	16-Jul-12	1.60	1.80	2.20	0.60	1.00	1.09	0	0	40	60	0	0	1.65	1.75	2.25	65.00	1.05	1.10	0	0	40	60	0	0
3	4	16-Jul-12	0	0.50	0.58	0	0.16	0.52	0	0	20	5	0	0	0	0.85	1.55	0	0.39	0.74	0	0	20	5	0	0
4	4	16-Jul-12	2.20	3.00	3.50	1.05	1.10	1.20	0	0	40	50	0	0	2.25	3.10	3.20	1.00	1.15	1.25	0	0	40	50	0	0
5	4	16-Jul-12	1.25	1.55	1.65	0.20	0.51	0.75	0	0	20	15	0	0	1.20	1.35	1.70	0.20	0.13	0.48	0	0	20	15	0	0
6	4	16-Jul-12	1.00	1.50	1.65	0.10	0.15	0.23	0	0	50	0	0	0	1.20	1.38	1.50	0.25	0.36	0.42	0	0	50	0	0	0
7	4	17-Jul-12	0.80	0.90	1.50	0.35	0.55	0.70	0	0	70	15	0	0	1.40	1.55	1.60	0.35	0.42	0.45	0	0	60	20	0	0
8	4	17-Jul-12	2.50	3.00	3.70	0.20	0.25	1.40	0	0	40	60	0	0	2.65	3.05	3.75	0.50	0.70	2.60	0	0	40	60	0	0
9	4	17-Jul-12	1.70	3.50	4.00	0.55	0.70	0.97	0	0	60	40	0	0	3.20	3.50	4.50	0.25	0.35	0.55	0	0	70	30	0	0
11	4	17-Jul-12	3.00	3.50	4.00	1.40	1.60	1.60	0	0	30	60	10	0	2.95	3.55	4.00	1.45	1.55	1.65	0	0	30	60	10	0
12	4	17-Jul-12	3.00	3.30	3.60	0.40	0.50	1.20	0	0	70	30	0	0	2.95	3.35	3.65	0.45	0.60	1.20	0	0	70	30	0	0
13	4	17-Jul-12	1.80	2.00	2.40	0.73	1.10	1.20	0	0	60	10	0	0	1.75	2.05	2.50	0.75	1.15	1.30	0	0	60	10	0	0
14	4	17-Jul-12	0	0.82	1.80	0	0.19	0.47	0	0	10	5	0	0	3.00	3.00	3.80	0.90	0.90	1.16	0	0	40	15	0	0
15	4	18-Jul-12	3.00	3.20	3.80	0.90	0.98	1.10	0	0	90	10	0	0	3.10	3.25	3.75	0.90	0.15	1.00	0	0	90	10	0	0
16	4	18-Jul-12	0	1.08	1.95	0	0.09	0.31	0	0	0	0	0	100	2.70	3.50	4.20	0.15	0.20	0.35	0	0	0	0	0	100
17	4	18-Jul-12	1.85	2.10	2.47	0.40	0.60	0.72	0	65	35	0	0	0	1.90	2.30	2.35	0.60	0.80	1.01	0	70	30	0	0	0
18	4	18-Jul-12	3.20	3.90	4.20	1.10	1.50	1.83	0	0	0	0	0	100	0	0.99	0.65	0	0.60	1.00	0	0	0	0	0	0
19	3	13-Jul-12	0.80	1.20	1.60	0.05	0.42	0.56	10	50	40	0	0	0	0.80	1.20	1.90	0	0	0.10	100	0	0	0	0	0
20	3	09-Jul-12	2.00	2.35	2.60	0	0	0	20	10	0	60	10	0	2.50	2.55	2.58	0.04	0.05	0.05	20	0	30	50	0	0
21	3	09-Jul-12	1.80	2.80	3.20	0	0	0	20	0	10	30	40	0	1.70	2.70	3.10	0	0	0	20	0	10	30	40	0
22	3	09-Jul-12	2.00	2.70	3.00	0	0.05	0.05	30	10	10	40	10	0	1.50	2.10	2.65	0	0	0	30	10	10	40	10	0
23	3	09-Jul-12	2.55	3.00	3.20	0	0	0	30	70	0	0	0	0	2.40	2.60	3.10	0	0	0	30	70	0	0	0	0
24	3	09-Jul-12	2.00	2.44	2.84	0.10	0.12	0.17	50	0	0	0	0	0	1.50	1.90	2.00	0.28	0.27	0.34	40	30	30	0	0	0
25	3	10-Jul-12	1.50	2.00	2.40	0.25	0.46	0.57	100	0	0	0	0	0	1.20	1.40	1.60	0	0	0	100	0	0	0	0	0
26	3	13-Jul-12	0	1.20	1.90	0	0	0	0	0	0	0	0	100	0	1.30	2.60	0	0	0	0	0	0	0	0	100
27	3	13-Jul-12	2.40	2.60	2.80	0	0	0.05	100	0	0	0	0	0	2.15	2.31	2.80	0	0	0.05	100	0	0	0	0	0

