Columbia River Project Water Use Plan

Lower Columbia River Fish Management Plan

Lower Columbia Sculpin and Dace Life History Assessment

Implementation Year 5

Reference: CLBMON-43

Lower Columbia River Sculpin and Dace Life History Assessment Year 5 Final Technical Report

Study Period: March 2013 to April 2014

AMEC Environment & Infrastructure
a Division of AMEC Americas Limited
Suite 601E, 601 Front St. Nelson, BC
Canada V1L 4B6

Report Date: September 18, 2014

Lower Columbia River Sculpin and Dace Life History Assessment (CLBMON-43)

Year 5 Report (2013)





Prepared for:

BC Hydro
Burnaby, BC

Prepared by:

AMEC Environment & Infrastructure
Nelson, BC

September 18, 2014
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CLBMON-43 Lower Columbia River Sculpin and Dace Life History Assessment

Year 5
FINAL TECHNICAL REPORT

Version 1.0
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Submitted to:

BC Hydro
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AMEC Project No. VE51872.2013

Cover Photos: Clockwise from top left: Lower Columbia River at LCR_24.5R in September 2013; Female Umatilla dace (*Rhinichthys umatilla*) in spawning condition with red lips captured at Sloc_39.4L on August 10, 2011; Columbia sculpin (*Cottus hubbsi*) captured at Kootenay Mouth on May 27, 2010; Snorkelling near Trozzo Creek at Sloc_37.8L on July 17, 2013; Sculpin nest found on the LCR at an Unknown Tributary in Robson on June 5, 2012.

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IMPORTANT NOTICE

This report was prepared exclusively for BC Hydro by AMEC Environment & Infrastructure Limited, a division of AMEC Americas Limited. The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in AMEC services and based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by BC Hydro only, subject to the terms and conditions of its contract with AMEC. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

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Louise Porto, MSc., R.P.Bio.	Senior Aquatic Habitat Biologist, Co-author
Crystal Lawrence, BSc., R.P.Bio.	Aquatic Biologist, Co-author
Rachel Keeler, MSc., R.P.Bio.	Aquatic Biologist, Senior Review
Katherine Fraser	Field Technician, Data Entry
Paul Kwon	GIS Technician

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Clint Tarala	Field Technician – Subcontractor
Robyn Irvine	Contributing Analyst (HSI), Poisson Consulting Ltd.
Joe Thorley	Contributing Analyst (Pool Stranding Risk), Poisson Consulting Ltd.

EXECUTIVE SUMMARY

The Columbia River Water Use Plan Consultative Committee identified that limited information was available to assess the potential impacts of seasonal operations of Hugh L. Keenleyside Dam (HLK) on sculpins and dace in the lower Columbia River (LCR) that are listed under the Species-At-Risk Act (SARA). Specifically, Umatilla Dace, Columbia Sculpin and Shorthead Sculpin are listed as species of *Special Concern* under SARA. During this process, several data gaps were identified with respect to fish habitat use and productivity in the LCR. The LCR sculpin and dace life history assessment (CLBMON-43) program's main objective is to collect information on the life history, timing, and habitat use of four sculpins (Prickly, Torrent, Columbia, and Shorthead) and two dace (Umatilla and Longnose) species that may be affected by water level fluctuations resulting from daily and seasonal operations of HLK. While all six species require study, the focus of the study is on the federally listed species (Shorthead and Columbia sculpins and Umatilla Dace) in the LCR. This is the final report for the five years of study conducted under this program. Included is a synthesis for all five years for the LCR study area with comparison information for target species in the unregulated tributaries that were sampled during this program including: Umatilla Dace in the Slocan River; Columbia Sculpins in the Similkameen River system; and, Shorthead Sculpins in Pass Creek. Also included is a summary for data collected between March 2013 and April 2014 (Year 5) to be consistent with previous years of study. The following table is a summary of the findings pertaining to the management questions for this program.

Management Question	Final Year Status
How do water level fluctuations (diel and seasonal) in the lower Columbia River affect the distribution and habitat use of sculpins and dace, especially the listed species?	**Sculpins**: - **Diel** differences in habitat use were not commonly observed for sculpins and **diel water level changes** did not appear to influence their habitat use. - **Seasonal** differences in habitat use were observed for some sculpins depending on species and life stage. - **Seasonal water level fluctuations** in the LCR influenced the short-term distribution of sculpins, but habitat use for these species was not affected. Flow fluctuations in fall influenced sculpins to move more frequently, whereas in spring, fall and winter, movement direction was influenced and tended to be towards the thalweg away from dewatering nearshore areas. Limited sample sizes prevent drawing conclusions for the summer period. **Dace**: - **Diel** differences in habitat use were not commonly observed for dace and **diel water level changes** did not appear to influence their habitat use. - **Seasonal** differences in habitat use were observed for Umatilla dace during the spring/summer on the unregulated Slocan River as they were captured in newly flooded shallow water habitats. In addition, young of the year (YOY) Umatilla dace were observed using flooded vegetation during the fall/winter period on the LCR; this habitat type was not available in the unregulated Slocan River because this is a period of naturally low water levels. - It is inconclusive at this time whether **seasonal water level fluctuations** influence the short-term distribution and habitat use of dace. Low sample sizes limited conclusions.
What seasonal and diel habitat shifts do sculpins and dace (especially the listed species) make in response to water level fluctuations?	**Sculpins:** - **Seasonal** and **diel** shifts in habitat use were not commonly observed for sculpins. **Dace:** - **Seasonal** habitat shifts were observed for Umatilla Dace as they were captured in seasonally flooded terrestrial vegetation during freshet on the unregulated Slocan River. - **Diel** habitat shifts have only been observed for Umatilla Dace in the Slocan River during summer when daytime habitats were deeper and further from shore compared to night and dusk, respectively, but these were not related to flow fluctuations.

Management Question	Final Year Status
Does the operation of HLK Dam alter these natural movements? Specifically, does the risk of stranding increase?	**Sculpins:** - The **operations** of HLK increased the natural movement rates of tagged sculpins during fall and influenced the direction of movements during spring and winter. However, these alterations in their natural movements did not increase the **risk of stranding** because tagged sculpins moved away from areas that became dewatered towards the deeper thalweg. Increased movements during fall may have implications on sculpin energetics because they are using more energy to move away from dewatered areas instead of feeding or avoiding predators. Limited information on the natural movements of sculpins during summer precludes conclusions for this season. **Dace:** - We cannot conclude whether operations from HLK alter the natural movements of dace because limited information exists at this time.
Which operations, and at what season, pose the highest risk of stranding or interference with the normal life cycles of sculpins and dace?	- The **highest risk of stranding** and interference with the normal life cycles of **sculpins** and **dace** results when flow reductions occur during the spawning, incubation and early rearing period (June-late September) for these species. **Sculpin** nests became dewatered when flows declined during the spawning and incubation period (May to July in the LCR study area) and male **sculpins** actively guarding the nests occasionally became stranded during this time; this occurred on both the unregulated Pass Creek and regulated LCR (at index sites below the Kootenay River). Additionally, flow manipulation during the sculpin spawning period may cause microhabitat changes and result in lowered embryo survival and/or complete nest mortality. **Dace** YOY were observed to become stranded in pools during the summer period when the LCR receded. - Increased **relative pool stranding risk** for all life stages of sculpins and juvenile/YOY dace may also occur during **HLK operations** where the magnitude of the drop is >500 m^3/s (18 kcfs), especially during lower river stages that are <20% Mean Annual Discharge. Although these conditions were not observed during the present study, they are still variables to consider for relative risk of pool stranding for these species.

1 INTRODUCTION

Operations of the Hugh L. Keenleyside Dam (HLK; Figure 1) affect the trophic productivity, quality and quantity of aquatic habitat, and the ecological health of the lower Columbia River (LCR; Aquametrix 1994, AMEC 2010a). As such, the Columbia River Water Use Plan (WUP) was initiated to address flow management issues with respect to impacts on competing water uses in the LCR, including fish, wildlife, domestic water supplies, recreationists, heritage uses, and electrical power needs. During the Columbia River WUP process, the Columbia River WUP Consultative Committee (CC) identified that biological data on threatened and endangered shallow water fish species, such as sculpins and dace, were lacking in the lower Columbia River (BC Hydro 2007). Specifically, limited information was available to assess potential impacts of seasonal operations of HLK Dam on endangered sculpins and dace in the LCR.

To address this data gap, the Columbia River WUP Consultative Committee recommended that "a study to determine the relative abundance, distribution, life histories, and habitat use of sculpins and dace in the lower Columbia River between HLK Dam and the US border" be undertaken (BC Hydro Terms of Reference (TOR) 2007). Species of interest include four species of sculpins and two species of dace: Prickly Sculpin (*Cottus asper*), Shorthead Sculpin (*C. confusus*), Columbia Sculpin (*C. hubbsi*), Torrent Sculpin (*C. rhotheus*), Longnose Dace (*Rhinichthys cataractae*) and Umatilla Dace (*R. umatilla*). Columbia Sculpins, Shorthead Sculpins and Umatilla Dace are listed as a species of *Special Concern* under the Species-At-Risk-Act (SARA; Government of Canada 2013). Shorthead Sculpins were reclassified from *Threatened* to of *Special Concern* in March 2013, which reflected an increase in the estimated number of locations in which this species is found (Government of Canada 2013).

Limited information existed on the ecology and behaviour of sculpins and dace in the lower Columbia River (McPhail 2007, AMEC 2010a). Previous studies targeting sculpins and dace mainly focused on methods to inventory and determine abundance and density of these species (R.L.& L. 1995, Golder 2002, AMEC 2003). Fish stranding and ramping studies conducted in the LCR by BC Hydro also provided information on distribution and relative abundance of these species. A few studies have collected seasonal and/or diel habitat use information on sculpins and dace (R.L.& L. 1995, AMEC 2003). Fish identification to the species level has been problematic and many have been misidentified in previous studies (as outlined in AMEC 2010a). Also, in order to rapidly identify fish species and to focus on specific project objectives, many studies did not always identify fishes to the species level, which limits the species specific information available (as outlined in AMEC 2010a).

It is important that the life history and habitat use of these species, in particular those federally listed, be assessed to determine potential impacts of flow fluctuations resulting from daily and seasonal operation of HLK Dam. It is also necessary to study these species' life history and habitat use in a natural, unregulated setting as limited general life history and habitat use information is available for some species and life stages included in this study. Therefore, the present program also conducted studies in the unregulated (i.e., no large hydroelectric dams present) Similkameen system (2009), Pass Creek (2010) and in the Slocan River (2011-2014) to fill in data gaps for some of the target species (AMEC 2010b, AMEC 2011, AMEC 2012a, AMEC 2013). Sampling in the Similkameen system, which included the Similkameen and Tulameen Rivers as well as Otter and Allison Creeks, was conducted because a number of this program's target species, most notably Columbia Sculpins, were present in high abundances (AMEC 2010a). Following initial life history information collection, methodology assessment and refinement in the Similkameen system (February to September 2009), studies were transferred to the LCR from October 2009 to 2014. Pass Creek, a tributary of the LCR, was studied because of high abundances of Shorthead Sculpins (McPhail 2007). In addition, studies on the unregulated Slocan River occurred to fill in data gaps for Umatilla Dace, since this species was observed in higher abundances than in the LCR (McPhail pers. comm. 2010).

2 OBJECTIVES

The **Management Questions** of the Lower Columbia River Sculpin and Dace Life History Assessment (CLBMON-43) as outlined in the Terms of Reference (TOR) for this project are provided below (BC Hydro TOR 2007):

1. How do water level fluctuations (diel and seasonal) in the lower Columbia River affect the distribution and habitat use of sculpins and dace, especially the listed species?
2. What seasonal and diel habitat shifts do sculpins and dace (especially the listed species) make in response to water level fluctuations?
3. Do the operations of Hugh L. Keenleyside Dam alter these natural movements? Specifically, does this risk of stranding increase?
4. Which operations, and at what season, pose the highest risk of stranding or interference with the normal life cycles of sculpins and dace?

As knowledge of the basic life history and habitat use requirements for most of these species is lacking, the TOR specified that the monitoring program be designed to answer the following **Specific Questions**:

A. Are there specific spawning areas utilized by the Columbia Sculpins and the Umatilla Dace and, if so, what are the temporal and biophysical characteristics of these areas?

B. Are there specific nursery areas used by Columbia Sculpins and Umatilla Dace and, if so, what are their biophysical characteristics?

C. Are there seasonal and diel shifts in habitat use by these species and, if so, how do these shifts relate to daily or seasonal water level fluctuations (diel and seasonal)?

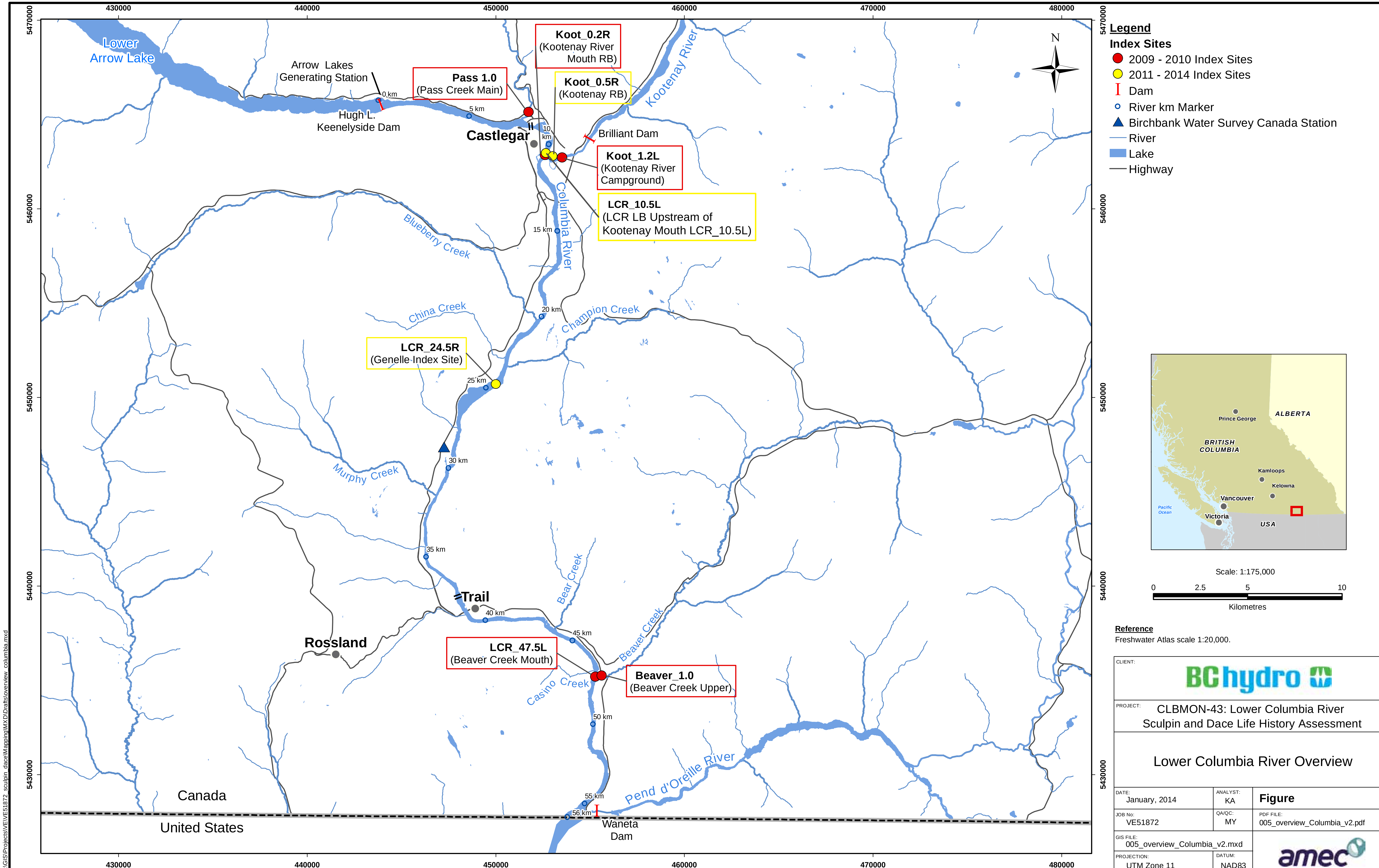
D. Do different age classes of Columbia Sculpins and Umatilla Dace use different habitats seasonally and, if so, do diel habitat shifts differ among age classes?

E. Are there over-wintering habitats used by these species and, if so, what are their biophysical characteristics?

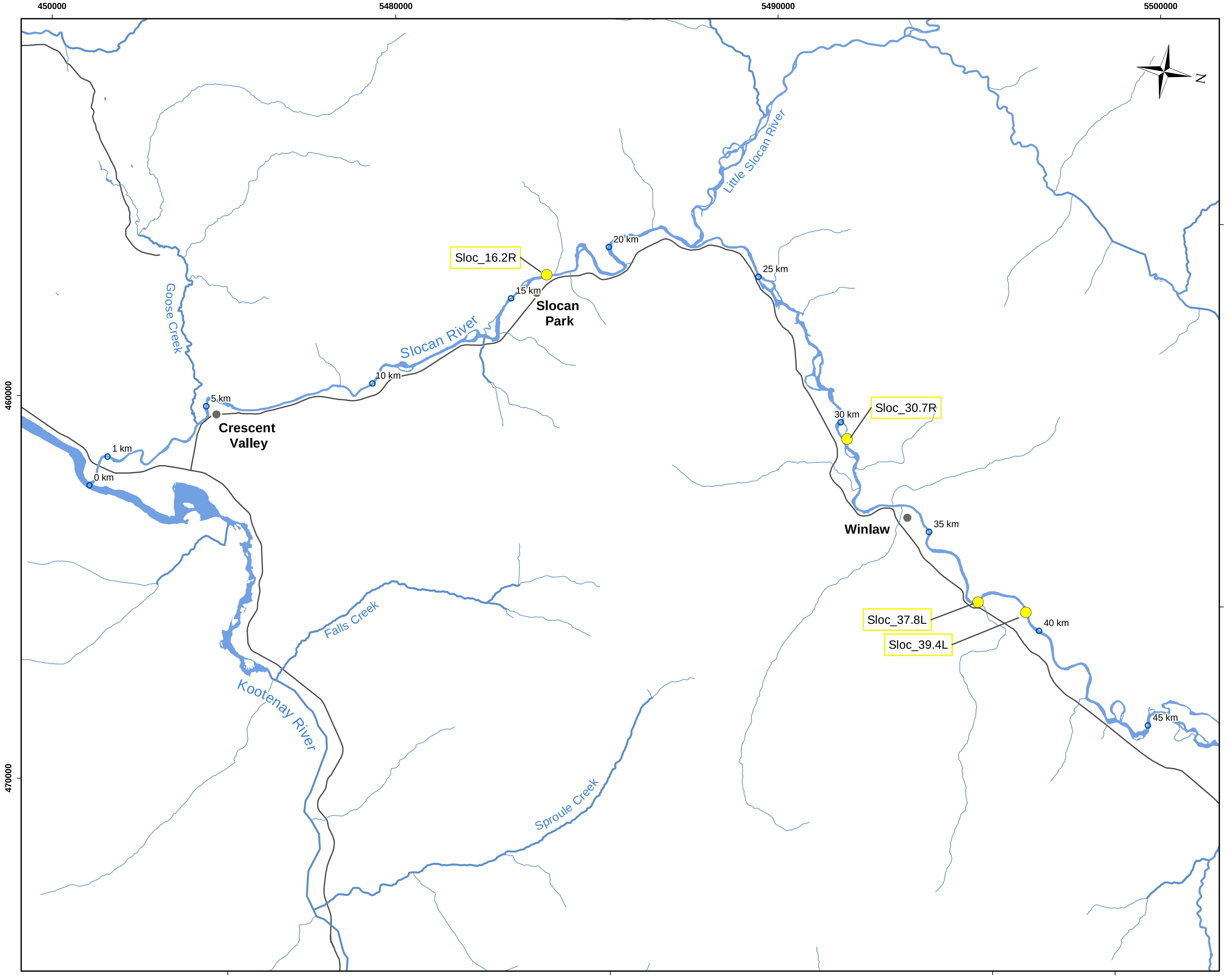
F. Do diel and seasonal water level fluctuations affect spawning behaviour, embryo survival, or adult nest guarding behaviour of Columbia Sculpins and Umatilla Dace?

2.1 Purpose

The following fulfills AMEC's commitment to provide BC Hydro with a final Technical Report for this program and adds to the dataset collected to support BC Hydro's Specific and Management Questions outlined above. This is the final report for the five years of study conducted under this program. Included is a synthesis for all five years for the LCR study area with comparison information for target species in the unregulated tributaries that were sampled during this program including: Umatilla Dace in the Slocan River; Columbia Sculpins in the Similkameen River system; and, Shorthead Sculpins in Pass Creek. Also included is a summary for data collected between March 2013 and April 2014 (Year 5) to be consistent with previous years of study.



Legend
Index Sites
2009 - 2010 Index Sites
2011 - 2014 Index Sites
Dam
River km Marker
Birchbank Water Survey Canada Station
River
Lake
Highway
Lower Arrow Lake
Arrow Lakes Generating Station
Hugh L. Keenelyside Dam
Pass 1.0 (Pass Creek Main)
Koot_0.2R (Kootenay River Mouth RB)
Koot_0.5R (Kootenay RB)
Kootenay River
Brilliant Dam
Castlegar
Koot_1.2L (Kootenay River Campground)
LCR_10.5L (LCR LB Upstream of Kootenay Mouth LCR_10.5L)
Columbia River
Blueberry Creek
China Creek
Champion Creek
LCR_24.5R (Genelle Index Site)
Murphy Creek
Bear Creek
Trail
Rossland
LCR_47.5L (Beaver Creek Mouth)
Beaver Creek
Beaver_1.0 (Beaver Creek Upper)
Casino Creek
Pend d'Oreille River
Waneta Dam
Canada
United States
0 km
5 km
10 km
15 km
20 km
25 km
30 km
35 km
40 km
45 km
50 km
55 km
56 km
430000
440000
450000
460000
470000
480000
5470000
5460000
5450000
5440000
5430000
N
Prince George
ALBERTA
BRITISH COLUMBIA
Kamloops
Kelowna
Vancouver
Pacific Ocean
Victoria
USA
Scale: 1:175,000
0
2.5
5
10
Kilometres
Reference
Freshwater Atlas scale 1:20,000.
CLIENT:
BChydro
PROJECT:
CLBMON-43: Lower Columbia River Sculpin and Dace Life History Assessment
Lower Columbia River Overview
DATE: January, 2014
ANALYST: KA
Figure
JOB No: VE51872
QA/QC: MY
PDF FILE: 005_overview_Columbia_v2.pdf
GIS FILE: 005_overview_Columbia_v2.mxd
PROJECTION: UTM Zone 11
DATUM: NAD83
amec



Legend

Index Sites

- 2012 - 2014 Index Sites
- River km Marker
- River
- Lake
- Highway

Scale:1:100,000

0 1.5 3 6

Kilometers

CLIENT: BC hydro

PROJECT: CLBMON-43: Lower Columbia River Sculpin and Dace Life History Assessment

Slocan River Overview

DATE: January, 2014	ANALYST: KA	Figure
JOB No: VE51872	QA/QC: MY	PDF FILE: 006_overview_Slocan_v2.pdf
GIS FILE: 006_overview_Slocan_v2.mxd		
PROJECTION: UTM Zone 11	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE51872_sculpin_dace\Mapping\MXD\Drafts\006_overview_Slocan_v2.mxd

3 METHODS

The main methods used during the overall program are presented below and information specific to Year 5 is also included. These techniques were successful in sampling target species. Most techniques were used each year, but methods may have varied during each season. A summary of the advantages and disadvantages of these and other methods tried and/or considered is provided in AMEC (2010b).

3.1 Study Areas

3.1.1 Lower Columbia River Study Area

The LCR study area encompassed the approximately 58 km section of the lower Columbia River from HLK to the U.S. Border as well as the lower Kootenay River below Brilliant Dam (Figure 1). However, the main focus of the study was concentrated around a number of index sites to monitor seasonal, diel and spawning habitat use and movements of various life stages. Index sites have been established over the duration of the program at locations in the lower Columbia and Kootenay Rivers (Figure 1). Rationale for the selection of index sites is provided in AMEC (2010b). Further information and description of these index sites are provided in AMEC (2010b, 2011, 2012).

In Year 5, three main index sites were the focus of repeated sampling because of their suitable habitats to study sculpins and/or dace, year-round accessibility and ability to monitor flow changes from either the lower Columbia or Kootenay Rivers or both. Non-index sites were also sampled in 2013 (Appendix A1) as well as in previous years (Appendix B). Appendix B contains maps, site descriptions and UTMs for all sites sampled in the LCR study area. Year 5 index sites included:

i) LCR_10.5L (LCR Left Bank (LB) upstream of Kootenay River mouth);

ii) LCR_24.5R (Genelle Index Site); and,

iii) Koot_0.5R (Kootenay River Right Bank (RB); Figure 1).

The mouths of several tributaries were also sampled; Beaver Creek, an unnamed creek in Robson and Rialto Creek Mouth (LCR_47.5L and LCR_2.8L, LCR_1.6L respectively). These locations were considered LCR mainstem sites as the flow regime appeared to be more influenced by LCR than tributary discharge.

3.1.1.1 Tributaries

Direct sampling of tributaries to the LCR was conducted in Beaver, Blueberry, Murphy, and Pass Creeks (AMEC 2010, AMEC 2011, AMEC 2012a) in previous years and at tributary mouths in 2013 (Section 3.1.1).

3.1.2 Slocan River Study Area

The Slocan River study area encompassed approximately 44 km from north of Winlaw to the confluence with the lower Kootenay River (Figure 2). Similar to the LCR study area, index sites were established on the Slocan River to focus on collecting Umatilla Dace life history and habitat use (AMEC 2011, 2012, 2013; Figure 2). In total, five index sites were sampled on the Slocan River and included: Sloc_16.2R, Sloc_30.7R, Sloc_37.8L, and Sloc_39.4L and Sloc_39.4R (Figure 2). In addition, two non-index sites were sampled to expand the search for adult Umatilla Dace in 2013: Sloc_30.0R and Sloc_43.1R (Figure 2, Appendix A2). Appendix B contains maps, site descriptions, and UTMs for all sites sampled in the Slocan River study area.

3.1.2.1 Tributaries

Direct sampling of tributaries to the Slocan River was conducted in Trozzo Creek and the Little Slocan River during this study (AMEC 2010b, AMEC 2011, AMEC 2012a; Appendix A2).

3.1.3 Similkameen River System

Sampling in the Similkameen watershed occurred in Year 1 (2009) to obtain information on select target species in an unregulated system to facilitate comparisons with the LCR study area. A summary and description of sample sites studied on the Similkameen River is provided in AMEC (2010b).

3.2 Sample Timing

Field sampling targeted specific life history periods for sculpins and dace and sample timing was generally similar each year. An example of a typical sampling year for the LCR and Slocan River is provided in Table 1. Yearly variations in sample timing were dependent upon the objectives that were the focus for that year. Detailed sample timing for each study year is provided in AMEC (2010b, 2011, 2012) and in Appendix A1 for Year 5.

Table 1: An example of tasks and associated sample periods for sculpins and dace studies in the LCR and Slocan River study areas.

Task	Sample Period	Frequency/Comments	Sites
LCR Sculpin and Dace PIT Tagging	May and September	Additional tagging at 2 index sites; 2 days each.	Genelle; LCR Upstream of Kootenay Mouth
LCR Sculpin and Dace Seasonal and Diel PIT tracking and EF surveys	Spring, summer, fall and winter	Day and night tracking surveys one day each season per site; timing dependent on flow reductions; 3 days each, 2 in winter.	Genelle; LCR Upstream of Kootenay Mouth; Kootenay RB
LCR Sculpin and Dace Flow Change PIT Tracking	Summer, fall and winter	Tracking surveys pre, during and after flow reductions. 4 days each and 5 for April 1 reduction.	Genelle; LCR Upstream of Kootenay Mouth
LCR Sculpin Spawning Habitat Use	Late May to late July	5 snorkel and PIT tracking surveys. 1 day each.	Genelle; LCR Upstream of Kootenay Mouth;

Task	Sample Period	Frequency/Comments	Sites
			others if required
LCR Dace Spawn Timing	mid-July to mid-September	Minnow trapping surveys every 2 weeks. 4 overnight minnow trap sets (8 days). Full river survey in August (4 days).	4 sites as per conditions dictate and similar to Year 3 sites.
LCR Sculpin and Dace YOY Diel Habitat Use	August/ September	Dip net, EF, snorkel surveys to ID habitat use	Fort Sheppard, Beaver Creek Mouth, Genelle, Kootenay RB
Slocan Umatilla Dace PIT and VIE tagging	May	Capture techniques will include minnow traps and backpack electrofishing. 4 sites and 2 days.	Sloc_16.2R; Sloc_30.7R; Sloc_37.8L; Sloc_39.4L
Slocan Dace Spawn Timing	mid-July to mid-September	Minnow trapping surveys every 2 weeks. Snorkel to identify potential spawning habitat when ripe females captured. 5 overnight minnow trap sets (co-ordinated with LCR MT).	4 sites
Slocan Dace Diel Habitat Use and Nearshore Habitat Use	July and August	Minnow trapping surveys that target dawn, day, dusk and night periods over 24 hours. 2 days each survey.	Sloc_30.7R; Sloc_37.8L; Sloc_39.4L
Slocan Sculpin and Dace YOY Diel Habitat Use	October, December, and January	Dip net, EF, snorkel surveys to ID habitat use	Sloc_16.2R; Sloc_30.7R; Sloc_37.8L; Sloc_39.4L

3.3 Environmental Parameters

In order to address the Management Questions outlined for this program (Section 2) information on discharge and water temperature was collected. Hourly discharge and water temperature records were obtained from the MS Access database provided by the BC Hydro contract authority for this program, except for the Slocan River where records were obtained directly from Water Survey Canada (WSC) gauge (No: 08NJ013 near Crescent Valley).

In addition, Hobo Tidbit v2 water temperature loggers were deployed to record water temperature every hour for the period of record and remain logging. Sites on the LCR and Slocan River included:

i) LCR_24.5R (Genelle Index Site; May 8, 2012 to December 21, 2013);

ii) Koot_0.2L (Kootenay River below Selkirk College; October 25, 2009 to October 30, 2013);

iii) Sloc_16.2R (Slocan Park; April 21, 2011 to December 19, 2013); and,

iv) Sloc_39.4L (Appledale; May 10, 2012 to December 19, 2013).

In addition, temperature loggers were deployed in the Similkameen River system (AMEC 2010), Pass Creek (AMEC 2011) and Beaver Creek (AMEC 2011). Mean daily discharge and water temperature records for the LCR study area and the Slocan River were plotted separately.

Dissolved oxygen (DO) was measured at LCR_24.5R twice during the 2013 spawning period. A calibrated YSI 85 was used to measure DO (mg/L) within one meter of three sculpin nests that were discovered on June 12, 2013. DO was measured again during the subsequent visit to the site in the same location on June 19, 2013.

3.4 Fish Capture, Observations, and Habitats Sampled

3.4.1 Backpack Electrofishing

Backpack electrofishing was used, where water levels and accessibility allowed, to determine species presence, spawn timing, behaviour and location (Specific Questions A and E). A Smith-Root LR-24 backpack electrofisher was used with conductivity settings based on current water quality conditions and fish response/recovery. Two crew members, one operating the electrofisher and the other dip netting, conducted electrofishing surveys in shallower (depths between 0 and 1.5 m) shoreline areas of interest. In high velocity areas, a lip seine, sometimes referred to as a pole seine, was used in place of a dip net. The lip seine (1.5 m wide and 1 m high) was held in place downstream of the electrofishing zone to collect any stunned fish as they drifted with the current. Measurements recorded during electrofishing surveys included: electrofishing start/end time; electrofishing seconds; electrofisher settings as well as the length and width of the area electrofished. Catch-per-unit-effort (CPUE) for backpack electrofishing was also calculated for each site/survey (Appendix C). Backpack electrofishing enabled sampling of all life stages as fish captured with this method during the program ranged between 12 and 150 mm in length. Note that sculpin lengths are measured by total length (TL) while dace are measured by fork length (FL).

Backpack electrofishing was also used to assess diel (day vs. night) differences in nearshore habitat use (Section 3.8). An area was delineated at each location and all wadable area was electrofished by a two-person crew in the day and again at night to replicate similar effort levels. Headlamps were worn by each crew member to illuminate the survey area at night; direct illumination of areas yet to be surveyed was avoided as much as possible to reduce potential startling of fish. All fish observed were collected and life history sampled as described in Section 3.5). Microhabitat information was measured at each point of Umatilla Dace capture; Longnose Dace and sculpin microhabitat information was collected during PIT tracking surveys (Section 3.4.7). Fishes were returned to the sample site immediately following the survey. The time interval between the day and night sampling was approximately 8 to 14 hours, depending on the season, to allow time for natural redistribution under normal flow conditions (i.e., sampling was not conducted during flow changes).

In the LCR study area, backpack electrofishing sampled depths that ranged from 0.02 to 1.5 m, average velocities ranged from 0 to 1.5 m/s and substrates were mostly cobble/gravel/fines with some boulder/sand sections. In the Slocan River study area, sampled depths ranged from 0.01 to 1.5 m, average velocities that ranged from 0 to 1.3 m/s and substrates that were mostly cobble/gravel with some boulder/sand sections. Backpack electrofishing in both study areas was restricted to shallow areas from the water's edge out to an area that was no deeper than 1.5 m, depending on velocity.

3.4.2 Snorkel Observations and Dip Netting

Snorkel surveys were conducted to collect microhabitat use information for egg, YOY, juvenile and adult life stages of sculpins and dace (Specific Questions A, B, C and E; Management Question 1, 2, and 4). Snorkel surveys were conducted by two crew members experienced with identification of sculpins and dace. Snorkelers entered the water at the downstream end of the area to be surveyed and swam in an upstream direction along the shoreline searching for sculpins and dace. One snorkeler swam along the shoreline and the other snorkeler swam approximately one body length beside the first snorkeler to cover deeper habitats that could be safely sampled (i.e., up to the point where swimming could not be maintained due to flow conditions). This method required disturbing the substrate (e.g., cobbles and boulders) to see if a fish was using it for cover or if a nest was present (Section 3.4.3). Systematic observations of all sculpin and dace habitats were completed as best as possible within the flow and habitat conditions experienced during each survey. CPUE was calculated for each site/survey to compare and assess methods (Appendix C; Section 3.9).

The following were recorded during each observation taken: fish species, estimated length (mm) and microhabitat information was estimated as outlined in Section 3.8. Fish were captured by hand-held aquarium dip nets, when possible, and sampled as outlined in Section 3.5. Dip netting allowed early life history stages to be sampled from slack, nearshore areas. Fish captured by this method were between 10 and 105 mm in length.

Habitats sampled during snorkelling were the same as those sampled by backpack electrofishing within the study area (Section 3.4.1).

3.4.3 Nest Assessments and Embryo Survival

Nest assessments were used to answer Specific Questions A and E as well as Management Questions 1 and 4 and were conducted during all years of study (AMEC 2010b, 2011, 2012, Appendix E). A male sculpin will establish and guard a nest rock under which female sculpins will deposit egg masses to be fertilized. More than one female can place eggs on the underside of a single male's rock throughout the spawning period and each clump of eggs deposited can be identified by the number, colour and egg stage (AMEC 2010a). Egg diameter is similar for all sculpin species, except for Prickly Sculpins, which lay significantly more eggs per clump with eggs smaller in diameter (AMEC 2010a, AMEC 2010b).

Less is known about dace spawning, but egg diameters of Umatilla Dace are smaller compared to Longnose Dace based on laboratory studies (Table 2) and field observations taken on Umatilla Dace during this study. For Longnose Dace, the male clears a patch of coarse gravel creating a depression to be used for spawning. Females lay eggs and males fertilize them over these cleaned gravel areas. It is unknown whether Umatilla Dace spawning is similar to Longnose Dace at this time. Further background information on the spawning of sculpins and dace is provided in AMEC (2010a and 2010b) and a summary of life history characteristic for each species is provided in (Table 2).

Sculpin nest searches were conducted by one or a combination of the following methods: PIT tag tracking, snorkel and/or substrate flip surveys. Nest searches for dace were more observational and occurred during fish capture and snorkelling surveys when mature/ripe individuals were collected. A limited number of dace (n=21) were PIT tagged during this study and none were tracked during the estimated spawning period.

Substrates (cobble/boulder) were carefully overturned to observe whether a nest was present. When a nest was observed the nest rock was carefully pulled to the surface either by hand or by a large dip net. Observations taken at each sculpin nest included: depth; velocity; UTM; number of egg masses; condition; colour; estimation of the proportion of eggs alive/dead/fungused; egg development stage; substrate type (i.e., cobble, boulder); rock dimensions; distance from shore; and other pertinent observations (e.g., presence of algae).

Surveys were conducted to look for egg deposition areas where Umatilla Dace were captured during the suspected spawning period in 2011 and 2012. However, it was not possible to conduct nest searches in 2013 because high precipitation limited visibility (2 m) and snorkel surveys were suspended due to inclement weather. In addition, all sampling on the Slocan River was suspended due to a jet fuel spill on a tributary of the Slocan River on July 26, 2013 that resulted in a “Do Not Use” Order by the BC Interior Health Association for the majority of August 2013. Therefore, snorkel surveys could not be conducted during the remainder of the UDC spawning period on the Slocan River.

Embryo survival was quantified by evaluating the percent survival of eggs in sculpin nests. A count of live and dead eggs was completed when sculpin nests were discovered. Sculpin nests were returned to the same location and marked with a brightly coloured disk. Care was taken not to disturb the eggs on each nest. However, if eggs were dislodged when the rock was overturned, the egg masses were preserved so that the eggs could be counted and their diameter measured. Photographs of all nests were also taken. Embryo survival was re-evaluated during subsequent surveys if nests were in accessible areas. However, nest handling may have impacted survival so only initial observations were used in embryo survival assessments.

Table 2: Lower Columbia River Sculpin and Dace Species Life History Summary

		Observed Habitats				Age of Maturity									
Species Name (BC Species Code)	**Conservation Status**	**Adult**	**Juvenile**	**YOY**	**Food Habits**	**Male**	**Female**	**Max age, total length (mm)**	**Adult Spawning Characteristics**	**Fecundity (# of eggs)**	**Timing of Egg Laying**	**Average Fertilized Egg Size (mm)** [1]	**Nest Attributes**	**Incubation Time**	**Larval Development**
Columbia Sculpin (CBA)	Special Concern (SARA); Blue; rare or uncommon (BC)	Riverine habitat[1], boulders and cobbles, water velocity **0.18**->0.3 m/s, depth 10-70 cm[2, 20]	Riffles, coarse gravel; **boulder/cobble**; velocity <0.2 m/s, depth <**50** cm[1, 20]	Stream margins[2] and seasonally flooded areas[1], velocity <0.1m/s, depth <20 cm[2]; **up to 4 m from shore in pool habitats <1 m deep, with cobble/boulders and little flow**[20]	Common: benthic invertebrates; Rare: rainbow trout eggs, nematodes and moss[2]	1+ to 2+[1]	2+[1]	5+, 106[1] **?, 110**[20]	Males: **dark body colour with orange stripe on dorsal fin; expressing milt**[1,20] Females: swollen abdomens[1]	**60**[20] Previously Unknown	**Late May to mid July, water temps 9.5-15°C.**[20] May to mid June, water temps 7-12 °C[1]	2.8	**Cobble (5-10% embedded), <0.5 m deep, <0.2 m/s column velocity**[20] Under rocks[1]	Unknown, likely 20-30 days	7.5 to 8.2 mm at hatching; 9.5 to 10.5 mm at emergence[1]
Shorthead Sculpin (CCN)	Special Concern (SARA); Blue; rare or uncommon (BC)	**Run**[20] and riffle habitat[1], cobble and boulders, water velocity 0.05 to 0.9 m/s, depth <**70** cm[1, 2, 20]	**Mostly run habitats, <0.3 m/s velocity, depth <65 cm.**[20] During spring, sand substrate, velocity <0.1 m/s, depth <20 cm then move to deeper, higher velocity, coarser substrate later in year[1]	River margin and seasonally flooded vegetation with mud/sand substrate, water velocity <0.1 m/s, and depth <10 cm[1] **up to 4 m from shore in pool habitats <1 m deep, with cobble/boulders and little flow**[20]	Common: benthic invertebrates; Rare: mollusks and fishes[1,9,3]	Likely 2+[1,3,4]	Likely 2+[1,3,4]	6+, 85[1] **?, 111**[20]	Males: **dark body colour with orange stripe on dorsal fin; expressing milt**[20] Females: **swollen abdomens**[1]	47 to 511[3,4,5, 20]	**Late May to mid July, water temps 8-15°C.**[20] previously unknown temperature[1]	3.2	**Boulder (5-10% embedded), <1.3 m deep, <0.5 m/s.**[20] Under rocks[1]	29 days, in laboratory studies[1]	7.5 mm at hatching; 9.5 to 10 mm TL emergence two weeks later[1]
Prickly Sculpin (CAS)	Not listed under SARA; Yellow (BC); populations are widespread and abundant	Use coastal estuaries, lakes, and rivers[1]. boulder substrate[2], mean water velocities <0.35 m/s, depths 10-69 cm[2]	In rivers, found in quiet margin sites and often associated with vegetation or small woody debris[1].	On coast, planktonic larvae hatch in or drift downstream to estuaries[1]. In rivers, newly formed fry are common in seasonally flooded vegetation along river margins[1].	Common: benthic invertebrates, snails[2]; Rare: fishes, detritus, worms and nematodes[1,2]; larval stage: microplankton[6]	1+ or 2+[1, 6]	2+[1]	8+, >200[1]	Males: dark body colour with orange stripe on dorsal fin; expressing milt[1] Females: swollen abdomens[1]	up to 10,000[1]	April to late June, 6-16°C[1].	1.7	Under rocks[1]	On coast:9-10 days to eyed stage and 15-16 days to hatch at 10°C[6]	On coast: 5 to 6 mm TL at hatch and emergence, planktonic for 25-35 days, larvae become benthic at 12 mm[1,6]
Torrent Sculpin (CRH)	Not listed under SARA; Yellow; populations are widespread and abundant (BC)	Lakes, streams, and rivers; prefer fast water with boulder and cobble substrate[1,2,7]; mean water velocities <0.35 m/s; depth from 0-100 cm[2]	Shallower and slower areas than adults (<30 cm and <0.2 m/s)[1,2,7]; seek shelter in flooded vegetation during freshet[1]	Quiet water with fine substrate, algae or vegetative growth at emergence[1,2,7]; move into deeper nearshore waters with coarser substrate and higher velocities later in year[1,2]	Common: benthic invertebrates; Rare: fishes, sculpin eggs, crayfish[1,2,8]	2+[1]	2+ or 3+[1]	7+, 135[1]	Males: dark body colour with orange stripe on dorsal fin; expressing milt[1] Females: swollen abdomens[1]	100 - 412[5]	Mid-April to mid-June with water between 7-15°C[1].	2.8	Under rocks[1]	Temperature dependent [1]	7.5 to 8 mm TL at hatching; emerge 2 weeks later at 10 to 12 mm TL[1]

		Observed Habitats				Age of Maturity									
Species Name (BC Species Code)	**Conservation Status**	**Adult**	**Juvenile**	**YOY**	**Food Habits**	**Male**	**Female**	**Max age, total length (mm)**	**Adult Spawning Characteristics**	**Fecundity (# of eggs)**	**Timing of Egg Laying**	**Average Fertilized Egg Size (mm)** [1]	**Nest Attributes**	**Incubation Time**	**Larval Development**
Umatilla Dace (UDC)	Special Concern (SARA); Threatened (COSEWIC); Red; species in peril because of rarity (BC)	**Typically found in pools; cobble/boulder substrates; depths 0.3-0.8 m; mean column velocity 0.08 m/s**[20]; found in areas with large boulders and water column velocities of 0.8 m/s and bottom velocities of 0.05 m/s[9]; depths >1 m[1,2,9] **Diel differences not observed**[20]	**Pool habitats with flooded vegetation and silt substrates; depths 0.15 m; little to no velocity**[20]; Shallow, quiet, vegetated areas during freshet[1]; 1+ nearshore during summer[2]; calmer (bottom velocity <0.5 m/s) areas with large gravel or boulder substrate, 10-69 cm deep[2] **Diel differences not observed**[20]	Quiet, shallow **(10-17** cm) river margins with fine substrate in **all seasons**, shifted to gravel cobble substrate later in the year[1, 20]. **Used flooded vegetation in spring and summer**[20]	Common: benthic invertebrates; Rare: periphyton and detritus[2,9]	1+ to 2+[1,13]	2+[1,13]	5+, 118[1]	Males: **Orange colouration on lips, fin insertions and fins; expression of milt** Females: **Orangey/red colouration on lips, fin insertions, fins; tubercles on dorsal surface; swollen urogenital pore; expression of eggs**[20]	300-3,200[1,10,13]	**Mid-July to mid-September; water temps between 12°C and 20°C**[20]; Likely mid-summer[1,10-13]	**1-1.6**[14,20]	No nest. Deposit eggs in gravel[1,13]	5-7 days @ 18°C (in lab)[14]	7 mm at hatching; emerge about one week at around 10 mm[1]
Longnose Dace (LNC)	Not listed under SARA; Yellow; populations are widespread and abundant (BC)	Riffle habitats; cobble and boulder substrates[2]; often found in shallow areas (<0.3 m) of rivers with faster flows (>0.5 m/s)[1,2,13,15-18]	Similar to adults but shallower[1,2,13,15-18]	Bedrock/ silt habitats; 10 to 19 cm deep; forage in the water column[2]	Common: benthic invertebrates; Rare: terrestrial insects, larval fishes, algae[1,2]; YOY forage pelagically on chironomid larvae, periphyton and plankton[1,15]	1+ to 2+[1,13]	2+[1]	5+,>120[1]	Males & Females: develop tubercles on dorsal surface of pelvic and pectoral fins; fine tubercles along scales; males are larger[1]	150-30,000[1]	Late May to early July with water temps of 10°C[1,2]	2.4	No nest. Deposit eggs in gravel[1,19]	Temperature dependent; lasts about a week @ 18°C[1]	6 mm at hatching; 8 mm when they begin exogenous feeding[1]

Sources: [1]McPhail 2007; [2]RL & L 1995a; [3]Peden In press B; [4]Gasser et al 1981; [5]Patten 1971; [6]Mason and Machidori 1976; [7]Finger 1982; [8]Pasch and Lyford 1972; [9]Peden and Orchard 1993; [10]Peden and Hughes 1981; [11]Peden and Hughes 1984; [12]Peden 1991; [13]McPhail 2003; [14]Haas 2001; [15]Gee and Northcote 1963; [16]Gibbons and Gee 1972; [17]Mullens and Burton 1995; [18]Mullens and Burton 1998; [19]Bartnik 1972; [20] AMEC current study

3.4.4 Minnow Trapping

Minnow traps were used to capture Umatilla Dace in the LCR, Kootenay and Slocan Rivers, since this method has been successfully used during the high water period (AMEC 2012a). In order to refine estimates of spawn timing, behaviour and location (Specific Questions A and E), minnow traps were deployed from vehicle/foot accessible areas. Minnow traps were set in the afternoon and collected the following day with set times between 16 and 24 hours. The only exception was a diurnal sample program conducted in the Slocan River in mid-July and mid-August during which traps were checked every 6 hours to capture the day, dusk, night and dawn periods (Section 3.4.8). A minimum of five traps were set at each site. All traps were baited with salmon roe encased within aluminum foil. Information recorded at each trap included: set and pull time, depth, velocity, habitat (e.g., substrate type and presence of vegetation) and distance from the shoreline. A general habitat overview, including photographs, was recorded at least once during the field season at each site. CPUE was calculated for every minnow trap at each site during each sample session (Appendix C). Minnow trapping captured fishes that ranged between 30 and 124 mm in length. The minimum girth of fish captured was limited by the mesh size of the traps (6.35 mm) and the maximum girth was limited by the trap entrance (25.4 mm).