			Downstream End of Site															Upstream End of Site														
			Depth (m)			Velocity (m/s)			Substrate Composition									Depth (m)			Velocity (m/s)			Substrate Composition								
Site	**Reach**	**Date**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**				**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**			
28	3	13-Jul-12	1.60	2.80	3.40	0	0	0.05	100	0	0	0	0	0				2.40	2.60	2.70	0.05	0.05	0.05	100	0	0	0	0	0			
29	3	13-Jul-12	2.50	3.10	3.50	0	0.05	0.10	0	0	50	50	0	0				1.80	2.50	3.20	0	0.05	0.15	20	0	40	40	0	0			
30	3	13-Jul-12	0	1.40	2.90	0	0	0.10	0	0	0	0	0	100				0	0.60	1.20	0	0	0	0	0	0	0	0	100			
31	3	13-Jul-12	2.40	2.80	3.40	0	0	0.10	100	0	0	0	0	0				3.06	3.50	3.90	0	0	0	100	0	0	0	0	0			
32	3	14-Jul-12	2.40	2.80	3.40	0	0	0	90	10	0	0	0	0				0	2.10	2.80	0	0	0	90	10	0	0	0	0			
33	3	14-Jul-12	3.20	4.00	4.50	0	0	0	90	10	0	0	0	0				0.80	1.80	2.70	0	0	0	90	10	0	0	0	0			
34	3	13-Jul-12	0	0.80	1.60	0	0	0	0	0	0	0	0	100				1.65	2.70	3.51	0	0	0	30	70	0	0	0	0			
35	3	12-Jul-12	0	0.49	3.60	0	0	0.01	0	0	0	0	0	100				0	0.70	1.78	0	0	0	0	0	0	0	0	100			
36	3	12-Jul-12	1.81	1.95	2.12	0	0	0	100	0	0	0	0	0				1.05	1.56	1.80	0.01	0.01	0.01	100	0	0	0	0	0			
37	3	12-Jul-12	0.70	1.10	1.70	0	0	0	100	0	0	0	0	0				1.55	1.80	2.15	0	0	0	100	0	0	0	0	0			
38	3	12-Jul-12	1.90	2.00	2.20	0	0	0	100	0	0	0	0	0				1.87	1.80	1.65	0	0	0	100	0	0	0	0	0			
39	3	12-Jul-12	2.50	2.78	3.00	0	0	0	30	70	0	0	0	0				1.90	2.30	2.88	0.05	0.13	0.20	50	50	0	0	0	0			
41	2	11-Jul-12	1.60	1.90	2.40	0	0	0	0	0	60	40	0	0				1.90	2.30	4.20	0	0	0	0	0	60	40	0	0			
44	2	11-Jul-12	0	2.40	3.50	0	0	0	0	0	0	0	100	0				0	1.10	2.20	0	0	0	0	0	0	10	90	0			
46	2	11-Jul-12	0	0.60	0.80	0	0	0	0	0	0	10	90	0				1.20	1.60	2.30	0	0	0	0	0	0	0	100	0			
47	2	11-Jul-12	1.50	1.80	2.90	0	0	0	0	0	10	30	60	0				1.50	1.30	3.10	0	0	0	0	0	10	30	60	0			
48	2	10-Jul-12	0	0.70	1.15	0	0	0	0	0	10	30	60	0				0	1.15	2.60	0	0	0	0	0	10	30	60	0			
51	2	10-Jul-12	0	0.90	1.50	0	0	0	0	0	0	0	100	0				0	1.52	3.20	0	0	0	0	0	0	0	100	0			
52	1	10-Jul-12	0	0.91	1.50	0	0	0	0	0	0	0	100	0				0	1.65	3.10	0	0	0	0	0	0	0	100	0			
54	1	10-Jul-12	1.60	1.85	2.50	0	0	0	20	80	0	0	0	0				0	0.79	1.07	0	0	0	20	80	0	0	0	0			
55	1	10-Jul-12	0	3.00	5.00	0	0	0	0	0	0	0	100	0				0	3.00	5.00	0	0	0	0	0	0	10	90	0			
Bias 1	4	16-Jul-12	1.50	1.90	2.00	0.20	0.25	0.30	0	60	40	0	0	0				1.80	2.10	2.50	0.30	0.30	0.40	0	60	40	0	0	0			
Bias 2	4	17-Jul-12	3.00	3.30	3.65	0.50	0.65	0.70	0	30	50	20	0	0				3.00	3.50	3.70	0.50	0.60	0.65	0	30	50	20	0	0			
Bias 3	4	17-Jul-12	2.60	3.00	3.50	1.50	1.70	2.00	0	0	30	70	0	0				2.00	2.40	3.00	0.45	0.55	0.72	0	0	30	70	0	0			
Bias 4	4	17-Jul-12	2.50	3.00	3.70	0.50	1.10	1.20	0	0	40	60	0	0				2.25	3.10	3.60	0.15	0.25	0.30	0	0	40	60	0	0			
Bias 5	4	17-Jul-12	0	0.27	0.51	0	0.03	0.08	0	0	0	0	0	100				0	0.30	0.75	0	0	0.05	0	0	0	0	0	100			