In the LCR study area, minnow traps were used to sample depths between 0 and 12.2 m. Average velocities at these locations ranged from 0 to 1.0 m/s and substrates associated with these locations included silt, sand, gravel, cobble, boulder, flooded vegetation and aquatic macrophytes. Horizontal distance from minnow trap sets to the wetted edge ranged from 0.5 to 15 m in the LCR study area (Appendix C1). There were no significant differences in depth, velocity or substrates between traps that captured UDC and those that did not in both study areas (AMEC 2012a).

In the Slocan River, minnow traps were used to sample depths between 0.1 and 5 m. Average velocities at these locations ranged from 0 to 1.0 m/s and substrates associated with these locations included silt, sand, gravel, cobble, boulder as well as flooded vegetation, aquatic macrophytes and some woody debris. Distance from minnow trap sets to the wetted edge ranged from 0 to 15 m in the Slocan study area (Appendix C1).

3.4.5 Young-of-the-Year Sampling

In order to answer Specific Questions A and B, young-of-the-year (YOY) sampling was conducted during the summer through winter period using dip netting, snorkelling and backpack electrofishing. These methods are detailed in Sections 3.4.1 and 3.4.2.

3.4.6 Passive Integrated Transponder Tagging

Passive Integrated Transponder (PIT) tags were implanted into anaesthetized adult dace and sculpins (>45 mm in length) in order to track movements and determine habitat use (Specific Questions A, C, D, and E as well as Management Questions 1 through 3). A small incision (3 to 4 mm in length) on the ventral surface, anterior to the urogenital papilla was made and a PIT tag was manually inserted into the peritoneal cavity (Keeler 2006; Zaroban and Anglea 2010). Low tag loss rates and no change in net-avoidance behaviour have been documented for PIT tags inserted into the body-cavity of Shorthead Sculpins (Zaroban and Anglea 2010). Sutures and glues were not used because the incisions were small and these techniques were not useful for tagging other sculpin species (Keeler 2006). Two sizes of PIT tags were used: 8.5 mm tags for fish between 45 and 60 mm; and, 12.5 mm tags for fishes >50 mm in length. Sculpins and dace between 50 and 60 mm ideally received larger tags, however, the smaller tag size was used for fish with narrow abdominal cavities. Following recovery from anaesthetic, tagged fish were held instream for approximately 24 hours in live boxes (modified Rubbermaid™ tubs with cut-out mesh windows for water flow). After this time, fishes were inspected to confirm survival, tag retention and normal swimming/holding behaviour before being released to the river.

3.4.7 Passive Integrated Transponder (PIT) Tag Tracking

The tracking of PIT tagged fish was conducted to help answer Specific Questions A, C, D, and E as well as Management Questions 1 through 3 (AMEC 2010b; AMEC 2011; AMEC 2012a). A portable handheld PIT tag antennae designed by Destron Fearing Corp. (MN, USA) was used similarly to a metal detector to scan wadable habitat for PIT tagged fish. One crew member systematically scanned the entire index site with the PIT tag antennae from the downstream end to the upstream boundary. Tag detection with the PIT tag antennae is approximately 15-20 cm for 8.5 mm tags and approximately 35-45 cm for 12.5 mm tags (AMEC 2010b). Upon locating a tagged fish, the location was marked with a flagged bolt labelled with the PIT number. The second crew member recorded the GPS location, microhabitat use information (Section 3.8) and distance and direction of movement from last location, if possible, on standardized data forms. Fish were determined to be alive if they moved when the substrate was gently disturbed (this was not done during tracking surveys prior to or during flow reductions).

3.4.8 Diel Sampling

Diel sampling was conducted to help answer Specific Questions C, D, and F as well as Management Questions 1 and 2. Diel surveys targeting the overall day/night period were conducted during most study years via backpack electrofishing, snorkelling, minnow trapping and PIT tag tracking following the methods outlined above (AMEC 2010b, AMEC 2011, AMEC 2012a, AMEC 2013, Appendix A).

Systematic diel sampling assessing dawn, day, dusk and night were conducted in Years 4 and 5 to provide additional information on diel habitat use. Minnow traps were deployed at four Slocan River index sites and were checked every 6 hours for a 24-hour period to determine diurnal nearshore habitat use for Umatilla Dace (Appendix A). General minnow trap deployment and data collection procedures are described in Section 3.4.4. Baited traps were set for intervals intended to capture activity during the day (09:00 – 15:00), dusk (15:00 – 21:00), night (21:00 – 03:00) and dawn (03:00 – 09:00). Traps were checked as close to the beginning and end times of these periods as possible. All fish captured were identified to species and released approximately 2 m away from the traps; if UDC were captured, a length measurement was taken and they were examined for external signs of sexual maturity (Section 3.5). This method was successfully used by other researchers to study diel cycles for small stream-dwelling species such as Speckled Dace, Blacknose Dace, Lake Chub, Threespine Sticklebacks and juvenile White Sucker (Reebs et al. 1995; Gryska 1998).

3.4.9 Flow Reduction Sampling

Flow reduction surveys were conducted in the LCR to answer the four Management Questions pertaining to the impacts of HLK operations on the movements and habitat use of sculpins and dace (AMEC 2010b, AMEC 2011, AMEC 2012a, AMEC 2013). Flow reduction surveys focused on the spring and fall periods when flow fluctuations are typically observed at HLK Dam (Table 3). Flow reduction sampling was conducted after receiving notice from BC Hydro that a scheduled event was planned from HLK Dam. Upon receiving notice, AMEC determined whether the reduction warranted a survey based on previous sampling, season, tagged number of fish present at index sites and flow notice timing. Sampling was usually conducted when reductions were >8 kcfs and enough tagged fish and notice was available to adequately deploy a crew. Sampling consisted of pre, during and post-flow tracking surveys. Tracking surveys were conducted as outlined in Section 3.4.7. Each site was tracked once prior to, once during or immediately following and once again within 2 weeks following the flow reduction (Table 3).

Pre-flow reduction tracking surveys were conducted prior to the commencement of HLK flow reductions, either one day or a few hours prior, depending on how much advance notice was available (Table 3). When advanced notice was given, additional capture and tagging of target species (Section 3.4.1 and 3.4.6) also occurred depending on the number of tagged fish previously located at index sites.

GPS track logs of the location of the wetted edge were collected prior to and following each flow reduction. Track logs were collected by one crew member walking slowly along the shoreline while holding a handheld GPS (Garmin 60Cx) set to log location coordinates every second. Tracking was also conducted outside of the repeated tracking area during pre- and post-reduction sampling to determine if tagged fish moved to upstream or downstream areas outside of the tracking site. This was completed by tracking a minimum of 50 m upstream and 50 m downstream beyond the boundaries of the repeated tracking area.

Table 3: Summary of flow reduction surveys conducted at Lower Columbia (LCR) and Kootenay (Koot) River sites, 2010-2014. Flow reductions resulted from Hugh L. Keenleyside Dam (HLK) operations.

Date	HLK (kcfs)	Approximate Vertical Reduction Observed (m)	Flow Reduction Time	Sample Sites	Sample Time	Sample Method	Pre-reduction sampling	Post-reduction sampling
March 30, 2010	29 to 22	0.5	07:00 to 08:00	Koot_0.2R	08:45 to 10:15	PIT Tracking	26-Mar-10	-
				Koot_1.2L	12:20 to 15:00		28-Mar-10	
March 31, 2010	22 to 15	0.5 to 1.0	07:00 to 08:00	Koot_0.2R	08:30 to 11:40	PIT Tracking	26-Mar-10	-
		0.1 to 0.2		Koot_1.2L	12:15 to 14:30		28-Mar-10	
May 7, 2010[1]	N/A	0.5	00:00 to 04:00	Koot_1.2L	01:35 to 04:25	PIT Tracking	5-May-10	7-May-10
March 30, 2012	49 to 39	0.3	07:00 to 10:00	LCR_10.5L	09:15 to 10:20	PIT Tracking	29-Mar-12	13-Apr-12
					11:45 to 12:38			
		0.2		LCR_24.5R	14:15 to 15:09	PIT Tracking		
March 31, 2012	39 to 29	0.3	07:00 to 10:00	LCR_10.5L	09:00 to 10:15	PIT Tracking	29-Mar-12	13-Apr-12
					10:40 to 11:53			
		0.25		LCR_24.5R	13:35 to 14:15	PIT Tracking	29-Mar-12	13-Apr-12
					14:35 to 15:35			
April 1, 2012	29 to 23	0.3	07:00 to 08:00	LCR_10.5L	08:32 to 10:01	PIT Tracking	31-Mar-12	13-Apr-12
		0.15		LCR_24.5R	12:02 to 13:04			
September 15, 2012	60 to 45	1.0	06:00 to 10:00	LCR_24.5R	12:15 to 13:25	PIT Tracking	14-Sep-12	17-Sep-12
				Koot_0.5R	10:20 to 10:35	Backpack Electrofishing		-
September 28, 2012	46 to 44	n/a	15:00 to 17:00	LCR_10.5L	-	PIT Tracking	28-Sep-12	4-Oct-12
September 29, 2012	44 to 32	1.0	07:00 to 09:00		10:30 to 12:45			
October 26, 2012	45 to 40	n/a	15:00 to 16:00	LCR_10.5L	-	PIT Tracking	26-Oct-12	8-Nov-12
October 27, 2012	40 to 30	0.75	08:00 to 09:00		11:35 to 13:15			
February 8, 2013	67 to 53.5	1.0	12:00 to 14:00	LCR_10.5L	15:20 to 16:15	PIT Tracking	8-Feb-13	14-Feb-13
				LCR_24.5R	17:00 to 18:40			
February 9, 2013	53.5 to 40	1.0	08:00 to 10:00	LCR_10.5L	11:30 to 12:47	PIT Tracking		
		1.0		LCR_24.5R	14:20 to 15:50			
		1.0		Koot_0.5R	13:05 to 13:30	Backpack Electrofishing	7-Feb-13	-
February 16, 2013	40 to 28	0.5	08:00 to 10:00	LCR_10.5L	11:25 to 12:55	PIT Tracking	14-Feb-13	21-Feb-13
		1.0		LCR_24.5R	14:55 to 16:10			
August 3, 2013	74.5 to 63	0.5	08:00 to 10:00	LCR_10.5L	13:06 to 14:24	PIT Tracking	1-Aug-13	7-Aug-13
		n/a		LCR_24.5R	15:15 to 16:05		2-Aug-13	7-Aug-13
September 21, 2013	55 to 40	n/a	08:00 to 10:00	LCR_10.5L	11:45 to 13:45	PIT Tracking	20-Sep-13	27-Sep-13
		n/a		LCR_24.5R	14:52 to 16:13		20-Sep-13	27-Sep-13
September 27, 2013	40 to 35	-	15:00	-				
September 28, 2013	35 to 21	n/a	08:00 to 10:00	LCR_10.5L	11:06 to 13:00	PIT Tracking	27-Sep-13	3-Oct-13
December 20, 2013	60 to 57	-	15:00	-				
December 21, 2013	57 to 46	0.75	07:00 to 09:00	LCR_10.5L	10:15 to 11:55	PIT Tracking	20-Dec-13	-
		0.75		LCR_24.5R	12:22 to 13:31		20-Dec-13	-
February 1, 2014	46 to 32	0.8	07:00 to 09:00	LCR_10.5L	10:05 to 11:34	PIT Tracking	30-Jan-14	4-Feb-14
		0.8		LCR_24.5R	12:30 to 13:45		30-Jan-14	4-Feb-14
February 15, 2014	30 to 20	0.6	08:00 to 09:00	LCR_10.5L	11:50 to 12:55	PIT Tracking	13-Feb-14	20-Feb-14
		0.45		LCR_24.5R	14:15 to 15:12		13-Feb-14	20-Feb-14
March 29, 2014	30 to 26	0.15	8:00	LCR_10.5L	10:05 to 11:15	PIT Tracking	28-Mar-14	31-Mar-14
		0.15		LCR_24.5R	13:10 to 14:15		28-Mar-14	31-Mar-14
April 1, 2014	26 to 18	0.5	08:00 to 09:00	LCR_10.5L	10:12 to 11:45	PIT Tracking	31-Mar-14	2-Apr-14
		0.5		LCR_24.5R	13:20 to 14:30		31-Mar-14	2-Apr-14

Notes:
[1] A BRD load shaping reduction was observed between 01:35 and 04:25 on May 7, 2010 at site Koot_1.2L. The approximate vertical reduction was 0.5 m (200 m3/s at Birchbank). A visual assessment of dewatered areas as well as PIT tracking was conducted.
"n/a" No data available
"-" No survey conducted

3.5 Fish Life History Sampling

Captured fishes were identified to species and target species were measured for length (to the nearest mm) and assessed for ripeness/maturity (i.e., slight pressure on the abdomen was used to see if milt or eggs were expressed). If males were expressing milt and if females' expressed eggs or abdomens appeared soft or urogenital pores swollen then they were considered sexually mature and in spawning or just post-spawning condition (Section 3.9.3). In addition to these characteristics, Umatilla Dace displaying red pigmentation on the lips and fin insertions were potentially in spawning condition and these characteristics were recorded when observed. Fish were also inspected for any anomalies and those of interest were photographed and/or vouchered.

3.6 Verification of Sculpin and Dace Identification

Identification of sculpins and dace to the species level can be difficult due to similar external features attributed to several of these species (AMEC 2010a). In 2011, voucher samples of adult and juvenile Umatilla Dace were sent to Dr. Don McPhail (Curator Emeritus, University of British Columbia Fish Museum, Vancouver, BC) to confirm species identification. Additional samples of sculpins were also sent to Dr. McPhail in previous years (AMEC 2010b, 2011) and photographs were collected during the 2012 study period to confirm species identification. Dr. McPhail confirmed that all vouchered specimens were correctly identified.

3.7 Incidental Captures From Other Programs

Sculpins and dace captured incidentally during other programs in the LCR, for example the Upper Columbia White Sturgeon Management Program and Lower Columbia River Physical Habitat and Ecological Productivity (CLBMON-44), have been reported previously (AMEC 2012a, AMEC 2013). No incidental captures were reported from these programs in Year 5.

3.8 Microhabitat Use Measurements

Habitat use information was recorded at locations where target fish species were observed order to answer Specific Questions A, C, D and E as well as Management Questions 1, 2 and 3. Information was collected during tracking surveys (including flow reduction surveys), snorkel surveys, YOY sampling and nest assessments. Standard measurements recorded included depth (m), mean column water velocity (m/s) taken at 60% mean depth, substrate type, % substrate embeddedness, presence of vegetation (i.e., aquatic macrophytes, flooded terrestrial vegetation, woody debris), location (i.e., bank (left, right, center), distance to shore (m)), and other relevant observations. Substrate categories included silt (<0.6 mm), sand (0.6-4 mm), gravel (4-64 mm), cobble (64-256 mm) or boulder (>256 mm but not bedrock). Microhabitat measurements were also taken opportunistically during backpack electrofishing when the capture locations of target species were directly observed.

Sculpin nest rocks were measured along three axis dimensions. Substrate availability was also measured at two LCR index sites (Genelle-LCR_24.5R and Kootenay River mouth-LDR_10.5L) and transects were completed from highest water wetted edge to maximum wadable depth and randomly selected substrates were measured in three dimensions.

3.9 Data Analyses

The TOR specified that this program was qualitative in nature, therefore most data were tabulated and summarized by descriptive statistics (means, standard deviation, standard error, 95% confidence limits), where possible. Data was entered into a customized Microsoft Access database set up with standardized forms, data integrity checking and validation rules. All descriptive statistics and analyses were compiled using JMP (Version 10.0) statistical software unless otherwise noted. Comparative statistics and modelling were used to evaluate data trends where possible. Data distributions were inspected using histograms to assess normality of the distribution and applicable transformations were used when required. Means and standard deviations are presented where applicable and are used when means/medians are similar for relevant data. Analysis of Variance (ANOVA) was used for multiple comparisons and Tukey's post hoc test was used to compare pairs of means unless otherwise specified. Statistical significance was set at $p < 0.05$.

3.9.1 Season Designation

Seasons were defined by calendar dates to facilitate comparisons between years for all compiled data in this report (Table 4).

Table 4: First day of season for each sample year for the Lower Columbia (LCR) and Slocan river study areas, 2010-2014. Sampling was only conducted during fall 2009.

Year	Summer	Fall	Winter	Spring
2010	Jun 21	Sep 23	Dec 21	Mar 20
2011	Jun 21	Sep 23	Dec 22	Mar 20
2012	Jun 20	Sep 22	Dec 21	Mar 20
2013	Jun 21	Sep 22	Dec 21	Mar 20
2014	-	-	-	Mar 20

One exception was made to Table 4 season designations; a flow reduction occurring on September 21, 2013 was considered fall as discharge conditions were more representative of fall than summer at that time.

Calendar dates were used during initial years of reporting (AMEC 2010b, AMEC 2011), but in subsequent years delineation was based on the ascending/descending limb of the river system's hydrograph as well as season (AMEC 2012a) or the separation between spring and summer was considered peak discharge in each system (AMEC 2013).

3.9.2 Catch-Per-Unit-Effort

The calculation of catch-per-unit effort (CPUE) was dependent on sample methods used. For example, minnow trapping was calculated using hours as the unit of effort to obtain a catch rate per hour. Backpack electrofishing and snorkel surveys were calculated using both sample effort time (seconds and hours, respectively) and square meter of area sampled as the unit of effort.

Using sample area as the unit of effort allowed for direct comparisons of CPUE (also referred to as catch rates) between backpack electrofishing and snorkelling methods; comparisons were not made between these two methods and minnow trapping as different units of effort were used.

Diel minnow trap Umatilla Dace catch numbers and CPUE were compared by ANOVA at each time interval (day, dusk, night and dawn) with statistical significance set at $p < 0.05$.

3.9.3 Life Stage and Maturity Designation

Comparisons among age classes were facilitated by assigning life stages to all captured individuals based on general life history and development for sculpin and dace species. General life history categories included adult, juvenile and YOY (Table 5). The length values attributed to each life stage category were standardized in Year 3 based on findings from the three years of study as well as information provided in the literature on these species (AMEC 2010a; Table 2).

YOY sculpin and dace <18 mm FL were difficult to identify to species and therefore analyses conducted on this life stage were often completed by pooling observations by genus. Newly emerged YOY Umatilla Dace are approximately 10 mm FL (McPhail 2007) and hatch occurs 5-7 days after spawning under laboratory conditions at 18°C (Haas 2001). Umatilla Dace YOY between 19-35 mm FL were classified into that year's spawning cohort. Columbia, Shorthead and Torrent Sculpins are approximately 8 mm at hatch and 10 mm at emergence; the incubation period lasts approximately 20-30 days and emergence occurs up to two weeks after hatching (McPhail 2007). Prickly Sculpins are 6 mm at hatch after incubating for approximately 15 days; larvae are planktonic for 25-35 days before becoming benthic at 12 mm (Mason and Machidori 1976).

Table 5: Life stage categories and associated lengths for sculpins (total length) and dace (fork length).

Life Stage	Length
Adult	>45 mm
Juvenile	>35 to 45 mm
YOY	Up to 35 mm for Columbia & Shorthead Sculpins & Umatilla Dace; Up to 40 mm for Prickly & Torrent Sculpins

Maturity stages were assigned to adult fish when possible using the following adapted definitions from Ricker (1971):

Mature – Adult that potentially has or will spawn; displaying external sexual characteristics such as colouration/tubercles. Sexual products not extruded when light pressure is applied.

Immature – Adult that hasn't yet spawned (difficult to ascertain in these species).

Gravid – Sexual products ripe but are not extruded when light pressure is applied; egg completely round, some already translucent and ripe.

Ripe/Spawning – Flowing milt or expressing eggs when light pressure is applied.

Spawning/Spent – Not fully empty. No opaque eggs left in ovary.

Spent – The sexual products have been discharged; genital aperture inflamed.

3.9.4 Habitat Suitability, Use, and Preference

Habitat data were compared by season, day versus night and life stage for target species where information was available. Methods used in these analyses were those that collected direct microhabitat use measurements and included backpack electrofishing, snorkel, PIT tracking, seine netting, nest assessments and YOY sampling. Habitat use observations collected during flow reductions were not included as part of general analyses because these data were considered biased and not representative of actual overall use. Information was pooled for all years that data were available (2010 to 2014) to increase sample size.

3.9.4.1 Habitat Suitability Indices

Habitat Suitability Index (HSI) modelling was conducted by Poisson Consulting Ltd. (Poisson) using the following methods. Microhabitat data collected during this study by all sample methods were included in HSI modelling with the exception of that collected during PIT-tracking surveys during HLK flow changes (as outlined above). Models were fitted to data using a Bayesian model following the methods of Thomas et al. (2004) and Hightower et al. (2012). A ranking of zero is considered unsuitable habitat while 1.0 is optimum habitat. The modelling approach assumed there was a direct linear relationship between the calculated suitability index and the species carrying capacity in the habitat. When there were no availability data, equal availability over the range of the habitat variable was assumed. With availability, the model tested if habitats were used in proportion to their availability; where this was not true, a preference for the habitat type used more than its proportion was indicated.

The model estimated the probability of the i^{th} fish (P_j) of using habitat category *j*, which was modelled as:

$$Pj = \frac{w_j a_j}{\sum_{j=1}^{h}(w_j a_j)}$$

where *a* is the proportion of available habitat in category *j*, w_j is the unscaled relative probability of using habitat *i* if all habitats are equally available.

A vague, low information prior was utilized since it was unknown what habitat preferences existed for the species of study. Models were run for 10,000 iterations and if they failed to converge, the number of iterations was doubled until convergence was attained or until three doublings of iterations occurred without convergence. The R-hat value was assessed to ensure convergence by determining it was less than 1.1 (Kéry and Schaub 2011). The R-hat assessed within and between chain variance to provide an assessment of whether it was likely that convergence was achieved. Bayesian credible intervals at the 95% level were calculated using the method outlined in Hightower et al. (2012).

Depth and mean column velocity were modelled as continuous single variable determinants of habitat suitability using a multinomial gamma distribution. The gamma distribution is a two parameter probability distribution, which in this case was parameterized with a shape parameter $\alpha = k$ and an inverse scale parameter $\beta = 1/\theta$, also called a rate parameter. The predicted distributions from the model could vary by shape, rate or both parameters. The multinomial distribution was where each independent trial can result in success for exactly one of the defined categories and each category had a fixed probability of success. Although depth and velocity were measured as continuous variables, they were aggregated into bins in order to allow the use of the multinomial distribution. Since habitat availability data for depth and velocity were not always available for the systems under study, availability of each category of depth or velocity was considered equally available. This was the standard assumption for habitat suitability index calculations since it is rare to have habitat availability data and therefore to truly be able to assess preference as opposed to use (Rosenfeld 2003). There were very few data points collected in water deeper than 2.5 m because of the challenge of sampling target species in a large river system and limited methods that were available for data collection. However, there were 11 data points where fish were found in water between 2.6 and 7.5 m. These data points were removed from the dataset because of the bias they would cause in the analysis. No fish were encountered in water with velocities higher than 2.0 m/s so the velocity variable was capped at this value for model predictions to retain relevance and accuracy.

Depth and velocity habitat suitability were also modelled to consider diel period, season and life stage. Diel period included day or night sampling. Seasons were grouped as outlined in Table 4, with the exception of fall, which comprised both fall and winter seasons because data points were too sparse for the two seasons to be separated. Life stage categories included young-of-year, juvenile, and adult as outlined in Section 3.9.3.

Substrate habitat suitability was modelled as a categorical single variable determinant of habitat suitability using a Dirichlet distribution; this distribution is the conjugate prior of the categorical distribution and multinomial distribution. The silt category was assigned to any vegetation observations based on discussions with the field crew (Section 3.8). Categorical Bayesian HSI models were fitted and 95% credible intervals calculated. If one substrate type was uniformly the most preferred over all draws of the model fitting, its probability of use was always one and therefore had no credibility interval associated with it. In addition, substrate habitat suitability was analyzed for sculpin nesting habitat. Substrate dimensions for nest rocks (Section 3.8) were ordered from largest to smallest and the second dimension was used as the determinant variable in the analysis since this would determine the sieve size through which each substrate sample would drop. Substrate availability data measured at LCR index sites (Section 3.8) were compared to nest selection data to determine if sculpin were exhibiting a preference based on what substrates were available. Depth and velocity at sculpin nest sites were not assessed for habitat suitability because it was difficult to determine whether these variables were similar to what sculpins initially selected as it was unknown how long they had been at nest sites prior to their discovery. Nest substrate embeddedness could not be analysed due to insufficient variability; data were heaped at 5% embeddedness.

HSI and habitat preference analyses and related data plots was completed using R 3.0.2 (R Core Team 2013), the JAGS library (Plummer 2003), the jaggernaut library (Thorley 2013) and the ggplot2 library (Wickham 2009). HSI models for depth, velocity and substrate were conducted by genera (sculpins and dace) and separate target species (Umatilla Dace, Columbia and Shorthead Sculpins) where possible. Models were run separated for study area (LCR and Slocan River) and to investigate the factors of season, diel period and life stage, where possible. The variables and species for which models converge are summarized in Table 6. Model code is provided in Appendix F.

Table 6: HSI models run by system and species group. The main variable HSI model was run on its own and then with each of the factors for all species and species groups for which there were sufficient data. Data were separated out by river system since different habitats are available in each system. Models that converged within parameter bounds are represented by species or genera codes, those that did not converge are represented with dashes.

Model: Main Variable	River System	Model: Main Variable	Model: Secondary Factors	Species or Species Groups (CC =Sculpins,DC=Dace, CCN=Shorthead Sculpin, CBA=Columbia Sculpin, UDC=Umatilla Dace)				
Depth	Columbia	Depth	None	CC	DC	CBA	CCN	UDC
			Diel Period	CC	DC	---	---	UDC
			Life Stage	---	---	---	---	UDC
			Season	---	---	CBA	---	---
Depth	Slocan	Depth	None	CC	DC	CBA	---	UDC
			Diel Period	CC	DC	---	---	---
			Life Stage	---	---	---	---	---
			Season	CC	DC	---	---	---
Substrate	Columbia	Substrate	None	CC	DC	CBA	CCN	UDC
Substrate	Slocan	Substrate	None	CC	DC	---	---	UDC
Nesting Substrate	Columbia	Nesting Substrate	None	CC	---	---	---	---
Velocity	Columbia	Velocity	None	CC	DC	CBA	CCN	UDC
			Diel Period	---		CBA	---	UDC
			Life Stage	---	DC	CBA	---	UDC
			Season	---		CBA	---	UDC
Velocity	Slocan	Velocity	None	CC	DC	CBA	---	UDC
			Diel Period	CC	DC	---	---	---
			Life Stage	CC	---	---	---	---
			Season	CC	DC	---	---	---

3.9.5 Water Level Fluctuations in LCR Study Area

3.9.6 Movement Analysis

To compare movements during both flow reduction and non-flow reduction surveys, PIT-tracking data were reviewed and only sculpins and dace confirmed to be alive were included in the analysis. The distances moved by PIT-tagged adult sculpins and dace were determined by calculating the difference between detection locations over time. If field displacement measurements were not available, the Pythagorean Theorem ($a^2+b^2=c^2$) was used to calculate the displacement as the shortest distance (i.e., as the crow flies) between easting and northing UTMs for one detection location and the next. Movement rate was calculated as meters displaced between tracking observations (hours). Time periods were standardized by 24 hr period. Movement rate and direction were calculated for each flow reduction only for PIT-tagged fish that were observed during consecutive stages of the reduction. Habitat variables were pooled by season for all tracked sculpins and dace observed prior to, immediately after and following flow reductions. Means with standard deviation were calculated for movement rates and habitat variables, where appropriate. ANOVA was used to determine if differences in habitat use and movement rates before, during and after flow reductions were statistically significant ($p < 0.05$), while Chi Squared test was used to explore differences in the direction of movement ($p < 0.05$).

3.9.7 Pool Stranding Risk Analysis

Analyses to determine risk of pool stranding in the LCR for sculpins and dace was conducted by Poisson Consulting Ltd. (Thorley 2014, URL: http://www.poissonconsulting.ca/f/1090742912). Fish stranding data were provided by Golder Associates in the form of an Microsoft Access database (CLBMON-42). Discharge data were queried from a BC Hydro database maintained by Poisson Consulting. The focus of this analysis was on pool stranding information because information collected during interstitial stranding is biased and not proportional to the total amount of habitat exposed (R. Irvine, Statistician Poisson Consulting Ltd. pers. comm. 2014). Methods for fish stranding field collections are provided in CLBMON-42 (Golder 2012). In general, crews are dispatched to salvage stranded fish from areas of concern in the LCR following a flow reduction. At each site the crew records: number of pools observed; number of pools surveyed; and, number of fish counted by species, genus, family or all species in the surveyed pools. Data preparation assumptions included:

- Fish species code LND refers to Longnose Dace (LNC).
- The proportion of unidentified fish that were dace was the same as the proportion of identified fish (2.1%).
- The Genelle (Mainland) (right bank) site was recontoured in February 2003. Other sites that were recontoured included Genelle Cobble Island, Norn's Creek Fan and Millenium Park (Appendix B).
- The magnitude of a reduction event was the difference between the peak discharge in the previous 24 hours and the discharge at the time of the survey.
- The rate of a reduction event was the weighted mean hourly drop between the peak and the time of survey. Drops that were subsequently inundated prior to the survey were assigned zero weight while partially inundated drops were discounted accordingly.
- The time of a reduction event was the mean time between the peak and the survey weighted by the discounted drops.
- The delay was the number of hours between the time of the reduction event and the time of the survey.
- The stage was the discharge at the time of the reduction as the percent mean annual discharge (% MAD) of the section of river to take into account differences in river size.
- The diel period was whether or not the time of reduction occurred in daylight.

Hierarchical Bayesian models were fitted to the stranding data using R version 3.1.0 (Team 2013) and JAGS 3.4.0 (Plummer 2012), which interfaced with each other via jaggernaut 1.8.1 (Thorley 2014). For additional information on hierarchical Bayesian modelling in the BUGS language, of which JAGS uses a dialect, the reader is referred to Kéry and Schaub (2011) pages 41-44.

Unless specified, the models assumed vague (low information) prior distributions (Kéry and Schaub 2011, p. 36). The posterior distributions were estimated from a minimum of 1,000 Markov Chain Monte Carlo (MCMC) samples thinned from the second halves of three chains (Kéry and Schaub 2011, pp. 38-40). Model convergence was confirmed by ensuring that Rhat (Kéry and Schaub 2011, p. 40) was less than 1.1 for each of the parameters in the model (Kéry and Schaub 2011, p. 61). Model adequacy was confirmed by examination of residual plots.

The posterior distributions of the fixed (Kéry and Schaub 2011, p. 75) parameters are summarised in terms of a point estimate (mean), lower and upper 95% credible limits (2.5^{th} and 97.5^{th} percentiles), the standard deviation (SD), percent relative error (half the 95% credible interval as a percent of the point estimate) and significance (Kéry and Schaub 2011, p. 37,42).

Variable selection was achieved by dropping uninformative explanatory variables where a variable was considered to be uninformative if its percent relative error was ≥ 100%. In the case of fixed effects this is approximately equivalent to dropping insignificant variables, i.e., those with a significance ≥0.05.

The results are displayed graphically by plotting the modelled relationships between particular variables and the response with 95% credible intervals (CRIs) with the remaining variables held constant. In general, continuous and discrete fixed variables are held constant at their mean and first level values respectively while random variables are held constant at their typical values (expected values of the underlying hyperdistributions) (Kéry and Schaub 2011, pp. 77-82). Where informative the influence of particular variables is expressed in terms of the effect size (i.e., percent change in the response variable) with 95% CRIs (Bradford et al. 2005). Plots were produced using the ggplot2 R package (Wickham 2009).

The probability of stranding a threshold number of fish was analysed using a hierarchical Bayesian general linear mixed model (GLMM) (Kéry and Schaub 2011, pp. 73-74). Key assumptions of the GLMM include:

- The probability of stranding varies with the magnitude of the reduction, the stage, whether a site has been recontoured and the day of the year as a second order polynomial;
- The probability of stranding can vary randomly with the site and year; and,
- Stranding events are Bernoulli distributed.

Due to lack of data and species identification concerns, data were analyzed at the genus level for sculpins and dace overall. The probability of stranding a threshold number of one or more (n>1) and ten or more (n>10) sculpins and dace was used. These numbers were chosen based on biological assumptions of the risk of stranding rare/listed species and statistical experience with previous stranding analyses conducted for the LCR (Irvine et al. 2014). Preliminary analysis indicated that the data were not overdispersed and that the rate of reduction, the delay between the reduction and salvage and the diel period were not informative predictors of the probability of stranding and thus these parameters were not added to the final models. The R and JAGS code is provided online at https://github.com/poissonconsulting/lcr-stranding-13.

4 RESULTS

Results have also been synthesized for the entire program to facilitate discussion of the management and detailed questions. Information previously reported has also been incorporated to provide comparison between the regulated LCR and unregulated systems, where appropriate.

4.1 Environmental Parameters

4.1.1.1 LCR Study Area

The hydrograph on the LCR below HLK Dam followed a similar pattern throughout the duration of the study program with flows increasing in April, reaching peak freshet in June/July and then decreasing around August with a second smaller peak typically in the fall between September and November (Figure 3). Average annual flows were similar between years (2,200 to 2,600 m^3/s) with the exception of 2010 when flows averaged 1,600 m^3/s over that year; in 2009 sampling occurred on the Similkameen system (AMEC 2010b). The magnitude of peak discharge over the study period was highest in 2012 (6043 m^3/s on July 21), followed by 2013 (4434 m^3/s on July 5) and 2011 (4155 m^3/s on July 9) and lowest in 2010 (2767 m^3/s on June 16) (Figure 3). Peak discharge in 2012 was the highest recorded since the construction of HLK in 1967. The ascending limb of the hydrograph typically was observed from April/May to July and descending limb from mid- to late July to late September/early October (Figure 3). Lowest flows occurred in spring during 2010 (809 m^3/s on April 15), followed by 2011 (1,255 m^3/s on April 6), whereas in 2012 and 2013 lowest flows were observed during the fall period (1,079 m^3/s on November 4, 2012 and 1092 m^3/s on October 11, 2013).

Water temperatures in the LCR study area typically reached yearly maxima in August after peak discharge was observed and steadily declined to minimum temperatures (between 2 and 3°C) around December (Figure 3). Highest water temperatures were observed in 2010 (20°C on August 14) and 2013 (19°C on August 8) when peak discharge was lower compared to the other study years (Figure 3). Maximum water temperatures in 2012/2013 did not go above 18°C (Figure 3).

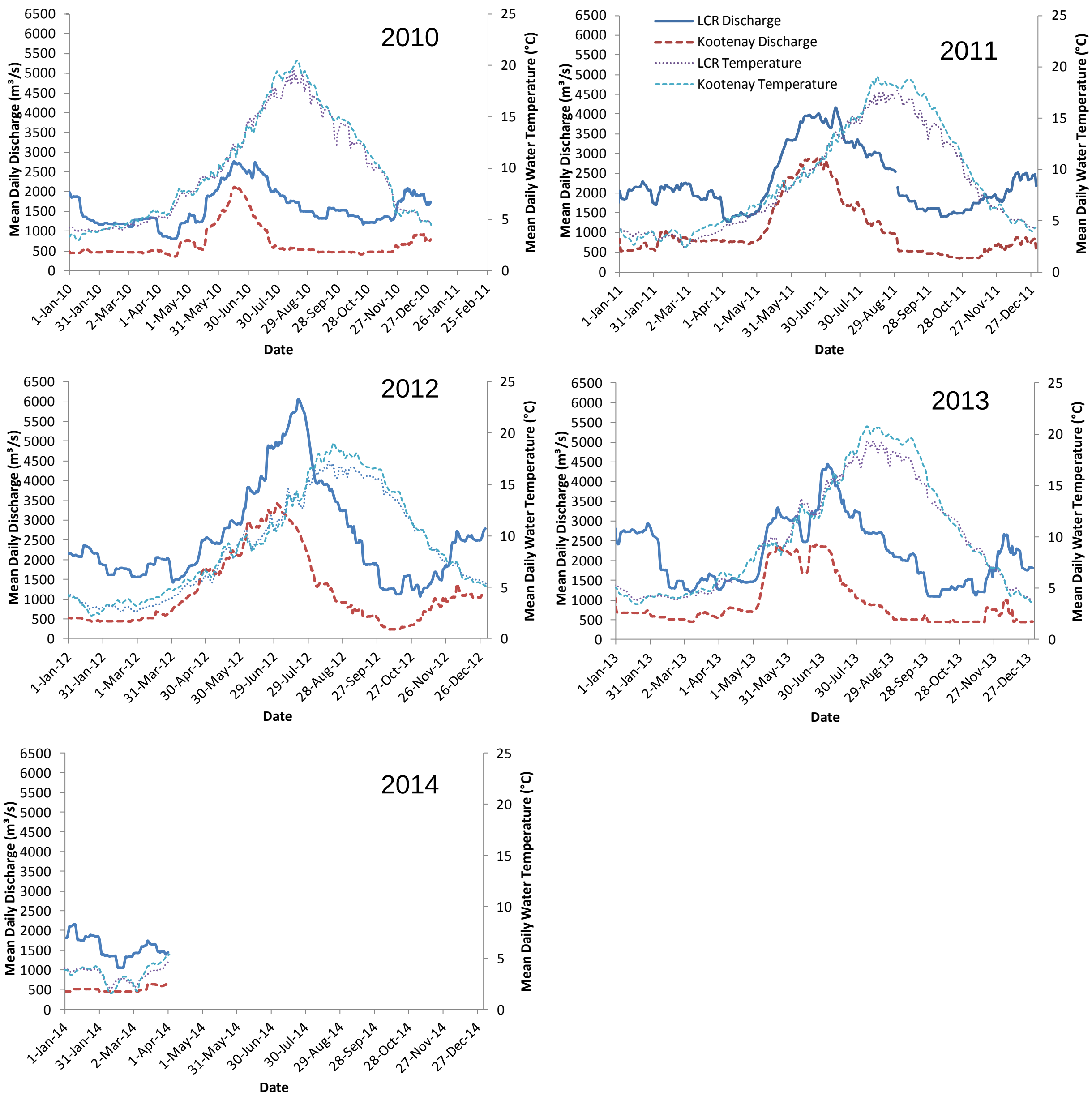


Figure 3: Discharge and water temperature for the Lower Columbia River (LCR) study area (BBK; WSC Station No: 08NE0558) and for the Kootenay River, January 2010 to April 2014.

4.1.1.2 Slocan River

Discharge on the Slocan River (at Crescent Valley) typically peaked in June/early July, with the exception of 2013 where peak flows were observed in May with a second peak in June (Figure

4). Low flows were observed in late August with sometimes a small increase in the fall, likely due to storm events (Figure 4). On average, flows were similar between years (103 to 117 m^3/s). The magnitude of peak discharge over the study period was highest in 2012 (587 m^3/s on June 24), followed by 2011 (492 m^3/s on June 30) and 2013 (470 m^3/s on May 22 and second peak of 463 m^3/s on June 20) (Figure 4). The ascending limb of the hydrograph typically was observed in April/May and descending limb from early July to early September; in 2013 the descending limb was approximately one month earlier (Figure 4). Lowest flows occurred in February/March (approximately 16 to 17 m^3/s), with the exception of 2011 where lowest flows occurred in December (18 m^3/s).

Water temperatures on the Slocan River typically reached yearly maxima in August (approximately 20°C) after peak discharge was observed and steadily declined to near freezing temperatures from December to March (Figure 4).

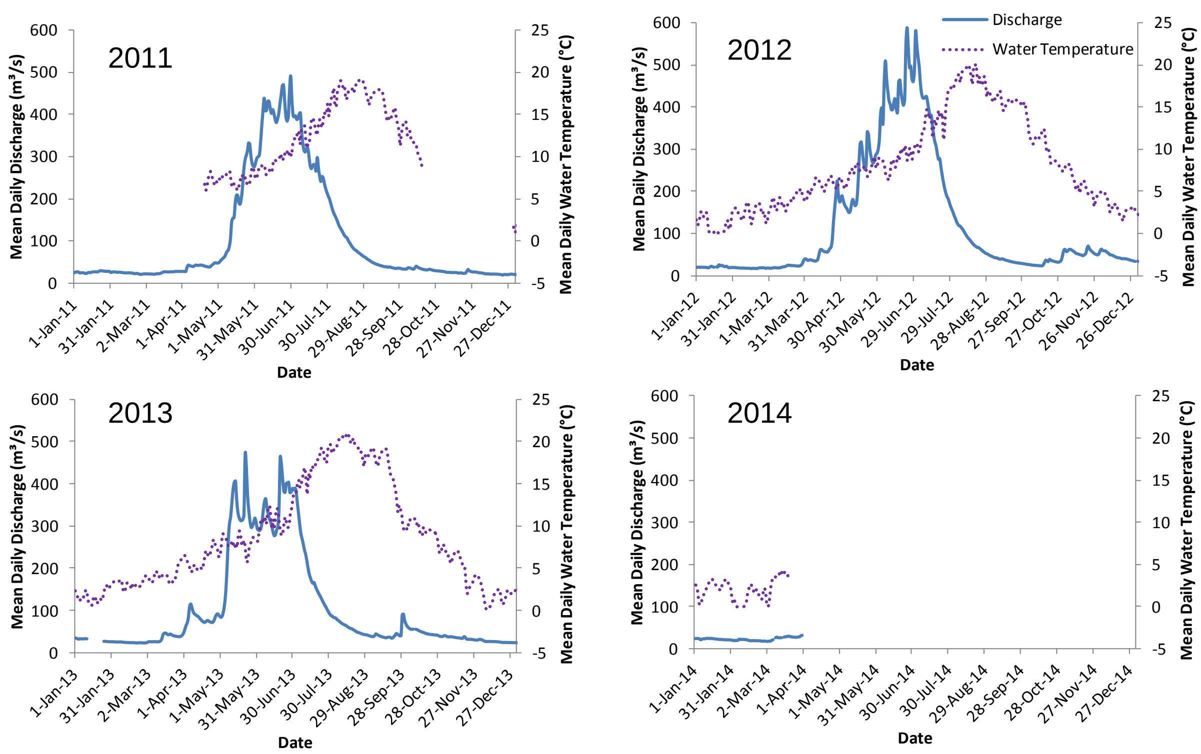


Figure 4: Discharge and water temperature for the Slocan River, January 2010 to April 2014. Discharge was measured at Crescent Valley (WSC Station No: 08NJ013) and water temperature was monitored at Slocan Park (Sloc_16.2R).

4.2 Fish Distribution and Catch Rates

In total, 114,276 seconds of backpack electrofishing (EF), 5,266 seconds of boat electrofishing, 7,868 hours of minnow trapping (MT), 200 hours of PIT-tag tracking and 78 hours of snorkelling were expended in the LCR study area from 2009 to 2014. Dip and seine netting, substrate flips and visual observation surveys were also conducted but these efforts were difficult to quantify. All efforts resulted in the capture of 17,436 fishes that included 594 Umatilla Dace, 286 Columbia Sculpins and 415 Shorthead Sculpins (Table 7). In addition, PIT-tagged sculpins and dace were relocated 710 times and included 8 Umatilla Dace, 93 Columbia Sculpins and 119 Shorthead Sculpins.

In the Slocan River, 55,043 seconds of backpack electrofishing, 11,553 hours of minnow trapping, 10 hours of snorkelling, 5 hours of larval drift netting were expended from 2009 to 2014. Dip netting and visual observation surveys were also conducted, but efforts were difficult to quantify. All efforts resulted in the capture of 5,802 fishes that included 688 Umatilla Dace (Table 7). In the Similkameen study area, 24,384 seconds of backpack electrofishing in winter and summer 2009 resulted in the capture of 989 Columbia Sculpins. In Pass Creek 1,896 seconds of backpack electrofishing in fall 2009 resulted in the capture of 497 Shorthead Sculpins.

Distribution maps outlining Umatilla Dace, Columbia Sculpin and Shorthead Sculpin capture locations in the LCR are provided in Appendix B. Further information for these species is provided below.

Table 7: Total captures of Umatilla Dace, Columbia Sculpins and Shorthead Sculpins in the lower Columbia (LCR) and Slocan study areas by main capture methods used, 2009-2014. Catch- per- Unit-Effort (CPUE) is provided in brackets.

Capture Method	LCR			Slocan
	Umatilla Dace	Columbia Sculpin	Shorthead Sculpin	Umatilla Dace
Minnow Trapping	61 (0.008)	0 (0)	0 (0)	425 (0.04)
Backpack Electrofishing	468 (0.009)	259 (0.005)	295 (0.005)	222 (0.006)
Snorkeling	7 (0.0002)	26 (0.0007)	64 (0.0018)	40 (0.0036)
Other	58	1	9	1
Total	**594**	**286**	**368**	**688**

Note: CPUE was calculated as fish captured per hour of effort for minnow trapping and as fish captured per square meter for electrofishing and snorkelling. Total effort for each species was not provided due to these different CPUE calculations. Other methods included seine, drift and dip netting, lip seining and visual observations but CPUE was not calculated.