			Downstream End of Site												Upstream End of Site											
			Depth (m)			Velocity (m/s)			Substrate Composition						Depth (m)			Velocity (m/s)			Substrate Composition					
Site	**Reach**	**Date**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**
Bias 6	4	18-Jul-12	3.00	3.15	3.25	0.60	0.65	0.68	0	35	65	0	0	0	3.10	3.05	3.25	0.55	0.70	0.75	0	35	65	0	0	0
Bias 7	4	18-Jul-12	3.30	3.80	4.20	0.55	0.70	0.90	0	0	0	0	0	100	3.20	3.90	4.20	1.10	1.50	1.80	0	0	0	0	0	100
Begbie D/S	2	11-Jul-12	0.80	1.50	1.90	0	0	0	0	80	20	0	0	0	0	0.80	2.20	0	0	0	10	50	40	0	0	0
Begbie U/S	2	11-Jul-12	0.80	1.40	1.80	0	0.15	0.15	10	50	40	0	0	0	0.40	0.80	1.20	0.05	0.35	0.50	10	40	40	10	0	0
Drimmie D/S	2	11-Jul-12	2.85	2.85	3.00	0	0	0	40	60	0	0	0	0	1.80	2.00	1.90	0	0	0	40	60	0	0	0	0
Drimmie U/S	2	11-Jul-12	1.37	1.35	1.35	0.38	0.34	0.25	0	100	0	0	0	0	0.85	1.13	1.26	0	0	0	0	100	0	0	0	0
Illicillewaet D/S	2	12-Jul-12	2.80	3.00	3.70	0.22	0.35	0.50	100	0	0	0	0	0	2.30	2.70	3.00	0.30	0.50	0.60	100	0	0	0	0	0
Illicillewaet U/S	2	12-Jul-12	2.10	3.00	3.80	0.65	0.70	0.70	30	30	40	0	0	0	1.30	2.80	3.50	0.27	0.60	0.65	10	40	50	0	0	0
Jordan D/S	3	13-Jul-12	0	0.90	2.60	0	0.15	0.25	0	0	0	0	0	100	0	1.40	2.10	0	0.05	0.30	0	0	10	10		80
Jordan U/S	3	13-Jul-12	0.80	1.20	1.40	0.05	0.20	0.25	10	20	70	0	0	0	0	1.50	1.40	0	0	0.05	20	10	70	0	0	0
Tonkawatla D/S	3	12-Jul-12	1.25	2.54	2.56	0	0	0	100	0	0	0	0	0	1.90	2.22	2.06	0	0	0	100	0	0	0	0	0
Tonkawatla U/S	3	12-Jul-12	0.90	1.22	2.80	0	0	0.05	100	0	0	0	0	0	1.21	2.38	3.11	0.10	0.50	0.20	50	50	0	0	0	0

F = fines G = gravel C = cobble B = boulder R = bedrock RR = riprap

Appendix 4c. Habitat summary information for the September sampling trip. Mid-site data has been omitted from table for clarity. Depth and velocity data are provided for stations at the shoreline (0 m), and 1.5 and 3.0 from the shoreline.

			Downstream End of Site												Upstream End of Site											
			Depth (m)			Velocity (m/s)			Substrate Composition						Depth (m)			Velocity (m/s)			Substrate Composition					
Site	Reach	Date	0 m	1.5 m	3 m	0 m	1.5 m	3 m	F	G	C	B	R	RR	0 m	1.5 m	3 m	0 m	1.5 m	3 m	F	G	C	B	R	RR
1	4	18-Sep-12	0	0.42	0.84	0	0.17	0.11	0	60	30	10	0	0	0	0.59	1.14	0	0.38	0.74	0	10	60	30	0	0
2	4	18-Sep-12	0.70	0.90	1.14	0.80	1.01	1.01	0	5	95	0	0	0	0.60	0.70	1.05	0.70	1.01	1.01	0	0	95	5	0	0
3	4	18-Sep-12	0	0.55	1.50	0	0.01	0.25	0	70	30	0	0	0	0	0.68	1.00	0	0.41	0.57	0	10	80	10	0	0
4	4	18-Sep-12	0	0.69	1.85	0	0.33	0.70	0	20	70	10	0	0	0	0.47	1.42	0	0.23	0.53	5	0	60	35	0	0
5	4	18-Sep-12	0.67	1.00	1.25	0.63	0.65	0.70	0	50	45	5	0	0	0.85	0.95	1.08	0.78	0.80	0.85	0	80	20	0	0	0
6	4	18-Sep-12	0.85	0.85	0.94	0.53	0.53	0.65	0	60	40	0	0	0	1.05	1.15	1.25	0.51	0.53	0.65	0	50	50	0	0	0
7	4	18-Sep-12	0.81	0.88	0.95	0.51	0.52	0.55	0	70	30	0	0	0	0.81	0.86	0.95	0.69	0.71	0.75	0	75	25	0	0	0
8	4	18-Sep-12	0	0.33	1.78	0	0.02	0.13	0	0	5	25	70	0	0	0.55	1.20	0	0.02	0.27	0	0	20	80	0	0
9	4	11-Sep-12	0	0.40	0.91	0	0.11	0.03	0	0	40	60	0	0	0	0.60	0.87	0	0.01	0.10	25	0	75	0	0	0
10	4	11-Sep-12	0	3.00	4.00	0	1.72	1.70	0	0	0	0	100	0	0	0.70	1.60	0	1.60	1.80	0	0	0	0	100	0
11	4	11-Sep-12	0.60	1.20	1.90	0.50	0.90	1.03	0	0	60	40	0	0	0	0.40	0.78	0	0.01	0.01	0	0	0	0	100	0
12	4	11-Sep-12	0	0.88	1.92	0	0.45	0.54	0	0	20	80	0	0	1.00	1.45	1.55	0.70	0.88	0.98	0	35	60	5	0	0
13	4	11-Sep-12	0	0.27	0.78	0	0.11	0.53	10	0	60	30	0	0	0	0.47	1.00	0	0.25	0.32	0	30	60	10	0	0
14	4	11-Sep-12	0	0.90	1.33	0	0.72	0.97	0	30	60	10	0	0	0	0.66	1.38	0	0.14	0.34	0	40	60	0	0	0
15	4	11-Sep-12	0	1.30	2.50	0	0.60	0.75	0	0	10	90	0	0	0	1.10	2.60	0	0.50	0.78	0	0	10	90	0	0
16	4	19-Sep-12	0	0.66	2.41	0	0.08	0.58	0	0	0	0	0	100	0	0.51	1.88	0	0.10	0.30	0	0	0	0	0	100
17	4	19-Sep-12	0.74	0.78	0.85	0.26	0.28	0.28	10	30	60	0	0	0	0.74	0.77	0.88	0.27	0.29	0.30	0	40	60	0	0	0
18	4	19-Sep-12	0	0.74	2.90	0	0.05	0.29	0	0	0	0	0	100	0	1.06	2.25	0	0.24	0.89	0	0	0	0	0	100
19	3	10-Sep-12	0.71	0.74	0.82	0.24	0.28	0.30	0	0	100	0	0	0	0.67	0.74	0.70	0.40	0.45	0.40	0	0	100	0	0	0
20	3	10-Sep-12	0	0.15	0.45	0	0	0	100	0	0	0	0	0	0	0.24	0.36	0	0.15	0.08	10	10	80	0	0	0
21	3	10-Sep-12	0	0.70	1.10	0	0.70	0.90	0	0	25	75	0	0	0	0.44	0.78	0	0.05	0.15	0	0	0	0	100	0
22	3	10-Sep-12	0	0.25	0.65	0	0	0.08	30	60	10	0	0	0	0	0.51	1.07	0	0.30	0.08	10	80	10	0	0	0
23	3	10-Sep-12	0	0.44	0.67	0	0	0	65	25	10	0	0	0	0	0.49	0.90	0	0	0	90	5	5	0	0	0
24	3	10-Sep-12	0.70	0.73	0.74	0.89	0.89	0.91	0	0	50	50	0	0	0.94	0.95	1.05	0.83	0.85	0.85	0	50	50	0	0	0
25	3	10-Sep-12	0.54	0.57	0.65	0.35	0.38	0.40	0	0	50	50	0	0	0.25	0.40	0.47	0.20	0.20	0.20	0	0	50	50	0	0
26	3	10-Sep-12	0	0.79	1.50	0	0.02	0.13	0	0	0	0	0	100	0	0.61	1.48	0	0	0.05	0	0	0	0	0	100