4.2.1 Umatilla Dace

Overall, the majority of Umatilla Dace in the LCR study area were captured in the lower Kootenay River, predominantly at Koot_0.5R (Figure 1). Catch-rates were highest in fall and lowest in spring for both minnow traps and backpack electrofishing (Table 8). Umatilla Dace were distributed throughout the LCR study area (Appendix B). Sites with the highest number of UDC captures over the course of this study have included: Koot_0.5R, Koot_1.2L, LCR_47.5L and LCR_53.1L.

In the Slocan River study area, Umatilla Dace captures were highest at Sloc_30.7L (Figure 2; Appendix C). CPUE was highest in fall and lowest in spring for both minnow trapping and backpack electrofishing (Table 9). Sites with the highest number of UDC captures over the course of this study were: Sloc_16.2R, Sloc_30.7R and Sloc_37.8L. Details are provided below.

Umatilla Dace were not captured in the Similkameen study area or in Pass Creek.

Life stages of Umatilla Dace captured varied by collection method. Only juveniles and adults were captured by minnow traps, whereas all life stages were captured by backpack electrofishing although the majority of the EF catch was comprised mostly of YOY. All life stages were observed during snorkel surveys. Additional information on life stage is provided in Section 4.3.

4.2.1.1 LCR Study Area

Backpack electrofishing was the most successful way to capture Umatilla Dace followed by minnow trapping in the LCR study area based on actual numbers captured (Table 7). Of the 594 Umatilla Dace captured in the LCR study area, 401 (68%) were from the lower Kootenay River, predominantly captured at Koot_0.5R by backpack electrofishing. The remaining 193 were captured at sites throughout the LCR mainstem by various methods.

Average CPUE for Umatilla Dace captured in the LCR study area varied by method and sampling season. On a seasonal basis, CPUE was similar using minnow traps in summer and fall and lowest in spring; no UDC were captured during spring surveys (Table 8). CPUE was highest during fall and winter followed by summer and lowest during spring using backpack electrofishing. Snorkelling CPUE was low compared to other methods but similar catch-rates resulted during spring and summer surveys; fall/winter surveys were not conducted (Table 8). The following sites had the highest Umatilla Dace CPUE (all methods): Koot_0.5R, Koot_1.2L, LCR_2.8L, LCR_18.8L, LCR_25.1R, LCR_24.5R, LCR_47.5L and LCR_53.1L (Appendix B).

Table 8: Average Catch-Per-Unit-Effort (CPUE) by season, method and species in the LCR study area, 2009-2014. Results are also presented for all fish captured. Methods include minnow trapping (MT), backpack electrofishing (EF) and snorkelling (SW). CPUE for MT =fish/hr and for EF and SW =fish/m^2.

Season	Umatilla Dace			Columbia Sculpin			Shorthead Sculpin			All Fish Captured		
	MT	EF	SW	MT	EF	SW	MT	EF	SW	MT	EF	SW
Spring	0.000	0.005	0.0002	0	0.003	0.0009	0	0.003	0.0007	0.018	0.038	0.019
Summer	0.008	0.009	0.0002	0	0.012	0.0006	0	0.008	0.0039	0.063	0.699	0.122
Fall	0.010	0.015	-	0	0.003	-	0	0.012	-	0.159	0.117	-
Winter	-	0.012	-	-	0.005	-	-	0.001	-	-	0.034	-

Note: “-“ denotes that no sampling was conducted.

In the LCR study area, no significant diel (day/night) differences in catch-rates were observed for Umatilla Dace during any season (spring: n=3, p=0.76; summer: n=3, p=0.18; fall: n=2, p=0.96; winter: n=2, p=0.92) using backpack electrofishing. Umatilla Dace were not observed during diel snorkel surveys conducted during spring, but were observed during daytime only surveys in spring (n=6) and summer (n=1). Umatilla Dace were not observed during diel tracking surveys in spring, summer, and fall in the LCR study area. However, Umatilla Dace were tracked during the day in spring (n=5), fall (n=1), and winter (n=2); night surveys were not conducted within 24 hours of these observations.

4.2.1.2 Slocan River

In total, 688 Umatilla Dace were captured in the Slocan River. Minnow trapping (n=425) was the most successful way to capture adult Umatilla Dace, whereas backpack electrofishing captured all life stages (n=222).

As with the LCR study area, Umatilla Dace CPUE in the Slocan River varied by season and capture method used. On a seasonal basis, minnow trap CPUE was highest during fall and summer and approximately four times lower in spring. Highest catch-rates using backpack electrofishing was observed during fall and winter while spring and summer had the lowest catch-rates (Table 9). Of the four index sites on the Slocan River, CPUE was highest at Sloc_30.7R for both minnow trapping and backpack electrofishing. Higher catch-rates were also observed at Sloc_16.2R using minnow traps and at Sloc_37.8L using backpack electrofishing (Appendix C).

Similar to the LCR study area, highest minnow trap CPUE was observed in summer and fall with lower catch-rates in spring on the Slocan River (Table 9). However, minnow trap CPUE was much higher in the Slocan River during all seasons compared to the LCR study area (Table 8 and Table 9). Backpack electrofishing CPUE was very similar in both systems on a season-by-season basis with highest catch-rates observed in fall and lowest in spring (Table 8 and Table 9).

Table 9: Average Catch-Per-Unit-Effort (CPUE) by season, method and species in the Slocan River, 2009-2014. Results are also presented for all fishes captured. Methods include minnow trapping (MT) and backpack electrofishing (EF). CPUE for MT = fish/hr and for EF = fish/m^2.

Season	Umatilla Dace			All Fish Captured		
	MT	EF	SW	MT	EF	SW
Spring	0.012	0.002	0.001	0.075	0.038	0.005
Summer	0.041	0.006	0.004	0.159	0.106	0.102
Fall	0.045	0.015	-	0.146	0.166	-
Winter	-	0.013	-	-	0.068	-

Note: "-" denotes that no sampling was conducted.

In the Slocan River, no significant diel (day/night) differences for capturing Umatilla Dace (CPUE) were observed among seasons (spring: n=6, p=0.72; summer: n=6, p=0.41; fall: n=8, p=0.59; winter: n=3, p=0.85) with backpack electrofishing and snorkelling (summer: n=3, p=0.92; spring: n=1).

Diel minnow trap experiments conducted during summer 2012 and 2013 suggested significant differences in catch-rates at different times of the day (p=0.02; Figure 5). Tukey's post-hoc comparisons showed catch-rates were significantly higher during dusk compared to night (p=0.03), but significant differences were not observed between the other time periods (day, dusk, night and dawn). UDC catch-rates were lowest at night during these experiments; UDC were not captured at night in 2013. Overall, more Umatilla Dace were captured during the 24-hour sample period in July 2013 than in August 2012 and August 2013 both in terms of numbers caught (45, 24 and 22, respectively) and catch-per-unit-effort (0.08, 0.06 and 0.06 UDC/hour, respectively). UDC were not captured during diel sampling conducted in Trozzo Creek, a tributary to the Slocan River at Sloc_37.8L (August 2013; Appendix C).

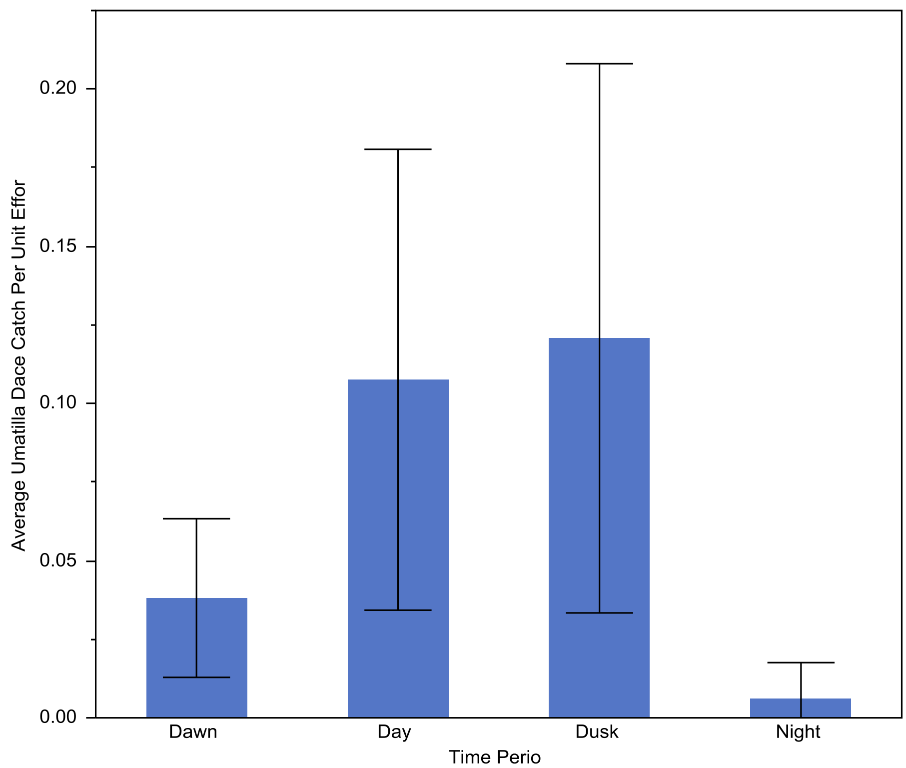


Figure 5: Average Catch-Per-Unit-Effort for Umatilla Dace captured in minnow traps checked at 6-hour intervals over a 24-hour period to capture day, dusk, night and dawn at index sites in the Slocan River, summer 2012/2013. Bars represent 95% confidence intervals.

4.2.2 Columbia Sculpin

Overall in the LCR study area, catch-rates for Columbia Sculpins were highest using backpack electrofishing followed by snorkelling (Appendix C). Summer CPUE was higher compared to other seasons using backpack electrofishing, whereas catch-rates were similar using snorkelling during spring and summer. Columbia Sculpins were not captured in minnow traps in the LCR study area. Columbia Sculpins were distributed throughout the LCR study area (Appendix B). Sites with the highest capture rates over the course of this study have included LCR_24.5R and LCR_47.2R.

Columbia Sculpin catch-rates were higher in the Similkameen study area compared to the LCR study area (refer to details below). Columbia Sculpins have been captured in the Slocan River (AMEC 2012a, AMEC 2013, Appendix B), but identification to the species level was a lower priority because of the focus on Umatilla Dace. Therefore, CPUE calculations have not been included for Columbia Sculpins in the Slocan River. Columbia Sculpins were not captured in Pass Creek.

4.2.2.1 LCR Study Area

The majority of Columbia Sculpins captured in the LCR study area were by backpack electrofishing (n=259) with only one fish captured using boat electrofishing and few observations during snorkelling (n=26) between 2009 and 2014 (Table 7). Of the 286 Columbia Sculpins captured in total, 93% were captured predominantly at index site LCR_24.5R. Fifteen of the 21 Columbia Sculpins captured in the lower Kootenay River were located at Koot_1.2L.

Columbia Sculpin CPUE was highest using backpack electrofishing in the LCR study area (Table 8). Backpack electrofishing catch-rates were highest during summer and lowest during spring, fall and winter (Table 8). Snorkel survey observation rates were low during both spring and summer seasons when these types of surveys were conducted. Columbia Sculpins were not captured in minnow traps set in the LCR study area. Locations with the highest Columbia Sculpin CPUE included LCR_47.2R and LCR_24.5R in the LCR and Koot_0.2R and Koot_1.2L in the lower Kootenay River. Sampling for Columbia Sculpins was focused at two index sites (LCR_24.5R and LCR_10.5L) between 2012 and 2014; these locations were selected for more in-depth study based on high CPUE (AMEC 2012a).

There was no difference in the number of PIT tagged Columbia Sculpins that were observed during the day or night during diel tracking surveys in the fall (n=4; p=0.67); none were observed during spring or summer diel tracking. Columbia Sculpins were not captured during day/night comparative electrofishing surveys in the LCR study area.

4.2.2.2 Similkameen System

In the Similkameen system, Columbia Sculpins were captured by backpack electrofishing, which was the only method of capture employed (AMEC 2010b). Surveys of similar effort were conducted in winter and summer 2009. CPUE for Columbia Sculpins was higher in summer (CPUE=0.18 fish/m^2) than winter (CPUE=0.04 fish/m^2), the only seasons when sampling was conducted. Catch-rates were higher in the Similkameen study area compared to the LCR study area during these two seasons (Table 8). The majority of Columbia Sculpins captured in the Similkameen system (n=989) were located in Otter Creek (n=675), a tributary of the Tulameen River, which is a tributary to the Similkameen River. Catch-rates in Otter Creek were higher when compared to the LCR and overall Similkameen study areas in both winter (CPUE=0.11 fish/m^2) and summer (CPUE=0.36 fish/m^2).

Diel differences in catch-rates were not observed in the Similkameen system. The number of tracked PIT-tagged Columbia Sculpins was the same day and night in spring (n=19), summer (n=26) and fall (n=73) in Otter and Allison Creeks, which are entirely wadable. Diel electrofishing surveys were not completed in the Similkameen system.

4.2.3 Shorthead Sculpin

Overall in the LCR study area, CPUE was highest using backpack electrofishing compared to snorkelling. Higher catch-rates were observed during fall using backpack electrofishing and during summer when conducting snorkel surveys. Shorthead Sculpins were not captured in minnow traps in the LCR study area. Shorthead Sculpins were distributed throughout the LCR study area (Appendix B). The following sites had the highest catch-rates during this study: Koot_0.3L, Koot_0.6R, LCR_10.5L, LCR_24.5R and LCR_47.2R.

Shorthead Sculpins were captured in the Slocan and Little Slocan Rivers, but they were not always identified to the species level because Umatilla Dace were the sampling priority (AMEC 2010a, AMEC 2012a, AMEC 2013, Appendix B). Therefore, CPUE calculations have not been included for Shorthead Sculpins captured in the Slocan River.

Shorthead Sculpins were sampled in the unregulated Pass Creek, a tributary to the LCR. Electrofishing surveys were conducted in fall 2009 and CPUE at that time was 235 times higher than that observed in the LCR study area when electrofishing was used. Shorthead Sculpins were also captured in Beaver Creek; details are provided below.

4.2.3.1 LCR Study Area

The majority of Shorthead Sculpins were captured by backpack electrofishing (n=295) with fewer captured by boat electrofishing (n=4), lip seining (n=3) and observed during snorkelling (n=64) (Table 7). Two Shorthead Sculpins were also identified in rock baskets used for a concurrent WUP project in 2012 (CLBMON-44: Lower Columbia River Physical Habitat and Ecological Productivity). Shorthead Sculpin CPUE was highest using backpack electrofishing in the LCR study area; CPUE was highest during fall followed by summer (Table 8). Catch-rates for snorkeling were over five times higher during summer compared to spring when surveys were conducted. Locations with the highest capture rates included: Koot_0.3L, Koot_0.6R, LCR_10.5L, LCR_24.5R and LCR_47.2R. Sampling for Shorthead Sculpins was focused at the two index sites between 2012 and 2014; these locations were selected for more in-depth study based on high CPUE (AMEC 2012a).

Diel differences in catch-rates were not observed in the LCR study area for Shorthead Sculpins. No significant differences were observed during backpack electrofishing surveys conducted during the day than the night in spring (n=3; p=0.37); Shorthead Sculpins were not captured during summer, fall and winter diel surveys. There was no difference in the number of PIT tagged Shorthead Sculpins observed during diel tracking surveys in fall (n=4; p=0.08); no fish were observed during spring or summer diel tracking.

4.2.3.2 Pass and Beaver Creeks

In Pass Creek, an unregulated tributary to the LCR, Shorthead Sculpins were only sampled by backpack electrofishing in fall 2009 (AMEC 2010b). A total of 527 Shorthead Sculpins were captured in Pass Creek and catch-rates were 235 times higher (1.2 fish/m^2) compared to the LCR study area for this period (0.012 fish/m^2; Table 8). Diel differences in catch-rates were also not observed in Pass Creek. The number of PIT-tagged Shorthead Sculpins observed was similar during day (n=134) and night (n=128) surveys conducted in spring.

Shorthead Sculpins were also captured in Beaver Creek in fall 2009 by backpack electrofishing (AMEC 2010b). A total of 60 Shorthead Sculpins were captured in Beaver Creek and catch-rates were 10 times higher (0.05 fish/m^2) compared to the LCR study area for this period (0.012 fish/m^2; Table 8). Diel sampling was not conducted in Beaver Creek.

4.3 Life Stage

The following section presents a life stage summary for all target species observed in the study area during the entire program.

4.3.1 Umatilla Dace

The majority of Umatilla Dace captured in the LCR study area were young-of-the year (YOY; n=291) followed by juveniles (n=212) with only 99 of the 594 fish classified as adults (Appendix D). The majority of adults were captured in summer (n=65) followed by spring (n=12) and fall (n=12) with only one adult captured in winter (Appendix D). Numbers of juveniles were highest in summer (n=103) followed by spring (n=54) and fall (n=56); none were captured in winter (Appendix D). YOY were captured in similar numbers during all seasons except summer, which had approximately half the catch (Appendix D).

Adults comprised the majority of the catch (n=497) in the Slocan River followed by YOY (n=150) and juveniles (n=41; Appendix D). The majority of adults were captured in the summer (n=389) with lower numbers in spring (n=46) and fall (n=62); none were captured in winter (Appendix D). Juveniles were mainly captured in the summer (n=36) with very few captured in spring (n=2) and fall (n=3); none were captured in winter (Appendix D). The majority of YOY were captured in fall (n=100) followed by winter (n=35) and lower numbers in spring (n=13) and very few in summer (n=2; Appendix D).

4.3.2 Columbia Sculpin

The majority of Columbia Sculpins captured in the LCR study area were adults (n=232) followed by YOY (n=37) and juveniles (n=17; Appendix D). Adults have been captured in all seasons with the majority observed in summer (n=112) and spring (n=78) and lower numbers in fall (n=15) and winter (n=27; Appendix D). Low numbers of juveniles were captured in all seasons (Table 10). Columbia Sculpin YOY were identified during summer (n=35) and fall (n=29) with fewer in spring (n=17); none were observed/identified in winter (Appendix D).

The majority of Columbia Sculpin captured in the Similkameen system were adults (n=706) followed by juveniles (n=202) and YOY (n=76; Appendix D). All three life stages were present during summer and winter when sampling was conducted in this system; other seasons were not sampled at this time (AMEC 2010b; Appendix D). However, very few YOY were collected during summer (n=3) likely because this life stage was not catchable for that cohort year until winter (n=73; Appendix D). A higher number of juveniles were observed during summer (n=181) compared to winter (n=21; Appendix D), similar to adults (summer n=470; winter n=236; Appendix D). Additional information is also provided in AMEC (2010b).

4.3.3 Shorthead Sculpin

The majority of Shorthead Sculpins captured in the LCR study area were adults (n=236) with lower numbers of juvenile (n=51) and YOY (n=81) life stages (Appendix D). Higher numbers of adults were captured in summer (n=110) followed by spring (n=85), fall (n=35) and winter (n=5; Appendix D). Juveniles and YOY were captured in low numbers during spring, summer, and fall; none were captured in winter (Appendix D).

Adults (n=245) comprised the majority of the Shorthead Sculpin catch in Pass Creek during all seasons (Appendix D). Higher numbers of juveniles were captured in fall (n=204) compared to other seasons (Appendix D). YOY were identified in fall (n=37) with few identified in summer (n=3; Appendix D). Sampling was not conducting during winter on Pass Creek (AMEC 2011).

4.4 Spawning Behaviour, Timing, and Habitats

The following section describes spawning behaviour, spawn timing, and spawning habitat use for target species. Observations for sculpins were obtained from surveys conducted in the LCR study area, whereas information for Umatilla Dace was based on sampling in the Slocan River because mature Umatilla Dace were not observed in the LCR at this time. A summary of spawn timing and associated daily average water temperatures for target species in the study area observed during this program is provided in Table 10 and detailed below for each species.

Table 10: Summary of spawn timing and associated daily average water temperatures for target species in the lower Columbia River, Similkameen River system and Slocan River study areas, 2009-2013.

Species	LCR Study Area		Unregulated Tributaries							
	Columbia River		Pass Creek		Tulameen River		Otter Creek		Slocan River	
	Time Period	Water Temperature (°C)	Time Period	Water Temperature (°C)	Time Period	Water Temperature (°C)	Time Period	Water Temperature (°C)	Time Period	Water Temperature (°C)
Columbia Sculpin	Late May to mid July	9.5 to 15	-	-	Mid June to early July	8 to 15	Mid May to Mid June	8 to 15	-	-
Shorthead Sculpin	Late May to mid July	9.5 to 15	Mid June to late July	8 to 14	-	-	-	-	-	-
Umatilla Dace	-	-	-	-	-	-	-	-	Early July to Mid September	16 to 21

Note: "-" data not available or applicable.

4.4.1 Umatilla Dace

4.4.1.1 Spawning Observations and Habitats

A total of 39 adult Umatilla Dace were captured during the 5 year program, all of which were classified as mature from the Slocan River study area (Appendix E1). Of these 39 fish, 9 were classified as male and 8 as female based on spawning colouration (see below) and/or the expression of eggs/milt (Appendix E1). The remaining 22 fish were of unknown sex but had colouration suggesting they were in pre/post spawning condition. There were no discernible diel capture periods for these mature fish (Appendix E1).

Mature Umatilla Dace were not observed in the LCR study area even though similar effort was expended during the spawning season in both the LCR and Slocan study areas (Section 4.2); additional habitats/efforts were also targeted that were similar to capture sites on the Slocan River without finding mature fish (Section 4.2).

External characteristics for ripe females expressing eggs included red/orange colouration on lips, pelvic and pectoral fins/fin insertions and some females also had tubercles on their dorsal surfaces (Figure 6, Figure 7). One female captured in 2013 that expressed eggs did not have tubercles or display any colouration. Expressed eggs were either opaque and 1 mm in diameter or yellow and 1.3 to 1.5 mm in diameter (Figure 7). One spent female captured on August 12, 2013 had a soft, hollow abdomen and expressed only two eggs, potentially suggesting spawning was completed. Two fish displaying female external characteristics were likely spent (September 7, 2011 and August 13, 2013) as they were also observed to have flaccid abdomens and swollen urogenital pores; they did not express eggs (Appendix E1).

Ripe males that expressed milt had orange colouration on lips, fins and fin insertions; tubercles were observed on the dorsal surface of two males captured in 2013 (Figure 6, Appendix E1).

It is possible that mature Umatilla Dace were captured in minnow traps set close to their spawning locations or that these fish were seeking out a sheltered area to spawn. Umatilla Dace in spawning condition were captured in traps set at depths between 0.2 and 1.2 m, average water column velocities between 0 and 0.3 m/s and in substrates including flooded vegetation (n=7), silt (n=3), aquatic macrophytes (n=1) and cobble (n=1).

Fertilized Umatilla Dace eggs were not observed during this study.

Figure 6: Sexually mature female Umatilla dace observed in the Slocan River at km 39.4L on August 9, 2011 (left) and male observed at km 37.8L on June 14, 2013 (right).

Figure 7: Umatilla Dace female in spawning condition observed in the Slocan River at km 37.8L on July 18 (left) and July 30 (right), 2013.

Unidentified dace YOY were observed in the Slocan River in early August, but their small size confounded identification to the species level. Confirmed Umatilla Dace YOY representing each cohort year were observed in late September/October 2011, 2012 and 2013. Although no mature Umatilla Dace were observed in the LCR study area, YOY (19-30 mm fork length) were also collected from September to October during this study program (2010-2013).

4.4.1.2 Spawn Timing

Mature Umatilla Dace (i.e., displaying spawning colouration and expressing eggs/milt) collected during this program suggest that spawning may occur from early-July to mid-September when water temperatures are between 10°C and 21°C (Figure 8). Ripe fish were observed between 16°C and 21°C. Spawning likely begins soon after the peak of freshet during the descending limb of the hydrograph over the period of annual maximum water temperature (Figure 8). In 2013, spawning likely occurred after the second peak of discharge was observed in the hydrograph (Figure 8); in 2011 and 2012 only one discharge peak was apparent (Figure 8).

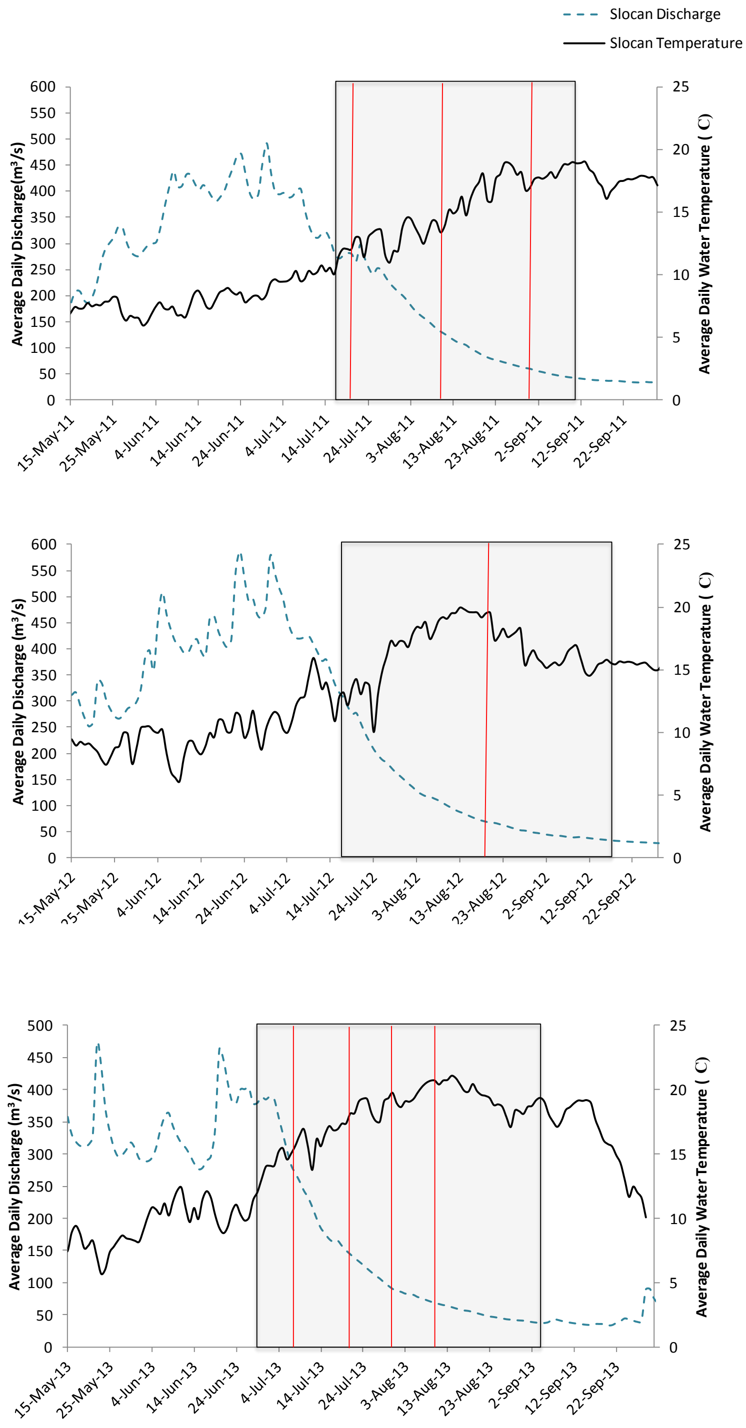


Figure 8: Estimated spawning periods for Umatilla Dace in the Slocan River in 2011, 2012 and 2013. Discharge was recorded at Crescent Valley (WSC No.08NJ13). Water temperatures were recorded at Sloc_39.4L (Appledale). Red lines indicate dates when mature Umatilla Dace were observed.

4.4.2 General Sculpin Species

The following provides an overview of spawning habitats and timing based on the collection of all sculpin nests and provides the most comprehensive information based on sample size to date. Specific spawning information for Shorthead and Columbia sculpins is provided in Sections 4.4.3 and 4.4.4 and is based on fewer individuals that were identified to species.

4.4.2.1 Spawning Observations and Habitats

General spawning habitat use is based on 100 sculpin nests observed in the LCR between 2010 and 2013. Nests were observed at LCR index sites (LCR_10.5L and LCR_24.5R) as well as at non-index sites (LCR_1.6L, LCR_2.8L, LCR_8.2L) (Appendix E2).

Sculpin nests were observed between 0.05 and 12 m from the shoreline in run and pool habitats. Nests were located on boulder and cobble substrate (0-40% embedded) at depths between 0 and 1.8 m with velocities between 0 and 0.6 m/s (Appendix E2). The number of egg masses per nest ranged from 0 to 5 and stages varied from recently fertilized (yellow/pink and milky) to entirely hatched with only egg cases remaining (Appendix E2). Figure 9 provides an example of a sculpin nest with 5 egg masses containing eggs at two stages: i) yellow/milky (bottom two clumps in photograph); and, ii) eyed but not yet moving (top three clumps of the photograph). Egg diameters ranged from 2.1 to 4.0 mm except for Prickly Sculpin eggs that reached a maximum diameter of 1.9 mm. The total number of eggs per nest ranged from 5 to 357, except for one Prickly Sculpin nest observed that had 507 eggs (Appendix E2).

Figure 9: Unknown sculpin species nest with five egg depositions observed at LCR_24.5R (Genelle) on June 12, 2013.

The model assessing habitat use and habitat preference (use given the actual availability) for substrate type of sculpin nests in the LCR study area found that there was a significantly different HSI curve for habitat use and habitat preference. The difference was statistically significant at the $p < 0.05$ level and indicated a preference for larger substrate centered around a mode of 200 mm (i.e., cobble) (Figure 10). Individual sculpin species were unable to be assessed separately since there were insufficient data. The analysis for nest site habitat use was attempted for substrate embeddedness, but was unable to be completed due to the large number of data points at 5% embeddedness. The heaped data at 5% embeddedness are informative of preference without analysis since there was a range of embeddedness represented in the available habitat and the majority of nest sites were located in 5% embedded habitat (R. Irvine pers. comm., 2014).

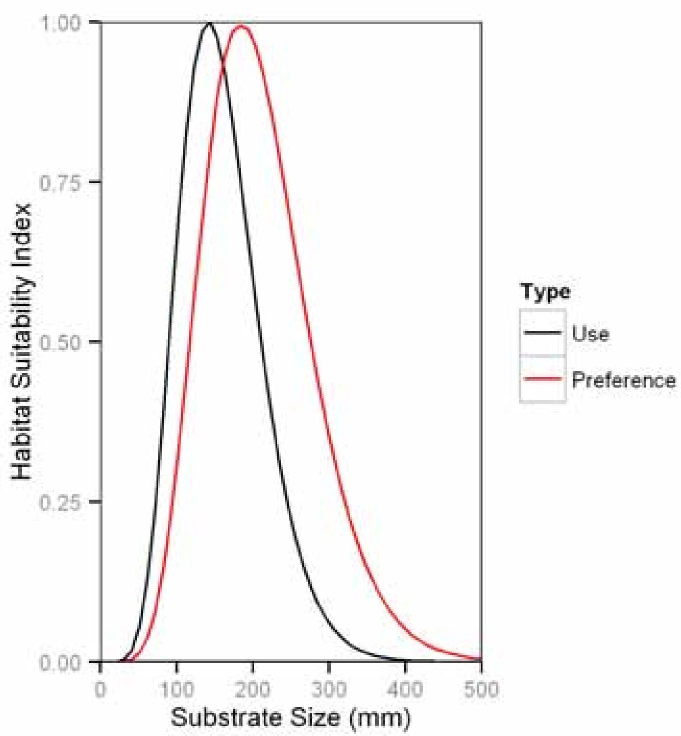


Figure 10: HSI for substrates used and preferred by nesting Cottus species (aggregated) in the Columbia River system.

4.4.2.2 Spawn Timing

Sculpin spawning in the LCR study area occurs between late May and early July when water temperature is between 8°C to 16°C (Figure 11). Water temperatures gradually increased through the spawning period, but spawning was usually completed prior to its peak (Figure 11). The majority of spawning was observed along the ascending limb of the hydrograph during all years (Figure 11 and Figure 3). In 2010 and 2011 the tail-end of spawning occurred as water levels started to recede, but the majority of spawning was completed by peak discharge (Figure 11). Discharge generally increased steadily and peaked once in the later portion of the spawning period or after spawning was completed. However, in 2013 two peaks in discharge were observed during the spawning period (Figure 11).

In 2013, fluctuating water levels during the sculpin spawning period resulted in nest dewatering in the LCR. Thirteen nests, including two Torrent Sculpins and 11 unknown sculpin species, were observed to become dewatered at LCR index sites following flow reductions, predominantly out of the Kootenay River, between June 8 and 19, 2013 (Figure 3). Dewatered nests were observed between 0 and 1.5 m from the wetted edge. Nests that had been observed and viable on June 12, 2013 were checked the next day following an overnight reduction in water level (~0.3 m vertically). The first sign of stress observed was the presence of red veins within eggs, even while eyed eggs were still moving (Figure 12). Desiccation was first noticeable within eggs along the edge of a nest followed by desiccation of the entire nest (Figure 12). Predation by invertebrates was also observed at nests that were completely dewatered as well as at those that remained in residual pockets of water, but had been abandoned by the male. None of the dewatered nests were viable after being re-wetted when water levels increased (Appendix E2).

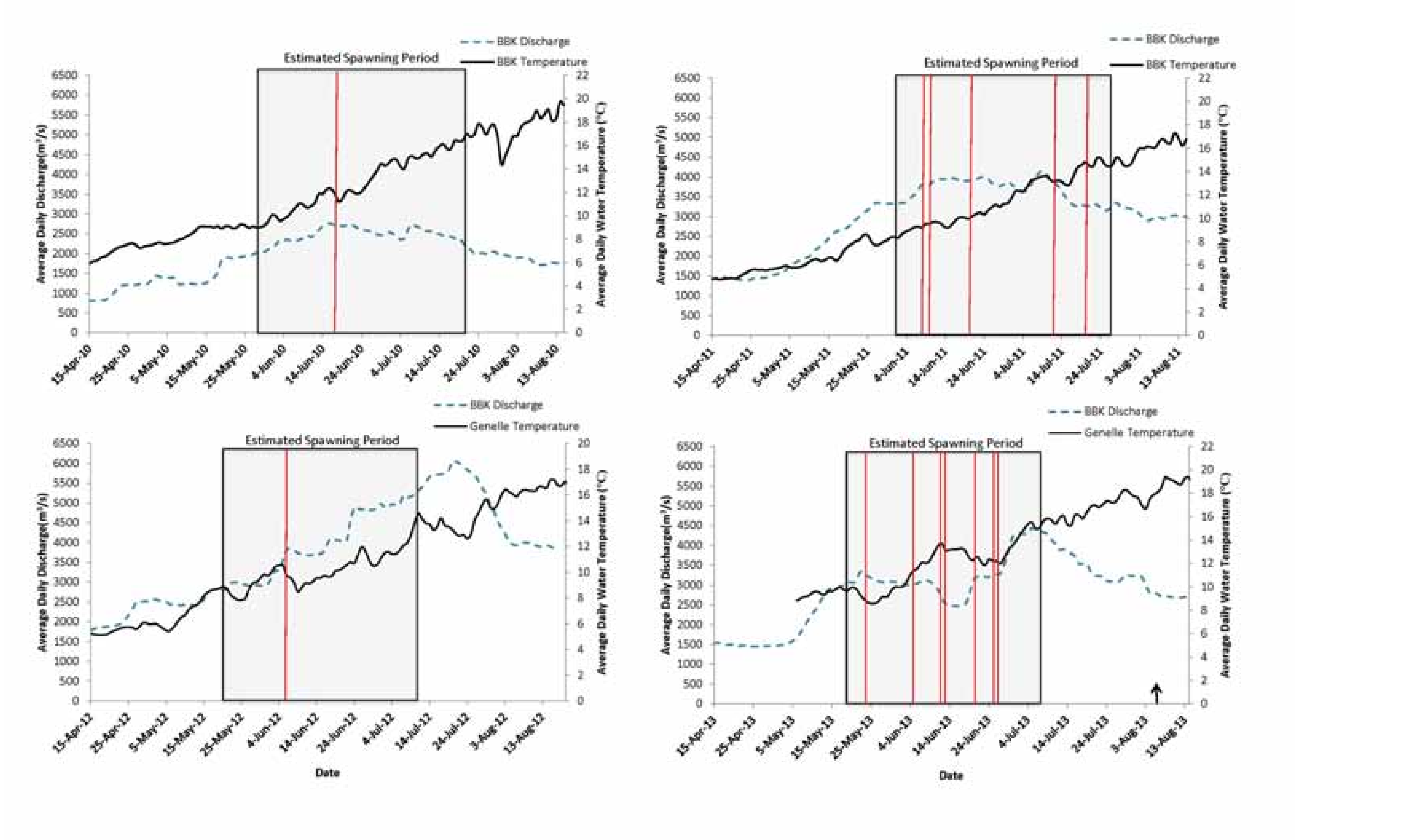


Figure 11: Estimated spawning period for all sculpin species in the LCR in 2010, 2011, 2012 and 2013. Discharge was measured at BBK (Birchbank; WSC Station No: 08NE0558) and water temperature was measured at BBK in 2010 and 2011 and at LCR_24.5R (Genelle) in 2012 and 2013.

Nests that did not become dewatered during the reductions were located in shallower and lower velocity areas than previous (Appendix E2). Dissolved oxygen levels measured in proximity to sculpin nests at LCR_24.5R were similar when discovered (June 12 = 10.57 mg/L) and when nearing hatch the following week (June 19 = 10.93 mg/L; Section 3.3). One male Torrent Sculpin was observed in a dewatered location approximately 0.3 m from shore within 0.2 m of a dewatered sculpin nest at LCR_2.8L on June 13, 2013. No males were observed the other 12 dewatered nests.

Figure 12: Two stages of nest mortality observed following dewatering on June 13, 2013 included observation of red veins within viable eggs (left) and desiccation (right).

4.4.3 Columbia Sculpin

The following provides a summary of Columbia Sculpin spawning habitats and timing observed in the LCR study area based on the identification of seven males guarding nests. Comparisons to observations of Columbia Sculpin spawning in the unregulated Similkameen study area are included where possible.

4.4.3.1 Spawning Observations and Habitats

Columbia Sculpin spawning observations are based on five nests observed at the two index sites in 2013, one nest observed at LCR_24.5R in 2011 and one nest observed at LCR_8.2L in 2010. These males were 70 to 95 mm total length, darkly coloured often with an orange stripe along the tip of the dorsal fin and an engorged urogenital pore (Figure 13). Columbia Sculpin nests were observed 0.5 to 3 m from the shoreline in run and pool habitats. Nests were located at depths between 0.25 and 1.15 m with average velocity between 0.04 and 0.34 m/s with little to no bottom velocity. Nests were on cobble and boulder substrate that were minimally embedded (5-10%) (Appendix E2).

Columbia Sculpin nests consisted of either one or four egg masses. The total number of eggs per nest ranged from 5 to 220 with the highest number of eggs (n=220) coming from a single clump of very recently deposited eggs at LCR_8.2L on June 17, 2010. Egg diameter was between 2.1 and 2.7 mm. The egg stages observed included recently fertilized eggs, eggs that were eyed, but not moving as well as eggs that were eyed and moving.

Columbia Sculpin nests in unregulated tributaries to the Similkameen River (Otter Creek, Allison Creek and the Tulameen River) were located at similar distances from shore, depths and on similar substrates to those in the LCR (Appendix E2). However, nests were located in riffle/run habitat with higher velocity (0.36 to 0.74 m/s) on more embedded substrate (10-50%) than in the LCR. Columbia Sculpin nests had 1, 2 or 3 egg masses containing between 99 and 658 eggs that were approximately 3 mm diameter. Egg stages observed were similar to those in the LCR study area (Appendix E2).

Figure 13: Nest-guarding Columbia sculpin male captured at LCR_24.5R on June 12, 2013.

4.4.3.2 Spawn Timing

Spawn timing for Columbia Sculpins in the LCR study area was estimated to range from late May to mid-July when daily average water temperatures were between 8°C and 15°C (Figure 7). The majority of spawning was observed along the ascending limb and peak of the hydrograph (Figure 7). Additional spawn timing information for general sculpin species in the LCR is provided in Section 4.4.2.2.

The Columbia sculpin spawning period in Otter Creek, a tributary to the Tulameen River in the Similkameen River watershed, occurred from mid-May to mid-June when daily average water temperatures were between 8°C and 15°C in 2009 (Figure 15). In the Tulameen River, Columbia Sculpin spawning occurred between early June and mid-July when daily average water temperatures were between 8°C and 17°C in 2009 (Figure 16). In both systems, spawning occurred during the descending limb of the hydrograph.

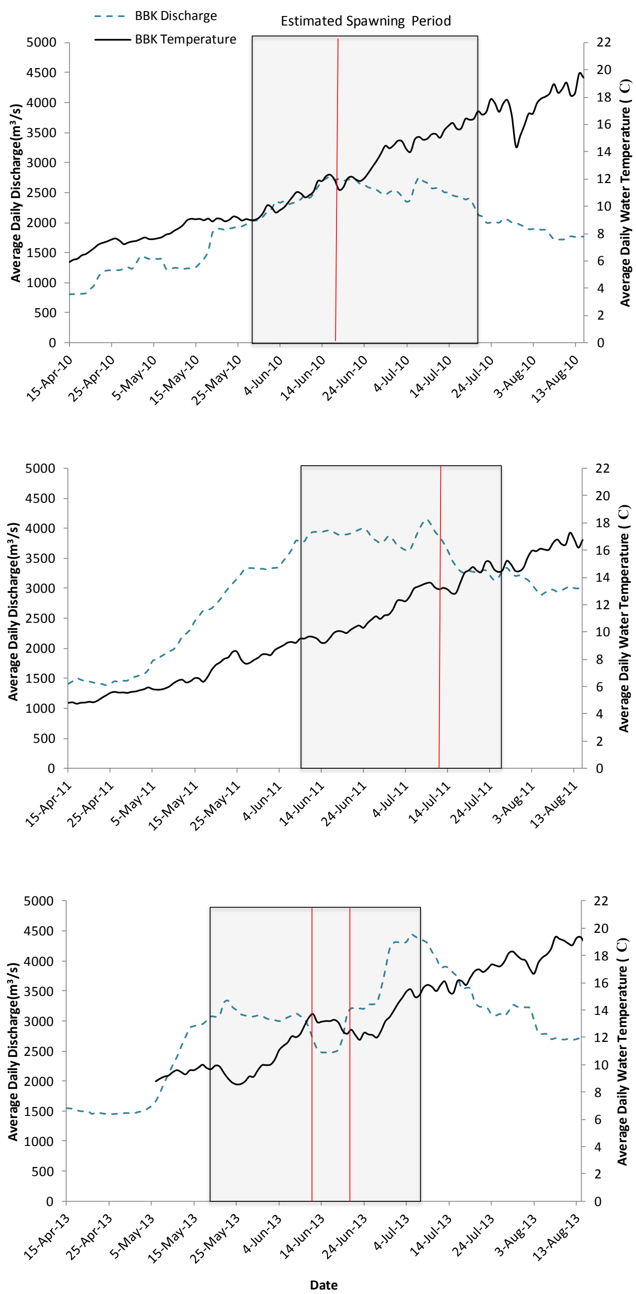


Figure 14: Estimated spawning period for Columbia Sculpins in the LCR, 2010, 2011 and 2013. Discharge was measured at BBK (Birchbank; WSC Station No: 08NE0558) and water temperature was measured at LCR_25.4R (Genelle). The red line indicates dates when nests were observed.

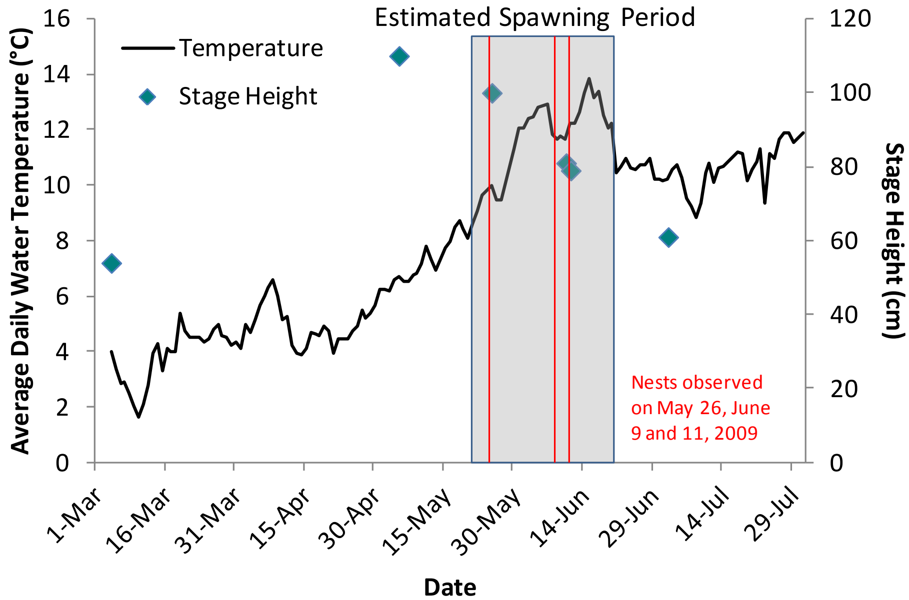


Figure 15: Estimated spawning period for Columbia Sculpins in the Otter Creek in the Similkameen study area, 2009. Stage height and water temperature were measured within the Otter Creek study site. The red line indicates dates when nests were observed.

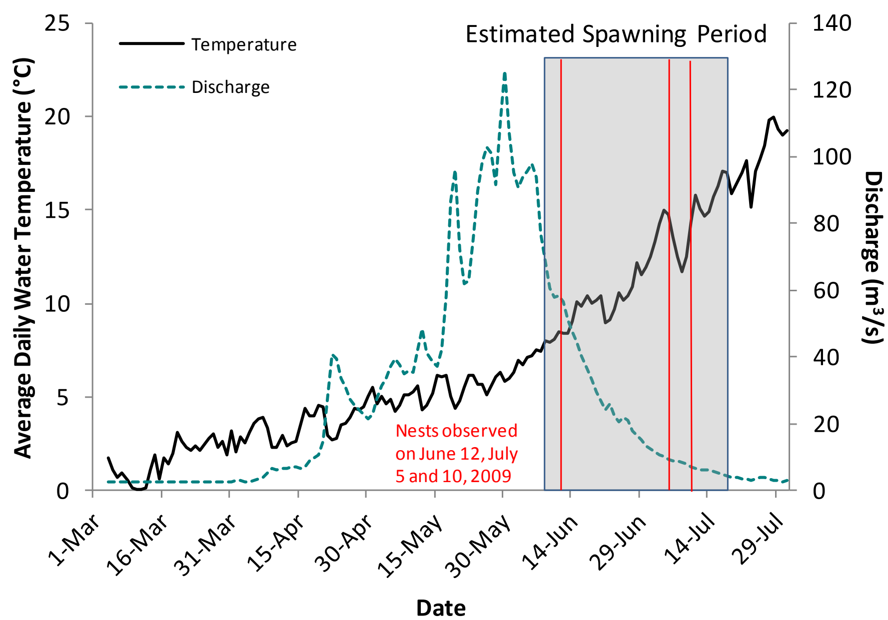


Figure 16: Estimated spawning period for Columbia Sculpins in the Tulameen River in the Similkameen study area, 2009. Discharge was measured near Princeton (WSC Station No. 08NL024) and water temperature was measured in the Tulameen River study site. The red line indicates dates when nests were observed.

4.4.4 Shorthead Sculpin

The following provides a summary of Shorthead Sculpin spawning habitats and timing observed in the LCR study area based on the identification of five males guarding nests. Comparisons to observations of Shorthead Sculpin spawning in Pass Creek, an unregulated tributary to the LCR, are included where possible.

4.4.4.1 Spawning Observations and Habitats

Shorthead Sculpin spawning was observed at LCR 10.5L on June 9, 2011 (n=2) and May 24, 2013 (n=1) and at LCR_24.5R on July 20, 2011 (n=1) and June 19, 2013 (n=1) (Appendix E2). Nest guarding males were darkly coloured often with an orange stripe along the tip of the dorsal fin and an engorged urogenital pore (Figure 17). Nests were 1.5 to 5 m from the wetted edge in run and pool habitats. Nests were located at depths between 0.3 and 1.3 m with average velocity between 0 and 0.53 m/s with little to no bottom velocity. Nests were on cobble and boulder substrates that were minimally embedded (5-10%) (Appendix E2).

Shorthead Sculpin nests in the LCR study area consisted of either one or two egg masses that had between 40 and 135 eggs per nest (Appendix E2). Egg diameters were approximately 3 mm and eggs displayed characteristics of being recently deposited in late May/early June (yellow and milky) and closer to hatching in late June/July (eyed, moving and hatching) (Appendix E2).

Figure 17: Nest-guarding Shorthead Sculpin male captured in Pass Creek on July 14, 2010.

Shorthead Sculpin spawning was observed in Pass Creek, an unregulated tributary to the LCR, in mid-July 2010. Five nests were observed in similar habitats to those in the LCR except that average water velocity was higher (0.45 to 0.66 m/s) and substrate was more embedded (5 to 40%). Pass Creek nests had similar numbers of egg masses and eggs as observed for Shorthead Sculpin nests in the LCR; egg diameters were not recorded for nests collected in Pass Creek (Appendix E2). In Pass Creek, one male Shorthead Sculpin, observed guarding his nest, was found stranded on July 14, 2010; the fish remained in a small pocket of water below the nest boulder, which was located approximately 0.15 m from the wetted edge (Figure 18).

Figure 18: Shorthead Sculpin male and nest were observed on the indicated rock in its current location 15 cm from the wetted edge (red line) of Pass Creek on July 14, 2010.

4.4.4.2 Spawn Timing

Spawn timing for Shorthead Sculpins in the LCR study area was estimated to range from late May to mid-July when daily average water temperatures were between 8°C and 15°C (Figure 19). Spawning occurred during the peak annual discharge period in the LCR (Figure 19). Additional spawn timing information for general sculpin species in the LCR is provided in Section 4.4.2.2.

In Pass Creek, spawn timing for Shorthead Sculpins was estimated to range from mid- to late June or late July, when average daily water temperatures were between 8°C and 14°C (Figure 20). Water levels were near annual peak as spawning commenced and then receded during the remainder of the spawning period; discharge is not available for Pass Creek (Figure 20).

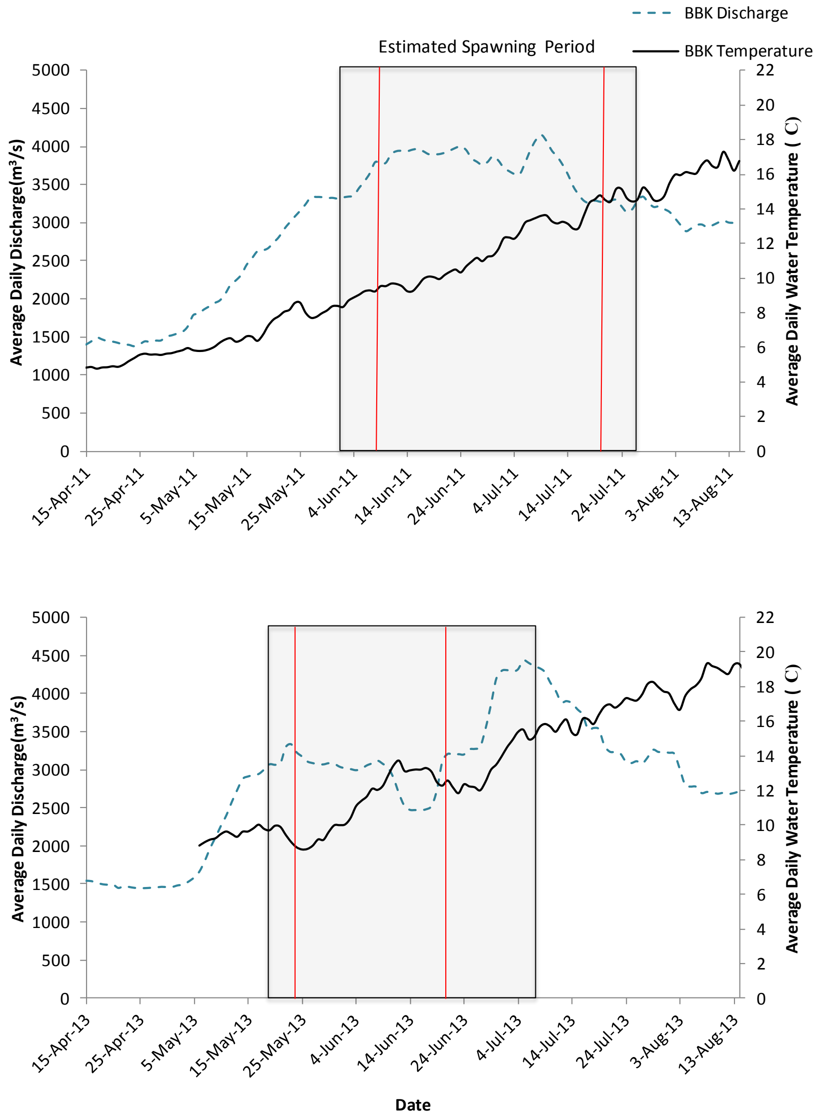


Figure 19: Estimated spawning period for Shorthead Sculpins in the LCR, 2011 and 2013; fish were not identified to species in 2012. Discharge was measured at BBK (Birchbank; WSC Station No: 08NE0558) and water temperature was measured at LCR_25.4R (Genelle). The red line indicates dates when nests were observed.

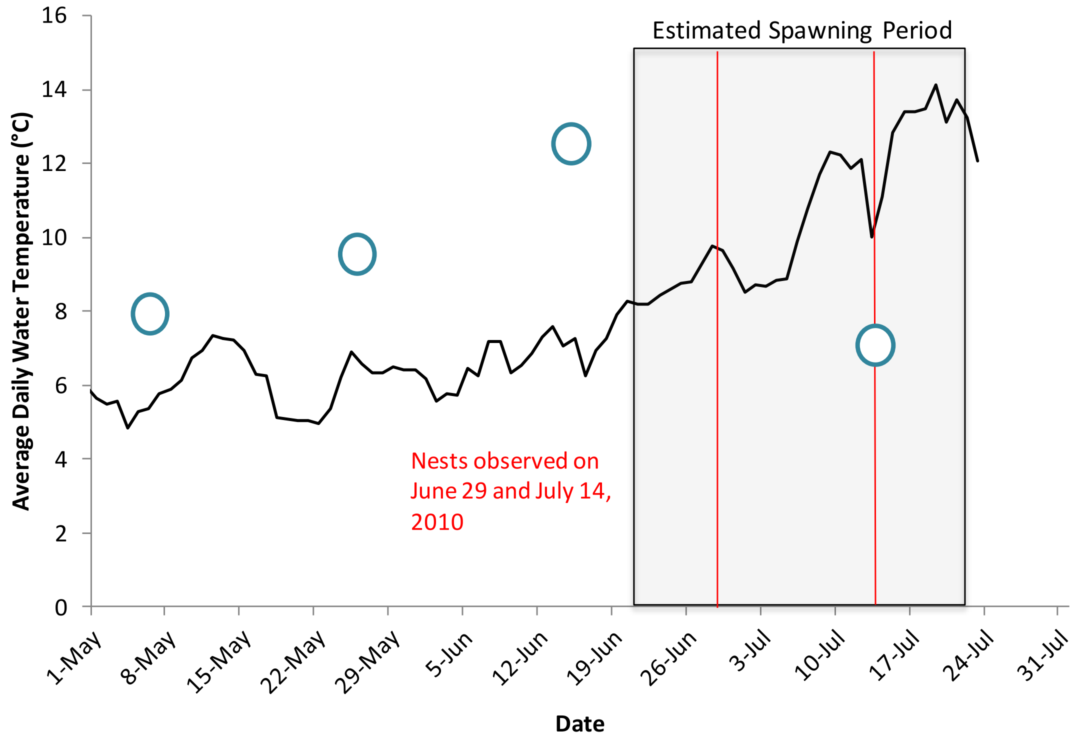


Figure 20: Estimated spawning period for Shorthead Sculpins in Pass Creek, 2010. Water temperature was recorded within the Pass Creek index site until July 23, 2010. Circles indicate dates of tracking surveys with relative water levels based on photos taken from a benchmark location. Red lines indicate dates when nests were observed.

4.5 Embryo Survival

In the LCR study area, overall sculpin embryo survival (percent viable eggs observed in nests) was 72% and ranged from 0 to 100% during this program (Table 11). On average, embryo survival was lower at the LCR_24.5R index site than at other locations (Table 11). This site had the lowest embryo survival observed during the entire program in 2010 (19%; SD=15), followed by 2011 (57%; SD=42) (Table 11); high water levels in 2012 precluded assessment at most locations. However, embryo survival at LCR_24.5R in 2013 was similar to that observed at other LCR index sites (Table 11).

Embryo survival was not directly measured in the Similkameen system (AMEC 2010b) since survival was high for all nests observed. In Pass Creek, embryo survival was approximately 99% for the five sculpin nests observed (Appendix E2).

Fertilized dace eggs were not observed during the present study and therefore embryo survival is not available.

Table 11: Embryo survival (% viable eggs) in sculpin nests located at LCR sample sites, 2010-2013.

Location	Year	Number of Nests Assessed	Embryo Survival (%)			
			Average	Standard Deviation	Minimum	Maximum
LCR_1.6L	2013	1	100	-	100	100
LCR_2.8L	2011	5	94	9	80	100
	2012	4	74	49	0	100
	2013	4	100	0	100	100
LCR_8.2L	2010	1	100	-	100	100
LCR_10.5L	2011	4	98	1	0	100
	2013	13	79	37	0	100
LCR_24.5R	2010	11	19	15	0	50
	2011	8	57	42	0	100
	2013	28	79	33	0	100

Note – only nests located for the first time are included in this table as handling nest rocks may have influenced survival.

4.6 Habitat Suitability and Seasonal/Diel Use

Overall habitat suitability for Umatilla Dace, Columbia and Shorthead sculpins is provided below. In addition, habitat information by season, diel period and life stage is also presented with the exception of spawning habitat, which was provided in Section 4.4. Comparisons between the regulated LCR study area and the unregulated systems are included where possible.

4.6.1 Umatilla Dace

4.6.1.1 Habitat Suitability

The depth of habitats used by Umatilla Dace in the Slocan and LCR study areas were slightly different as fish in the Slocan River appear to use deeper water (<2.0 m) more often than those in the Columbia River (<1.3 m) (Figure 21). Peak habitat use for UDC on the Slocan River is at depths around 0.2 m, whereas on the LCR fish appear to use depths less than 0.1 m more frequently (Figure 21). Similar to depth HSI, UDC on the Slocan River used slightly higher velocity areas (<0.25 m/s) compared to the LCR (0 m/s or slightly above zero velocity) (Figure 22). UDC used silt most often on both systems, but fish in the LCR also had a high use of cobble (Figure 23).

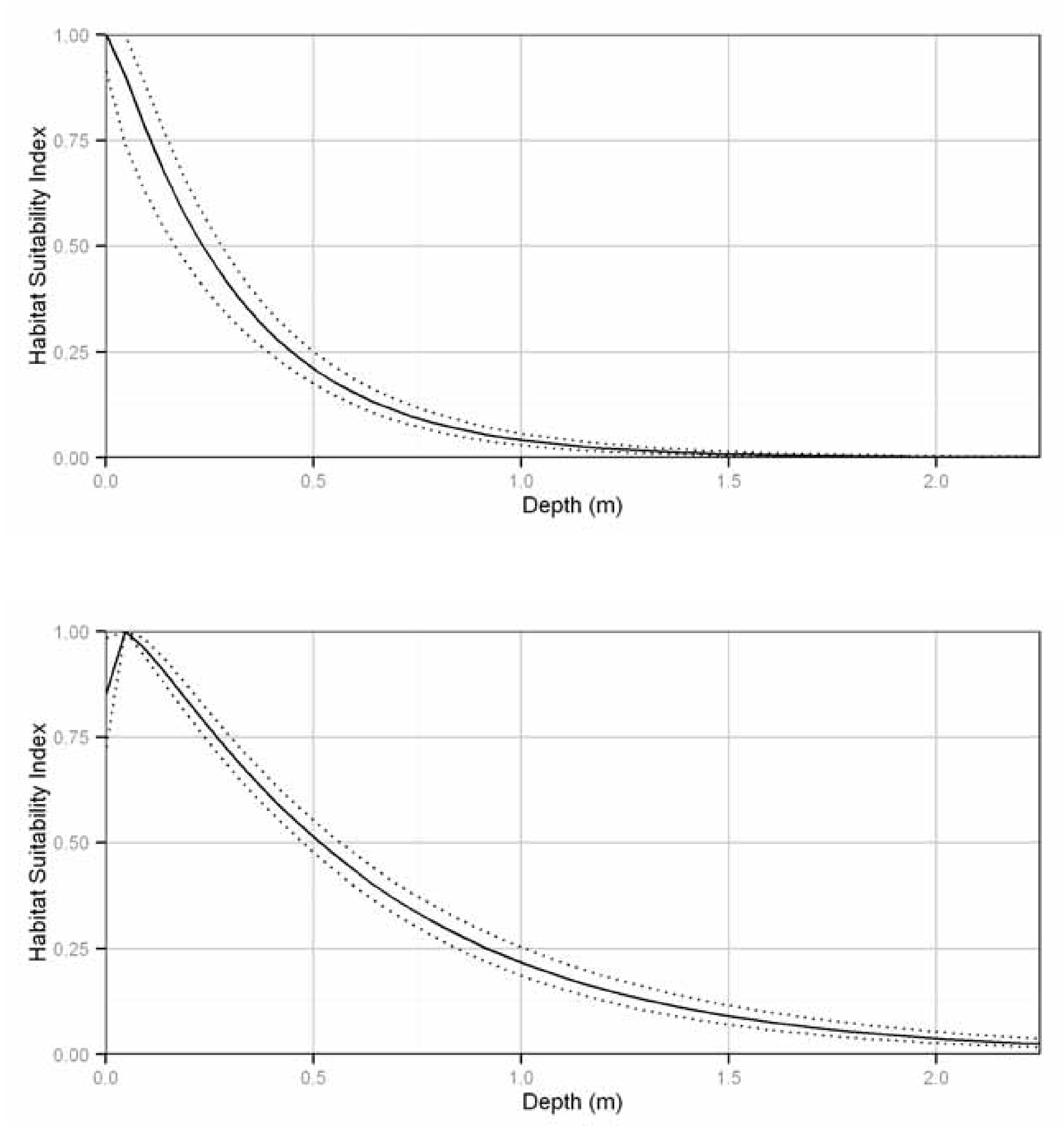


Figure 21: Depth Habitat Suitability Indices (HSI) for Umatilla Dace in the Lower Columbia River (top) and the Slocan River (bottom) study areas with 95% credible intervals.

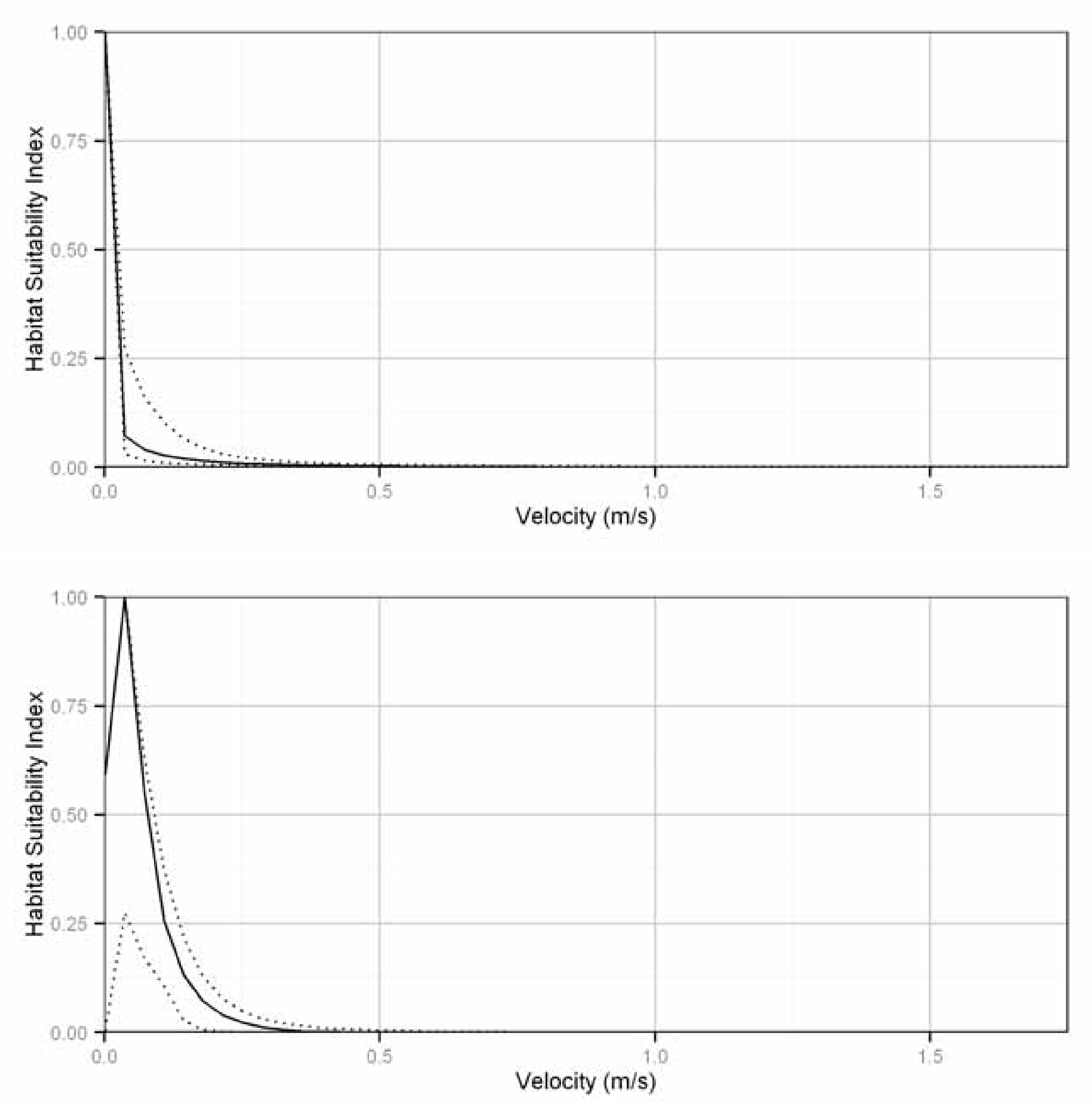


Figure 22: Velocity Habitat Suitability Indices (HSI) for Umatilla Dace in the Lower Columbia River (top) and the Slocan River (bottom) study areas with 95% credible intervals.

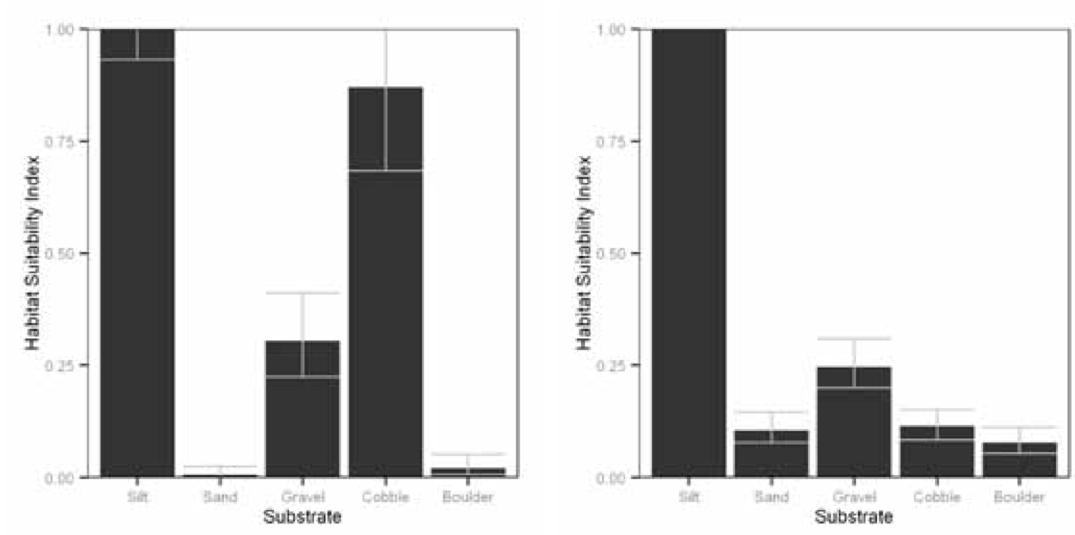


Figure 23: Substrate Habitat Suitability Indices (HSI) for Umatilla Dace in the Lower Columbia River (left) and the Slocan River (right) study areas with 95% credible intervals.

4.6.1.2 Life Stage

In both systems, adults were observed in generally deeper habitats compared to juveniles and YOY (Figure 24). Juveniles used deeper habitats than YOY on the LCR, but on the Slocan River use of depths by these two life stages was similar (Figure 24). Velocity was similar between life stages on both systems (Figure 25) as was the predominant use of pool habitats (Table 12).

In the LCR, the majority of adults and juveniles were captured in either silt with flooded vegetation or cobble, while YOY were observed using a range of substrates predominated by cobble and silt with flooded vegetation (Table 12). In the Slocan River, adults and juveniles were observed using mainly silt with flooded vegetation and aquatic macrophytes (Table 12). Young of the year were predominantly observed using gravel and cobble substrates (Table 12).

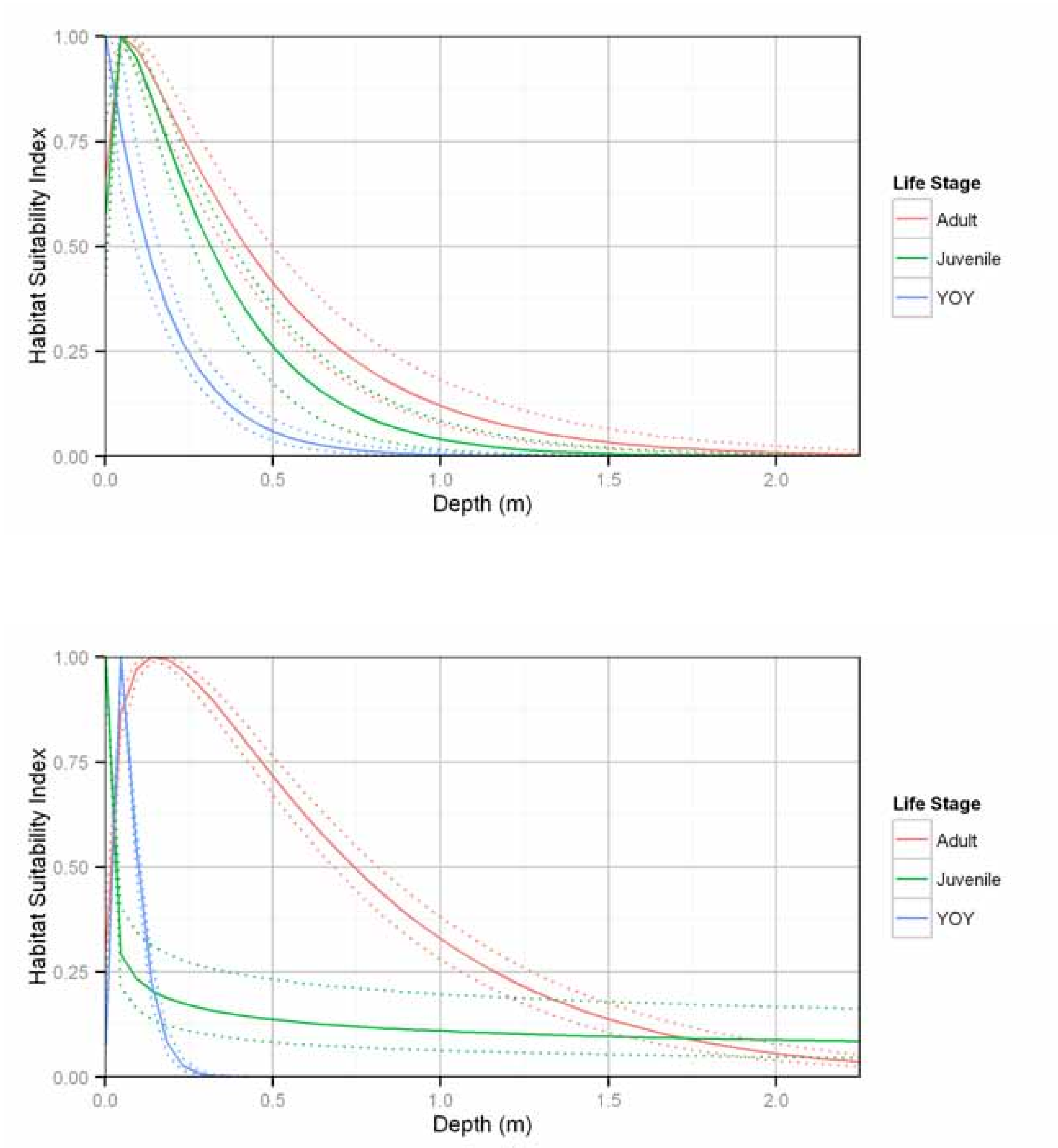


Figure 24: Habitat Suitability Indices (HSI) for depth and life stage of Umatilla Dace in the Lower Columbia River (top) and Slocan River study area (bottom) with 95% credible intervals.

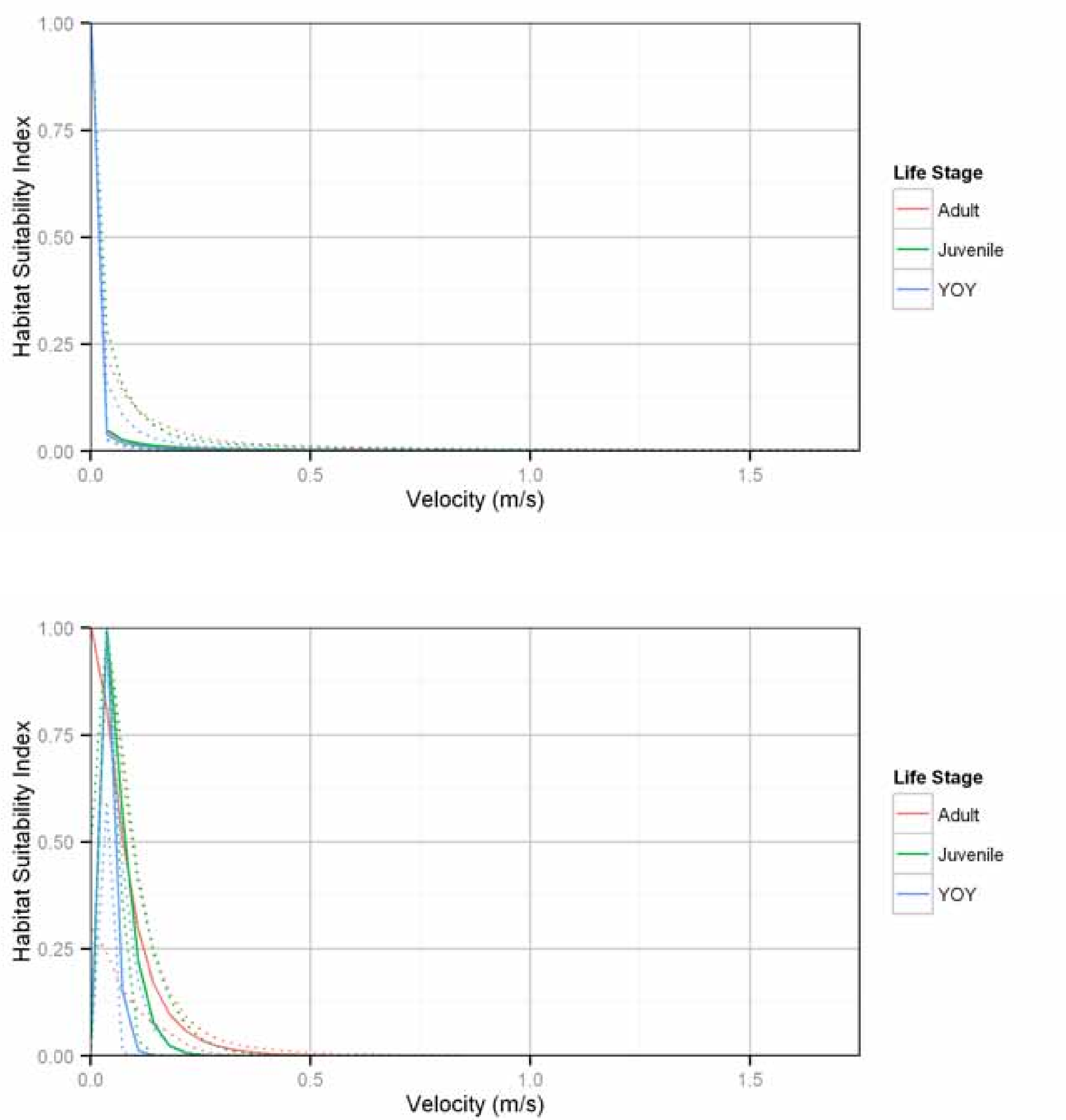


Figure 25: Habitat Suitability Indices (HSI) for velocity and life stage of Umatilla Dace in the Lower Columbia River (top) and Slocan Columbia River study area (bottom) with 95% credible intervals.

Table 12: Habitat characteristics observed for adult, juvenile and young-of-year (YOY) Umatilla Dace in the LCR study area and the Slocan River, 2009-2014. Observations based on fish captured by all methods combined where direct habitat measurement was possible. Means are presented with standard deviation in parentheses.

Life Stage	LCR Study Area					Slocan River				
	Sample Size	Depth (m)	Velocity (m/s)	Substrate	Habitat Type	Sample Size	Depth (m)	Velocity (m/s)	Substrate	Habitat Type
Adult	77	0.61 (0.57)	0.05 (0.10)	Flooded Vegetation (59%) Cobble (33%) Silt (6%) Sand (1%) Bedrock (1%)	Pool (83%) Riffle (11%) Run (6%)	474	0.69 (0.47)	0.05 (0.08)	Flooded Vegetation (40%) Silt (30%) Aquatic Macrophytes (12%) Sand (9%) Boulder (6%) Gravel (2%) Woody Debris (1%)	Pool (69%) Run (29%) Riffle (2%)
Juvenile	98	0.38 (0.24)	0.02 (0.05)	Flooded Vegetation (74%) Cobble (13%) Silt (6%) Gravel (6%) Boulder (2%)	Pool (90%) Run (10%)	38	0.43 (0.37)	0.02 (0.07)	Silt (72%) Flooded Vegetation (15%) Aquatic Macrophytes (5%) Cobble (5%) Woody Debris (3%)	Pool (100%)
YOY	186	0.20 (0.13)	0.01 (0.02)	Cobble (43%) Flooded Vegetation (25%) Gravel (16%) Silt (16%)	Pool (82%) Run (18%	137	0.17 (0.09)	0.05 (0.06)	Gravel (66%) Cobble (23%) Silt (4%) Boulder (3%) Aquatic Macrophytes (2%) Flooded Vegetation (2%)	Pool (70%) Run (30%)

4.6.1.3 Season

Umatilla Dace made use of a wider range of depths in summer, but peak use was similar in all seasons on the LCR (Figure 26; Table 13); models did not converge for the Slocan River. Velocity did not differ between seasons for both the LCR and Slocan River (Figure 27). UDC in both systems used mostly pool followed by run habitats in all seasons (Table 13).

In the LCR, substrates at point of capture varied by season with summer use dominated by silt with flooded vegetation, spring and fall dominated by cobble and winter by silt with flooded vegetation (Table 13). Umatilla Dace in the Slocan River were observed using a variety of substrates in all seasons; silt with flooded vegetation were used in spring and summer while higher proportions of gravel and cobble were used in the fall and winter (Table 13). Not enough observations were available to make comparisons between season and life stage for both systems.

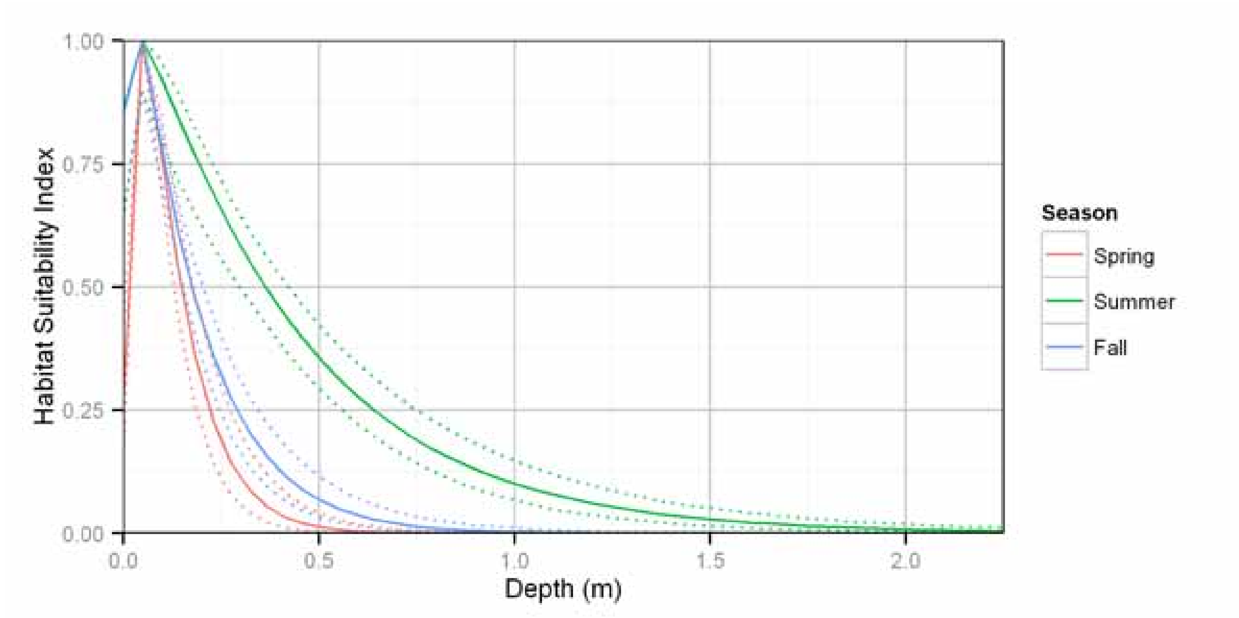


Figure 26: Habitat Suitability Indices (HSI) for depth and season of Umatilla Dace in the Lower Columbia River study area with 95% credible intervals. Models for the Slocan River did not converge.

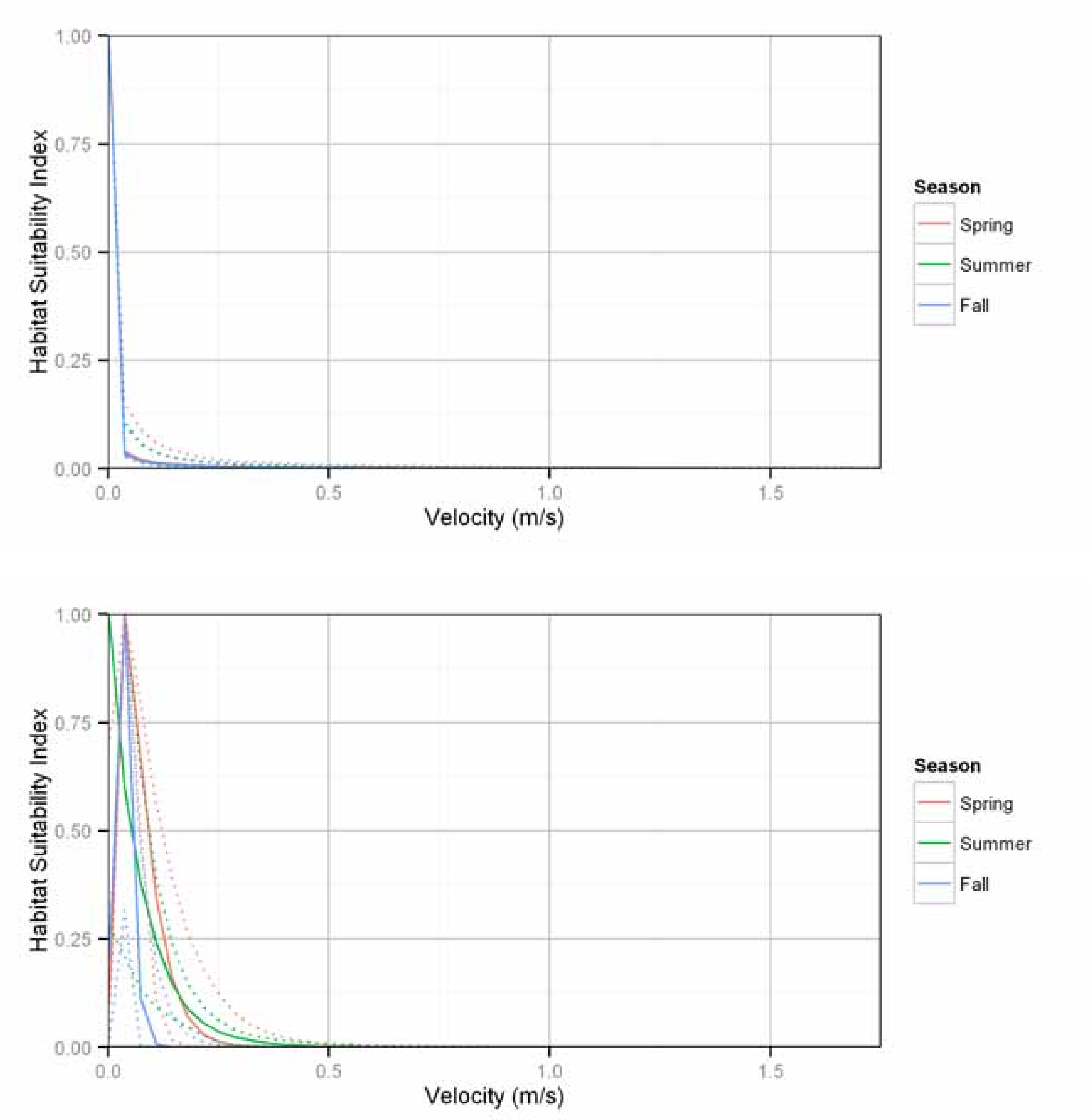


Figure 27: Habitat Suitability Indices (HSI) for velocity and season of Umatilla Dace in the Lower Columbia River (top) and Slocan River study area (bottom) with 95% credible intervals.

Table 13: Habitat characteristics observed for Umatilla Dace in the Regulated LCR study area and the Unregulated Slocan River during different seasons, 2009-2014. Observations based on fish captured by all methods combined when direct habitat measurement was possible. Means are presented with standard deviation in parentheses.

Season	LCR Study Area					Slocan River				
	Sample Size	Depth (m)	Velocity (m/s)	Substrate	Habitat Type	Sample Size	Depth (m)	Velocity (m/s)	Substrate	Habitat Type
Spring	72	0.32 (0.48)	0.03 (0.07)	Cobble (63%) Flooded Vegetation (29%) Gravel (8%)	Pool (94%) Riffle (4%) Run (2%)	48	0.44 (0.26)	0.06 (0.11)	Flooded Vegetation (65%) Silt (17%) Cobble (9%) Boulder (9%)	Pool (58%) Run (42%)
Summer	169	0.45 (0.33)	0.02 (0.06)	Flooded Vegetation (82%) Silt (7%) Cobble (5%) Gravel (4%) Boulder (1%) Sand (1%)	Pool (97%) Run (3%)	453	0.69 (0.48)	0.04 (0.08)	Flooded Vegetation (36%) Silt (35%) Aquatic Macrophytes (10%) Sand (10%) Boulder (5%) Cobble (2%)	Pool (86%) Run (11%) Riffle (2%)
Fall	44	0.23 (0.29)	0.03 (0.07)	Cobble (82%) Gravel (16%) Boulder (2%)	Run (51%) Pool (49%)	113	0.24 (0.26)	0.05 (0.06)	Gravel (54%) Cobble (25%) Aquatic Macrophytes (10%) Boulder (6%) Silt (5%)	Pool (60%) Run (40%)
Winter	77	0.17 (0.10)	0.002 (0.01)	Silt (42%) Flooded Vegetation (21%) Gravel (21%) Cobble (16%)	Pool (98%) Run (2%)	35	0.18 (0.09)	0.03 (0.04)	Gravel (80%) Cobble (11%) Silt (6%) Boulder (3%)	Pool (89%) Run (11%)

4.6.1.4 Diel

In the LCR study area, Umatilla Dace used deeper habitats at night compared to the day but peak suitability was still shallow water (Figure 28); there was no difference in velocity selected between these diel periods (Figure 29).

Diel minnow trapping experiments in the Slocan River during summer observed that Umatilla Dace were in significantly deeper locations during the day than at night (ANOVA p=0.01; Tukey’s p=0.03) and further from shore during the day than at dusk (ANOVA p=0.01; Tukey’s p=0.007). Differences in substrate and average velocity were not observed.

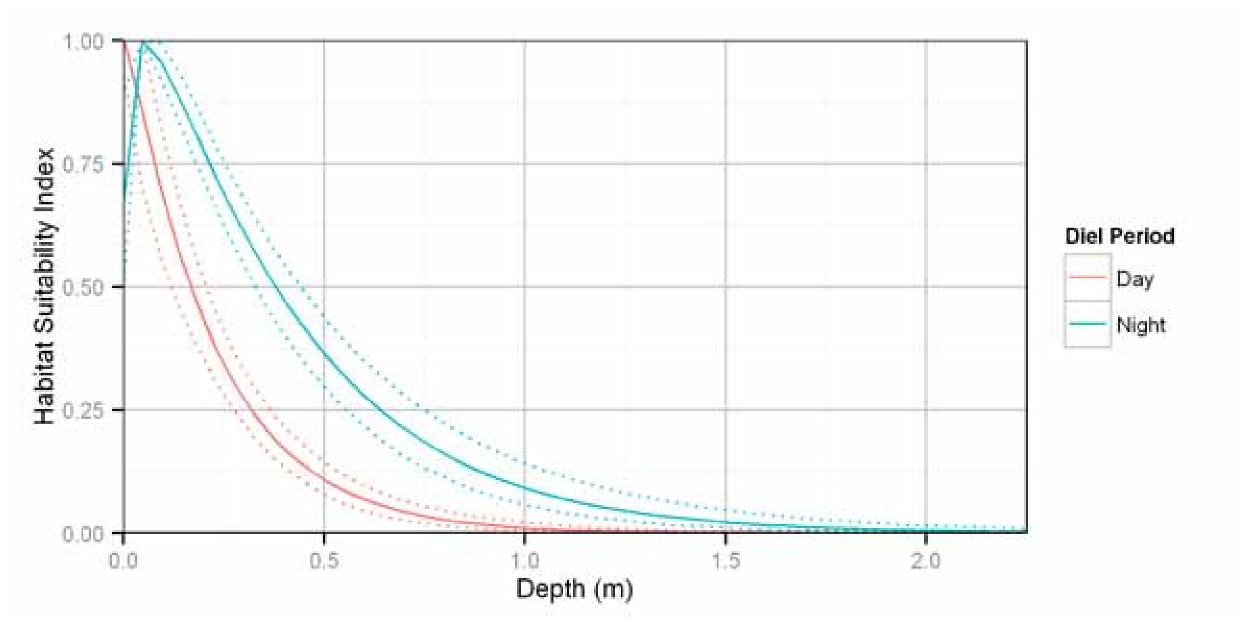


Figure 28: Habitat Suitability Indices (HSI) for depth and diel period of Umatilla Dace in the Lower Columbia River study area with 95% credible intervals. Models for the Slocan River did not converge.