			Downstream End of Site												Upstream End of Site											
			Depth (m)			Velocity (m/s)			Substrate Composition						Depth (m)			Velocity (m/s)			Substrate Composition					
Site	**Reach**	**Date**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**
27	3	17-Sep-12	0	0.13	0.15	0	0.01	0.06	20	70	10	0	0	0	0	0.27	0.45	0	0.06	0.03	40	60	0	0	0	0
28	3	14-Sep-12	0	0.40	0.96	0	0.08	0.08	5	25	70	0	0	0	0.76	0.84	1.50	0.03	0.04	0.07	20	70	10	0	0	0
29	3	14-Sep-12	0	0.51	0.90	0	0.24	0.20	0	0	0	0	0	100	0	0.62	0.85	0	0.10	0.37	0	0	0	0	0	100
30	3	14-Sep-12	0	0.25	0.78	0	0.02	0.21	70	20	0	10	0	0	0	0.46	0.90	0	0.05	0.35	0	0	0	0	0	100
31	3	14-Sep-12	0.70	0.88	0.98	0.60	0.65	0.67	0	95	5	0	0	0	0.85	1.15	1.23	0.95	1.00	1.02	0	95	5	0	0	0
32	3	14-Sep-12	0	0.60	1.34	0	0	0.11	5	75	20	0	0	0	0	0.40	1.14	0	0	0	90	10	0	0	0	0
33	3	14-Sep-12	0	0.61	1.45	0	0.21	0.29	0	80	20	0	0	0	0	0.46	1.39	0	0.19	0.40	5	80	15	0	0	0
34	3	14-Sep-12	0	0.91	2.15	0	0.21	0.03	0	0	0	0	0	100	0	0.68	1.39	0	0.21	0.34	0	75	25	0	0	0
35	3	14-Sep-12	0.25	1.03	2.55	0	0.32	0.59	0	0	0	0	0	100	0	0.60	1.78	0	0.08	0.25	0	0	0	0	0	100
36	3	17-Sep-12	0	0.88	1.41	0	0.19	0.34	30	70	0	0	0	0	0	0.47	0.85	0	0.32	0.42	5	95	0	0	0	0
37	3	17-Sep-12	0	0.63	0.72	0	0.21	0.27	70	30	0	0	0	0	0	0.75	1.55	0	0.26	0.45	35	50	10	5	0	0
38	3	17-Sep-12	0	0.54	1.16	0	0.14	0.26	100	0	0	0	0	0	0	0.57	0.98	0	0.08	0.21	80	20	0	0	0	0
39	3	17-Sep-12	0	0.20	0.71	0	0.26	0.62	0	60	40	0	0	0	0	0.59	1.36	0	0.26	0.18	0	5	95	0	0	0
40	2	12-Sep-12	0	0.36	0.67	0	0.17	0.38	30	60	10	0	0	0	0	0.95	1.36	0	0.04	0.10	95	5	0	0	0	0
41	2	13-Sep-12	0	1.03	1.50	0	0	0.07	85	5	5	5	0	0	0	1.11	1.50	0	0.10	0.11	85	5	5	5	0	0
42	2	13-Sep-12	0	0.44	0.68	0	0.07	0.18	85	15	0	0	0	0	0	0.43	0.55	0	0.05	0.32	100	0	0	0	0	0
43	2	13-Sep-12	0.58	1.17	1.33	0	0.02	0.11	100	0	0	0	0	0	0	0.67	1.26	0	0.08	0.25	100	0	0	0	0	0
44	2	12-Sep-12	0	1.55	1.59	0	0	0.01	0	0	0	50	50	0	0	0.96	2.11	0	0.04	0.05	0	0	0	40	60	0
45	2	13-Sep-12	0	0.24	0.33	0	0	0	100	0	0	0	0	0	0	0.50	0.60	0	0.06	0.15	100	0	0	0	0	0
46	2	13-Sep-12	0	0.79	0.95	0	0	0.02	100	0	0	0	0	0	0	0.65	0.87	0	0	0	100	0	0	0	0	0
47	2	14-Sep-12	0	1.41	2.26	0	0.20	0.21	0	5	5	40	50	0	0	0.94	1.70	0	0.07	0.11	0	10	40	50	0	0
48	2	12-Sep-12	0	0.56	1.35	0	0	0	0	45	40	15	0	0	0	0.49	0.97	0	0	0	0	5	5	10	80	0
51	2	12-Sep-12	0	0.56	1.07	0	0	0	0	0	10	30	60	0	0	0.88	1.88	0	0	0	0	0	0	40	60	0
52	1	12-Sep-12	0	1.04	2.05	0	0	0	0	20	20	60	0	0	0	0.50	0.67	0	0	0	0	0	0	10	90	0
53	1	12-Sep-12	0	0.26	0.36	0	0	0	100	0	0	0	0	0	0.82	0.92	0.97	0.02	0.02	0.02	100	0	0	0	0	0
54	1	12-Sep-12	0	0.28	0.65	0	0	0	100	0	0	0	0	0	0	0.35	0.70	0	0	0	90	10	0	0	0	0