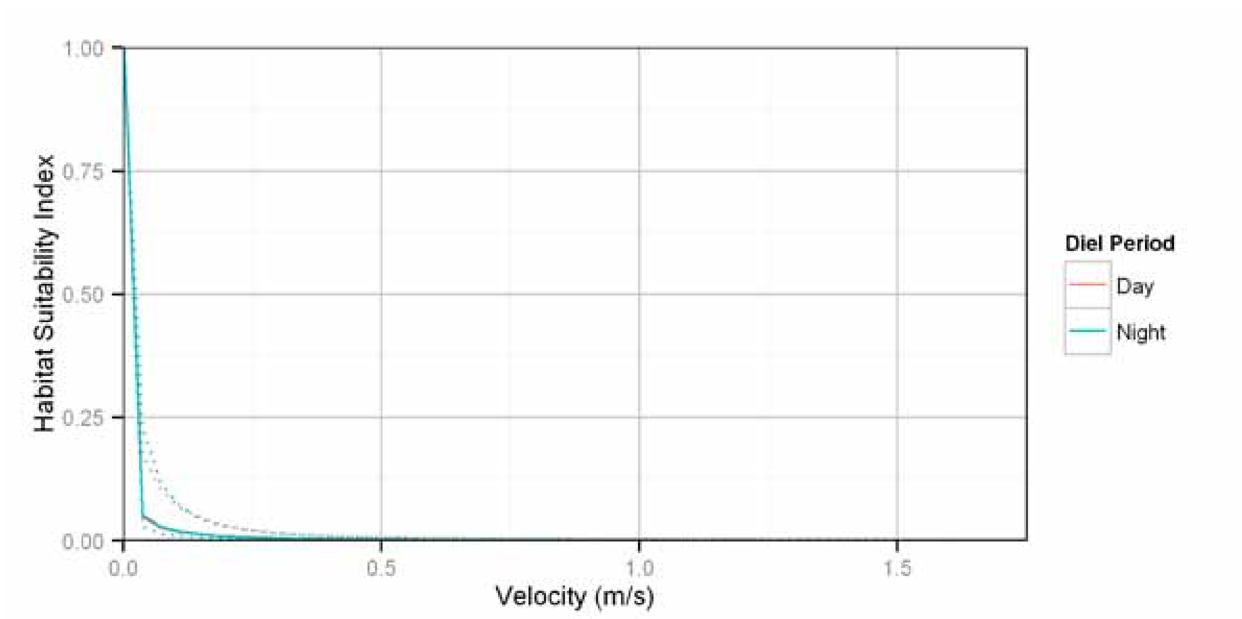


Figure 29: Habitat Suitability Indices (HSI) for velocity and diel period of Umatilla Dace in the Lower Columbia River study area with 95% credible intervals. Models for the Slocan River did not converge.

4.6.2 Columbia Sculpin

4.6.2.1 Habitat Suitability

Peak habitat use by Columbia Sculpins is at depths around 0.3 m and velocities of 0.2 m/s (Figure 30 and Figure 31). Cobble was used almost exclusively by Columbia Sculpins with some use of boulder substrates (Figure 32).

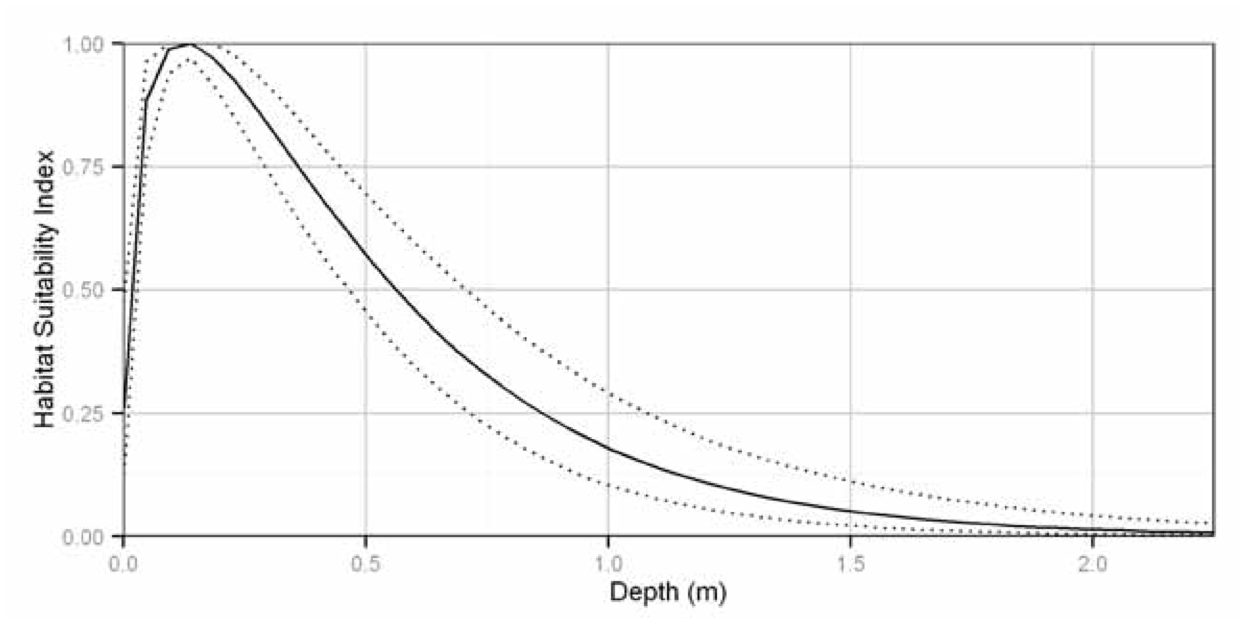


Figure 30: Depth Habitat Suitability Indices (HSI) for Columbia Sculpins in the Lower Columbia River study area with 95% credible intervals.

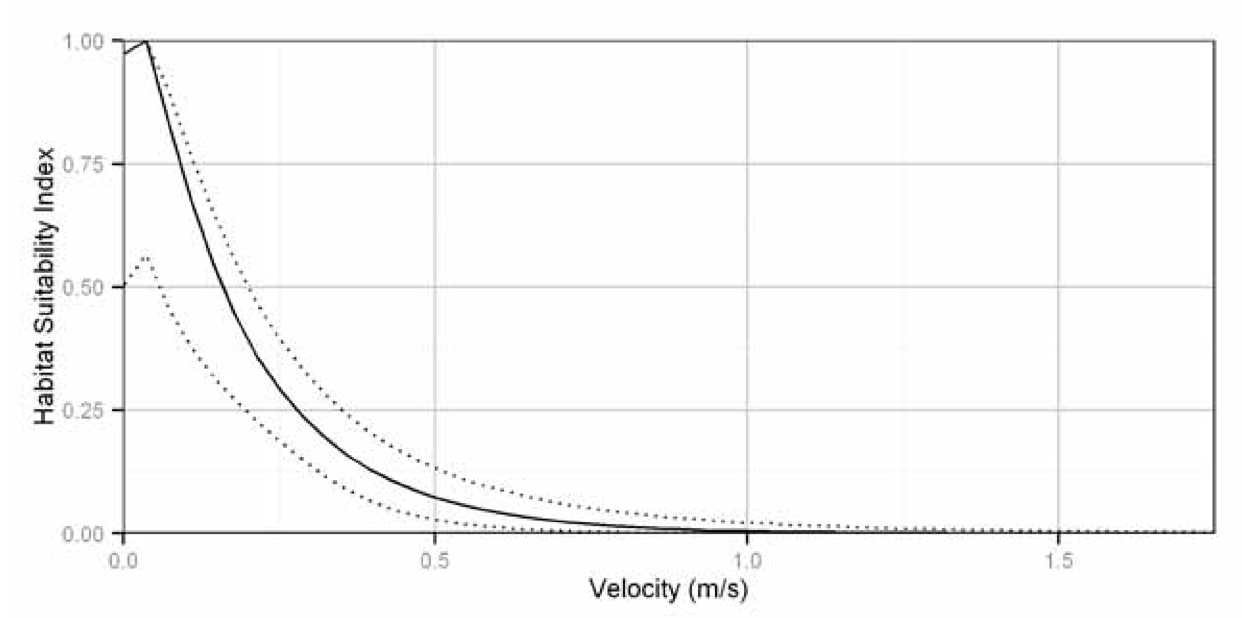


Figure 31: Velocity Habitat Suitability Indices (HSI) for Columbia Sculpins in the Lower Columbia River study area with 95% credible intervals.

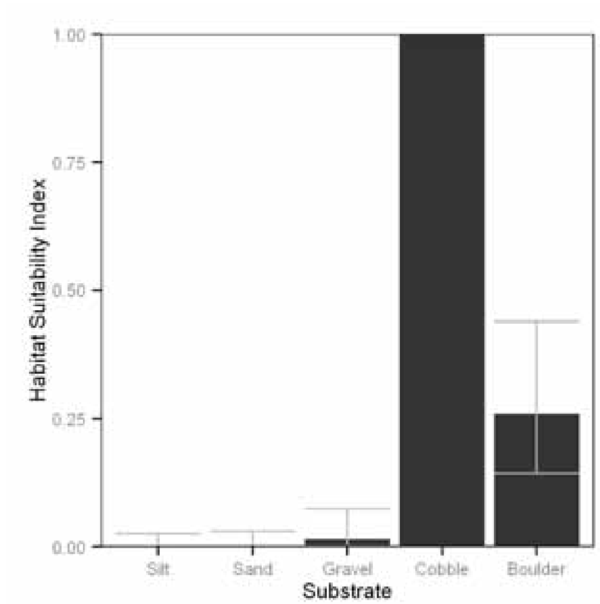


Figure 32: Substrate Habitat Suitability Indices (HSI) for Columbia Sculpins in the Lower Columbia River study area with 95% credible intervals.

4.6.2.2 Life Stage

In the LCR study area, adult and juvenile Columbia Sculpins were observed at similar depths, but YOY were observed in deeper water (Table 14); velocities were similar and use overlapped between life stages (Table 14). All life stages were observed to use predominantly cobble and boulder substrate, with YOY using cobble exclusively (Table 14). The majority of adults and YOY were observed in run and pool habitats; this information was not available for juveniles (Table 14). Habitat use observations for juvenile and YOY Columbia Sculpins were limited (n=6 and 3, respectively).

Table 14: Habitat characteristics observed for adult, juvenile and young-of-year (YOY) Columbia Sculpins in the LCR study area, 2009-2014. Observations based on fish captured by all methods combined where direct habitat measurement was possible. Means are presented with standard deviation in parentheses.

Life Stage	Sample Size	LCR Study Area			
		Depth	Velocity	Substrate	Habitat Type
Adult	110	0.57 (0.37)	0.17 (0.18)	Cobble (84%) Boulder (14%) Gravel (2%)	Run (60%) Pool (40%)
Juvenile	6	0.50 (0.06)	0.26 (0.20)	Boulder (50%) Cobble (50%)	-
YOY	3	0.93 (0.38)	0.23 (0.25)	Cobble (100%)	Run (50%) Pool (50%)

Notes: "-" = No habitat information available.

4.6.2.3 Season

In the LCR study area, Columbia Sculpins were observed in similar habitats during all seasons, which included the predominant use of cobble substrate and run habitat (Table 15). Columbia Sculpins were observed in shallower areas in the fall/winter (Table 15) and in areas with higher velocity during summer compared to other seasons (Table 15). HSI were not available as models did not converge. Not enough observations were available to make comparisons between season and life stage.

Table 15: Habitat characteristics observed for Columbia Sculpins in the LCR study area during different seasons, 2009-2014. Observations based on fish captured by all methods combined when direct habitat measurement was possible. Means are presented with standard deviation in parentheses.

Season	Sample Size	LCR Study Area			
		Depth	Velocity	Substrate	Habitat Type
Spring	50	0.67 (0.44)	0.15 (0.15)	Cobble (75%); Boulder (25%)	Run (63%) Pool (37%)
Summer	18	0.64 (0.26)	0.32 (0.25)	Cobble (100%)	Run (67%) Pool (33%)
Fall	9	0.47 (0.24)	0.18 (0.17)	Cobble (88%) Gravel (12%)	Run (56%) Pool (44%)
Winter	42	0.46 (0.29)	0.17 (0.18)	Cobble (83%) Gravel (2%) Boulder (15%)	Run (55%) Pool (45%)

4.6.2.4 Diel

In the LCR study area, Columbia Sculpins used similar habitats during day and night (Table 16) although sample sizes at night were low.

Table 16: Habitat characteristics observed for Columbia Sculpins in the LCR study area during different seasons, 2009-2014. Observations based on fish captured by all methods combined when direct habitat measurement was possible. Means are presented with standard deviation in parentheses.

Day/Night	Sample Size	LCR Study Area			
		Depth	Velocity	Substrate	Habitat Type
Day	116	0.58 (0.37)	0.18 (0.19)	Cobble (82%) Boulder (16%) Gravel (2%)	Run (59%) Pool (41%)
Night	3	0.40 (0.17)	0.25 (0.13)	Cobble (100%)	Run (100%)

4.6.3 Shorthead Sculpin

4.6.3.1 Habitat Suitability

Peak habitat use by Shorthead Sculpins is at depths around 0.2 m and velocities of 0.1 m/s (Figure 33 and Figure 34). Cobble was used almost exclusively by Shorthead Sculpins with some use of boulder and gravel substrates (Figure 35).

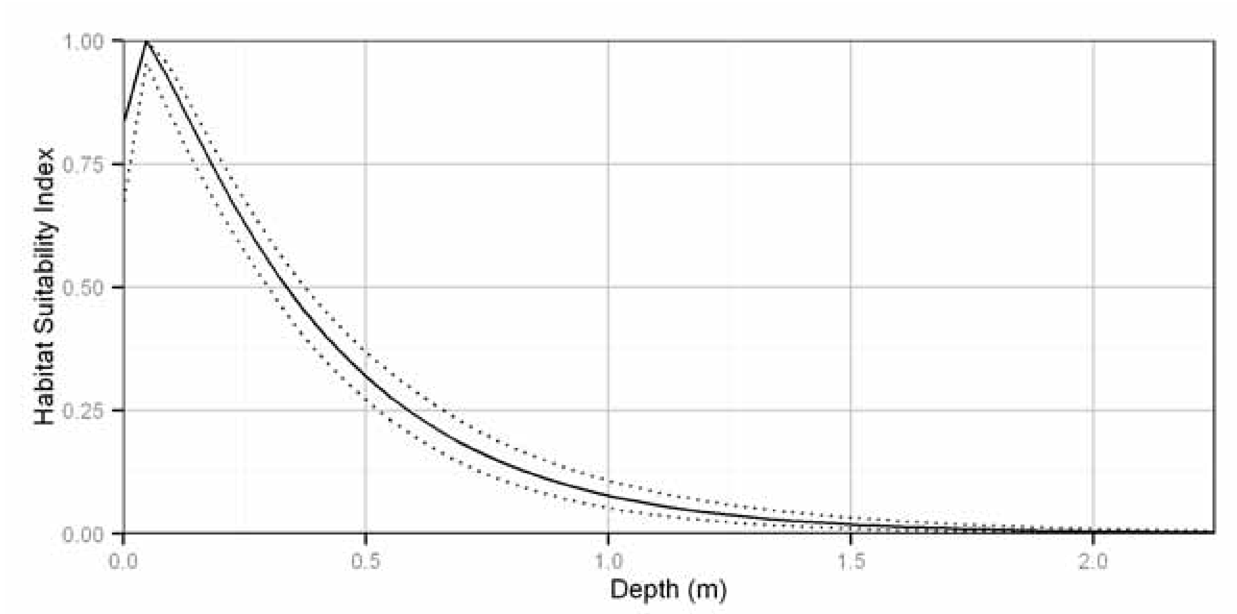


Figure 33: Depth Habitat Suitability Indices (HSI) for Shorthead Sculpins in the Lower Columbia River study area with 95% credible intervals.

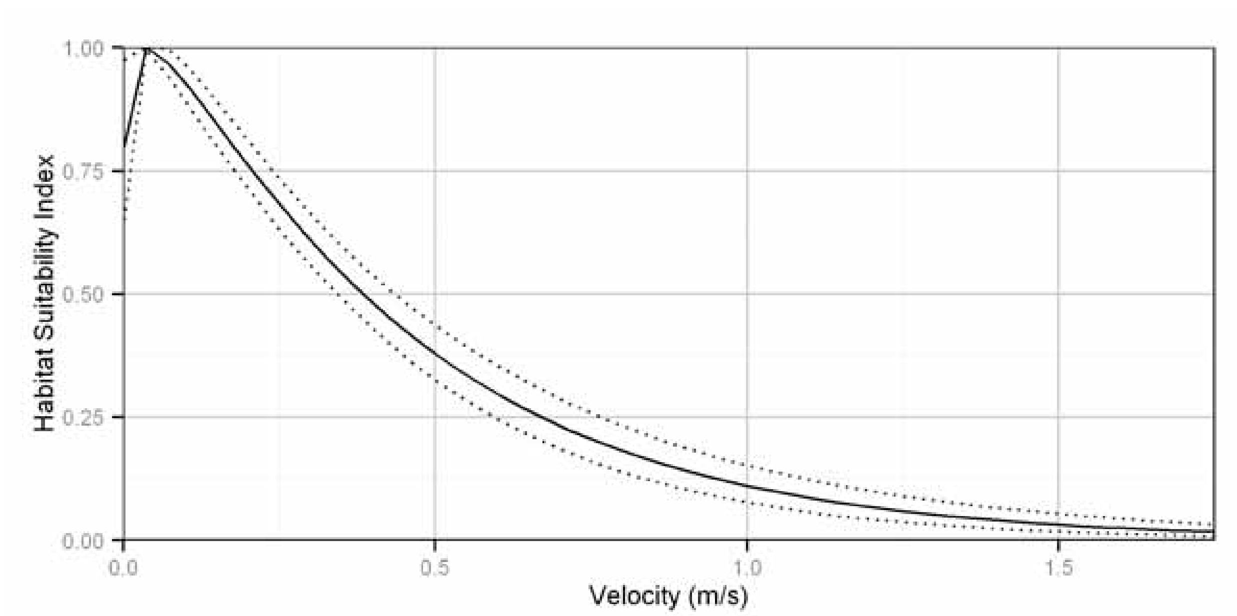


Figure 34: Velocity Habitat Suitability Indices (HSI) for Shorthead Sculpins in the Lower Columbia River study area with 95% credible intervals.

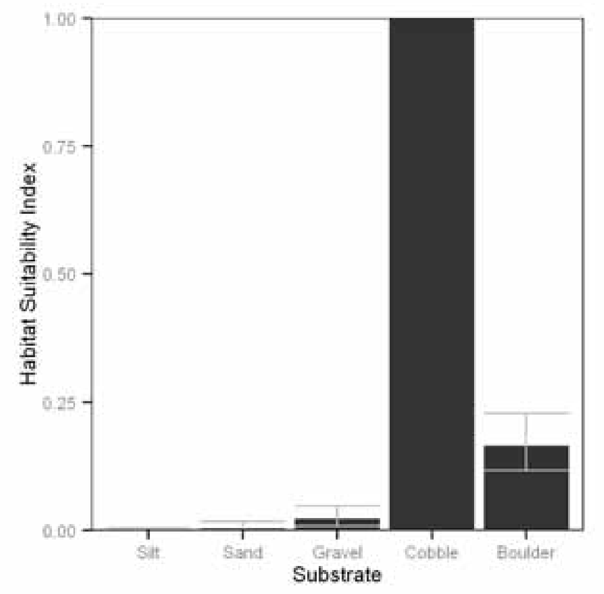


Figure 35: Substrate Habitat Suitability Indices (HSI) for Shorthead Sculpins in the Lower Columbia River study area with 95% credible intervals.

4.6.3.2 Life Stage

In the LCR study area, all life stages of Shorthead Sculpins were observed in very similar habitats (Table 17).

Table 17: Habitat characteristics observed for adult, juvenile and young-of-year (YOY) Shorthead Sculpins in the LCR study area, 2009-2014. Observations based on fish captured by all methods combined where direct habitat measurement was possible. Means are presented with standard deviation in parentheses.

Life Stage	Sample Size	LCR Study Area			
		Depth	Velocity	Substrate	Habitat Type
Adult	154	0.64 (0.47)	0.24 (0.23)	Cobble (75%) Boulder (21%) Gravel (4%)	Run (72%) Pool (19%) Riffle (9%)
Juvenile	24	0.77 (0.55)	0.28 (0.21)	Cobble (74%) Boulder (26%)	Run (95%) Pool (5%)
YOY	13	0.72 (0.29)	0.17 (0.13)	Cobble (54%) Flooded Vegetation (23%) Gravel (15%) Sand (8%)	Run (64%) Pool (29%) Riffle (7%)

4.6.3.3 Season

In the LCR study area, Shorthead Sculpins were observed in shallow, low velocity pool areas in winter compared to the deeper, faster run habitats they were observed in during other seasons (Table 18). The majority of Shorthead Sculpins were observed using cobble substrate in all seasons, followed by boulder in spring and summer and gravel in fall and winter (Table 18).

Table 18: Habitat characteristics observed for Shorthead Sculpins in the LCR study area during different seasons, 2009-2014. Observations based on fish captured by all methods combined where direct habitat measurement was possible. Means are presented with standard deviation in parentheses.

Season	Sample Size	LCR Study Area			
		Depth	Velocity	Substrate	Habitat Type
Spring	62	0.84 (0.65)	0.21 (0.15)	Cobble (74%) Boulder (26%)	Run (88%) Pool (8%) Riffle (4%)
Summer	66	0.68 (0.34)	0.34 (0.26)	Cobble (62%) Boulder (29%) Flooded Vegetation (4%) Gravel (3%) Sand (2%)	Run (68%) Riffle (20%) Pool (12%)
Fall	46	0.66 (1.02)	0.21 (0.21)	Cobble (82%) Gravel (13%) Boulder (5%)	Run (86%) Pool (14%)
Winter	19	0.46 (0.32)	0.06 (0.09)	Cobble (89%) Gravel (11%)	Pool (74%) Run (26%)

4.6.3.4 Diel

In the LCR study area, Shorthead Sculpins used similar habitats during day and night; sample sizes at night were low (Table 19).

Table 19: Habitat characteristics observed for Columbia Sculpins in the LCR study area during different seasons, 2009-2014. Observations based on fish captured by all methods combined when direct habitat measurement was possible. Means are presented with standard deviation in parentheses.

Day/Night	Sample Size	LCR Study Area			
		Depth	Velocity	Substrate	Habitat Type
Day	182	0.67 (0.49)	0.24 (0.23)	Cobble (76%) Boulder (18%) Gravel (4%) Flooded Vegetation (2%) Sand (1%)	Run (72%) Pool (20%) Riffle (8%)
Night	9	0.59 (0.27)	0.23 (0.13)	Boulder (67%) Cobble (22%) Gravel (11%)	Run (89%) Riffle (11%)

4.7 Nursery Areas

4.7.1 Umatilla Dace

Young-of-the-year (YOY) Umatilla Dace were observed in the LCR study area in all seasons, (Table 20) and have been captured in relatively shallow, nearshore areas with negligible flow. In spring and summer, YOY were predominantly captured in seasonally flooded vegetation. In fall, when low flows are generally observed in the LCR study area, YOY were captured in cobble areas while during winter, when flows were higher than seasonal lows, YOY were predominantly located in silt and flooded vegetation (Table 20). YOY were also observed to use undercut banks as cover during winter at Koot_0.5R (AMEC 2013).

The majority of Umatilla Dace YOY in the LCR study area have been captured at Koot_0.5R during this program. Umatilla Dace YOY have also been captured at the following locations in the LCR study area: i) LCR_2.8L; ii) LCR_10.5L; iii) LCR_16.7L; iv) LCR_24.5R; v) LCR_38.4L; vi) LCR_43.9L; vii) LCR_47.5L; viii) LCR_51.4R; ix) LCR_53.1L; x) Koot_0.2L; and, xi) Koot_1.2L (Appendix B). In addition to these locations, unidentified larval Dace (i.e., too small to identify to species and may have included Umatilla Dace) were captured at LCR_38.4L as well as the locations listed above (Appendix B). Larval dace were often located in similar habitats as larval suckers (*Catostomus* spp.) during the summer and early fall during this program. Mixed schools of dace and sucker YOY, estimated to contain thousands of individuals, were observed along flooded shorelines.

Table 20: Seasonal habitat characteristics observed for young-of-year (YOY) Umatilla Dace in the Regulated LCR study area and the Unregulated Slocan River, 2009-2014. Observations based on fish captured by all methods combined where direct habitat measurement was possible. Means are presented, where appropriate, with standard deviation in parentheses.

Season	LCR Study Area					Slocan River				
	Sample Size	Depth (m)	Velocity (m/s)	Substrate	Habitat Type	Sample Size	Depth (m)	Velocity (m/s)	Substrate	Habitat Type
Spring	47	0.21 (0.09)	0.01 (0.02)	Cobble (60%) Flooded Vegetation (32%) Gravel (9%)	Pool (100%)	3	0.23 (0.06)	0 (0)	Flooded Vegetation (67%) Silt (33%)	Pool (100%)
Summer	30	0.33 (0.20)	0.01 (0.02)	Flooded Vegetation (73%) Gravel (20%) Silt (4%) Cobble (3%)	Pool (100%)	1	0.25 (-)	0 (-)	Flooded Vegetation (100%)	-
Fall	35	0.15 (0.07)	0.01 (0.02)	Cobble (85%) Gravel (13%) Boulder (2%)	Pool (47%) Run (52%)	98	0.16 (0.09)	0.05 (0.06)	Gravel (63%) Cobble (28%) Silt (3%) Boulder (3%) Aquatic Macrophytes (3%)	Pool (58%) Run (42%)
Winter	74	0.16 (0.08)	0 (0)	Silt (43%) Flooded Vegetation (22%) Gravel (22%) Cobble (13%)	Pool (100%)	35	0.18 (0.09)	0.03 (0.04)	Gravel (80%) Cobble (11%) Silt (6%) Boulder (3%)	Pool (89%) Run (11%)

In the Slocan River, Umatilla Dace YOY were located in nearshore areas with similar depths and velocities as observed in the LCR study area during all seasons (Table 20). During spring and summer, larval Umatilla Dace were associated with flooded vegetation/silt, whereas in fall and winter gravel/cobble substrates were predominantly used. Substrates used in the Slocan study area during the winter period were different than those used in the LCR study area (silt/flooded vegetation) because areas of flooded terrestrial vegetation were not present at Slocan River index sites at this time; LCR discharge has a second peak during winter due to water regulation (Section 4.1). Umatilla Dace YOY were observed at the following locations in the Slocan River: i) Sloc_16.2R; ii) Sloc_30.7R; iii) Sloc_37.8L; and, iv) Sloc_39.4L (Appendix B).

4.7.2 Sculpins

Identification of recently emerged YOY sculpins to species was very difficult, especially for Columbia and Shorthead sculpins. Therefore, a general description of nursery habitat for all YOY sculpins observed in the LCR study area is provided in Table 21. Fall and winter habitat data are very limited since direct habitat use of YOY sculpins during those seasons is not available (Table 21). Sculpin YOY used deeper pool habitats during summer over cobble/boulder substrates whereas in spring they were mostly located in shallower run habitats with higher velocity and cobble substrates (Table 21). During summer, YOY sculpins were often observed resting on top of substrates sometimes with multiple individuals on the same rock, potentially indicating that they were either hatched nearby or even under the observed rock.

Table 21: Habitat characteristics observed for young-of-year (YOY) sculpins in the LCR study area in spring and summer, 2010-2014. Observations based on fish captured by all methods combined where direct habitat measurement was possible. Means are presented with standard deviation in parentheses.

Season	LCR Study Area				
	Sample Size	Depth (m)	Velocity (m/s)	Substrate	Habitat Type
Spring	27	0.61 (0.40)	0.14 (0.08)	Cobble (85%) Boulder (11%) Silt (4%)	Run (88%) Pool (12%)
Summer	651	0.82 (0.34)	0.10 (0.15)	Cobble (45%) Boulder (29%) Gravel (13%) Flooded Vegetation (6%) Silt (5%) Sand (2%)	Pool (60%) Run (39%) Riffle (1%)
Fall	0	-	-	-	-
Winter	1	0.3 (-)	0 (-)	Gravel	Pool

Sculpin YOY have been located at numerous locations in the LCR study area during this program and have included the following locations: LCR_0.3R, LCR_1.5L, LCR_2.8L, LCR_5.0R, LCR_7.9L, LCR_8.4L, LCR_10.3L, LCR_10.5L, LCR_11.0R, LCR_16.7L, LCR_24.5R, LCR_25.1R, LCR_43.8L, LCR_43.9L, LCR_47.2R, LCR_47.5L, LCR_49.4L, LCR_51.4R, LCR_53.1L, LCR_55.5L the Kootenay River at Koot_0.2R, Koot_0.3L, Koot_0.5R, Koot_0.6R, Koot_1.2L as well as Beaver and Pass Creeks (Appendix B).

4.8 Water Level Fluctuations in the LCR Study Area

Results below summarize findings of flow-reduction sampling in the LCR study area (Table 3). Timing of flow reduction sampling and the associated HLK discharge changes are presented in Figure 36.

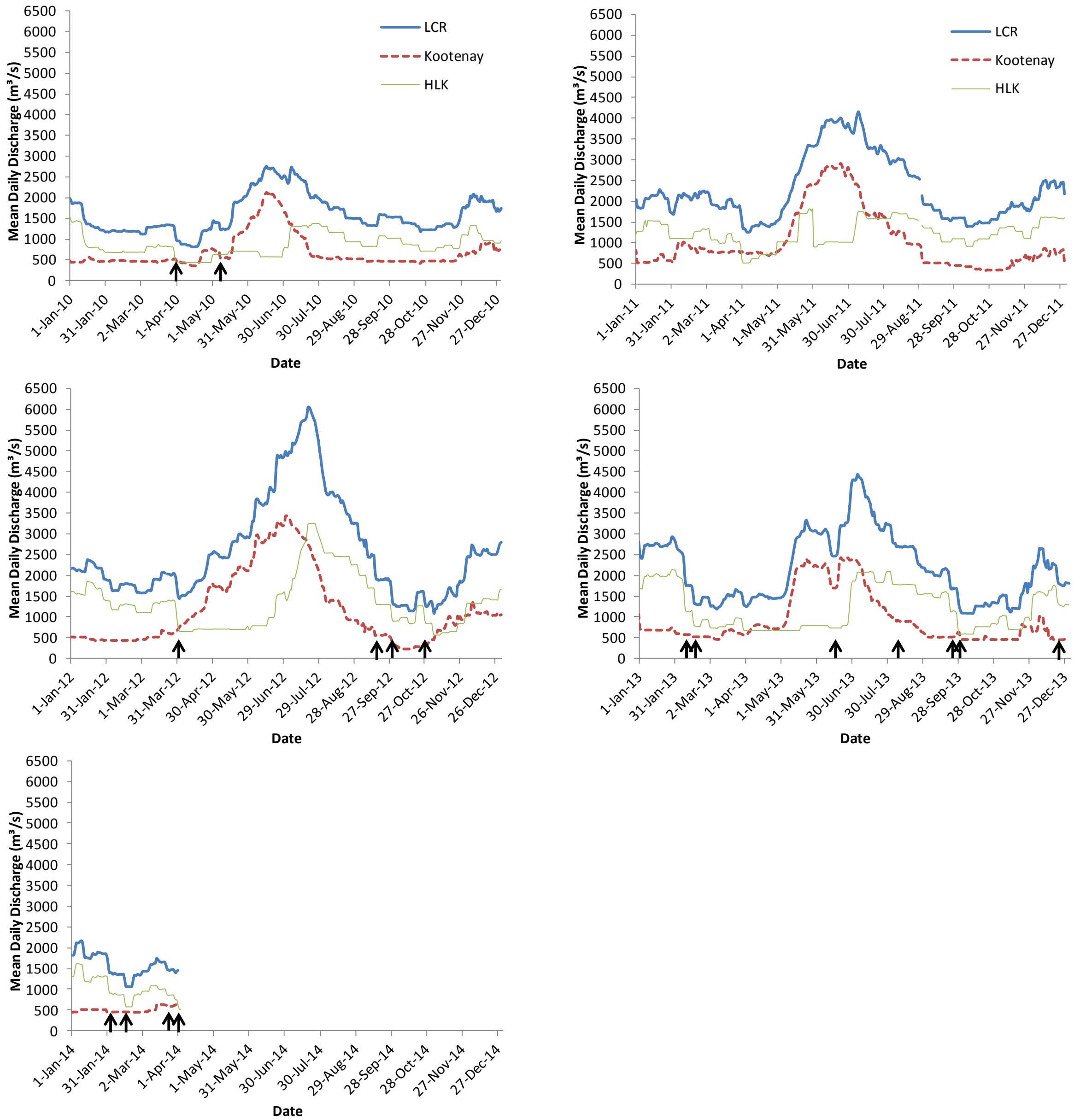


Figure 36: Discharge for the Lower Columbia River (LCR) study area (BBK; WSC Station No: 08NE0558), Hugh L. Keenleyside and Arrow Lakes Generating Station combined (HLK) and for the Kootenay River, January 2010 to April 2014. Black arrows indicate dates when flow reduction sampling was conducted.

4.8.1 Movement and Habitats

Seasonal flow reduction observations and habitat use summaries are provided below. Results are summarized at the general sculpin or dace species level. All movement data collected for individual fish, which were relocated at least once at index sites LCR_10.5L and LCR_24.5R, are provided in Appendix G; movement data for individual fish at previous index sites Koot_1.2L and Koot_0.2R were provided in AMEC (2011). Maps of individual fish locations and movement before, during and after Year 5 flow reductions are provided in Appendix H; maps for previous years are provided in AMEC (2013).

4.8.1.1 Dace

4.8.1.1.1 Spring

Dace were observed to make similar movements during (0.02 m/hr; LNC=4 and UDC=2) and after spring flow reductions (0.04 m/hr; LNC=1 and UDC=1) (Table 22). The movement of one dace was not associated with a flow reduction (LNC= 0.6 m/hr); statistical comparisons were not possible. Dace habitat use was similar for all habitat variables before, during and after spring flow reductions except for mean depth (p=0.0419) (Table 23). Tukey's post hoc comparisons indicated mean depth was significantly shallower during spring flow reductions compared with after (p=0.035). Habitats in which dace were observed before, during and after flow reductions fall within the HSI curves for depth, velocity and substrate for adult Umatilla Dace in the LCR (Section 4.6.1).

Table 22: Direction and movement of PIT-tagged dace during and after spring flow reductions at Hugh L. Keenleyside Dam, 2010-2014. Seasonal movement rates not associated with flow reductions are included for reference.

Flow Reduction Dates	HLK Discharge		Approximate Vertical Reduction Observed (m)	Location	Total Number of PIT Tags Located			During Flow Reductions			After Flow Reductions			Comments
	Pre-reduction (kcfs)	Post-reduction (kcfs)			Pre	Reduction	Post	Mean Movement Rate (m/hr)	Direction[1]	Number Observed	Mean Movement Rate (m/hr)	Direction[1]	Number Observed	
March 30, 2010	29	22	0.5	Koot_1.2L	0	1	0	-	-	0	-	-	0	
March 30, 2012	49	39	0.2	LCR_24.5R	1	1	0	0.02 (-)	Out (100%)	1	-	-	0	
March 31, 2012	39	29	0.25	LCR_24.5R	0	1	0	0.06 (-)	Out (100%)	1	-	-	0	Subsequent tracking sessions conducted within a 2 hour time period.
					-	1	-	0 (-)	None (100%)	1	-	-	-	
April 1, 2012	29	23	0.15	LCR_24.5R	-	1	1	0.05 (-)	US (100%)	1	0.03 (-)	Unk (100%)	1	
March 29, 2014	30	26	0.15	LCR_24.5R	1	1	1	0 (-)	None (100%)	1	0.04 (-)	Out (100%)	1	
April 1, 2014	26	18	0.5	LCR_24.5R	1	1	0	0 (-)	None (100%)	1	-	-	0	
Spring Flow Reduction Movement								**0.02 (0.03)**	**None (50%) Out (33%) US (17%)**	**6**	**0.04 (0.004)**	**Out (50%) Unk (50%)**	**2**	
Spring Non-Flow Reduction Movements								**0.6 (-)**	**Out (100%)**	**1**	**-**	**-**	**-**	

Notes: [1] DS= downstream; US = upstream; Out = away from shore; In = toward shore; None = no movement; Unk = unknown.

Table 23: Dace species habitat use observed during PIT-tag tracking surveys before, during and after spring flow reductions at Hugh L. Keenleyside Dam, 2010-2014. Means are presented, where appropriate, with standard deviation in parentheses.

Flow Reduction Phase	Sample Size	Depth (m)	Average Velocity (m/s)	Substrate	Distance to Shore (m)	Embededness (%)
Before	3	0.40 (0.26)	0.11 (0.13)	Cobble (100%)	1.5 (0.9)	5 (0)
During	7	0.30 (0.25)	0.09 (0.09)	Cobble (100%)	1.4 (1.7)	8 (10)
After	3	0.81 (0.24)	0.15 (0.07)	Cobble (100%)	2.5 (0.5)	10 (9)

4.8.1.1.2 Summer and Fall

Dace were not located during summer or fall flow reduction PIT tracking surveys.

4.8.1.1.3 Winter

Dace observed during (LNC=1) and following (LNC=1; UDC=1) winter flow reductions did not move; they remained in locations that stayed wetted (Table 24). Dace used similar habitats before, immediately after and following winter flow reductions (Table 25). Mean depths and velocities were within the HSI calculated for dace in the LCR (Figure 21 and Figure 22). Habitats in which dace were observed before, during and after flow reductions fall within the HSI curves for depth, velocity and substrate for adult Umatilla Dace in the LCR (Section 4.6.1)

Table 24: Direction and movement of PIT-tagged dace during and after winter flow reductions at Hugh L. Keenleyside Dam, 2013.

Flow Reduction Dates	HLK Discharge		Approximate Vertical Reduction Observed (m)	Location	Total Number of PIT Tags Located			During Flow Reductions			After Flow Reductions		
	Pre-reduction (kcfs)	Post-reduction (kcfs)			Pre	Reduction	Post	Mean Movement Rate (m/hr)	Direction[1]	Number Observed	Mean Movement Rate (m/hr)	Direction[1]	Number Observed
February 8 - 9, 2013	67	40	1.75	LCR_24.5R	0	1	1	-	-	0	0 (-)	None (100%)	1
February 16, 2013	40	28	1	LCR_24.5R	1	2	1	0 (-)	None (100%)	1	0 (-)	None (100%)	1
Winter Flow Reduction Movement								**0 (-)**	**None (100%)**	**1**	**0 (0)**	**None (100%)**	**2**

Notes: [1] DS= downstream; US = upstream; Out = away from shore; In = toward shore; None = no movement; Unk = unknown.

Table 25: Dace species habitat use observed during PIT-tag tracking surveys before (pre), immediately after (reduction) and in follow-up (post) to winter flow reductions at Hugh L. Keenleyside Dam, 2010-2014. Means are presented, where appropriate, with standard deviation in parentheses.

Flow Reduction Phase	Sample Size	Depth (m)	Average Velocity (m/s)	Substrate	Distance to Shore (m)	Embededness (%)
Before	1	0.63 (-)	0.08 (-)	Cobble (100%)	2.8 (-)	10 (-)
During	3	0.34 (0.16)	0.03 (0.03)	Cobble (100%)	1.5 (1.2)	8 (3)
After	2	0.55 (0.12)	0.04 (0.06)	Cobble (100%)	2.1 (0.9)	10 (0)

4.8.1.2 Sculpins

4.8.1.2.1 Spring

The rate of sculpin movements was not significantly different before, during, and after flow reductions in spring (p=0.29; Table 26).

Significant differences were observed in the direction of movements during, after and outside of flow reductions in winter (p <0.0001). More sculpins moved away from the shore and fewer remained in their previous locations during flow reductions than after or outside of flow reductions (Table 26). Sculpins were observed in significantly different depths before, during and after spring flow reductions (p=0.006); differences in other habitat variables were not observed (Table 27). Tukey's post hoc comparisons indicated mean depth was significantly shallower during spring flow reductions compared with after (p=0.007). Habitats in which sculpins were observed before, during and after spring flow reductions fall within the HSI curves for depth, velocity and substrate for sculpins in the LCR (Section 4.6).

Table 26: Direction and movement of PIT-tagged sculpins during and after spring flow reductions at Hugh L. Keenleyside Dam, 2010-2014. Seasonal movement rates not associated with flow reductions are included for reference.

Flow Reduction Dates	HLK Discharge		Approximate Vertical Reduction Observed (m)	Location	Total Number of PIT Tags			During Flow Reductions			After Flow Reductions			Comments
	Pre-reduction (kcfs)	Post-reduction (kcfs)			Pre	Reduction	Post	Mean Movement Rate (m/hr)	Direction[1]	Number Observed	Mean Movement Rate (m/hr)	Direction[1]	Number Observed	
March 30, 2010	29	22	0.5	Koot_0.2R	1	2	-	0.2 (-)	Out (100%)	1	-	-	-	Subsequent tracking sessions conducted within
				Koot_1.2L	21	18	-	0.003 (0.007)	None (75%) US (25%)	12	-	-	-	
March 31, 2010	22	15	0.5	Koot_0.2R	-	1	-	0.17 (-)	Out (100%)	1	-	-	-	
				Koot_1.2L	-	17	-	0.008 (0.03)	None (93%) Unk (7%)	15	-	-	-	
May 7, 2010	-	-	0.5	Koot_1.2L	9	11	7	0.10 (0.05)	Unk (100%)	7	0.13 (0.15)	None (50%) Unk (50%)	6	Night reduction; movement from dewatered areas (n=2)
March 30, 2012	49	39	0.3	LCR_10.5L	5	3	-	0.02 (0.02)	None (50%) US (50%)	2	-	-	-	Subsequent tracking sessions conducted within a 2 hour time
					-	4	-	0.11 (0.14)	None (66%) Out (33%)	4	-	-	-	
			0.2	LCR_24.5R	13	4	-	0.04 (0.06)	DS (33%) Out (33%) None (33%)	3	-	-	-	
March 31, 2012	39	29	0.3	LCR_10.5L	-	6	-	0.12 (0.18)	None (50%) Out (25%) US (25%)	5	-	-	-	Subsequent tracking sessions conducted within a 2 hour time period.
					-	6	-	0.12 (0.24)	None (40%) US (40%) Out (20%)	6	-	-	-	
			0.25	LCR_24.5R	-	5	-	0.07 (0.02)	Out (66%) In (33%)	3	-	-	-	Subsequent tracking sessions conducted within a 2 hour time
					-	6	-	0.30 (0.62)	None (60%) Out (40%)	5	-	-	-	
April 1, 2012	29	23	0.3	LCR_10.5L	-	5	2	0.09 (0.30)	None (33%) US (33%) Unk (33%)	5	0.07 (0.1)	Unk (100%)	2	
			0.15	LCR_24.5R	-	9	9	0.07 (0.12)	None (50%) DS (17%) Out (17%) Unk (16%)	5	0.01 (0.01)	Unk (100%)	6	
March 29, 2014	30	26	0.15	LCR_10.5L	1	2	2	0.03 (-)	Out (100%)	1	0 (1)	None (100%)	1	No dewatered PIT tags.
			0.15	LCR_24.5R	6	6	4	0 (0)	None (100%)	5	0.01 (0.02)	None (75%) Out (25%)	4	No dewatered PIT tags.
April 1, 2014	26	18	0.5	LCR_10.5L	2	7	7	0.04 (-)	Out (100%)	1	0.03 (0.08)	None (80%) DS (20%)	5	No dewatered PIT tags.
			0.5	LCR_24.5R	4	10	10	0.03 (0.06)	None (75%) DS (25%)	4	0.01 (0.02)	None (88%) DS (12%)	8	No dewatered PIT tags; movement from dewatered areas (n=1)
Spring Flow Reduction Movements								**0.07 (0.18)**	**None (54%) Out (15%) US (9%) DS (4%) In (1%) Unk (17%)**	**85**	**0.04 (0.08)**	**None (60%) Unk (34%) DS (6%)**	**32**	
Spring Non-Flow Reduction Movements								**0.10 (0.21)**	**None (62%) Out (5%) US (5%) DS (11%) In (14%) Unk (3%)**	**37**	**-**	**-**	**-**	

Notes: [1] DS= downstream; US = upstream; Out = away from shore; In = toward shore; None = no movement; Unk = unknown.

Table 27: Sculpin species habitat use observed during PIT-tag tracking surveys before, during and after spring flow reductions at Hugh L. Keenleyside Dam, 2010-2014. Means are presented, where appropriate, with standard deviation in parentheses.

Flow Reduction Phase	Sample Size	Depth (m)	Average Velocity (m/s)	Substrate	Distance to Shore (m)	Embededness (%)
Before	61	0.55 (0.24)	0.11 (0.13)	Cobble (57%) Boulder (38%) Gravel (2%) Unknown (3%)	2.8 (1.5)	13 (9)
During	116	0.47 (0.25)	0.09 (0.09)	Cobble (90%) Boulder (8%) Gravel (1%) Unknown (1%)	2.5 (1.6)	13 (12)
After	49	0.60 (0.27)	0.14 (0.14)	Cobble (82%) Boulder (16%) Gravel (2%)	2.8 (1.4)	12 (14)

4.8.1.2.2 Summer

Overall, one Torrent Sculpin was tracked during the two summer flow reductions (Table 28). Sculpins were observed in shallower and slower habitats during and after summer flow reductions compared with habitats before; small sample sizes prevented statistical comparisons (Table 30).

Table 28: Direction and movement of a PIT-tagged sculpin during and after summer flow reductions at Hugh L. Keenleyside Dam, 2012-2013.

Flow Reduction Dates	HLK Discharge		Approximate Vertical Reduction Observed (m)	Location	Total Number of PIT Tags			During Flow Reductions			After Flow Reductions			Comments
	Pre-reduction (kcfs)	Post-reduction (kcfs)			Pre	Reduction	Post	Mean Movement Rate (m/hr)	Direction[1]	Number Observed	Mean Movement Rate (m/hr)	Direction[1]	Number Observed	
September 15, 2012	60	45	1	LCR_24.5R	1	0	0	-	-	-	-	-	-	No dewatered PIT tags.
August 3, 2013	74.5	63	0.5	LCR_10.5L	1	1	1	0	None (100%)	1	0.03 (0)	Unk (100%)	1	No dewatered PIT tags.
				LCR_24.5R	0	0	0	-	-	-	-	-	-	
Summer Flow Reduction Movements								**0**	**None (100%)**	**1**	**0.03 (0)**	**Unk (100%)**	**1**	
Summer Non-Flow Reduction Movements								**0.06 (0.09)**	**US (50%) DS (50%)**	**2**	**-**	**-**	**-**	

Notes: [1] DS= downstream; US = upstream; Out = away from shore; In = toward shore; None = no movement; Unk = unknown.

Table 29: Sculpin species habitat use observed during PIT-tag tracking surveys before, during and after summer flow reductions at Hugh L. Keenleyside Dam, 2010-2014. Means are presented, where appropriate, with standard deviation in parentheses.