			Downstream End of Site												Upstream End of Site											
			Depth (m)			Velocity (m/s)			Substrate Composition						Depth (m)			Velocity (m/s)			Substrate Composition					
Site	**Reach**	**Date**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**	**0 m**	**1.5 m**	**3 m**	**0 m**	**1.5 m**	**3 m**	**F**	**G**	**C**	**B**	**R**	**RR**
55	1	12-Sep-12	0	0.92	1.45	0	0	0	10	60	10	20	0	0	0	0.71	1.95	0	0	0	10	5	5	5	75	0
56	1	12-Sep-12	0	0.47	0.85	0	0	0	100	0	0	0	0	0	0	0.40	0.87	0	0	0	100	0	0	0	0	0
Bias 1	4	18-Sep-12	0	0.39	1.22	0	0	0.02	10	30	50	10	0	0	0	0.30	1.70	0	0.05	0.05	5	0	20	75	0	0
Bias 2	4	18-Sep-12	0	0.55	1.22	0	0.02	0.05	0	20	70	10	0	0	0	0.67	1.45	0	0.14	0.45	0	50	40	10	0	0
Bias 3	4	18-Sep-12	0	0.53	1.00	0	0.32	0.84	0	5	60	35	0	0	0	0.40	1.15	0	0.02	0.27	0	40	55	5	0	0
Bias 4	4	18-Sep-12	0	0.40	1.10	0	0.26	0.47	0	5	25	70	0	0	0	0.34	1.29	0	0.03	0.05	0	0	0	40	60	0
Bias 5	4	11-Sep-12	0	0.42	0.55	0	0	0	0	0	0	0	0	100	0	0.59	1.12	0	0.12	0.46	0	0	0	0	0	100
Bias 6	4	11-Sep-12	0.62	0.65	0.70	0.42	0.40	0.40	0	10	60	30	0	0	0	0.66	1.35	0	0.32	0.63	0	20	75	5	0	0
Bias 7	4	19-Sep-12	0	0.75	1.90	0	0.05	0.16	0	0	0	0	0	100	0	0.74	2.90	0	0.05	0.29	0	0	0	0	0	100
Begbie D/S	2	13-Sep-12	0	0.25	0.33	0	1.01	0.85	5	55	30	10	0	0	0	0.22	0.30	0	0.42	0.85	5	55	30	10	0	0
BegbieU/S	2	13-Sep-12	0	0.36	0.50	0	0.11	0.75	5	25	50	20	0	0	0	0.46	0.40	0	0.11	0.45	15	30	25	20	10	0
Drimmie D/S	2	12-Sep-12	0	1.30	1.43	0	0	0	100	0	0	0	0	0	0	0.99	1.40	0	0	0	90	5	5	0	0	0
Illecillewaet D/S	2	17-Sep-12	0	0.30	0.74	0	0.12	0.23	25	60	15	0	0	0	0	0.55	0.89	0	0.06	0.22	10	60	30	0	0	0
Illecillewaet U/S	2	17-Sep-12	0	0.45	0.63	0	0.03	0.12	30	10	60	0	0	0	0	0.55	0.69	0	0.38	0.45	30	10	60	0	0	0
Jordan D/S	3	19-Sep-12	0	0.76	2.25	0	0.01	0.01	0	0	0	0	0	100	0	0.70	2.51	0	0	0	0	5	0	0	0	95
JordanU/S	3	19-Sep-12	0	0.19	0.45	0	0.05	0.09	0	10	40	50	0	0	0	0.31	0.57	0	0.11	0.19	10	5	35	50	0	0
Tonkawatla D/S	3	17-Sep-12	0	0.87	1.50	0	0	0	100	0	0	0	0	0	0	0.91	1.26	0	0	0	95	0	0	5	0	0

F = fines G = gravel C = cobble B = boulder R = bedrock RR = riprap

Appendix 5

Fish Collection Summary Information

Appendix 5a. Fish collection summary information for the May sampling trip.

Site	Reach	Date	EF sec.	BB A	BB J	BT A	BT J	KO A	KO J	MW A	MW J	NSC A	NSC J	RB A	RB J	RSC A	RSC J	CAS A	CAS J	CCG A	CCG J	PCC A	PCC J	CSU A	CSU J	COTT A	COTT J
1	4	05-Jun-12	262															3	1							2	0
2	4	05-Jun-12	281															1	0								
3	4	05-Jun-12	231															1	0							2	0
11	4	31-May-12	322			0	1											3	0							20	15
12	4	31-May-12	336															1	0							10	3
13	4	31-May-12	298															7	0	2	0					38	10
14	4	31-May-12	335															10	0							13	8
15	4	31-May-12	256															14	2	2	0					40	37
16	4	01-Jun-12	348			0	1											11	0							13	10
17	4	01-Jun-12	305																							0	1
18	4	01-Jun-12	359											1	0	2	0	10	2							21	13
19	3	28-May-12	294							0	2																
20	3	28-May-12	169																								
21	3	28-May-12	244			2	0	1	0	1	1			0	2	1	0										
22	3	28-May-12	297			0	1			1	0			0	1	1	0	1	0							1	0
23	3	28-May-12	224			0	1	1	0							2	0									1	0
24	3	29-May-12	272																								
25	3	29-May-12	274			1	0																				
26	3	29-May-12	488							0	2			0	2	2	0	2	0							5	0
27	3	02-Jun-12	378															1	0	1	0						
28	3	02-Jun-12	366			0	1							0	2			0	1	0	1					21	12
31	3	30-May-12	431	1	0					0	5							2	0								
32	3	30-May-12	335			0	1			1	0			0	1	16	12	7	1							20	10
33	3	30-May-12	239													1	1	13	5	2	0					30	10
34	3	29-May-12	347											0	1	4	0	3	1	1	0					20	10
35	3	29-May-12	355											0	2			3	0							15	10
36	3	31-May-12	419							5	1							1	0					2	0	3	0
37	3	29-May-12	286													4	2			1	0					5	0
38	3	30-May-12	255							1	4							1	0							3	0
39	3	29-May-12	287							0	1					1	1	2	0	1	0					15	10
40	2	05-Jun-12	246																	0	1					2	0

Site	Reach	Date	EF sec.	BB A	BB J	BT A	BT J	KO A	KO J	MW A	MW J	NSC A	NSC J	RB A	RB J	RSC A	RSC J	CAS A	CAS J	CCG A	CCG J	PCC A	PCC J	CSU A	CSU J	COTT A	COTT J
41	2	05-Jun-12	305											0	1					1	0					5	0
42	2	05-Jun-12	251			0	1			0	5																
43	2	05-Jun-12	257							0	1											0	7				
44	2	04-Jun-12	332			0	2									8	0					0	1			1	0
45	2	04-Jun-12	257																	1	0					2	0
46	2	04-Jun-12	299													1	0									2	0
47	2	04-Jun-12	317			0	1									7	0	1	0							2	2
48	2	31-May-12	313			0	1					0	3	0	1	18	3	1	0								
49	2	31-May-12	263					0	1	0	2							15	1							25	0
50	2	31-May-12	196	0	1											1	0	9	0							9	0
51	2	31-May-12	299	0	1	0	1					0	2			56	20	4	1			0	1			10	0
52	1	30-May-12	350									0	2			10	0	2	0					0	1	10	5
53	1	30-May-12	278					0	2	0	6					3	0	1	0			0	1			3	0
54	1	30-May-12	311			0	1			0	2					5	0	6	0							5	0
55	1	30-May-12	305			0	1			3	1	0	2	0	3	28	32	2	0	2	0	1	0	0	1	15	0
56	1	30-May-12	227					0	2	1	4					0	3					0	1				
Bias 5	4	31-May-12	354							1	1							3	1							7	0
Bias 6	4	01-Jun-12	300																								
Bias 7	4	01-Jun-12	300			1	0							1	1	2	0	17	0							37	33
Begbie D/S	2	04-Jun-12	131											0	1												
Begbie U/S	2	04-Jun-12	135			0	1							0	2												
Drimmie D/S	2	01-Jun-12	281			0	2							0	2												
Drimmie U/S	2	01-Jun-12	232																								
Illecillewaet D/S	2	29-May-12	147											0	1												
Illecillewaet U/S	2	01-Jun-12	154			0	1											1	0	4	1					0	1
Jordan D/S	3	01-Jun-12	170							1	0			0	1												
Jordan U/S	3	02-Jun-12	234											0	1					2	0						
Tonkawatla D/S	3	29-May-12	148			1	0			0	1															2	0
Tonkawatla U/S	3	01-Jun-12	230			0	1							0	9			0	1								

BB = Burbot	BT = Bull trout	KO = Kokanee	MW = Mountain Whitefish
NSC = Northern Pikeminnow	RB = Rainbow Trout	RSC = Redside Shiner	CAS = Prickly Sculpin
CCG = Slimy Sculpin	PCC = Peamouth Chub	CSU = Largescale Sucker	COTT = Sculpin (general)

A = Adult
J = Juvenile

Appendix 5b. Fish collection summary information for the July sampling trip.