Flow Reduction Phase	Sample Size	Depth (m)	Average Velocity (m/s)	Substrate	Distance to Shore (m)	Embededness (%)
Before	3	0.49 (0.27)	0.12 (0.12)	Boulder (33%) Cobble (33%) Sand (34%)	1.8 (1.1)	35 (56)
During	1	0.25 (-)	0.01 (-)	Boulder (100%)	1 (-)	0 (-)
After	4	0.27 (0.07)	0.04 (0.05)	Cobble (75%) Boulder (25%)	1.2 (0.4)	5 (0)

4.8.1.2.3 Fall

There were statistically significant differences in movement rates of sculpins before, during and after flow reductions during fall (p=0.002; Table 30). Tukey's post hoc testing indicated the mean movement during flow reductions (0.10 m/hr) is significantly different than movement following (0.04 m/hr; p=0.03) or not associated with (0.03 m/hr; p=0.003) flow reductions. Significant differences were observed in the direction of movements during, after and not associated with flow reductions in fall (p<0.0001). More sculpins moved away from the shore and less remained in their previous locations during flow reductions than periods after or not associated with flow reductions. Sculpins were observed at significantly different distances from shore before, during and after fall flow reductions (p=0.02); Tukey's post hoc comparisons indicated sculpins were further from shore before fall flow reductions compared with after (p=0.02) (Table 31). Differences in other habitat variables were not observed (Table 31). Habitats in which sculpins were observed before, during and after fall flow reductions fall within the HSI curves for depth, velocity and substrate for sculpins in the LCR (Section 4.6).

Table 30: Direction and movement of PIT-tagged sculpins during and after fall flow reductions at Hugh L. Keenleyside Dam, 2012-2013. Seasonal movement rates not associated with flow reductions are included for reference.

Flow Reduction Dates	HLK Discharge		Approximate Vertical Reduction Observed (m)	Location	Total Number of PIT Tags			During Flow Reductions			After Flow Reductions			Comments
	Pre-reduction (kcfs)	Post-reduction (kcfs)			Pre	Reduction	Post	Mean Movement Rate (m/hr)	Direction[1]	Number Observed	Mean Movement Rate (m/hr)	Direction[1]	Number Observed	
September 28 - 29, 2012	46	32	1	LCR_10.5L	12	14	7	0.2 (0.1)	DS (12.5%) US (12.5%) Out (75 %)	8	0.1 (0.1)	DS (50%) Unk (50%)	2	No dewatered PIT tags; movement from dewatered areas (n=7).
October 26 - 27, 2012	45	30	0.75	LCR_10.5L	2	9	4	0.02 (0.03)	None (50%) Out (50%)	2	0.002 (0.002)	DS (33%) In (33%) Out (34%)	3	No dewatered PIT tags; movement from dewatered areas (n=2).
September 21, 2013	55	40	-	LCR_10.5L	19	17	10	0.09 (0.10)	None (40%) Out (33%) DS (13%) US (7%) Unk (7%)	15	0.02 (0.04)	None (38%) Out (12%) Unk (50%)	8	No dewatered PIT tags; movement from dewatered areas (n=4).
			-	LCR_24.5R	5	3	3	0.09 (0.07)	Out (67%) US (33%)	3	0.01 (0.02)	In (67%) DS (33%)	3	No dewatered PIT tags.
September 28, 2013	35	21	-	LCR_10.5L	15	8	8	0.03 (0.03)	None (50%) Out (33%) DS (17%)	6	0.09 (0.10)	DS (50%) US (50%)	2	No dewatered PIT tags; movement from dewatered areas (n=2).
			-	LCR_24.5R	2	-	4	-	-	-	-	-	-	No flow reduction tracking
Fall Flow Reduction Mean Movements								**0.10 (0.10)**	**Out (47%) None (29%) DS (12%) US (9%) Unk (3%)**	**34**	**0.04 (0.05)**	**Out (11%) None (17%) DS (22%) US (5%) In (17%) Unk (28%)**	**18**	
Fall Non-Flow Reduction Movements								**0.03 (0.06)**	**Out (11%) None (68%) DS (14%) US (7%)**	**28**	**-**	**-**	**-**	

Notes: [1] DS= downstream; US = upstream; Out = away from shore; In = toward shore; None = no movement; Unk = unknown.

Table 31: Sculpin species habitat use observed during PIT-tag tracking surveys before, during and after fall flow reductions at Hugh L. Keenleyside Dam, 2010-2014. Means are presented, where appropriate, with standard deviation in parentheses.

Flow Reduction Phase	Sample Size	Depth (m)	Average Velocity (m/s)	Substrate	Distance to Shore (m)	Embededness (%)
Before	45	0.51 (0.24)	0.16 (0.18)	Cobble (87%) Boulder (9%) Gravel (4%)	2.33 (1.16)	6 (2)
During	53	0.45 (0.25)	0.13 (0.17)	Cobble (81%) Boulder (9.5%) Gravel (9.5%)	2.54 (2.05)	7 (3)
After	35	0.53 (0.24)	0.2 (0.21)	Cobble (91%) Gravel (9%)	3.45 (2.12)	6 (4)

4.8.1.2.4 Winter

Sculpin movement was not significantly different before, during, and after flow reductions in winter (p=0.39; Table 32). Significant differences were observed in the direction of movements during, after and not associated with flow reductions in winter (p=0.01). More sculpins moved away from the shore and less remained in their previous locations during flow reductions than after or not associated with flow reductions (Table 32). Significant differences in habitats used before, during and after winter flow reductions were not observed (Table 33). Habitats in which sculpins were observed fall within the HSI curves for depth, velocity and substrate for sculpins in the LCR (Section 4.6).

Table 32: Direction and movement of PIT-tagged sculpins during and after winter flow reductions at Hugh L. Keenleyside Dam, 2012-2013. Seasonal movement rates not associated with flow reductions are included for reference.

Flow Reduction Dates	HLK Discharge		Approximate Vertical Reduction Observed (m)	Location	Total Number of PIT Tags			During Flow Reductions			After Flow Reductions			Comments
	Pre-reduction (kcfs)	Post-reduction (kcfs)			Pre	Reduction	Post	Mean Movement Rate (m/hr)	Direction[1]	Number Observed	Mean Movement Rate (m/hr)	Direction[1]	Number Observed	
February 8 - 9, 2013	67	40	1.5	LCR_10.5L	1	8	7	0	None (100%)	1	0.01 (0.01)	DS (20%) US (20%) Out (40%) Unk (20%)	5	No dewatered PIT tags.
			1.75	LCR_24.5R	4	10	8	0.09 (0.07)	None (17%) Out (83%)	6	0.01 (0.02)	DS (29%) Out (14%) None (43%) Unk (14%)	7	No dewatered PIT tags.
February 16, 2013	40	28	0.5	LCR_10.5L	7	7	2	0.01 (0.01)	None (50%) Out (50%)	4	0.08 (0.04)	US (50%) Unk (50%)	2	No dewatered PIT tags.
			1	LCR_24.5R	8	10	7	0.02 (0.03)	DS (33%) Out (17%) None (50%)	6	0.005 (0.006)	DS (25%) US (25%) None (50%)	4	No dewatered PIT tags.
December 21, 2013	57	46	0.8	LCR_10.5L	2	4	-	0.02 (0.03)	None (50%) US (50%)	2	-	-	-	No dewatered PIT tags.
			0.8	LCR_24.5R	0	0	-	-	-	0	-	-	0	No dewatered PIT tags.
February 1, 2014	46	32	0.8	LCR_10.5L	9	7	1	0.07 (0.06)	DS (50%) US (50%)	4	0.13 (-)	US (100%)	1	No dewatered PIT tags.
			0.7	LCR_24.5R	13	9	5	0.05 (0.04)	None (17%) Out (50%) Unk (33%)	6	0.01 (0.02)	None (60%) DS (20%) US (20%)	5	No dewatered PIT tags; movement from dewatered areas (n=3)
February 15, 2014	30	20	0.6	LCR_10.5L	0	3	3	-	-	0	0 (-)	None (100%)	1	No dewatered PIT tags.
			0.5	LCR_24.5R	5	6	3	0.02 (-)	Out (100%)	1	0 (0)	None (100%)	2	No dewatered PIT tags.
Winter Flow Reduction Movements								**0.04 (0.05)**	**Out (39%) None (32%) DS (13%) US (10%) Unk (6%)**	**31**	**0.02 (0.03)**	**None (40%) DS (19%) US (19%) Out (1%) Unk (1%)**	**27**	
Winter Non-Flow Reduction Movements								**0.07 (0.24)**	**None (85%) Out (7%) US (8%)**	**13**	**-**	**-**	**-**	

Notes: [1] DS= downstream; US = upstream; Out = away from shore; In = toward shore; None = no movement; Unk = unknown.

Table 33: Sculpin species habitat use observed during PIT-tag tracking surveys before, during and after winter flow reductions at Hugh L. Keenleyside Dam, 2010-2014. Means are presented, where appropriate, with standard deviation in parentheses.

Flow Reduction Phase	Sample Size	Depth (m)	Average Velocity (m/s)	Substrate	Distance to Shore (m)	Embededness (%)
Before	43	0.52 (0.25)	0.12 (0.14)	Cobble (88%) Boulder (7%) Gravel (3%) Unknown (2%)	2.4 (1.2)	9 (7)
During	69	0.44 (0.32)	0.11 (0.14)	Cobble (88%) Boulder (12%)	2.0 (1.5)	8 (7)
After	35	0.49 (0.25)	0.09 (0.13)	Cobble (86%) Boulder (11%) Gravel (3%)	2.4 (2.1)	9 (8)

4.8.2 Pool Stranding Risk

Results (i.e., significance) for models run for the probability of stranding n≥1 and n≥10 individuals were similar with the few exceptions for sculpins identified below. Therefore, results are presented for the probability of pool stranding n≥1. The posterior distributions for the *fixed* (Kery and Schaub 2011 p. 75) parameters in each model including the significance values are tabulated in Thorley (2014: URL: http://www.poissonconsulting.ca/f/1090742912). It's important to realise that as indicated in the methods, the plots show the probability of field crews observing 1 or more (or 10 or more individuals) at a typical uncontoured site in a typical year during a reduction of mean magnitude on an average day of the year. As such they provide information on the relative risk and importance of particular variables, but should not be interpreted as the absolute probability of stranding for the entire river.

4.8.2.1 Dace

At the probability of stranding one or more dace level, statistically significant variables included magnitude, river stage, day of the year, site and year; recontoured state was not significant but graphs were included for comparison purposes (Figure 37 to Figure 42). The probability of stranding one or more dace increased from approximately 5% to 20% when the magnitude of the drop increases from 500 m^3/s to 1,000 m^3/s (Figure 37). The higher the river stage (% MAD), the lower the probability of stranding dace (Figure 38). The probability of stranding one or more dace drops from approximately 9% to near zero when river stage increases from 20% MAD to over 200% MAD (Figure 38). Day of the year was a significant predictor of stranding one or more dace with highest risk during summer (June/July) (Figure 39). The probability of stranding one or more dace was not significant before or after recontouring at the four LCR sites (Figure 40). The probability of stranding one or more dace was significant at the site level with over 20% probability at Kootenay River (Koot_0.4L and Koot_0.5R), Genelle Mainland (LCR_24.0R), Genelle Lower Cobble Island (LCR_26.0M), Birchbank Snye (LCR_30.0R), Gyro Boat Launch (LCR_38.0L) and Fort Shepherd Launch (LCR_54.0L) (Figure 41). Year was a significant predictor of the probability of stranding one or more dace with >5% risk in 2000, 2002, 2006, and 2008-2014 (Figure 42).

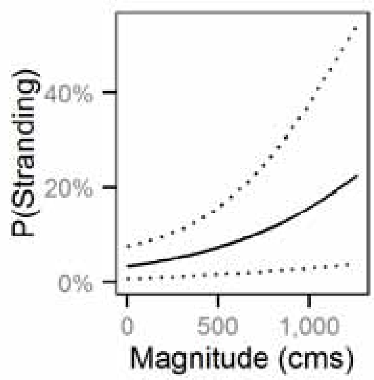


Figure 37: Expected probability of stranding one or more dace by magnitude of reduction with 95% credible intervals (CRI).

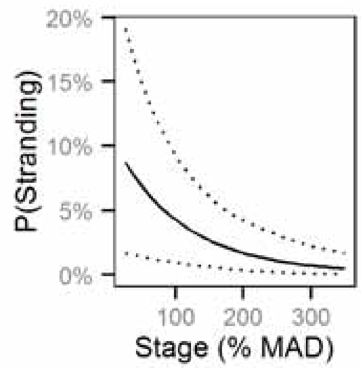


Figure 38: Expected probability of stranding one or more dace by river stage as percent Mean Annual Discharge (% MAD) with 95% credible intervals (CRI).

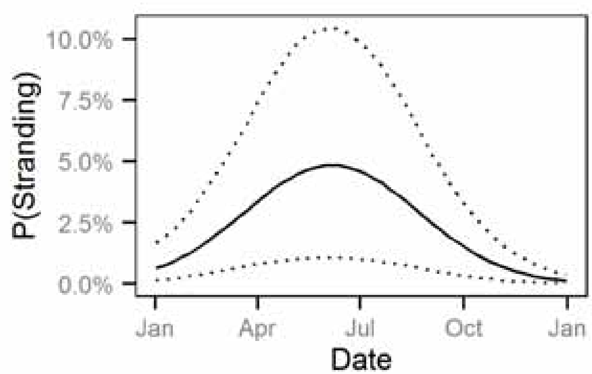


Figure 39: Expected probability of stranding one or more dace by day of the year with 95% credible intervals (CRI).

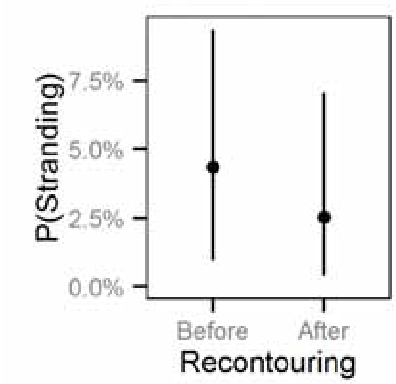


Figure 40: Expected probability of stranding one or more dace by before or after recontouring with 95% credible intervals (CRI).

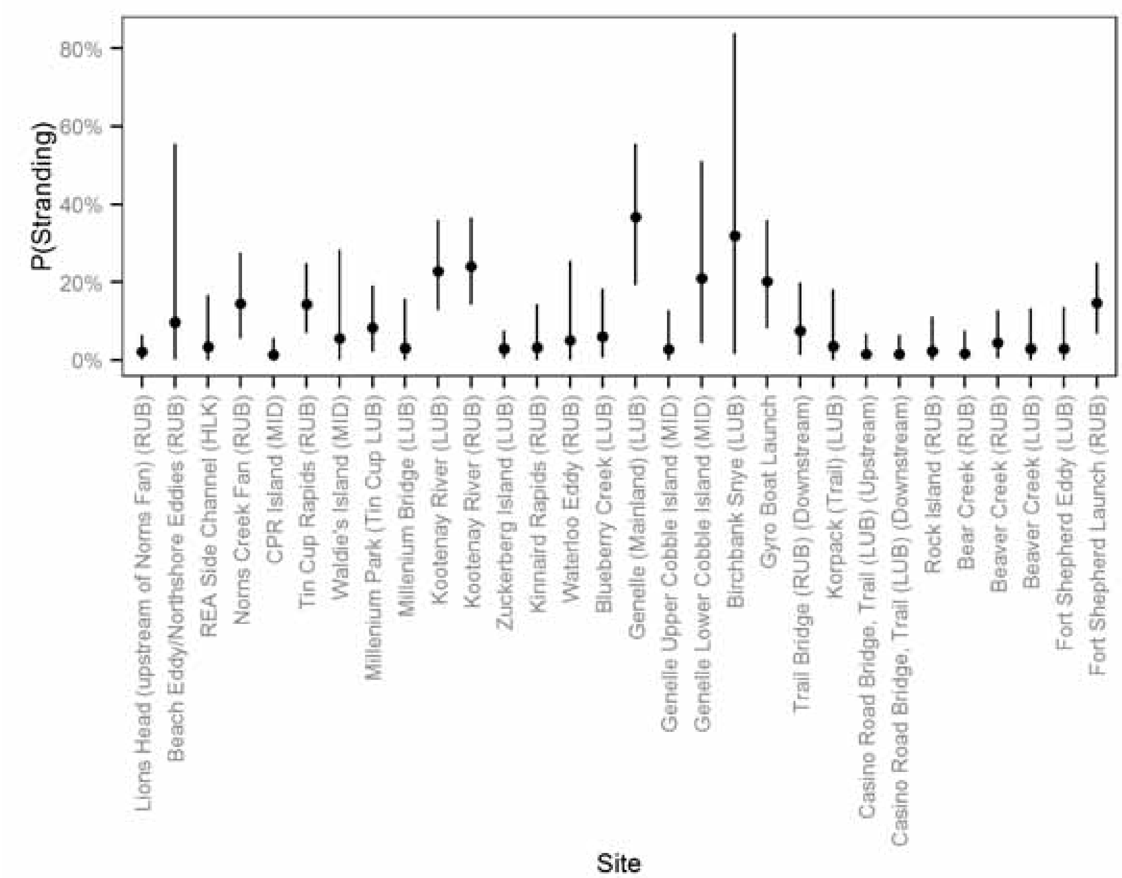


Figure 41: Expected probability of stranding one or more dace by site with 95% credible intervals (CRI). LUB = left bank as viewed facing upstream; RUB = right upstream bank.

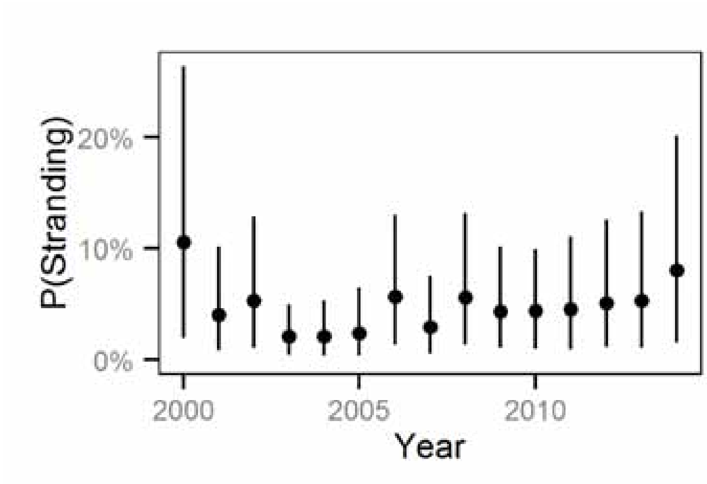


Figure 42: Expected probability of stranding one or more dace by year with 95% credible intervals (CRI).

4.8.2.2 Sculpins

At the probability of stranding one or more sculpins level, statistically significant variables included magnitude, river stage, day of the year, recontoured state, site and year (Figure 43 to Figure 48; http://www.poissonconsulting.ca/f/1090742912). The probability of stranding one or more sculpins increased from approximately 5% to 20% when the magnitude of the drop increased from 500 m^3/s to 1,000 m^3/s (Figure 43); this was not significant at the level of stranding ten or more sculpins (Thorley 2014, URL: http://www.poissonconsulting.ca/f/1090742912). The higher the river stage (% MAD), the lower the probability of stranding sculpins (Figure 44). The probability of stranding one or more sculpins drops from approximately 15% to near zero when river stage increases from 20% MAD to over 200% MAD (Figure 44). Although day of the year was significant at the one or more sculpin level, there was no distinct period for increased probability of stranding (Figure 45). However, at the ten or more sculpin level, there is increased stranding during summer (July) (Figure 45). There was a significant effect of recontouring within LCR sites with decreased probability of stranding one or more sculpins associated with the physical restructuring of habitats (after) (Figure 46). The probability of stranding one or more sculpin was significant at the site level with over 20% probability at Norn's Creek Fan (LCR_7.0L), Tin Cup Rapids (LCR_9.0L), Millenium Park (LCR_10.0R), Genelle Mainland (LCR_24.0R), and Genelle Lower Cobble Island (LCR_26.0M) (Figure 47). Year was a significant predictor of the probability of stranding one or more sculpins with >5% risk in 2000, 2002, and 2010-2014 (Figure 48).

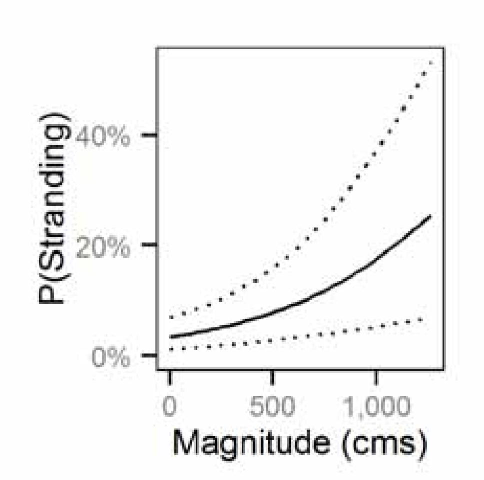


Figure 43: Expected probability of stranding one or more sculpin by magnitude of reduction with 95% credible intervals (CRI).

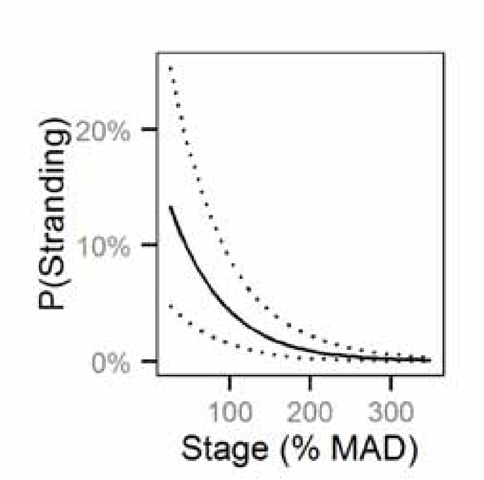


Figure 44: Expected probability of stranding one or more sculpin by river stage with 95% credible intervals (CRI).

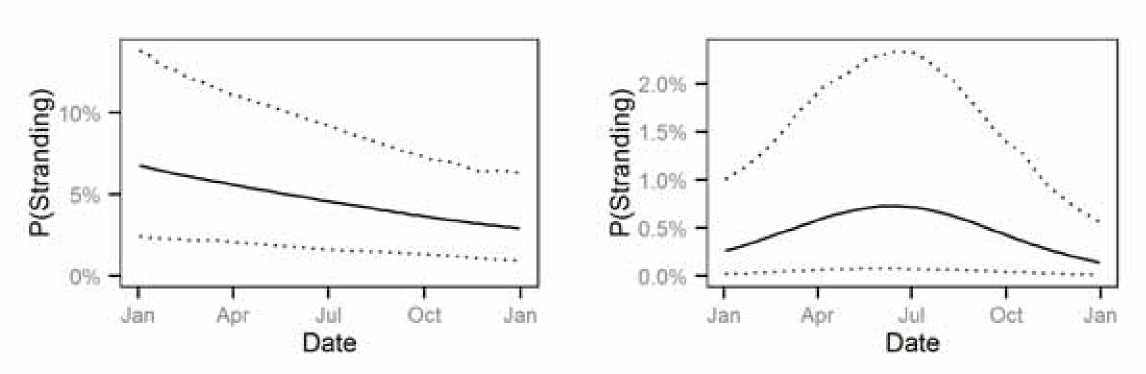


Figure 45: Expected probability of stranding one or more sculpin (left) and ten or more sculpin (right) by day of the year with 95% credible intervals (CRI).

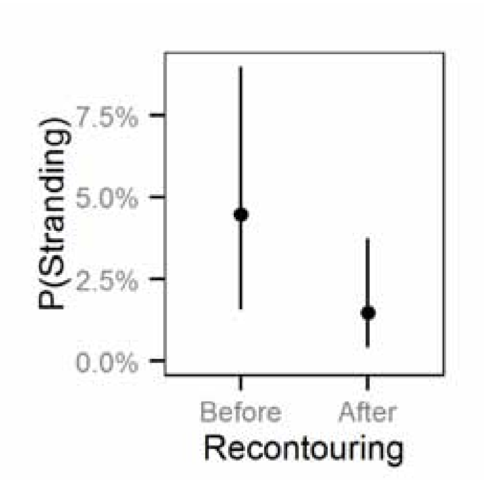


Figure 46: Expected probability of stranding one or more sculpin by before or after recontouring with 95% credible intervals (CRI).

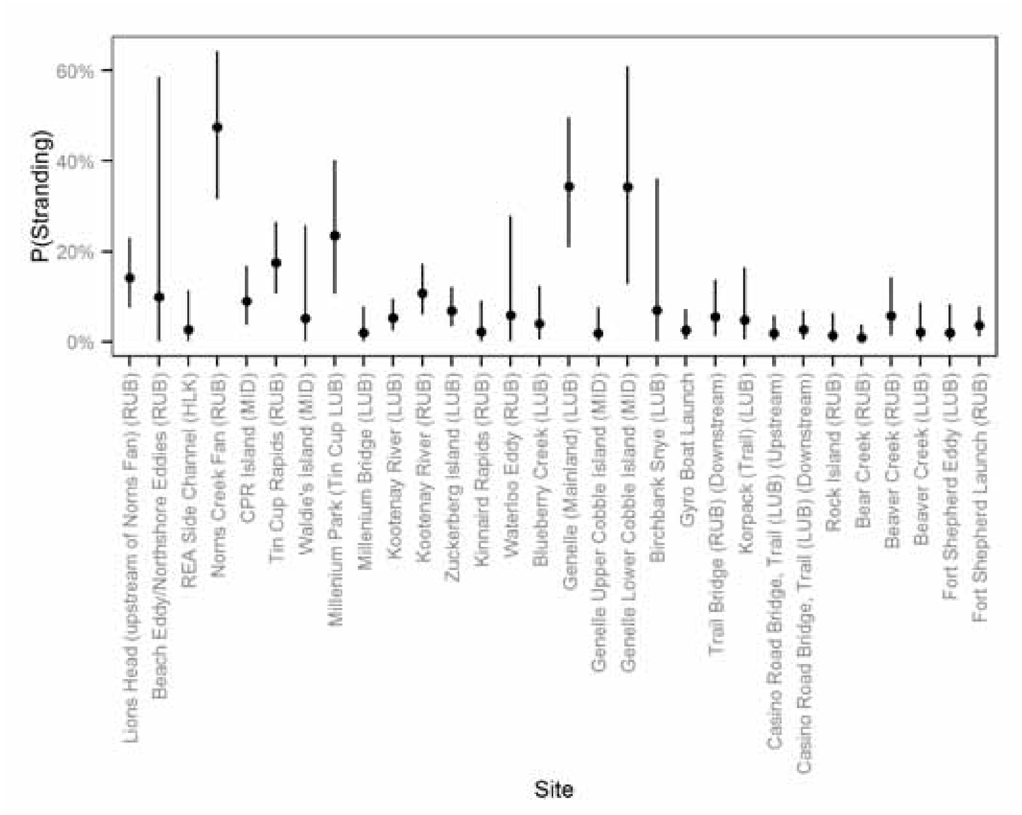


Figure 47: Expected probability of stranding one or more sculpin by site with 95% credible intervals (CRI). LUB = left bank as viewed facing upstream; RUB = right upstream bank.

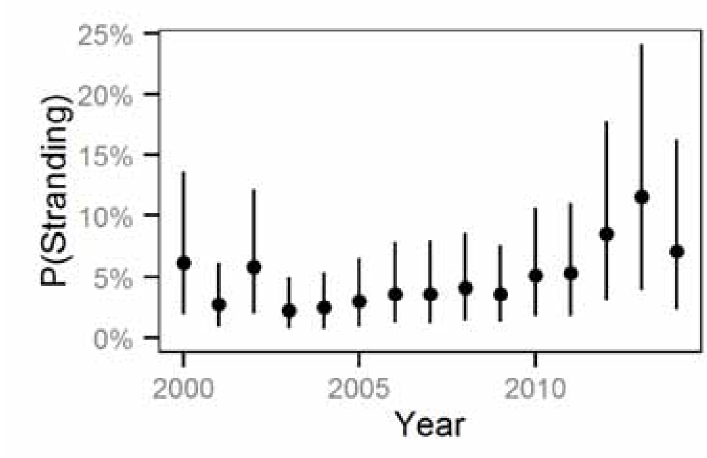


Figure 48: Expected probability of stranding one or more sculpin by year with 95% credible intervals (CRI).

5 DISCUSSION

The following discussion is structured in terms of the six Specific and the four broad Management Questions. Specific Questions are presented first because information collected to answer these questions provides the basis for answering the broader Management Questions specified for this program. The letter and/or number for each question are referenced in parentheses under each subheading. Information on Shorthead Sculpins is also included as this species is SARA-listed as being of *Special Concern*, but was not specifically included within some of the Specific Questions below.

5.1 Are there specific spawning areas utilized by the Columbia Sculpin and the Umatilla Dace and, if so, what are the temporal and biophysical characteristics of these areas? (A)

5.1.1 Umatilla Dace

There were no mature Umatilla Dace observed in spawning condition despite expending extensive effort within the LCR study area. No dace were observed over 77 mm FL during all years of this study, which is similar to that observed during stranding and ramping studies on the LCR where Umatilla Dace were not larger than 58 mm FL (Golder 2007, Golder 2012). The only confirmed large adult Umatilla Dace (122 mm TL) captured within the LCR study area was observed on the lower Kootenay River during boat electrofishing surveys conducted in the Brilliant Dam tailwater area on August 12, 2010 (Golder 2011). However, this fish was not in spawning condition and was collected at depths between 6 and 12 m, with turbulent flow and low amounts of substrate interstices (Golder 2011). A spawning population of Umatilla Dace is also present in the Brilliant Headpond above Brilliant Dam based on the capture of mature adults and YOY (AMEC 2012b).

Based on observations of YOY captured during this study, it is assumed that a spawning population of Umatilla Dace exists in the LCR and that mature adults are in habitats that were too difficult to sample although similar LCR habitats were targeted when mature fish were captured from the Slocan River. Although the majority of UDC YOY have been captured at Koot_0.5R during this program, it is unlikely that they have been entrained from populations located upstream of Brilliant Dam because YOY have been captured throughout the LCR study area from km 2.8 to km 53.1. Therefore based on observations in the Slocan River (see below), Umatilla Dace are hypothesized to spawn in the LCR study area between early July and mid-September. The spawning time likely occurs when daily average water temperatures are between 16°C and 21°C at Birchbank, which generally encompasses the descending limb of the hydrograph to the low flow period in late summer (Figure 3).

In the Slocan River, specific spawning areas utilized by Umatilla Dace are not known at this time, but they may be close to the locations where mature fish were captured. Mature males and females (i.e. displaying spawning colouration and/or expressing milt or eggs) were captured in minnow traps set along low velocity shoreline areas with flooded vegetation and/or aquatic macrophytes, silt substrates and at water depths ranging from 0.2 to 1.5 m.

Spawn timing in the Slocan River, based on the presence of ripe fish, was estimated to occur from mid-July through to mid-September when daily average water temperatures were between 12°C and 21°C. The spawning period was estimated to commence in mid-summer approximately two weeks after peak discharge and last throughout the descending limb of the hydrograph through to the low flow period in late summer. Actual spawning behaviour was not directly observed nor were fertilized eggs observed during this program.

Based on diel sampling in the Slocan River, mature UDC were more active in shoreline areas during dawn, day and dusk. Whether these fish were drawn into the baited traps to feed, seek shelter or spawn remains unknown. Information from the literature only indicated that Umatilla Dace deposit eggs in gravel and that they may spawn in mid-summer because near-ripe individuals were collected in July and the closely related leopard and speckled dace species also spawn at this time (Peden and Hughes 1981, 1984; Peden 1991; McPhail 2003, 2007).

5.1.2 Columbia Sculpin

In the LCR study area, Columbia Sculpin were observed spawning at LCR_8.4L (CPR Bridge at Robson) in mid-June 2010; direct spawning was not observed in the LCR during previous studies (R. L. & L. 1995). In addition to direct spawning, one nest was observed at LCR_24.5R in 2011 and five were observed at the two index sites (LCR_10.5L and LCR_24) in 2013.

Spawn timing, which includes the deposition, incubation, and hatching of eggs for Columbia Sculpin in the LCR study area, was estimated to occur between late May and late July, which is predominantly during the ascending limb of the hydrograph around peak freshet when daily average water temperatures were between 9.5°C and 15°C. Egg deposition occurs predominantly during the ascending limb, but hatching can occur when water levels are receding. In the unregulated system, spawning, egg deposition and hatching occurred during the descending limb of the hydrograph (AMEC 2010b).

Spawning habitat characteristics for Columbia Sculpin nests observed in the LCR study area included run and pool habitat with unembedded boulder and cobble substrates at depths from 0.25 to 1.15 m and average velocities from 0.04 to 0.34 m/s. These nest sites were similar to spawning areas utilized between late May and mid-June in the Similkameen River watershed, an unregulated system where a larger population of this species resides (AMEC 2010b). However, Columbia Sculpin nests in the LCR can be located in pool habitat with low velocity, which was not observed in the unregulated system. For example, in Otter Creek, Columbia Sculpin were observed to use run or riffle habitat with boulder and cobble substrates having an embeddedness ranging between 10% and 40%. Nests were located where depths ranged from 0.27 to 0.67 m, with average velocities ranging from 0.36 to 0.74 m/s (AMEC 2010b). In the Tulameen River, Columbia Sculpin nests were in riffle habitats with boulder and cobble substrates (10 to 30% embeddedness) at depths ranging from 0.10 to 0.48 m and average velocity ranging from 0.17 to 1.11 m/s (AMEC 2010b). Areas with similar biophysical characteristics within the LCR study area may also provide spawning habitats for this species. Also, other sites where Columbia Sculpins (and larval stages) have been captured, but not observed to be spawning may be potential spawning areas for this species (Appendix B).

In the Similkameen River watershed, it was determined that spawning was more influenced by water temperature than discharge, since both Otter Creek and the Tulameen River had very different discharge regimes and spawning was observed at water temperatures between 8°C and 15°C on both these systems (AMEC 2010b). In Otter Creek, this occurred from mid-May to mid-June, whereas in the Tulameen River, the spawning period occurred from early to mid-June until early to mid-July. McPhail (2007) indicated that Columbia Sculpins spawn in spring with water temperatures between 7ºC to 12ºC from mid-May to late June in Otter Creek.

5.1.3 Shorthead Sculpin

In the LCR study area, Shorthead Sculpin spawning was observed at LCR_24.5R and LCR_10.5L. Spawning habitat characteristics for the five Shorthead Sculpin nests observed in the LCR study area included run and pool habitats with unembedded cobble and boulder substrates at depths from 0.3 to 1.3 m and average velocities from 0 to 0.53 m/s. These nest sites were located in similar substrates to those observed in Pass Creek, an unregulated tributary of the LCR where a larger concentration of individuals has been observed (AMEC 2010b). For example, five nests in Pass Creek were observed in run habitat with boulder and cobble substrates that were between 5 to 40% embedded. However, four of the five nests observed in the LCR study area were in slower velocities (0 to 0.17 m/s) compared to nests at Pass Creek (depth=0.42 to 0.62 m; velocity= 0.43 to 0.66 m/s). LCR nests were deeper than in Pass Creek, though the maximum depth in which observations were made in Pass Creek was approximately 1 m as velocities became too high to access deeper areas during the spawning period (AMEC 2011). Areas with similar biophysical characteristics within the LCR study area may also provide spawning habitats for this species. Also, other sites where Shorthead Sculpins (and larval stages) have been captured, but not directly observed to be spawning may be potential spawning areas for this species (Appendix B).

Spawn timing for Shorthead Sculpins in the LCR study area was estimated to occur between late May and late July, which is predominantly during the ascending limb of the hydrograph around peak freshet when daily average water temperatures were between 9.5°C and 15°C (Table 10). Egg deposition occurs predominantly during the ascending limb, but hatching can occur when water levels are receding.

In the unregulated Pass Creek, spawn timing was estimated to range from mid-June to late July when average daily water temperatures were between 8°C to 14°C, similar to the LCR study area, but this occurred along the descending limb of the hydrograph (AMEC 2011). Gasser et al. (1981) indicated that Shorthead Sculpins in the Big Lost River (Idaho, USA) had an egg deposition time restricted to less than two weeks starting in mid-April. McPhail (2007) indicated that Shorthead Sculpins in B.C probably spawn in early May and the breeding season likely extends to mid-July based on observations of eyed eggs in nests at this time.

5.2 Are there specific nursery areas used by Columbia Sculpin and Umatilla Dace and, if so, what are their biophysical characteristics? (B)

5.2.1 Umatilla Dace

In the regulated LCR study area, Umatilla Dace YOY have been captured at Koot_0.2R, Koot_0.5R, Koot_1.2L, LCR_2.8L, LCR_10.5L, LCR_16.7L, LCR_24.5R, LCR_38.4L, LCR_43.9L, LCR_47.5L, LCR_51.4R, LCR_53.1L (Appendix B). Nursery areas in the fall, when Umatilla Dace can be identified to species following emergence during the summer, consisted of shallow, low velocity, nearshore areas with mainly cobble substrates. Moving into winter, YOY were located at similar depths and velocities as fall though they were closer to the shore in areas of silt and flooded terrestrial vegetation. In spring and summer, Umatilla Dace YOY were observed in more variable depths in pool areas with negligible flow and substrates including flooded vegetation, gravel and silt. Nursery habitats used in the unregulated Slocan River were very similar though YOY were located in predominantly gravel areas in winter.

General larval dace habitats also provide information on nursery areas for Umatilla Dace because small dace (<15 mm) were potentially either Longnose or Umatilla Dace. Larval dace were observed from late July to mid-October. In the LCR study area, larval dace habitats included shallow, nearshore, pool areas with negligible flow and flooded vegetation, silt, cobble or boulder substrate between late July and early October. Larval dace were often located in similar habitats as larval suckers (*Catostomus* spp.) during the summer and early fall. Combined schools of dace and sucker YOY, estimated to contain thousands of individuals, were found along flooded shorelines. These areas had water temperatures up to 10°C warmer than adjacent mainstem areas (AMEC 2011).

In the Slocan River, dace YOY were close to the shoreline and mostly in pool habitats (silt/sand), but they were also present in riffles (cobble/gravel). In early August, Umatilla Dace fry (~10 mm TL) were observed foraging in the mid-column during the day along the quiet margins of the Slocan River (McPhail 2007). These areas of the Slocan River were shallow (<10 cm), had no measurable current and had sand or silt substrate (McPhail 2007). By late August, fry were still foraging in the mid-column in shallow water (<10 cm), but they had shifted to areas dominated by cobble and gravel substrates (McPhail 2007). In the Similkameen River, Peden and Orchard (1993) found similar YOY habitat use as described for the Slocan River by McPhail (2007). These shallow areas had water temperatures that were as much as 4ºC above the rest of the river and may have helped growth (Peden and Orchard 1993).

In general, dace YOY and juveniles are not as bottom oriented as adults (R.L.&L. 1995, McPhail 2003, 2007). A school of approximately 2000 dace fry (not identified to species; may have included Umatilla Dace) was observed during the summer of 1994 while conducting a snorkel float in the lower Columbia River at the Waneta Eddy, indicating this may be an important location for YOY life stages (R.L.&L. 1995). These dace were in the water column and did not exhibit a specific orientation to the current and fish were observed holding in and around large rip-rap boulders that comprise the north shore of the eddy (R.L. &L. 1995).

5.2.2 Columbia Sculpin

In the LCR study area, 37 (YOY) Columbia Sculpins were identified to species at Koot_0.2R, Koot_1.2L, LCR_2.8L, LCR_10.5L, LCR_16.7L, LCR_24.5R, LCR_47.2R, LCR_47.5L and LCR_49.4L. Columbia Sculpin YOY were in ~1 m, moderate velocity pool and run habitats with cobble substrates, though habitat observations were only available for three individuals. However, YOY identified as general sculpins (too small to determine species) have been observed at numerous locations throughout the study area and likely include larval Columbia Sculpins. Habitat characteristics of these general nursery areas were similar in spring and summer and included the predominant use of cobble and boulder substrates, water depths between 0.1 and 1.5 m and average velocities ranging from 0 to 0.5 m/s in pool and run habitat. YOY sculpins have often been observed resting on top of large substrates (e.g., boulders) sometimes with multiple individuals on the same rock, potentially indicative that they were hatched nearby or even under the observed rock (AMEC 2011).

These results suggest that a greater diversity of nursery habitats may be used by Columbia Sculpins in the LCR than have previously been described. McPhail (2007) indicated that YOY Columbia Sculpins use flooded vegetation as shelter in the margins at times of high water. In the lower Columbia and Kootenay Rivers, R.L.&L. (1995) located YOY Columbia Sculpins mostly along stream margins with depths <0.2 m and velocities <0.1 m/s suggesting that these shallower, low flow areas most likely provide refuge from predators, since these areas were not used by larger fish.

In the unregulated Similkameen River watershed, one larval Columbia Sculpin (16 mm TL) was captured in Otter Creek in early July under a patch of flooded grass in a pool that had fine substrate, water depth was 0.3 m and water velocity was negligible (AMEC 2010b).

5.2.3 Shorthead Sculpin

In the LCR study area, 79 YOY Shorthead Sculpins have been identified to species at Koot_0.2R, Koot_0.3L, Koot_0.6R, Koot_1.2L, LCR_10.5L, LCR_16.7L, LCR_24.5R, LCR_47.2R, LCR_47.5L and LCR_53.1L (Appendix B). Shorthead Sculpin YOY (n=13) were observed in predominantly run habitat in cobble, flooded vegetation, gravel and sand substrates at depths between 0.4 to 1 m and average velocity between 0 and 0.4 m/s. General nursery areas for sculpins were outlined above for Columbia Sculpins and would apply to this species as well.

As for Columbia Sculpins, Shorthead Sculpins may utilize a greater diversity of nursery habitats than those previously described. Newly hatched Shorthead Sculpins were observed in the Slocan River in early July in flooded vegetation along the edges of the river (McPhail 2007). These locations had mud/sand substrate, were <10 cm deep and had water velocities <0.1 m/s (McPhail 2007). Shorthead Sculpin YOY were captured in Pass Creek in October 2009, in habitats with average depth and velocity of 0.3 m and 0.6 m/s, respectively, and substrates consisting mainly of cobble followed by gravel (AMEC 2010b).

5.3 Are there seasonal and diel shifts in habitat use by these species and, if so, how do these shifts relate to daily or seasonal water level fluctuations (diel and seasonal)? (C)

5.3.1 Umatilla Dace

Seasonal shifts in habitat were observed for Umatilla Dace on both systems, but observations indicated that diel habitat shifts may not occur. Diel habitat use shifts were not observed during seasonal sampling in either the regulated LCR or unregulated Slocan River study areas, though sample sizes have been small. Umatilla Dace were not found in nearshore areas or specific habitat types in higher abundances during one specific diel period (dawn, day, dusk or night) on the Slocan River during summer.

Flooded vegetation made available during high water periods (i.e. freshet) appears to be an important habitat for Umatilla Dace. In the LCR study area, Umatilla Dace were observed in similar depths, velocities and habitat types during all seasons except for fall when they were in areas with cobble compared to flooded vegetation and silt, as was predominant during all other seasons.

In the unregulated Slocan River, Umatilla Dace were located in deeper and faster water in spring and summer than in other seasons, likely due to freshet conditions. The use of specific substrates varied by season and was more diverse in the Slocan River compared to the LCR study area. Flooded vegetation was only used in the Slocan River by UDC during spring and summer as this type of habitat is not available in this unregulated system during the fall and winter. Umatilla Dace YOY use shallow, low or no velocity nearshore areas with variable substrates year round in both the regulated and unregulated systems.

Longnose Dace are known to be nocturnal and this strategy has been attributed to predator avoidance and possible competition from juvenile rainbow trout (*Oncorhynchus mykiss*) while Blacknose Dace (*Rhinichthys atratulus*) are diurnal, which was not considered a disadvantage to predator avoidance as higher light levels allow rapid predator detection and avoidance (Reebs et al. 1995). Habitat use for Umatilla Dace has been related to fish size, with larger fish located in the deepest, fastest sections of the river and using larger substrate for cover (Peden and Orchard 1993, R.L.&L. 1995, McPhail 2003, 2007). R.L.&L. (1995) suggested that diel habitat shifts may occur during winter, spring and fall because Umatilla Dace were more abundant in nearshore catches during the day compared to night potentially shifting to deeper habitats that could not be sampled. In addition, a greater abundance of large fish was recorded in the nearshore area during summer and fall compared to other seasons suggesting a seasonal habitat shift for this species (R.L.&L. 1995).

5.3.2 Columbia Sculpin

In general, the abundance of Columbia Sculpins in nearshore habitat was highest during the summer compared with other seasons. Diel habitat shifts were not apparent, although nighttime observations were low (n=3). Additional details pertaining to overwinter habitat use are provided in Section 5.5.2 and sculpin nesting habitats are provided in Section 5.1.2.

Seasonal habitat shifts were not apparent for Columbia Sculpins in the LCR study area. Columbia Sculpins were captured at similar depths, velocities, substrates and habitat types in all seasons.

In the unregulated Similkameen River system, adult Columbia Sculpins used similar habitats during both day and night and this did not seem to change seasonally (AMEC 2010b).

5.3.3 Shorthead Sculpin

In general, the abundance of Shorthead Sculpins in nearshore habitat was highest during the fall compared with other seasons in the LCR study area. Shorthead Sculpins were observed in shallower, slower velocity pool habitat in winter compared with other seasons that were dominated by observations in run habitat at deeper, faster velocity locations. The majority of Shorthead Sculpins were observed using cobble substrate in all seasons. Water levels in the LCR study area increased to approximately half of peak discharge in late fall through winter. Backflooding has been observed during this time within sections of LCR index sites and may explain why winter habitat use appears to be in slower, pool areas.

Shorthead Sculpins were observed at similar depths, velocities, substrates and habitat types during day and night in the LCR study area; diel habitat shifts were not apparent. Additional details pertaining to overwinter habitat use are provided in Section 5.5.2 and sculpin nesting habitats are provided in Section 5.1.3.