Site	Reach	Date	EF sec.	BB A	BB J	BT A	BT J	KO A	KO J	MW A	MW J	NSC A	NSC J	RB A	RB J	RSC A	RSC J	CAS A	CAS J	CCG A	CCG J	LSU A	LSU J	PCC A	PCC J	TC A	TC J	EB A	EB J	CSU A	CSU J	COTT A	COTT J
1	4	16-Jul-12	204							4	1																						
2	4	16-Jul-12	278											0	1																		
3	4	16-Jul-12	255					1	2	0	2																						
4	4	16-Jul-12	322					1	0																								
5	4	16-Jul-12	308					2	0	3	0																			1	0		
6	4	16-Jul-12	301			1	0			2	2																						
7	4	17-Jul-12	270			2	0	1	0	0	1																			1	0		
8	4	17-Jul-12	144																														
9	4	17-Jul-12	329							1	0																						
11	4	17-Jul-12	269							2	1																						
12	4	17-Jul-12	252																														
13	4	17-Jul-12	299																														
14	4	17-Jul-12	259							0	2																						
15	4	18-Jul-12	348																														
16	4	18-Jul-12	305											0	1											1	0						
17	4	18-Jul-12	284					3	0	2	2																						
18	4	18-Jul-12	295																														
19	3	13-Jul-12	296			0	1			0	4			0	2															1	0		
20	3	09-Jul-12	236					0	1																	1	0						
21	3	09-Jul-12	315																	1	0									1	0		
22	3	09-Jul-12	328							1	0			1	0															1	0		
23	3	09-Jul-12	331							1	0																						
24	3	09-Jul-12	347					0	1																					1	0		
25	3	10-Jul-12	349																							1	0			1	0		
26	3	13-Jul-12	368					0	2					0	1															1	0		
27	3	13-Jul-12	306					0	2																					12	0		
28	3	13-Jul-12	321					0	1																					2	0		
29	3	13-Jul-12	332					0	1									1	0									0	1				
30	3	13-Jul-12	355					0	5					0	2			1	0							0	1			1	0		
31	3	13-Jul-12	332							1	0																						
32	3	14-Jul-12	326																											2	0		

Site	Reach	Date	EF sec.	BB A	BB J	BT A	BT J	KO A	KO J	MW A	MW J	NSC A	NSC J	RB A	RB J	RSC A	RSC J	CAS A	CAS J	CCG A	CCG J	LSU A	LSU J	PCC A	PCC J	TC A	TC J	EB A	EB J	CSU A	CSU J	COTT A	COTT J
33	3	14-Jul-12	357							1	0			0	1			2	1											3	0		
34	3	13-Jul-12	358					0	1	1	1			0	2			1	1														
35	3	12-Jul-12	365					0	3					0	4			1	1	1	0											7	0
36	3	12-Jul-12	230																					1	0					2	0		
37	3	12-Jul-12	265					0	5	2	0							1	0														
38	3	12-Jul-12	242							2	1																			3	0		
39	3	12-Jul-12	277																											3	0		
41	2	11-Jul-12	310					0	1	6	0			0	1															1	0		
44	2	11-Jul-12	373											0	2			3	0														
46	2	11-Jul-12	249							7	0			0	1			2	0											3	0		
47	2	11-Jul-12	286											0	1			2	0														
48	2	10-Jul-12	257							8	1	0	1			0	1																
51	2	10-Jul-12	350							2	0					1	0	0	2													2	0
52	1	10-Jul-12	298																														
54	1	10-Jul-12	346													1	0													5	0		
55	1	10-Jul-12	335					0	1	7	7			0	1			1	0											1	0		
Bias 1	4	16-Jul-12	310			2	0			1	0																						
Bias 2	4	17-Jul-12	243			1	0			0	1																						
Bias 3	4	17-Jul-12	206																														
Bias 4	4	17-Jul-12	250																														
Bias 5	4	17-Jul-12	276			0	1	1	0	1	1							1	1							1	0					2	0
Bias 6	4	18-Jul-12	210																														
Bias 7	4	18-Jul-12	255							1	0																						

Site	Reach	Date	EF sec.	BB A	BB J	BT A	BT J	KO A	KO J	MW A	MW J	NSC A	NSC J	RB A	RB J	RSC A	RSC J	CAS A	CAS J	CCG A	CCG J	LSU A	LSU J	PCC A	PCC J	TC A	TC J	EB A	EB J	CSU A	CSU J	COTT A	COTT J
Begbie D/S	2	11-Jul-12	215			0	1			0	2					0	1			1	1												
Begbie U/S	2	11-Jul-12	183							1	8																			1	0		
Drimmie D/S	2	11-Jul-12	222							9	0											2	0							9	0		
Drimmie U/S	2	11-Jul-12	180							6	0													1	0					8	0		
Illicillewaet D/S	2	12-Jul-12	208							3	0											1	0	1	0					6	0		
Illicillewaet U/S	2	12-Jul-12	197							1	1																			4	0		
Jordan D/S	3	13-Jul-12	199																														
Jordan U/S	3	13-Jul-12	162							0	1			0	1																		
Tonkawatla D/S	3	12-Jul-12	185											0	1									1	0					6	0		
Tonkawatla U/S	3	12-Jul-12	175																			1	0	1	0					11	0		

BB = Burbot
BT = Bull trout
KO = Kokanee
MW = Mountain Whitefish
NSC = Northern Pikeminnow
RB = Rainbow Trout
RSC = Redside Shiner
CAS = Prickly Sculpin
CCG = Slimy Sculpin
LSU = Longnose Sucker
PCC = Peamouth Chub
TC = Tench
EB = Eastern Brook Trout
CSU = Largescale Sucker
COTT = Sculpin (general)

A = Adult
J = Juvenile

Appendix 5c. Fish collection summary information for the September sampling trip.

Site	Reach	Sample Date	Effort	BB A	BB J	BT A	BT J	KO A	KO J	MW A	MW J	NSC A	NSC J	RB A	RB J	RSC A	RSC J	CAS A	CAS J	CCG A	CCG J	LSU A	LSU J	PCC A	PCC J	YP A	YP J	CSU A	CSU J	COTT A	COTT J
1	4	18-Sep-12	220					1	4	1	2			1	0															6	0
2	4	18-Sep-12	204																												
3	4	18-Sep-12	245			0	1	1	2	3	0																			1	0
4	4	18-Sep-12	259					0	7									2	0											7	0
5	4	18-Sep-12	237					1	0	4	0																				
6	4	18-Sep-12	238							0	2																				
7	4	18-Sep-12	237							3	0																				
8	4	18-Sep-12	221			1	0	1	0	4	3			1	1																
9	4	11-Sep-12	307					4	0									3	0									1	1	18	8
10	4	11-Sep-12	296			3	0	1	0	1	0							0	1			2	0								
11	4	11-Sep-12	288					2	0	4	0																				
12	4	11-Sep-12	312					5	0									1	0									1	0	3	0
13	4	11-Sep-12	287					0	1									9	0	1	0									26	5
14	4	11-Sep-12	311					2	0									2	0											9	2
15	4	11-Sep-12	293			1	0	1	0	0	1							1	0												
16	4	19-Sep-12	239	2	0					1	0					2	0													3	0
17	4	19-Sep-12	236							0	4																				
18	4	19-Sep-12	262	1	0	2	0											1	1											4	0
19	3	10-Sep-12	263			1	0			1	1											1	0					1	0		
20	3	10-Sep-12	271					16	3	21	7																				
21	3	10-Sep-12	228			4	0	2	1					1	2			1	0												
22	3	10-Sep-12	227			2	0	0	3	6	3	1	0					1	0											9	0
23	3	10-Sep-12	277					0	5							1	0	3	0							0	2			11	0
24	3	10-Sep-12	238																												
25	3	10-Sep-12	245							1	1																				
26	3	10-Sep-12	293					7	3	2	0	1	0	0	4													2	0		
27	3	17-Sep-12	576					0	30																						
28	3	14-Sep-12	324			3	0	3	0	5	1							2	0									4	0	21	12
29	3	14-Sep-12	276							4	9			1	0			5	0												
30	3	14-Sep-12	251			1	0	0	1	5	17			1	1			1	0											25	10
31	3	14-Sep-12	263							2	7																				

Site	Reach	Sample Date	Effort	BB A	BB J	BT A	BT J	KO A	KO J	MW A	MW J	NSC A	NSC J	RB A	RB J	RSC A	RSC J	CAS A	CAS J	CCG A	CCG J	LSU A	LSU J	PCC A	PCC J	YP A	YP J	CSU A	CSU J	COTT A	COTT J
32	3	14-Sep-12	252					0	1	2	0			0	1	2	0	15	1											15	10
33	3	14-Sep-12	266															13	0											44	25
34	3	14-Sep-12	263			1	0	1	3			0	1	0	6	5	0	2	0	1	0									20	0
35	3	14-Sep-12	265	0	2			1	0					0	2			8	0											20	15
36	3	17-Sep-12	262					6	2									3	0											2	0
37	3	17-Sep-12	235					18	7	0	2							2	0											6	0
38	3	17-Sep-12	232					7	4	0	1							1	0											2	0
39	3	17-Sep-12	246					1	4	1	2							3	0									9	0	18	10
40	2	12-Sep-12	235							0	1															0	1	2	0	2	0
41	2	13-Sep-12	217					0	2	1	0							10	1	1	0									8	3
42	2	13-Sep-12	232					0	1	0	4															0	1	1	0		
43	2	13-Sep-12	212			1	0	0	3	0	6					1	0	3	0											3	0
44	2	12-Sep-12	334							0	1					15	0	3	0												
45	2	13-Sep-12	210					0	1	0	3	1	0			1	0	1	0					0	1						
46	2	13-Sep-12	261							1	1	1	0					3	0	3	0									6	3
47	2	14-Sep-12	311									1	0	0	1	3	3	7	0	1	0									9	6
48	2	12-Sep-12	306									0	1			19	5	4	0											4	1
51	2	12-Sep-12	300									0	1			20	0	4	0									0	1		
52	1	12-Sep-12	220									0	1			18	4	5	0												
53	1	12-Sep-12	179							5	6																				
54	1	12-Sep-12	179									1	0															1	0		
55	1	12-Sep-12	286											0	1	60	15	2	0												
56	1	12-Sep-12	152																											1	1
Bias 1	4	18-Sep-12	238							11	6																	1	0		
Bias 2	4	18-Sep-12	172							8	0							1	0												
Bias 3	4	18-Sep-12	235	1	0	3	0	1	0									3	0											16	0
Bias 4	4	18-Sep-12	256			1	0	2	0	1	0			0	1			4	0			1	0							15	0
Bias 5	4	11-Sep-12	220			2	0	0	2	0	1							1	0											11	0
Bias 6	4	11-Sep-12	253			1	0	4	0	2	0							3	0											11	0
Bias 7	4	19-Sep-12	233									1	0	0	1	1	0	3	0												

Site	Reach	Sample Date	Effort	BT A	BT J	KO A	KO J	MW A	MW J	NSC A	NSC J	RB A	RB J	RSC A	RSC J	CAS A	CAS J	CCG A	CCG J	LSU A	LSU J	CSU A	CSU J	COTT A	COTT J
Begbie D/S	2	13-Sep-12	268											0	1										
Begbie U/S	2	13-Sep-12	246			0	1							0	12					1	3				
Drimmie D/S	2	12-Sep-12	125			1	0	2	0	2	0					1	0					0	1	3	0
Illecillewaet D/S	2	17-Sep-12	144											0	1			3	0	3	0				
Illecillewaet U/S	2	17-Sep-12	223															3	1						
Jordan D/S	3	19-Sep-12	155															3	0						
Jordan U/S	3	19-Sep-12	357			0	1							0	1										
Tonkawatla D/S	3	17-Sep-12	141			1	0											3	1						

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