In the unregulated Pass Creek, some seasonal shifts in habitats used by adult Shorthead Sculpins were observed (AMEC 2011). For example, average depth used by adults was observed to vary by season with the deepest water used in summer, followed by winter, and shallower depths used in spring. During spring, fish were observed moving into shallow, newly flooded areas along the left bank in the Pass Creek index site likely for feeding and seeking shelter from higher freshet flows since spawning was not observed at this time. Although overall velocity was observed to be higher in mid-spring than in early spring and summer, Shorthead Sculpins were observed in fastest currents during summer, whereas velocity used in winter and spring did not vary. The majority of Shorthead Sculpins were observed using cobble substrates in all seasons with embeddedness ranging between 5-10%, which was similar to that available in the entire site. Habitat use was not observed to be significantly different during the day versus night for Shorthead Sculpins and this did not vary between winter and spring; summer diel tracking was not completed due to different sampling priorities. Diel displacements in Pass Creek were not significantly different between seasons and species (AMEC 2011).

5.4 Do different age classes of Columbia Sculpin and Umatilla Dace use different habitats seasonally and, if so, do diel habitat shifts differ among age classes? (D)

5.4.1 Umatilla Dace

Seasonal shifts in habitat were observed for different life stages of Umatilla Dace on both systems, but observations indicated that diel habitat shifts may not occur. Based on observations from both systems, adult and juvenile Umatilla Dace seem to move into nearshore flooded areas during the spring/summer period and possibly move to deeper areas after the spawning period and/or in fall.

Umatilla Dace YOY also move into flooded areas during spring, but appear to be more abundant in nearshore areas during fall and winter than other seasons, likely to avoid high velocity areas and potentially to feed. Juveniles have not been captured during winter in either system over the course of this program. Only one adult was captured in the LCR study area in winter and no adults were captured in the Slocan River during this time. The highest YOY catch-rates were observed in winter for both systems, with fall nearly as high as winter in the Slocan River. The lowest YOY catch-rates were observed in spring for both systems. Refer to Section 5.2.1 for additional information on larval dace habitat use.

Diel habitat use shifts were not observed during seasonal sampling in either the regulated LCR or unregulated Slocan River study areas, though sample sizes have been small. Catch abundance during seasonal diel sampling was no different day and night in either system using backpack electrofishing, which mainly captured younger life stages (YOY and juveniles). Adult Umatilla Dace were observed to use nearshore areas more at dusk compared to night during the spawning period (summer) in the Slocan River. Adults were observed to use deeper habitats during day compared to night and were further from shore during day compared to dusk; differences in substrate use and velocity did not vary by time of day.

Seasonally flooded vegetation appears to be an important rearing and holding habitat for Umatilla Dace. In the Slocan River, juvenile Umatilla Dace (up to 40 mm) were observed in shallow, quiet areas and were often associated with flooded vegetation during freshet (McPhail 2007). By late August, juveniles were to deeper, faster habitats, were found closer to the shore and in shallower, slower water than adults, but were using more adult substrates (McPhail 2007). In the lower Columbia River, young juvenile (age-1+) Umatilla Dace were abundant in shallow nearshore environments during their second summer, but by fall had shifted to deeper, faster waters (R.L.&L. 1995). Peden and Orchard (1993) indicated that the shallow areas where YOY Umatilla Dace were observed had water temperatures that were as much as 4ºC above the rest of the river and may have helped growth.

5.4.2 Columbia Sculpin

The majority of Columbia Sculpins captured in the LCR study area were adults, which were observed in similar habitats during all seasons with the exception of summer when they were observed in higher velocity areas. All life stages were observed in similar habitats though YOY were observed in deeper areas; limited observations of juvenile and YOY Columbia Sculpins are available at this time. Diel differences in habitat use were not observed. Refer to Sections 5.3.2 and 5.6.2 for additional information on diel habitat use and spawning habitats used by Columbia Sculpins.

Seasonal habitat shifts are likely for juvenile and YOY sculpin life stages as they feed and develop into older life stages through the year. Sculpin YOY have been observed in deeper and slower water in a greater diversity of substrates than Columbia Sculpin adults and juveniles in the LCR study area over the course of this program. This differs from McPhail's (2007) observations where under most flow conditions juvenile Columbia Sculpins inhabit riffle habitat, while adult habitats are shallower and slower with coarse gravel. These habitat use differences observed for young Columbia Sculpins may be due to food availability, growth, predation or cannibalistic pressures from other sculpins. For example, juvenile Mottled Sculpins have been shown to prefer the same microhabitat as adults (Downhower and Brown 1979, Anderson 1985, van Snik Gray and Stauffer 1999), but are most abundant in slower, shallower areas because adults feed on sculpins 40 mm smaller than their own body length (Downhower and Brown 1979). McPhail (2007) also indicated that YOY Columbia Sculpins use flooded vegetation as shelter in the margins at times of high water and to avoid predators.

5.4.3 Shorthead Sculpin

Similarly to Columbia Sculpins, the majority of Shorthead Sculpins captured in the LCR study area were adults. In general, adults and juveniles used faster areas than YOY while all life stages used predominantly cobble substrates but YOY used a wider variety of substrates including flooded vegetation. Adults used deeper habitat in spring and faster areas in summer. Juveniles used deeper, slower habitats in spring compared with summer; habitat of juveniles was not observed in fall and winter. The majority of YOY were observed in summer so seasonal comparisons are not available at this time. Refer to Sections 5.3.3 and 5.6.3 for additional information on diel habitat use and spawning habitats used by Shorthead Sculpins.

As for Columbia Sculpins, seasonal shifts in habitats are likely required for juvenile and YOY Shorthead Sculpin life stages as they feed and grow throughout the year. Sculpin YOY have been observed in deeper and slower water in a greater diversity of substrates than Shorthead Sculpin adults and juveniles in the LCR study area over the course of this program. McPhail (2007) indicated that during high water in spring, juvenile Shorthead Sculpins were associated with low flows, shallow depths and sand substrates with scattered cobble and boulder for cover in B.C streams. As water levels subsided, juveniles moved to deeper habitats with higher water velocities and coarser substrate and some were observed in adult habitats by late September (McPhail 2007). Again these shifts are likely related to growth/feeding and predator avoidance.

5.5 Are there over-wintering habitats used by these species and, if so, what are their biophysical characteristics? (E)

5.5.1 Umatilla Dace

Over-winter habitats used by Umatilla Dace appear to vary by life stage. Older life stages of Umatilla Dace may use deeper, non-wadable areas in both the LCR and Slocan River study areas as over-wintering habitat. Only one Umatilla Dace adult was captured during winter at LCR_24.5R in nearshore run habitat with cobble substrate and low velocity (0.1 m/s); no adults were captured in the Slocan River during winter. In addition, juveniles were not captured in either system during winter surveys.

However, YOY were captured in higher abundances during fall and winter than in other seasons in both systems. Overwinter habitat used by Umatilla Dace YOY in both the regulated and unregulated system consisted of shallow, slow velocity areas with silt, gravel and cobble substrate very close to shore. In the LCR study area, YOY were also located in areas of terrestrial vegetation, which were flooded during winter because of increased discharge from HLK due to drafting of Arrow Lakes reservoir at this time (Figure 3). Flooded terrestrial vegetation that is now available during winter in the LCR may provide an additional habitat type for YOY at this time; this habitat was only available during the spring/summer high water period on the unregulated system.

5.5.2 Columbia Sculpin

No specific overwintering habitats were observed for Columbia Sculpins since they used similar overwinter habitats to those used during other seasons. Nearshore overwinter habitat consisted of depths between 0.05 and 1.1 m, average velocity between 0 and 0.6 m/s with predominantly cobble substrate in run and pool habitats. Catch-rates for Columbia Sculpins in nearshore areas were similar in winter to what was observed in spring and fall; the capture rate was two to three times higher in the summer.

More sculpins were observed immediately after winter flow reductions than had been located during pre-reduction surveys in the LCR. It may be that sculpins move to deeper water during fall and stay through spring. Alternatively, sculpins may remain in locations they establish in fall that become deeper and further away from shore as water levels increase during early winter in the LCR (Figure 3). However, the mechanism for this observation remains unclear at this time.

In the unregulated Similkameen system, habitat use for Columbia Sculpins was not observed to vary between spring, summer, and fall (a proxy for winter) (AMEC 2010b). Overwinter habitat included water depths ranging from 0.2 to 1 m, average water velocity ranging from 0.2 to 1 m/s and they mostly used unembedded cobble substrates followed by boulder (AMEC 2010b).

5.5.3 Shorthead Sculpin

Shorthead Sculpins used lower velocity, slightly shallower pool habitats in winter compared to those used during other seasons. Nearshore overwinter habitat consisted of depths between 0.09 and 1.4 m, average velocity between 0 and 0.3 m/s with predominantly cobble substrate in pool habitats. Catch-rates for Shorthead Sculpins in nearshore areas were lowest in winter compared to other seasons, which could suggest relocation to deep, unwadable habitat during the overwinter period. As discussed above, more sculpins were located after flow reductions during winter compared to the number observed prior. Refer to Section 5.5.2 for a discussion of this observation.

In the unregulated Pass Creek, Shorthead Sculpins were mostly observed to use similar habitats during the overwinter period as per other times of the year. One exception was for Shorthead Sculpins in Pass Creek that used higher average velocities during the overwinter period (0.69 m/s), but other habitat variables were similar to what was observed throughout the remainder of the year (AMEC 2011).

5.6 Do diel and seasonal water level fluctuations affect spawning behaviour, embryo survival, or adult nest guarding behaviour of Columbia Sculpin and Umatilla Dace? (F)

5.6.1 Umatilla Dace

5.6.1.1 Spawning Behaviour

It is unknown at this time if water level fluctuations affect Umatilla Dace spawning behaviour since actual spawning behaviour was not directly observed nor were fertilized eggs observed during the spawning season. However, Umatilla Dace were observed in spawning condition on the Slocan River in 2011, 2012 and 2013. This was the first time that these observations have been made in the wild (Haas 2001; D. McPhail, pers. comm., 2011). Males in spawning condition displayed orange pigmentation on their lips as well as on their pelvic and pectoral fin insertions and many expressed milt when slight pressure was applied to their abdomen. Females in spawning condition displayed bright red colouration on their lips and snout area and some females with these characteristics also expressed eggs. Spawn timing in the Slocan River, based on the presence of ripe fish, was estimated to occur from early-July through to mid-September along the descending limb of the hydrograph and when water temperatures were between 16°C and 21°C. Mature fish in spawning condition were not observed in the regulated LCR study area at this time despite expending high amounts of sampling effort during the spawning period. Twenty-nine Umatilla Dace larger than 55 mm fork length, the smallest length of a mature fish observed in the Slocan River, were located in the LCR study area, but none were mature. Based on observations taken in the Slocan River, it is estimated that spawning in the LCR study area may occur from early July to mid-September as water levels are receding following freshet.

5.6.1.2 Embryo Survival

Information for Umatilla Dace embryo survival was not obtained during the present study, since fertilized eggs were not observed during this study. Newly fertilized eggs are adhesive and about 2 mm in diameter (McPhail 2003, 2007). In the laboratory, Umatilla Dace eggs were observed to be very adhesive and easily damaged (Haas 2001). Hatching also occurred over a two day period and time to hatching at 18ºC ranged from 5 to 7 days (Haas 2001). Fry are approximately 7 mm when they hatch (McPhail 2003, 2007). It is likely that Umatilla Dace fry spend a week in the gravel after hatching before they emerge (McPhail 2003, 2007).

5.6.1.3 Adult Nest Guarding Behaviour

It is not known whether Umatilla Dace build and guard nests during the spawning period since direct observations were not obtained during the present study. Haas (2001) observed Umatilla Dace spawning under laboratory conditions, but detailed information on spawning behaviour and habitat was not provided. Spawning has not been observed in the wild.

5.6.2 Columbia Sculpin

5.6.2.1 Spawning Behaviour

Changes to the hydrograph in the regulated LCR may affect Columbia Sculpin spawning behaviour in terms of spawn timing. However, actual spawning behaviours (colouration, nest guarding and polygynous spawning behaviour) have not been observed to be affected at this time.

Columbia Sculpins in the unregulated Similkameen system were observed spawning during the descending limb of the hydrograph when water temperatures were between 8°C and 15°C. Even though different flow regimes were observed at index sites on the Similkameen system, the onset of spawning was triggered when water temperatures reached approximately 8°C (AMEC 2010b). In the regulated LCR study area, spawn timing for Columbia Sculpins occurred predominantly during the ascending limb of the hydrograph through to peak discharge when water temperatures were between 9.5°C and 15°C (early June to late July).

Spawning behaviour for Columbia Sculpins in both the regulated and unregulated systems were similar to what has been reported for this species. That is, breeding colouration was observed in adult male Columbia Sculpins that were guarding nests. Breeding males' entire bodies are black except for a band of orange along the upper tip of the first dorsal fin (McPhail 2007). Breeding females do not develop this obvious spawning colouration although they have noticeable swollen abdomens (McPhail 2007). Male sculpins are territorial and guard nests under rocks (McPhail 2007). Female sculpins deposit their adhesive eggs in a clump on the underside of the nest rock and the male fertilizes them and guards the nest until they hatch (McPhail 2007). Like many sculpin species, Columbia Sculpins are polygynous (McPhail 2007) and most of the Columbia Sculpin nests observed in both systems during this program had more than one clump of eggs indicating that more than one female deposited its eggs at the nest rock. In addition, mature Columbia Sculpin males were observed to move very little at index sites on the Similkameen system during the spawning period as they were likely guarding their nests. Spawning movements for tagged Columbia Sculpins in the LCR study area were not available due to the low number of observations collected during PIT tracking at index sites during the spawning period as increasing water levels made previously located nests inaccessible.

5.6.2.2 Embryo Survival

Flow manipulation through the sculpin spawning period may cause microhabitat changes at sculpin nest rock locations and result in lowered egg survival for Columbia Sculpins. However, it is not clear at this time whether lowered embryo survival was directly linked to water level fluctuations. In the LCR study area, Columbia Sculpin nests (n=7) contained predominantly viable eggs (mean percent survival = 93%). Nests with survival over 99% (n=5) were located at LCR_8.2L, LCR_10.5L and LCR_24.5R at stages of development ranging from freshly deposited to near hatching. The two nests with lower survival (82% and 70%) were located at LCR_24.5R in 2013 and 2011, respectively. Egg survival for Columbia Sculpins in natural systems is high. For example, in the Similkameen system egg survival ranged between 95% and 99% (AMEC 2010b). Larvae were often observed moving inside captured eggs from the

Similkameen system indicative of survival to hatch. Hatch rate may also be quite high as almost all of the eggs collected in the Similkameen system hatched directly in the sample bags they were collected in.

Information collected at 79 sculpin nest locations in the LCR study area may provide insight on general trends in embryo survival in the LCR, since these nests may have belonged to Columbia, Shorthead or Torrent Sculpins. Nests located in the upper LCR study area (i.e., LCR_1.6L, LCR_2.8L, LCR_8.2L and LCR_10.5L) had embryo survival rates generally greater than 98%, consistent with those observed in the Similkameen, though LCR_2.8L and LCR_10.5L had slightly lower survival in 2012 and 2013, respectively. However, downstream at LCR_24.5R (Genelle Index Site) egg survival for sculpin nests varied between 0 and 100% and averaged 19%, 57% and 79% in 2010, 2011 and 2013, respectively. Such low egg survival had not previously been reported for sculpins (D. McPhail, pers. comm., 2011).

An early peak and then recession of discharge in the LCR study area in 2013 resulted in 100% mortality of dewatered nests observed at LCR_2.8L, LCR_10.5L and LCR_24.5R. Inspection of the hydrograph indicates that it was unlikely that nests at LCR_24.5R became dewatered during the spawning periods in 2010, 2011 and 2012. In 2010, it was noted that nests were present near thick green algae, which covered some of the nest rocks, but it was not clear if survival rates were different on nest rocks with or without algae. At night, algae absorb oxygen and this pulse in low oxygen may affect egg survival (D. McPhail, pers. comm., 2010). In 2011, algae were not observed on the nest rocks as it had been the previous year. Additionally, nests with high egg survival located at LCR_10.5L, which is in an area with abundant Dydimo (*Didymosphenia geminata*). In addition, oxygen levels remained consistent throughout the spawning period at LCR_24.5R in 2013, suggesting that algae cover (and potentially low oxygen levels) was not the cause of the low nest survival observed. The nearshore and shoreline areas at this site (LCR_24.5R) consist of a series of cobble/boulder groynes that create a series of back eddies (Photo 4 in AMEC 2011), but the size of these back eddies vary with discharge. Therefore, a sculpin nest spawned at this site in run habitat with constantly flowing, oxygenated water may end up in a stagnant, warm pool as water levels change. The majority of nest locations monitored at LCR_24.5R in 2011 and 2013 were originally located in run habitat, but when reassessed 5-7 days later water levels were shallower, and velocities were slower and habitats were re-classified as 'pool'.

5.6.2.3 Adult Nest Guarding Behaviour

Dewatering of sculpin nests may affect nest guarding behaviour as males may abandon nests or not be able to perform typical nest guarding duties depending on resulting conditions. In 2013, male sculpins (including Columbia sculpins) abandoned their nests to presumably avoid becoming stranded and did not return once nests became re-wetted and nests were no longer viable.

In 2010 at LCR_24.5R, 11 spawning sculpins were observed guarding their nests even though the majority of eggs on these nests were dead and/or fungused. The low embryo survival at these nests suggests that males were not able to adequately perform typical nest guarding behaviours even though they remained with the nest. Males will guard nests by attacking potential intruders that approach the nest. They will also fan the eggs with their pectoral fins and clean the surface of the eggs with their anal fin by undulating their body laterally while upside-down under the nest rock (Goto 1988). The reason why males at LCR_24.5R were unable to perform these activities may be the result of the environmental factors observed at this location as suggested in Section 5.6.2.2.

5.6.3 Shorthead Sculpin

5.6.3.1 Spawning Behaviour

Changes to the hydrograph in the regulated LCR may affect Shorthead Sculpin spawning behaviour, in terms of spawn timing, compared to unregulated systems. However, actual spawning behaviour has not been observed to be affected at this time.

Shorthead Sculpins were observed to spawn in the unregulated Pass Creek from late June to late July when water temperatures were between 8°C and 15°C. Spawning was observed during the period when flows had likely just peaked and were beginning to recede. In the regulated LCR study area, spawning occurred during the same period as observed for Columbia Sculpins. That is, spawning occurred during the ascending limb of the hydrograph through peak discharge when water temperatures were between 9.5°C and 15°C (late May to late July).

Spawning behaviour for Shorthead Sculpins in both the regulated and unregulated systems were similar to what has been reported for this species. Male Shorthead Sculpins were territorial and were found under rocks (McPhail 2007). Adhesive eggs were observed in clumps on the underside of a male's nest rock (McPhail 2007). Male's were observed to be guarding their nests until the eggs hatched (McPhail 2007; see below). In British Columbia streams, nests contained several clumps of eggs suggesting that they are polygynous like other sculpin species (McPhail 2007). Shorthead Sculpin nests in both the unregulated and regulated system were also observed to contain more than one clump of eggs during this program.

5.6.3.2 Embryo Survival

Seasonal water level fluctuations have been observed to affect embryo survival for Shorthead Sculpins in the unregulated Pass Creek. In 2010, one nest was observed to be dewatered as water levels declined during spring freshet. The nest was still being guarded by the male (see below) and contained four egg masses with approximately 375 eyed, unmoving eggs of which 12 were dead. A small pool of water, elevated in temperature (21°C compared to 8°C in Pass Creek), remained under the rock, covering both the sculpin and his nest, but even if the larvae hatched it was unlikely that they could have survived because the nest was not connected to the flowing mainstem (AMEC 2011). However, other nests in Pass Creek were observed to have high egg survival (>95%) at that time. In the regulated LCR study area, five Shorthead Sculpin nests observed in 2011 and 2013 had high egg survival (>98%). As per Columbia Sculpins, it is possible that nests with low embryo survival observed at LCR_24.5R belonged to Shorthead Sculpins (Section 5.6.2.2).

5.6.3.3 Adult Nest Guarding Behaviour

Seasonal flow fluctuations may or may not alter the nest guarding behaviour of Shorthead Sculpins. That is, adult nest guarding behaviour was prevalent even when a Shorthead Sculpin nest was dewatered and stranded from the mainstem as observed in unregulated Pass Creek. One PIT tagged male Shorthead Sculpin was observed to be guarding its nest in an area stranded from the mainstem of Pass Creek on July 14, 2010 (Section 5.6.3.2). Water levels were declining in Pass Creek after the spring freshet. However, male sculpins were not located at 12 of 13 dewatered nests in the LCR study area in 2013 suggesting flow fluctuations can alter nest guarding behaviour (Section 5.6.2.3).

In the LCR study area, 11 spawning sculpins were observed guarding their nests at LCR_24.5R even though the majority of eggs on these nests were dead and/or fungused. It is possible that male sculpins were unable to perform typical nest guarding behaviour thus resulting in low embryo survival at this location (Section 5.6.2.3).

5.7 How do water level fluctuations (diel and seasonal) in the lower Columbia River affect the distribution and habitat use of sculpins and dace, especially the listed species? (#1)

5.7.1 Dace

It is inconclusive at this time whether water level fluctuations at HLK influence the short-term distribution and habitat use of dace located in shallow shoreline areas that are at risk of dewatering. Low numbers of Longnose and Umatilla dace were tagged and relocated during this study program. Preliminary information indicates that dace were located in shallower habitats during flow fluctuations in spring, but they were still within suitable habitats identified during this program. Mature Umatilla Dace were more active during the spring and summer periods and moved into nearshore areas for shelter, foraging and/or spawning, which may make them more prone to flow fluctuations during these seasons. This would be similar for juvenile and YOY life stages as they used the same habitats as adults during the spring/summer high water period. However, adults in the Slocan River used deeper locations that were farther from shore during the day in summer, which may be more favourable during daytime flow fluctuations. The one Longnose Dace that was relocated during a winter flow reduction at HLK remained in the same location because this area stayed wetted afterwards. Dace YOY were close to shore during all seasons in the LCR. YOY were most abundant in nearshore areas during the low-flow fall and moderate-flow winter periods. YOY were observed using flooded areas of silt and terrestrial vegetation during winter in the LCR, a habitat that is not available in unimpounded systems where discharge and water level is lowest during winter. Additional information about dace habitat use in the LCR is provided in Sections 5.3, 5.5, and 5.10.

5.7.2 Sculpins

Water level fluctuations at HLK may influence the short-term distribution of sculpins during fall and spring, but habitat use was still within suitability criteria determined during this program, for all seasons. During fall flow fluctuations at HLK, sculpins moved more frequently (0.10 m/hr) compared to movements observed not related to flow fluctuations (0.03-0.04 m/hr) during the same season. During spring flow reductions at HLK, sculpins were located in shallower locations during flow reductions, often because they remained in the same location as water levels dropped, but redistributed to depths similar to those observed prior; all depths were within the suitability criteria for sculpins in the LCR. During spring and winter, the rate of movements made during winter HLK flow reductions were not found to differ from post-flow reduction or seasonal movement rates. That is, tagged fish did not move more or less frequently or distribute themselves differently during flow reduction sampling compared to other periods.

Only one Torrent Sculpin was relocated during the two summer flow reduction sampling surveys conducted. This fish did not move during the flow fluctuation, but was observed in shallower, slower water during and after the flow reduction. Additional information about sculpin habitat use in the LCR is provided in Sections 5.3, 5.5 and 5.10.

5.8 What seasonal and diel habitat shifts do sculpins and dace (especially the listed species) make in response to water level fluctuations? (#2)

5.8.1 Dace

In the unregulated Slocan River, seasonal habitat shifts were observed for Umatilla Dace as they have been captured in areas of terrestrial vegetation that is seasonally flooded during freshet. Diel habitat shifts have only been observed for Umatilla Dace in the Slocan River during the daytime summer period when they were observed using deeper habitats that were further from shore compared to night and dusk, respectively, but these were not related to flow fluctuations.

In the LCR, dace movements during flow fluctuations indicated that habitat shifts were no different than during regular tracking surveys, but this is based on a very small sample size. Further information is provided in Sections 5.3 and 5.4.

5.8.2 Sculpins

In the unregulated systems, seasonal and diel shifts in habitat use were not commonly observed for sculpins. In the Similkameen River system, seasonal habitat shifts were not observed during peak flows in spring and during low flows (summer through the early spring period; AMEC 2010b). This finding was consistent for Shorthead Sculpins in Pass Creek, where they were observed in similar diel and seasonal habitats (AMEC 2011).

In the regulated LCR, tagged sculpins moved away from areas that became dewatered during HLK flow fluctuations, with the majority of displacements often only a few meters from their original location and directed toward the thalweg. Sculpins were also observed to move during reductions if they were in locations that did not dewater; however, these movements were less common and fish often remained in the same location. Because these movements were often only a few meters from their original locations, habitat use did not differ and was similar to suitability criteria determined during this program. Further information is provided in Sections 5.3 and 5.4.

5.9 Do the operations of Hugh L. Keenleyside Dam alter these natural movements? Specifically, does this risk of stranding increase? (#3)

The operations of HLK increased the movement rates of tagged sculpins during fall and influenced the direction of movements during spring and winter. However, this did not increase their risk of stranding because tagged sculpins moved away from areas that became dewatered towards the deeper thalweg. Sculpins were also observed to move during reductions if they were in locations that did not dewater, however, these movements were less common and fish often remained in the same location. Changes in river discharge have been linked to behavioural changes in fishes, including movement towards particular habitats. For example, Natsumeda (2007) observed that Japanese sculpins were more mobile and made more movements in an upstream direction and over a weir during high flow years compared to low flow years.

Increased movements during flow fluctuations that are outside observed natural movement rates for sculpins during fall may have implications on energetics (Webb 1986), since fish are moving more often to avoid stranding, but not using this energy for foraging and/or predator avoidance. During fall flow fluctuations a higher proportion of sculpins moved (71%) compared to those that did not (29%). This differed during fall regular tracking surveys where a higher proportion did not move (68%) compared to those that moved (32%). The majority of movements were directed towards the thalweg (47%) during flow reductions as sculpins relocated to deeper areas.

Change in the direction of movements that are outside observed natural movements during spring may interfere with pre-spawning activities. However, HLK flow reductions that occurred in spring (early April) were at least one month prior to observed sculpin spawning on the LCR. Spring is a time when sculpins are in spawning condition and the spawning period begins. Males are setting up territories and looking for nest rocks to attract females, whereas females are choosing males to spawn with.

While most tagged sculpins did not make discernible movements during regular (62%) and flow fluctuation (54%) tracking surveys in spring, the direction of movement for fish that did move was different during flow fluctuations compared to non-flow related movements. For example, the fish that did move during regular tracking surveys were predominantly directed toward shore (14%) with few moving away from shore (5%). During flow fluctuations fish that moved were less likely to move toward the shore (1%) and the majority of movements were directed away from shore (15%). While this movement away from shore likely reduced their risk of becoming stranded in areas that were dewatering, pre-spawning activities could have been interrupted and/or delayed. The disruption of spawning by flow changes has been related to the abandonment of spawning sites (Hamilton and Buell 1976 as cited in Nelson 1986), untimely or obstructed migration (Young et al. 2011 and references within), fewer reproduction events (John 1963) and poor yearly recruitment (Nelson 1986, Stalnaker et al. 1996, Young et al. 2011 and references within). However, few direct studies have been conducted and most are based on salmonids.

Movements that are outside observed natural movements during winter may also impact fish energetics (see above). Winter is often a period of inactivity for many riverine fishes because lowered water temperatures cause metabolic rates to decline so fish tend to remain more dormant as they require fewer food resources (Coutant 1976, McCullough et al. 2009). Fishes are likely more prone to stranding during winter because of this behaviour (e.g., Bradford 1997). In the LCR, the majority of tagged sculpins (85%) did not make discernible movements during regular winter tracking surveys. However, during flow fluctuation tracking surveys, fewer tagged sculpins remained in their original locations (32%) while the majority moved away from shore (39%). However, observations during this study suggest winter use of nearshore habitat by sculpins is low. During nearly all winter flow reduction tracking surveys, more sculpins were located in nearshore areas after water levels dropped and deeper locations were accessible. Additionally, catch-rates of sculpins was low during winter compared to other seasons. Discharge at HLK generally increases from November through December and it is possible that sculpins remain in overwintering locations established prior to these increases thus reducing the risk of stranding at this time. We cannot conclude whether operations at HLK alter the natural movements of dace because limited information exists at this time. Also, it is inconclusive whether sculpin movements during the summer are affected by operations due to low sample sizes obtained during this season. Additional information on stranding risk is provided in Section 5.10.

5.10 Which operations, and at what season, pose the highest risk of stranding or interference with the normal life cycles of sculpins and dace? (#4)

The highest risk of stranding and interference with the normal life cycles of sculpins and dace occurs during the spawning, incubation and early rearing period (May-August in the LCR) for these species. This finding is supported by the current study as well as the broader analysis of CLBMON-42 pool stranding observations (Thorley 2014).

Rapid flow reductions between June and August pose the highest risk of stranding for these species when they are actively spawning through to the early rearing period. More rapid decreases during the descending hydrograph phase were observed in 2012 and 2013 in the LCR, but these years also had highest observable flows during the current study. In 2012, LCR water level was influenced by flow reductions from both HLK and the Kootenay River in late July through September, whereas in 2013 it was influenced by a flow reduction from the Kootenay River in June and HLK reductions during July through September (Figure 3). It is suspected that rapid declines during this period in 2013 caused dewatering of numerous sculpin nests in the LCR (Section 5.6.2.3) and in turn caused 100% embryo mortality; male sculpins guarding nests also became dewatered at this time, but often moved to deeper areas to avoid becoming stranded. Embryo survival may also have been affected by the rapid hydrograph declines in 2012, but low embryo survival was also observed in 2011 and was unrelated to the hydrograph (Section 5.6.1.2).

Although direct stranding observations of spawning Umatilla Dace were not observed in the LCR, it is likely that spawning Umatilla Dace are not as prone to stranding as nest guarding sculpins. During summer, adults were closest to shore at dusk to spawn or forage, but returned to deeper habitats away from shore during the day, therefore making them less prone to strand during daytime flow fluctuations.

Younger life stages of sculpins and dace are at higher risk for stranding during the spring/summer period as they move into nearshore areas to forage and grow in warmer shallow waters, making them prone to stranding. Recently emerged dace YOY using seasonally flooded terrestrial areas have been observed stranded in pools near Beaver Creek mouth as the LCR receded in summer (AMEC 2011). In the LCR, all life stages of sculpins and juvenile/YOY dace species were observed to be prone to stranding below HLK during rapid discharge reductions (R.L.&L. 1995) and are often observed during fish salvage activities conducted below HLK (Golder 2013).

Increased pool stranding risk for all life stages of sculpins and juvenile/YOY dace may also occur during HLK operations where the magnitude of the drop is >500 m^3/s (18 kcfs), especially during lower river stages that are <20% MAD (Section 4.8.2). Although these conditions were not observed during the present study, they are still variables to consider for relative risk of pool stranding. Using 10 years of data collected in the LCR (CLBMON-42), Irvine et al. (2014) observed that the highest probability of pool stranding (all fish species) resulted from a large magnitude reduction completed in the afternoon in midsummer at low water levels when the nearshore had been inundated for a long period. Direct experiments conducted in the study area using native fish species (including sculpins and dace) to determine factors influencing fish stranding found that higher natural fish density, longer periods of wetted history and higher ramping rates all led to higher probabilities of pool stranding (Irvine et al. 2008). However, none of the factors were significant in predicting the probability of these species becoming stranded interstitially (Irvine et al. 2008), which may be more important for benthic species such as sculpins that are associated with larger cobble substrates that are prone to trap fish interstitially (Bell et al. 2008).

6 RECOMMENDATIONS

The following are recommended to help address knowledge gaps that remain for this program:

- Expend additional river-wide/systematic effort to locate adult Umatilla Dace in spawning condition in the LCR study area between mid-July and mid-August. A survey consisting of predominantly minnow trapping in both deep and shallow areas targeting areas with aquatic macrophytes and/or flooded vegetation is recommended.
- Evaluate sculpin embryo survival at locations downstream of LCR_24.5R to determine if low nest survival is a trend in downstream areas of the LCR.
- Ensure that information collected during interstitial stranding surveys (CLBMON-42 or other studies) is proportional to the total amount of habitat exposed in order to evaluate overall interstitial stranding risk. Interstitial stranding surveys could be focused in locations where high risk of pool stranding of dace and sculpins was identified: Kootenay River (Koot_0.4L and Koot_0.5R); Norn's Creek Fan (LCR_7.0L); Tin Cup Rapids (LCR_9.0L); Millenium Park (LCR_10.0R); Genelle Mainland (LCR_24.0R); Genelle Lower Cobble Island (LCR_26.0M); Birchbank Snye (LCR_30.0R); Gyro Boat Launch (LCR_38.0L); and, Fort Shepherd Launch (LCR_54.0L).

In addition, the following are suggestions for lowering stranding risk to sculpins and dace:

- Limit rapid water level reductions (or ensure more gradual, step-wise reductions) in the LCR between mid-May and mid-July, when possible. Sculpin nests, likely including those of Shorthead and Columbia Sculpins, were observed dewatered and desiccated following early/mid-June flow reductions. Male Shorthead and Torrent Sculpins were also observed to become stranded by remaining with nests that became dewatered.
- Reduce water levels to meet treaty requirements for Rainbow Trout spawning protection during winter rather than spring (April 1), when possible. Flow reductions during winter will have less influence on sculpin spawning behaviour than during spring.
- Maintain recontoured sites in the LCR as this mitigation was found to lower the risk of stranding sculpins.

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Personal Communications

McPhail, D. Professor Emeritis, University of British Columbia. Telephone Conversation: 2010.

Irvine, R. Statistical Ecologist, Poisson Consulting Ltd. Telephone Conversation: 2014.

APPENDIX A

Survey Summary (Year 5)

Table A1. Lower Columbia River (LCR) study area survey information, 2013-2014.

Waterbody	Site Name[1]	Descriptive Site Name[1]	Sample Date	Crew[2]	Survey Methods[3]	Effort (hours)	EF Seconds[3]	Flow Reduction	Day/ Night	Water Temp (°C)	Comments[4]
LCR	LCR_10.5L	CLB LB US Koot Mouth	25-Mar-13	CL, CT	EF1		2524	No	Day	5.1	Efished + 75 m on Koot side of site. Tagged fish released on 25-Mar-13 at 15:30 at 11U 0452624/ 5462896.
LCR	LCR_24.5R	Genelle Index Site	25-Mar-13	CL, CT	EF1		1641	No	Day	4.4	Efished + 50 m upstream of regular site. Tagged fish released at 12:00 25-Mar-13 at 11U 0450003/ 5450703.
LCR	LCR_24.5R	Genelle Index Site	8-May-13	CL, KF	EF1		1986	No	Day	9.1	UTM release location: 450009/5450707. Recaptured fish release location: 11U 449967/5450692.
LCR	LCR_24.5R	Genelle Index Site	8-May-13	CL, KF	TR1	1.4		No	Day	9.1	Water very silty due to high temperatures and rapid run-off.
LCR	LCR_10.5L	CLB LB US Koot Mouth	9-May-13	CL, KF	EF1		1655	No	Day	9.9	
LCR	LCR_10.5L	CLB LB US Koot Mouth	9-May-13	CL, KF	TR1	1.7		No	Day	9.9	
Kootenay River	Koot_0.5R	Kootenay River RB	22-May-13	CL, KF	EF1		760	No	Night	10.1	
LCR	LCR_10.5L	CLB LB US Koot Mouth	22-May-13	CL, KF	TR1	1.3		No	Night	10.5	
Kootenay River	Koot_0.5R	Kootenay River RB	23-May-13	CL, KF	EF1		447	No	Day	10.7	
Kootenay River	Koot_0.5R	Kootenay River RB	23-May-13	CL, KF	MT1, MT2, MT3, MT4, MT5, MT6, MT7	21.0		No	Overnight	10.7	
LCR	LCR_10.5L	CLB LB US Koot Mouth	23-May-13	CL, KF	TR1	1.3		No	Day	10.1	DO reading: 9.75 mg/L
LCR	LCR_24.5R	Genelle Index Site	23-May-13	CL, KF	TR1	1.3		No	Day	8.9	DO reading: 10.73 mg/L
LCR	LCR_10.5L	CLB LB US Koot Mouth	24-May-13	CL, KF	SW1	1.0		No	Day	8.9	
LCR	LCR_10.5L	CLB LB US Koot Mouth	24-May-13	CL, KF	TR1	1.0		No	Day	8.9	
LCR	LCR_24.5R	Genelle Index Site	24-May-13	CL, KF	SW1	1.3		No	Day	8.8	
LCR	LCR_24.5R	Genelle Index Site	24-May-13	CL, KF	TR1	1.3		No	Day	8.8	
LCR	LCR_10.5L	CLB LB US Koot Mouth	5-Jun-13	CL, KF	SW1	1.1		No	Day	12.3	DO: 11.40 mg/L.
LCR	LCR_10.5L	CLB LB US Koot Mouth	5-Jun-13	CL, KF	TR1	2.2		No	Day	12.3	DO: 11.40 mg/L.
LCR	LCR_24.5R	Genelle Index Site	5-Jun-13	CL, KF	SW1	1.6		No	Day	11.7	DO: 11.20 mg/L.
LCR	LCR_24.5R	Genelle Index Site	5-Jun-13	CL, KF	TR1	1.5		No	Day	11.7	DO: 11.20 mg/L.
Kootenay River	Koot_0.5R	Kootenay River RB	12-Jun-13	CL, KF	MT1, MT2, MT3, MT4, MT5	17.6		No	Overnight	14.3	
LCR	LCR_2.8L	Unk Trib Mouth Robson	12-Jun-13	CL, KF	MT1, MT2, MT3, MT4, MT5	17.3		No	Overnight	15.1	
LCR	LCR_24.5R	Genelle Index Site	12-Jun-13	CL, KF	SW1	1.8		No	Day	13.6	
LCR	LCR_24.5R	Genelle Index Site	12-Jun-13	CL, KF	TR1	1.3		No	Day	13.6	
LCR	LCR_24.5R	Genelle Index Site	12-Jun-13	CL, KF	VO1	2.7		No	Day	13.6	
LCR	LCR_47.5L	Beaver Creek Mouth	12-Jun-13	CL, KF	MT1, MT2, MT3, MT4, MT5	17.7		No	Overnight	14.1	
LCR	LCR_53.1L	Fort Sheppard Boat Launch	12-Jun-13	CL, KF	MT1, MT2, MT3, MT4, MT5	16.8		No	Overnight	14.5	
LCR	LCR_10.5L	CLB LB US Koot Mouth	13-Jun-13	CL, KF	TR1	2.1		No	Day	14.6	Not a flow reduction survey, but there was a flow reduction out of the Kootenay overnight.
LCR	LCR_10.5L	CLB LB US Koot Mouth	13-Jun-13	CL, KF	VO1	2.4		No	Day	14.6	Not a flow reduction survey, but there was a flow reduction out of the Kootenay overnight.
LCR	LCR_2.8L	Unk Trib Mouth Robson	13-Jun-13	CL, KF	VO1	0.1		No	Day	15.1	Shoreline check for stranded nests.
LCR	LCR_24.5R	Genelle Index Site	13-Jun-13	CL, KF	VO1	0.5		No	Day	13.4	Nest re-check following ~0.3 cm vert. drop in water level. Temp. logger downstream in 0.01 m of water, upstream logger dewatered.
LCR	LCR_10.5L	CLB LB US Koot Mouth	19-Jun-13	CL, KF	SW1	1.1		No	Day	13	DO: 10.32 mg/L
LCR	LCR_24.5R	Genelle Index Site	19-Jun-13	CL, KF	SW1	2.0		No	Day	12.4	DO: 10.93 mg/L
LCR	LCR_24.5R	Genelle Index Site	19-Jun-13	CL, KF	VO1	0.4		No	Day	12.4	DO: 10.93 mg/L
LCR	LCR_1.6L	Rialto Creek Mouth DS	26-Jun-13	CL, KF	SW1	0.8		No	Day	12.8	Net searches- one nest located.
LCR	LCR_2.8L	Unk Trib Mouth Robson	26-Jun-13	CL, KF	SW1	1.0		No	Day	13.4	Covered same area as previous survey; water level is higher and only one nest observed.
LCR	LCR_10.5L	CLB LB US Koot Mouth	27-Jun-13	CL, KF	SW1	1.3		No	Day	12.5	Tracked 20 m upstream of usual site end.
LCR	LCR_10.5L	CLB LB US Koot Mouth	27-Jun-13	CL, KF	TR1	1.3		No	Day	12.5	Tracked 20 m upstream of usual site end.
LCR	LCR_24.5R	Genelle Index Site	27-Jun-13	CL, KF	SW1	1.6		No	Day	11.9	DO reading: 9.75 mg/L
LCR	LCR_24.5R	Genelle Index Site	27-Jun-13	CL, KF	TR1	1.5		No	Day	11.9	DO reading: 9.75 mg/L
Kootenay River	Koot_0.5R	Kootenay River RB	10-Jul-13	CL, KF	MT1, MT2, MT3, MT4, MT5	19.5		No	Overnight	16.6	
LCR	LCR_2.8L	Unk Trib Mouth Robson	10-Jul-13	CL, KF	MT1, MT2, MT3, MT4, MT5	20.4		No	Overnight	15.6	Upstream of unknown creek mouth. Photo 22: site overview.
LCR	LCR_25.1R	Genelle	10-Jul-13	CL, KF	MT1, MT2, MT3, MT4, MT5	18.8		No	Overnight	19.5	Site sampled is directly next to trailer park (index site inaccesible due to high water).
LCR	LCR_47.5L	Beaver Creek Mouth	10-Jul-13	CL, KF	MT1, MT2, MT3, MT4, MT5	21.2		No	Overnight	18.9	
LCR	LCR_53.1L	Fort Sheppard Boat Launch	10-Jul-13	CL, KF	MT1, MT2, MT3, MT4, MT5	20.3		No	Overnight	16.7	
Kootenay River	Koot_0.5R	Kootenay River RB	11-Jul-13	CL, KF	EF1		343	No	Day	16.7	
LCR	LCR_47.5L	Beaver Creek Mouth	11-Jul-13	CL, KF	EF1		637	No	Day	18.8	Photo 23- site overview.
LCR	LCR_47.5L	Beaver Creek Mouth	11-Jul-13	CL, KF	LS1			No	Day	18.8	Photo 23- site overview.
Kootenay River	Koot_0.3L	Kootenay Oxbow	1-Aug-13	CL, CT	MT1, MT2, MT3, MT4, MT5	17.6		No	Overnight	20.3	
Kootenay River	Koot_0.5R	Kootenay River RB	1-Aug-13	CL, CT	EF1		446	No	Day	18.8	
Kootenay River	Koot_0.5R	Kootenay River RB	1-Aug-13	CL, CT	MT1, MT2, MT3, MT4, MT5	20.2		No	Overnight	18	
Kootenay River	LCR_47.5L	Beaver Creek Mouth	1-Aug-13	CL, CT	MT1, MT2, MT3, MT4, MT5	20.7		No	Overnight	17.3	
LCR	LCR_10.5L	CLB LB US Koot Mouth	1-Aug-13	CL, CT	TR1	1.3		No	Day	18.4	
LCR	LCR_25.1R	Genelle	1-Aug-13	CL, CT	MT1, MT2, MT3, MT4, MT5	20.8		No	Overnight	18.5	
LCR	LCR_24.5R	Genelle Index Site	2-Aug-13	CL, CT	TR1	1.1		No	Day	17	Pre flow reduction.

Table A1 continued

Waterbody	Site Name[1]	Descriptive Site Name[1]	Sample Date	Crew[2]	Survey Methods[3]	Effort (hours)	EF Seconds[3]	Flow Reduction	Day/ Night	Water Temp (°C)	Comments[4]
LCR	LCR_10.5L	CLB LB US Koot Mouth	3-Aug-13	CL, RK	TR1	1.3		Yes	Day	18.8	
LCR	LCR_24.5R	Genelle Index Site	3-Aug-13	CL, RK	TR1	0.8		Yes	Day	16.9	NFC (one dead tag).
Kootenay River	Koot_0.2R	Kootenay River Mouth RB	7-Aug-13	CL, KF	SW1	0.6		No	Day	21.4	
Kootenay River	Koot_0.5R	Kootenay River RB	7-Aug-13	CL, KF	EF1		613	No	Night	20.1	
Kootenay River	Koot_0.5R	Kootenay River RB	7-Aug-13	CL, KF	EF1		366	No	Day	21.4	Thousands of suckers and LNC.
LCR	LCR_10.5L	CLB LB US Koot Mouth	7-Aug-13	CL, KF	SW1	0.8		No	Day	19.8	
LCR	LCR_10.5L	CLB LB US Koot Mouth	7-Aug-13	CL, KF	TR1	0.9		No	Day	19.8	
LCR	LCR_10.5L	CLB LB US Koot Mouth	7-Aug-13	CL, KF	TR1	1.0		No	Night	19.9	All fish observed were actively moving.
LCR	LCR_24.5R	Genelle Index Site	7-Aug-13	CL, KF	TR1	1.5		No	Day	18.4	NFC.
LCR	LCR_10.5L	CLB LB US Koot Mouth	8-Aug-13	CL, KF	TR1	1.1		No	Day	20.1	
LCR	LCR_24.5R	Genelle Index Site	8-Aug-13	CL, KF	EF1		771	No	Day	19.5	
Kootenay River	Koot_0.5R	Kootenay River RB	14-Aug-13	CL, KF	MT1, MT2, MT3, MT4, MT5	19.2		No	Overnight	21.1	
LCR	LCR_10.5L	CLB LB US Koot Mouth	14-Aug-13	CL, KF	EF1		1144	No	Day	19.4	
LCR	LCR_24.5R	Genelle Index Site	14-Aug-13	CL, KF	EF1		1476	No	Day	19.5	
Kootenay River	Koot_0.6R	Kootenay RB site	15-Aug-13	CL, KF	EF1		551	No	Day	20.7	
LCR	LCR_2.8L	Unk Trib Mouth Robson	15-Aug-13	CL, KF	SW1	0.7		No	Day	17.7	
LCR	LCR_10.5L	CLB LB US Koot Mouth	29-Aug-13	KF, CT	TR1	1.2		No	Day	18	
LCR	LCR_24.5R	Genelle Index Site	29-Aug-13	KF, CT	TR1	1.6		No	Day	18	
LCR	LCR_10.5L	CLB LB US Koot Mouth	30-Aug-13	KF, CT	TR1	1.5		No	Day	18.5	
LCR	LCR_24.5R	Genelle Index Site	30-Aug-13	KF, CT	TR1	1.5		No	Day	18.5	
LCR	LCR_10.5L	CLB LB US Koot Mouth	11-Sep-13	CL, KF	EF1		1447	No	Day	19.7	Joanne Fisher from CCRIFC joined us.
LCR	LCR_24.5R	Genelle Index Site	11-Sep-13	CL, KF	EF1		2079	No	Day	18	Joanne Fisher from CCRIFC joined us.
LCR	LCR_10.5L	CLB LB US Koot Mouth	12-Sep-13	CL, KF	EF1		1358	No	Day	17.3	Joanne Fisher from CCRIFC joined us.
LCR	LCR_10.5L	CLB LB US Koot Mouth	19-Sep-13	CL, KF	TR1	1.6		No	Day	18.4	Pre flow reduction.
LCR	LCR_24.5R	Genelle Index Site	19-Sep-13	CL, KF	TR1	1.3		No	Day	16.4	Pre flow reduction.
LCR	LCR_10.5L	CLB LB US Koot Mouth	20-Sep-13	KF, CT	TR1	1.4		No	Day	18.3	Pre flow reduction.
LCR	LCR_24.5R	Genelle Index Site	20-Sep-13	KF, CT	TR1	1.3		No	Day	15.3	Pre flow reduction tracking.
LCR	LCR_10.5L	CLB LB US Koot Mouth	21-Sep-13	CL, KF	TR1	2.0		Yes	Day	17.5	Post flow reduction: ended at 10:00.
LCR	LCR_24.5R	Genelle Index Site	21-Sep-13	CL, KF	TR1	1.4		Yes	Day	15.9	Post flow reduction tracking.
Kootenay River	Koot_0.5R	Kootenay River RB	25-Sep-13	CL, KF	MT1, MT2, MT3, MT4, MT5	22.5		No	Overnight	17	
LCR	LCR_47.5L	Beaver Creek Mouth	25-Sep-13	CL, KF	MT1, MT2, MT3, MT4, MT5	18.9		No	Overnight	10.3	
LCR	LCR_53.1L	Fort Sheppard Boat Launch	25-Sep-13	CL, KF	MT1, MT2, MT3, MT4, MT5	18.9		No	Overnight	14	
LCR	LCR_10.5L	CLB LB US Koot Mouth	26-Sep-13	CL, KF	TR1	1.7		No	Day	14.6	
LCR	LCR_24.5R	Genelle Index Site	26-Sep-13	CL, KF	TR1	0.8		No	Day	15.3	
LCR	LCR_10.5L	CLB LB US Koot Mouth	27-Sep-13	CL, KF	TR1	1.7		No	Day	16	Pre flow reduction tracking.
LCR	LCR_10.5L	CLB LB US Koot Mouth	28-Sep-13	KF, CT	TR1	1.9		Yes	Day	15.8	Post flow reduction tracking.
LCR	LCR_10.5L	CLB LB US Koot Mouth	3-Oct-13	CL, KF	TR1	1.5		No	Day		Post flow reduction tracking; lowest water level ever observed at this site.
LCR	LCR_24.5R	Genelle Index Site	3-Oct-13	CL, KF	TR1	1.0		No	Day		Post flow reduction tracking.
Kootenay River	Koot_0.5R	Kootenay River RB	9-Oct-13	CL, KF	EF1		995	No	Day	14.8	
LCR	LCR_10.5L	CLB LB US Koot Mouth	9-Oct-13	CL, KF	TR1	1.5		No	Day	14.2	
LCR	LCR_24.5R	Genelle Index Site	9-Oct-13	CL, KF	TR1	1.2		No	Day	12.6	
Kootenay River	Koot_0.5R	Kootenay River RB	10-Oct-13	CL, KF	EF1		859	No	Night	12.1	
LCR	LCR_10.5L	CLB LB US Koot Mouth	10-Oct-13	CL, KF	TR1	1.3		No	Night	12.6	
LCR	LCR_24.5R	Genelle Index Site	10-Oct-13	CL, KF	TR1	1.1		No	Night	12.6	
LCR	LCR_10.5L	CLB LB US Koot Mouth	30-Oct-13	CL, KF	VO1			No	Day		Substrate inventory.
LCR	LCR_24.5R	Genelle Index Site	30-Oct-13	CL, KF	VO1			No	Day		Substrate inventory.
LCR	LCR_10.5L	CLB LB US Koot Mouth	20-Dec-13	CL, CD	TR1	1.4		No	Day		
LCR	LCR_24.5R	Genelle Index Site	20-Dec-13	CL, CD	TR1	1.2		No	Day		
LCR	LCR_10.5L	CLB LB US Koot Mouth	21-Dec-13	CL, CD	TR1	1.7		Yes	Day	4.3	Flow reduction #1. Approx. vertical reduction of 0.75 m, horizontal reduction of 2 m.
LCR	LCR_24.5R	Genelle Index Site	21-Dec-13	CL, CD	TR1	1.0		Yes	Day	4.3	Flow reduction #1. Approx. vertical reduction of 0.75 m, horizontal reduction of 2.5 m.
LCR	LCR_10.5L	CLB LB US Koot Mouth	22-Jan-14	CL, KF	EF1		2205	No	Day	3.6	
LCR	LCR_24.5R	Genelle Index Site	22-Jan-14	CL, KF	EF1		1900	No	Day	3.8	
LCR	LCR_10.5L	CLB LB US Koot Mouth	23-Jan-14	CL, KF	EF1		1193	No	Day	3.6	
LCR	LCR_24.5R	Genelle Index Site	23-Jan-14	CL, KF	EF1		1955	No	Day	3.8	
Kootenay River	Koot_0.5R	Kootenay River RB	29-Jan-14	CL, KF	EF1		721	No	Day	3.4	
LCR	LCR_10.5L	CLB LB US Koot Mouth	29-Jan-14	CL, KF	TR1	1.5		No	Day	3.8	
LCR	LCR_24.5R	Genelle Index Site	29-Jan-14	CL, KF	TR1	1.3		No	Day	3.7	
LCR	LCR_10.5L	CLB LB US Koot Mouth	30-Jan-14	CL, KF	TR1	1.4		No	Day	3.5	
LCR	LCR_24.5R	Genelle Index Site	30-Jan-14	CL, KF	TR1	1.2		No	Day	3.7	
LCR	LCR_10.5L	CLB LB US Koot Mouth	1-Feb-14	CL, KF	TR1	1.5		Yes	Day	3.6	Estimated vertical drop of 0.8 m, horizontal drop of approximately 2 m.
LCR	LCR_24.5R	Genelle Index Site	1-Feb-14	CL, KF	TR1	1.2		Yes	Day	3.7	
LCR	LCR_10.5L	CLB LB US Koot Mouth	4-Feb-14	CL, KF	TR1	0.9		No	Day	3	
LCR	LCR_24.5R	Genelle Index Site	4-Feb-14	CL, KF	TR1	0.7		Yes	Day	3	Post flow reduction.

Table A1 continued

Waterbody	Site Name[1]	Descriptive Site Name[1]	Sample Date	Crew[2]	Survey Methods[3]	Effort (hours)	EF Seconds[3]	Flow Reduction	Day/ Night	Water Temp (°C)	Comments[4]
LCR	LCR_10.5L	CLB LB US Koot Mouth	14-Feb-14	KF, CT	TR1	1.25		Yes	Day	2.3	Pre flow reduction tracking survey. NFC.
LCR	LCR_24.5R	Genelle Index Site	14-Feb-14	KF, CT	TR1	1		Yes	Day	2.6	Pre flow reduction tracking survey.
LCR	LCR_10.5L	CLB LB US Koot Mouth	15-Feb-14	KF, CT	TR1	1.1		Yes	Day	2.5	Flow reduction: at 800 from 30 to 25 kcfs, at 900 from 25 to 20 kcfs. Approx. 2.75 m linear drop, 60 cm vertical drop.
LCR	LCR_24.5R	Genelle Index Site	15-Feb-14	KF, CT	TR1	1.0		Yes	Day	2.8	Flow reduction: at 8:00 from 30 to 25 kcfs; at 9:00 from 25 to 20 kcfs; approx. 1.5 m linear drop and 0.45 m vertical drop.
LCR	LCR_24.5R	Genelle Index Site	20-Feb-14	KF, CT	TR1	1.2		No	Day	2.9	Post flow reduction tracking.
LCR	LCR_10.5L	CLB LB US Koot Mouth	20-Feb-14	KF, CT	TR1	1.4		No	Day	2.9	Post flow reduction tracking.
LCR	LCR_10.5L	CLB LB US Koot Mouth	25-Mar-14	CL, KF, CT	EF1	1.0	2586	No	Day	4	UTM release location: 452639/5462915 at 13:05 on 26-Mar-14.
LCR	LCR_24.5R	Genelle Index Site	25-Mar-14	CL, KF, CT	EF1	1.0	1847	No	Day	4	UTM release location: 449998/5450700 at 12:15 on 26-Mar-14.
LCR	LCR_10.5L	CLB LB US Koot Mouth	27-Mar-14	CL, KF	TR1	1.3		No	Day	5.2	
LCR	LCR_24.5R	Genelle Index Site	27-Mar-14	CL, KF	TR1	1.3		No	Day	4	
LCR	LCR_24.5R	Genelle Index Site	28-Mar-14	CL, LP	TR1	1.4		No	Day	4	
Kootenay River	Koot_0.5R	Kootenay River RB	28-Mar-14	CL, LP	EF1	0.3	792	No	Day	5.3	
LCR	LCR_10.5L	CLB LB US Koot Mouth	28-Mar-14	CL, LP	TR1	0.9		No	Day	3.3	
LCR	LCR_10.5L	CLB LB US Koot Mouth	29-Mar-14	CL, KF	TR1	1.2		Yes	Day	4.3	Flow reduction 30 kcfs to 25 kcfs (5 kcfs reduction); approx. 0.15 m vertical drop and 1 m horizontal drop.
LCR	LCR_24.5R	Genelle Index Site	29-Mar-14	CL, KF	TR1	1.1		Yes	Day	4.7	Flow reduction from 30 kcfs to 25 kcfs (5 kcfs reduction); approx. 0.15 m vertical drop and 1 m horizontal drop.
LCR	LCR_10.5L	CLB LB US Koot Mouth	31-Mar-14	CL, KF	TR1	1.0		No	Day	4.7	
LCR	LCR_24.5R	Genelle Index Site	31-Mar-14	CL, KF	TR1	1.2		No	Day	4.6	
LCR	LCR_10.5L	CLB LB US Koot Mouth	01-Apr-14	CL, KF	TR1	1.5		Yes	Day	4.6	8 kcfs flow reduction from 26 kcfs to 18 kcfs; approx. vertical reduction of 0.4 m and horizontal 2 m.
LCR	LCR_24.5R	Genelle Index Site	01-Apr-14	CL, KF	TR1	1.2		Yes	Day	5	8 kcfs flow reduction from 26 kcfs to 18 kcfs; approx. vertical drop of 0.5 m and 1 m horizontal drop.
LCR	LCR_24.5R	Genelle Index Site	02-Apr-14	CL, KF	TR1	1.0		No	Day	5.2	
LCR	LCR_10.5L	CLB LB US Koot Mouth	02-Apr-14	CL, KF	TR1	1.5		No	Day	4.6	

Notes

[1] L or LB= left downstream bank; R or RB= right downstream bank; DS= downstream; US= upstream

[2] CL= Crystal Lawrence; KF= Katy Fraser; LP= Louise Porto; CD= Christin Davis; RK= Rachel Keeler; CT= Clint Tarala (Clint Tarala Fish & Wildlife)

[3] EF= Backpack Electrofishing; TR= PIT Tag Tracking; MT= Minnow Trapping; SW= Snorkeling; VO= Visually Observed; LS= Lip Seining

[4] DO= dissolved oxygen; NFC= no fish captured; LNC= Longnose dace; CCRIFC= Canadian Columbia River Inter-Tribal Fishery Commission

APPENDIX B

Lower Columbia and Slocan River Distribution Maps and Site UTMs (Years 1 to 5)

Table B1. CLBMON-43 site locations, river kilometers and location descriptions. Similkameen study area sample locations are provided in AMEC (2010b).

Waterbody	Site Name/ River Km[1]	Descriptive Site Name[1]	UTM			Description[1,2]
			Zone	Easting	Northing	
Beaver Creek	Beaver_1.0	Beaver Creek Upper	11U	455621	5435251	
Beaver Creek	Beaver_1.1	Beaver Creek Bridge	11U	455911	5435141	At highway crossing.
Blueberry Creek	Blue_1.0	Blueberry Creek	11U	452124	5454134	
Kootenay River	Koot_0.2L	Kootenay River Mouth LB	11U	452724	5462610	Kootenay River Mouth LB; below Selkirk College.
Kootenay River	Koot_0.2R	Kootenay River Mouth RB	11U	452614	5462847	Kootenay River Mouth RB; around the point, 50 m US on LCR and 100 m US on LKR.
Kootenay River	Koot_0.3L	Kootenay Oxbow	11U	452826	5462585	Kootenay Oxbow
Kootenay River	Koot_0.4L	Kootenay Oxbow Outlet	11U	452844	5462470	Kootenay Oxbow Outlet; Accessed from lower Selkirk College Parking Lot
Kootenay River	Koot_0.5R	Kootenay River RB	11U	453027	5462799	Kootenay River RB; Below Brilliant Cultural center; most upstream access to Kootenay from orchard.
Kootenay River	Koot_0.6R	Kootenay RB site	11U	453059	5462804	Upstream of Kootenay River RB site.
Kootenay River	Koot_1.2L	Kootenay River Campground	11U	453515	5462721	Kootenay River Campground.
Lower Columbia River	LCR_0.3R	HLK	11U	444027	5465363	HLK accessed via sturgeon release area.
Lower Columbia River	LCR_1.5L	Rialto Creek Mouth US	11U	445146	5465709	Rialto Creek Mouth US; accessed by school bus turnabout on Syringa Park Rd; US of creek mouth.
Lower Columbia River	LCR_1.5L	LCR_1.5L	11U	445148	5465668	Duck blind DS of ALGS
Lower Columbia River	LCR_1.6L	Rialto Creek Mouth DS	11U	445210	5465731	Rialto Creek Mouth DS; accessed by school bus turnabout on Syringa Park Rd; DS of creek mouth.
Lower Columbia River	LCR_2.6M	LCR_2.6M	11U	446276	5465665	Unnamed trib across from Celgar- LB.
Lower Columbia River	LCR_2.8L	Unk Trib Mouth Robson	11U	446507	5465635	Unkown Trib Mouth Robson; at fishing pullout across from Celgar.
Lower Columbia River	LCR_3.0L	Unk Trib Mouth Robson DS	11U	446610	5465578	Unk Trib Mouth Robson DS; at fishing pullout across from Celgar; downstream of the trib mouth.
Lower Columbia River	LCR_5.0R	DS of Celgar	11U	448451	5464780	DS of Celgar.
Lower Columbia River	LCR_5.0R	LCR_5.0R	11U	448514	5464832	DS of Celgar near trib.
Lower Columbia River	LCR_5.6L	LCR_5.6L	11U	449197	5464841	Robson boat launch dock- LB.
Lower Columbia River	LCR_6.7R	Bay DS of Celgar	11U	450241	5464236	Bay DS of Celgar.
Lower Columbia River	LCR_7.0R	Across from Lions Head	11U	450545	5464193	Across from Lions Head.
Lower Columbia River	LCR_7.5L	LCR_7.5L	11U	451004	5464702	US of Norn's Fan DS of Lion's Head boat launch- RB.
Lower Columbia River	LCR_7.6M	LCR_7.6M	11U	451130	5464609	Norn's Fan Mouth- LB.
Lower Columbia River	LCR_7.7L	DS of Lions Head	11U	451275	5464781	DS of Lions Head; 300 m DS of boat launch, US edge of Norn's Fan; accessed from trail opposite Marshall Rd.
Lower Columbia River	LCR_7.9L	Norns Fan	11U	451477	5464869	Norns Fan.
Lower Columbia River	LCR_8.2L	Robson Bridge	11U	451648	5464559	Robson Bridge.
Lower Columbia River	LCR_8.3R	LCR_8.3R	11U	451606	5464307	Ecoscape productivity capture location - between CPR and Robson Bridge -2012.
Lower Columbia River	LCR_8.4L	CPR Bridge LB	11U	451812	5464442	CPR Bridge LB.
Lower Columbia River	LCR_8.6L	CPR Island - inside LB	11U	452130	5464363	CPR Island - inside LB.
Lower Columbia River	LCR_8.7L	LCR_8.7L	11U	452200	5464414	Cobble bar near CPR Island.
Lower Columbia River	LCR_8.7L	Waldie Trail - US	11U	452272	5464538	Waldie Trail - US; Shoreline along the Waldie Trail on LB of river; accessed from US- near CPR bridge.
Lower Columbia River	LCR_8.8L	LCR_8.8L	11U	452320	5464418	Between Waldie's and CPR Island- LB
Lower Columbia River	LCR_9.0L	LCR_9.0L	11U	452502	5464213	Ecoscape productivity capture location - near Waldie's island -2012
Lower Columbia River	LCR_9.2L	Waldie Trail - DS	11U	452761	5464326	Waldie Trail- DS; shoreline along the Waldie Trail on LB of river; accessed from DS- Brilliant Rd. entrance.
Lower Columbia River	LCR_9.8R	Millenium Park	11U	452798	5463638	Millenium Park.
Lower Columbia River	LCR_10.3L	Tin Cup LB	11U	452824	5463158	Tin Cup LB; access via same road as Koot Mouth, 1st road on right to river.
Lower Columbia River	LCR_10.4L	Tin Cup & Kootenay River Mouth LB	11U	452721	5463055	Tin Cup & Kootenay River Mouth; LB of LCR between Tin Cup Rapids and the mouth of Kootenay River.
Lower Columbia River	LCR_10.55L	CLB LB at Koot Mouth Point	11U	452632	5462887	CLB LB at Koot Mouth Point; From the point to about 50 m US on LB.
Lower Columbia River	LCR_10.5L	CLB LB US Koot Mouth	11U	452660	5462952	CLB LB US Koot Mouth; DS end of site begins about 50 m US of Koot mouth point.
Lower Columbia River	LCR_10.9R	LCR_10.9R	11U	452346	5462645	Across from Kootenay River mouth- RB.
Lower Columbia River	LCR_10.9R	Zuckerberg Island Sidechannel	11U	452232	5462602	Zuckerberg Island Sidechannel; across bridge, take first trail on right, end point of trail at point.
Lower Columbia River	LCR_11.0R	Zuckerberg Island under Bridge	11U	452181	5462755	Zuckerberg Island under Bridge; US end of sidechannel below breakwater.
Lower Columbia River	LCR_12.8L	LCR_12.8L	11U	453184	5461102	US of Kinnaird Bridge at Eddy- LB.
Lower Columbia River	LCR_15.8R	LCR_15.8R	11U	453232	5458096	Small bay near houses US of D-Bar-D- RB.
Lower Columbia River	LCR_16.7L	D-Bar-D	11U	453388	5457116	D-Bar-D; Lower Ootischenia; old gravel extraction area; large pool at low water.
Lower Columbia River	LCR_17.0L	Waterloo Eddy	11U	453304	5456743	Set in Waterloo Eddy backwater.
Lower Columbia River	LCR_18.1R	LCR_18.1R	11U	452302	5456132	Boulder field/pond between Dave's channel and D-Bar-D- RB.
Lower Columbia River	LCR_18.8L	Across from Blueberry	11U	452634	5455497	Across from Blueberry; sidechannel on left downstream bank- DD site.
Lower Columbia River	LCR_19.0L	LCR_19.0L	11U	452625	5455310	Dave's channel- LB.
Lower Columbia River	LCR_20.6R	LCR_20.6R	11U	452021	5453925	Dry bay DS of Blueberry Creek- RB.
Lower Columbia River	LCR_22.2R	LCR_22.2R	11U	450867	5452815	1km US of Genelle- RB.
Lower Columbia River	LCR_22.6L	LCR_22.6L	11U	450778	5452407	US of China Creek- LB.
Lower Columbia River	LCR_23.4L	LCR_23.4L	11U	450628	5451655	Trib across and DS of China Creek (Genelle)- LB.

Table B1 continued

Waterbody	Site Name/ River Km[1]	Descriptive Site Name[1]	UTM			Description[1,2]
			Zone	Easting	Northing	
Lower Columbia River	LCR_23.7R	Genelle US of Boat Launch	11U	450299	5451390	Genelle US of Boat Launch; accessed below first house after bend in trailer park rd.
Lower Columbia River	LCR_24.0R	Genelle Boat Launch	11U	450220	5451161	Genelle Boat Lauch.
Lower Columbia River	LCR_24.5R	Genelle Index Site	11U	449997	5450698	Genelle Index Site; mainstem, along right DS bank, across from white triangle bank marker, down 50 m.
Lower Columbia River	LCR_25.1R	Genelle Channel E	11U	449423	5450610	Genelle Channel E; at end of the riverbed road, in backflooded sidechannel from mainstem.
Lower Columbia River	LCR_25.1R	Genelle	11U	449487	5450459	Genelle.
Lower Columbia River	LCR_27.2L	LCR_27.2L	11U	448184	5448972	DS outlet of Genelle sidechannel- LB.
Lower Columbia River	LCR_27.5R	LCR_27.5R	11U	447908	5448725	Bedrock outcrop DS of Genelle- RB.
Lower Columbia River	LCR_28.4L	LCR_28.4L	11U	448069	5447783	200 m US of Birchbank station- LB.
Lower Columbia River	LCR_30.6R	LCR_30.6R	11U	447270	5445753	Below Birchbank Golf Course- RB.
Lower Columbia River	LCR_34.9L	LCR_34.9L	11U	446419	5441727	Across from Oasis/Rivervale- LB.
Lower Columbia River	LCR_36.5R	LCR_36.5R	11U	447193	5440439	Below upper most Cominco plant- RB.
Lower Columbia River	LCR_38.4L	Gyro Boat Launch	11U	448374	5439041	Gyro Boat Launch.
Lower Columbia River	LCR_38.8L	Trail Bridge	11U	448525	5438685	Trail Bridge; Left bank under the bridge.
Lower Columbia River	LCR_43.8L	Rock Island	11U	453010	5437831	Rock Island; vehicle accessible area DS of rock island and US of Bear Creek Mouth.
Lower Columbia River	LCR_43.9L	Bear Creek Mouth	11U	453045	5437744	Bear Creek Mouth; pullout below Trail mall, downstream of Rock Island.
Lower Columbia River	LCR_44.1L	LCR_44.1L	11U	453245	5437587	Below RV dealer.
Lower Columbia River	LCR_44.1R	LCR_44.1R	11U	453258	5437359	Across from Bear Creek and RV dealer- lots of garbage and golf balls.
Lower Columbia River	LCR_47.2R	LCR_47.2R	11U	455176	5435594	Casino Creek mouth- US fan.
Lower Columbia River	LCR_47.4L	CLB US of Beaver Creek	11U	455347	5435299	CLB US of Beaver Creek; US of the breakwater on the LB.
Lower Columbia River	LCR_47.5L	Beaver Creek Mouth	11U	455281	5435194	Beaver Creek Mouth.
Lower Columbia River	LCR_47.8L	LCR_47.8L	11U	455311	5434988	Beaver Creek boat launch.
Lower Columbia River	LCR_48.0L	Beaver Creek Boat Launch	11U	455328	5434693	Beaver Creek Boat Launch; eddy upstream of boat launch.
Lower Columbia River	LCR_49.4L	LCR_49.4L	11U	455215	5433369	Sand inlet below tower.
Lower Columbia River	LCR_51.4R	LCR_51.4R	11U	454877	5431437	Seasonal creek mouth across from Trimac land.
Lower Columbia River	LCR_53.1L	Fort Sheppard Boat Launch	11U	455900	5430092	Fort Sheppard Boat Launch.
Lower Columbia River	LCR_55.5L	Waneta	11U	454708	5427999	Waneta; left bank DS of Pend d'Oreille confluence.
Little Slocan River	LittleSloc_1.0	Lower Passmore Road Bridge - US RB	11U	452400	5488801	US of Road Bridge along RB.
Little Slocan River	LittleSloc_1.1	Near Slocan Confluence-LB	11U	452856	5488957	Along LB about 200 m US of confluence with main Slocan River.
Murphy Creek	Murphy_1.0	Murphy Creek	11U	446368	5445145	Upstream of culvert.
Pass Creek	Pass_1.0	Pass Creek Main	11U	451742	5465126	Accessed from north corner of Pass Creek soccer field.
Pass Creek	Pass_1.1	Pass Creek Extention Area	11U	451740	5465080	DS (rip rap bank) and US (pool and riffle crest) of high use area.
Slocan River	Koot_16.3R	Shoreacres at Slocan Mouth	11U	461975	5474305	Shoreacres at Slocan Mouth; north from Slocan River confluence upstream along RB.
Slocan River	Sloc_0.6L	Sloc_0.6L	11U	461527	5474294	Underneath Shoreacres bridge on the LB.
Slocan River	Sloc_0.8L	Sloc_0.8L	11U	461273	5474343	US of Hwy 3A bridge in Shoreacres.
Slocan River	Sloc_12.7R	Sloc_12.7R	11U	456758	5482890	Near end of Slocan Valley West Rd., below mailboxes.
Slocan River	Sloc_15.6M	Sloc_15.6M	11U	454822	5484610	Midway along Slocan Valley West Rd., along mid-channel bar.
Slocan River	Sloc_16.2R	Sloc_16.2R	11U	454414	5485121	DS of the Slocan Park Bridge.
Slocan River	Sloc_16.3L	Sloc_16.3L	11U	454410	5485325	DS from Slocan Park Bridge along LB.
Slocan River	Sloc_19.4L	Sloc_19.4L	11U	453715	5487003	Cobble/gravel bar near Passmore slide (old Passmore beach).
Slocan River	Sloc_21.5R	Sloc_21.5R	11U	452590	5487935	US of Passmore Bridge about 100 m along cobble bar.
Slocan River	Sloc_21.7R	Sloc_21.7R	11U	452642	5488082	Passmore Lower Rd, at staff gauge, across from horse farm.
Slocan River	Sloc_22.3R	Sloc_22.3R	11U	452820	5488498	Passmore Lower Rd, DS of Little Slocan River - trail access south of Wind River Ranch.
Slocan River	Sloc_25.8L	Sloc_25.8L	11U	454137	5491238	Vallican Bluffs, accessed by rail trail; pullout on west of Hwy 6.
Slocan River	Sloc_30.0R	Sloc_30.0R	11U	456951	5493550	DS outlet of sidechannel draining from site 30.7R
Slocan River	Sloc_30.2M	Sloc_30.2M	11U	457067	5493460	Below Cougar Bluff, along upstream edge of mid-channel bar and sidechannel.
Slocan River	Sloc_30.7R	Sloc_30.7R	11U	457321	5493736	Drake's Beach (aka Clark's Beach), access 50 m north of Drake St, in sidechannel.
Slocan River	Sloc_33.5L	Sloc_33.5L	11U	458912	5495044	Across highway from Sleep is for Sissies.
Slocan River	Sloc_34.0R	Sloc_34.0R	11U	458778	5495543	500 m DS of Winlaw Bridge on Slocan River Rd. at pullout.
Slocan River	Sloc_36.1R	Sloc_36.1R	11U	459793	5497012	Dock accessed via 6120 Slocan River Rd; Sharon and Len Block's property.
Slocan River	Sloc_37.6L	Sloc_37.6L	11U	461088	5497889	Trozzo Creek island at low water, directly below rail trail; pullout on west of Hwy 6.
Slocan River	Sloc_37.8L	Sloc_37.8L	11U	460990	5497915	Trozzo Creek mouth; pullout on west of Hwy 6.
Slocan River	Sloc_39.4L	Sloc_39.4L	11U	461034	5499210	Nixon Rd. end (old Appledale bridge location).
Slocan River	Sloc_39.4R	Sloc_39.4R	11U	460984	5499251	Appledale Lower Rd accessed via Perrys Back Rd. (old Appledale bridge location).
Slocan River	Sloc_4.8L	Sloc_4.8L	11U	459559	5476913	Crescent Valley Beach.
Slocan River	Sloc_43.1L	Sloc_43.1L	11U	463149	5501495	Perry's Bridge Rd., LB US of bridge.

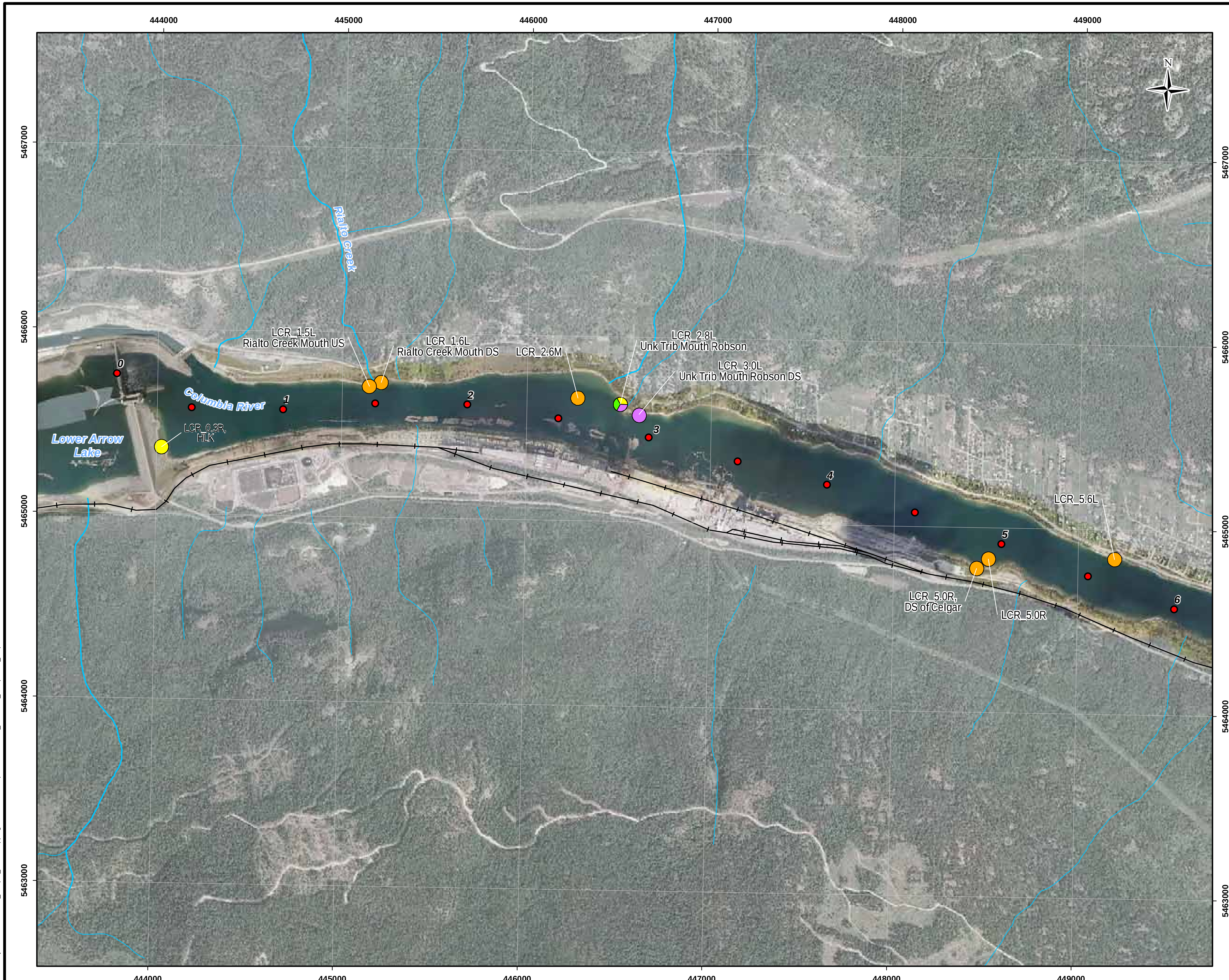
Table B1 continued

Waterbody	Site Name/ River Km[1]	Descriptive Site Name[1]	UTM			Description[1,2]
			Zone	Easting	Northing	
Slocan River	Sloc_43.1R	Sloc_43.1R	11U	462899	5501650	Perry's Bridge Rd., RB US of bridge, near mailboxes at high water.
Slocan River	Sloc_44.5L	Sloc_44.5L	11U	463802	5502535	At Brogran Creek outlet; from Harasomow Rd. take trail to Rail Trail and walk 500 m upstream.
Slocan River	Sloc_5.1L	Sloc_5.1L	11U	459285	5476865	US from Crescent Valley Beach, on corner.
Slocan River	Sloc_5.3L	Sloc_5.3L	11U	459232	5476941	US from Crescent Valley Beach, around corner.
Slocan River	Sloc_6.3R	Sloc_6.3R	11U	459309	5477922	US of Cresent Valley Bridge (access to Pass Creek Rd and Krestova) on RB.
Slocan River	Sloc_9.1L	Sloc_9.1L	11U	458301	5480347	Access via Kosiancic Rd. and walk along Rail Trail to bend in river.
Slocan River	Sloc_9.3L	Sloc_9.3L	11U	458374	5480489	Access via Kosiancic Rd. and walk along Rail Trail to bend in river.
Trozzo Creek	Trozzo_1.0	Trozzo Creek	11U	460991	5497965	Lowest 75 m of creek to outlet at Slocan River

Notes

[1] L or LB= left downstream bank; R or RB= right downstream bank; M= middle bank; HLK= Hugh Keenleyside Dam; US= upstream; DS= downstream; CLB= Columbia River; E= East, trib= tributary

[2] LCR= Lower Columbia River; LKR= Lower Kootenay River; CPR= Canadian Pacific Railway



Legend

- Populated Place
- Km Mark

2010-2014 Sample Locations

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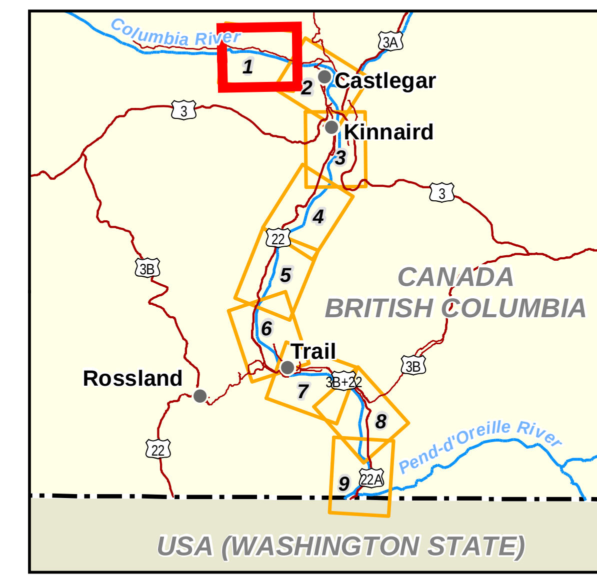

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Meters

Reference

British Columbia Imagery WMS
http://openmaps.gov.bc.ca

CLIENT: BC hydro

PROJECT: CLBMON-43 LCR Sculpin and Dace Life History Assessment

Lower Columbia River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: January, 2014	ANALYST: WR	Figure	1 of 9
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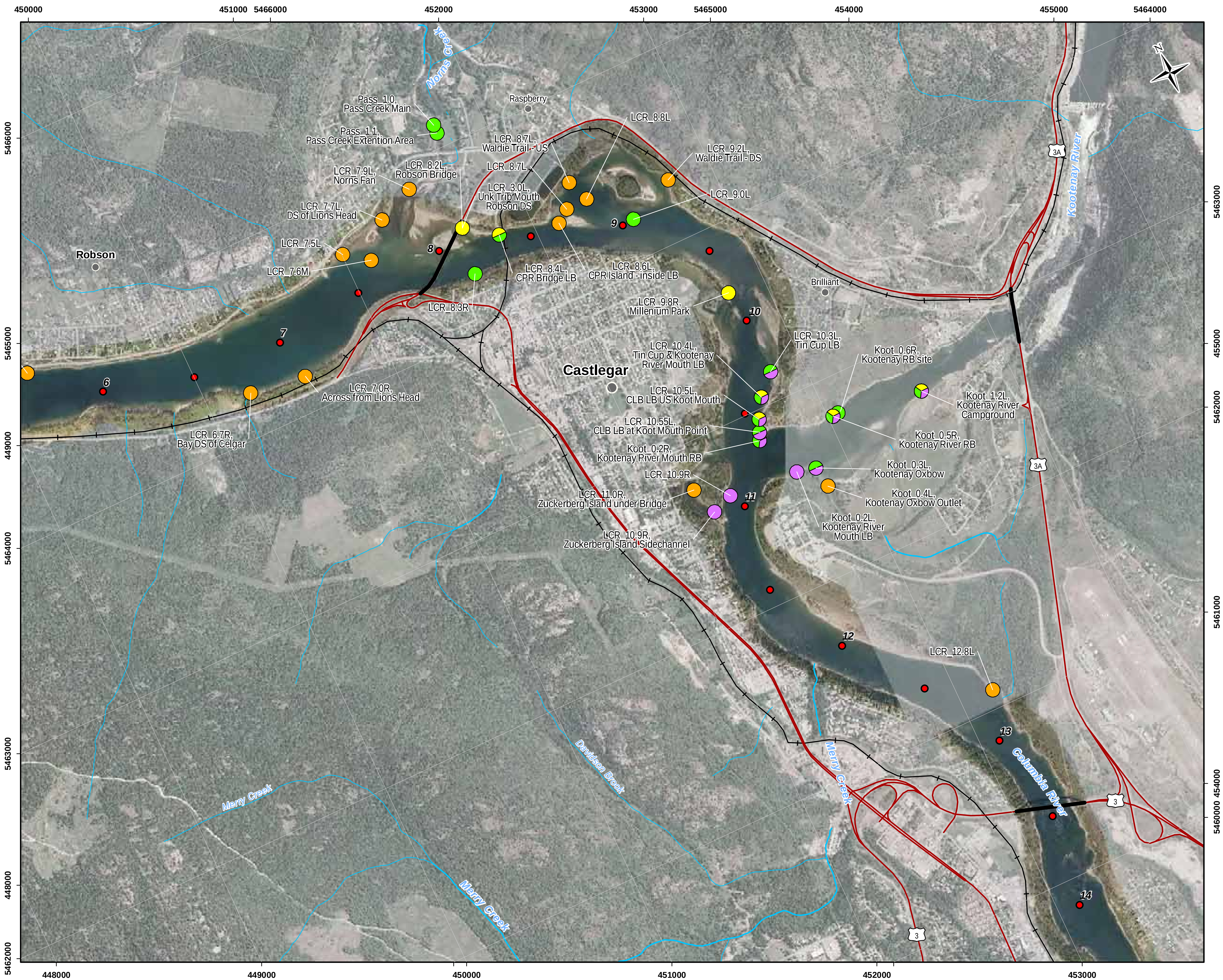

Legend
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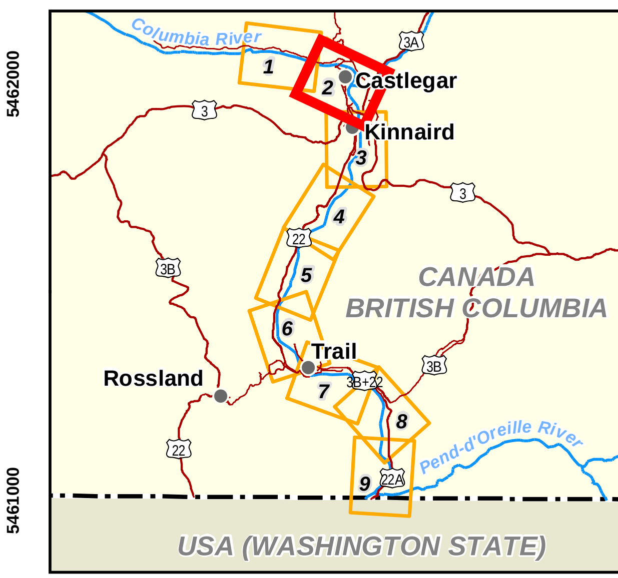

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BC hydro

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Lower Columbia River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: January, 2014	ANALYST: WR	Figure	2 of 9
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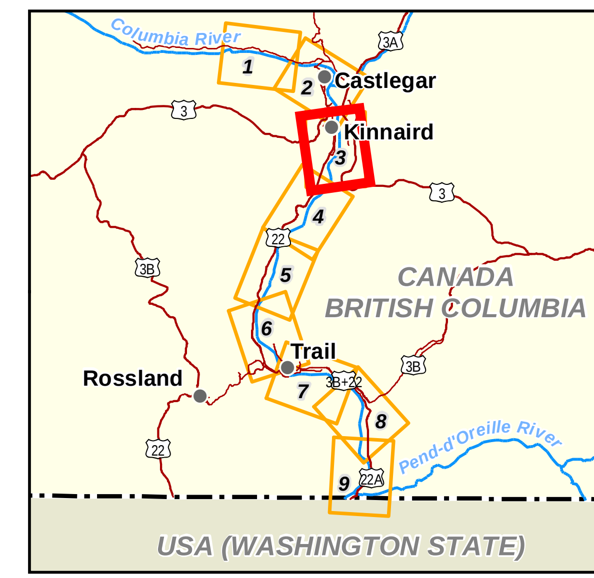

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Lower Columbia River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: January, 2014	ANALYST: WR	Figure	3 of 9
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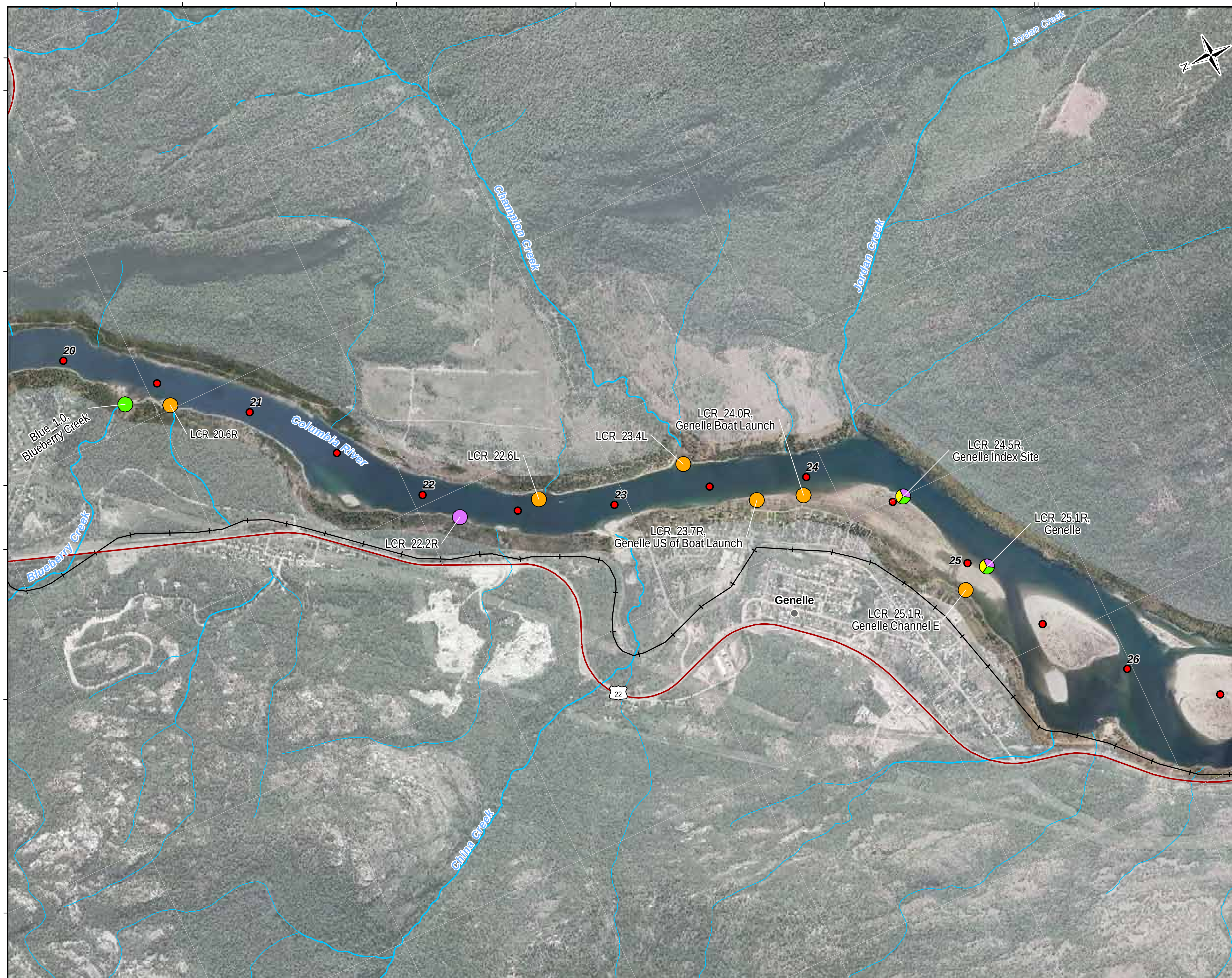

Legend

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- Km Mark

2010-2014 Sample Locations

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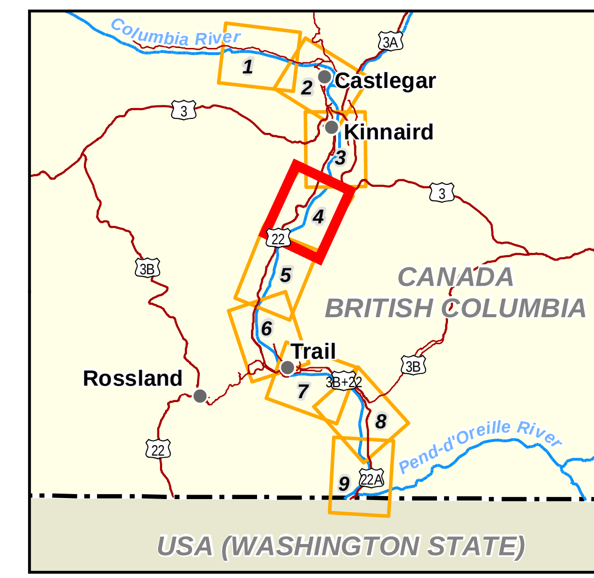

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CLIENT: BC hydro

PROJECT: CLBMON-43 LCR Sculpin and Dace Life History Assessment

Lower Columbia River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: January, 2014	ANALYST: WR	Figure 4 of 9
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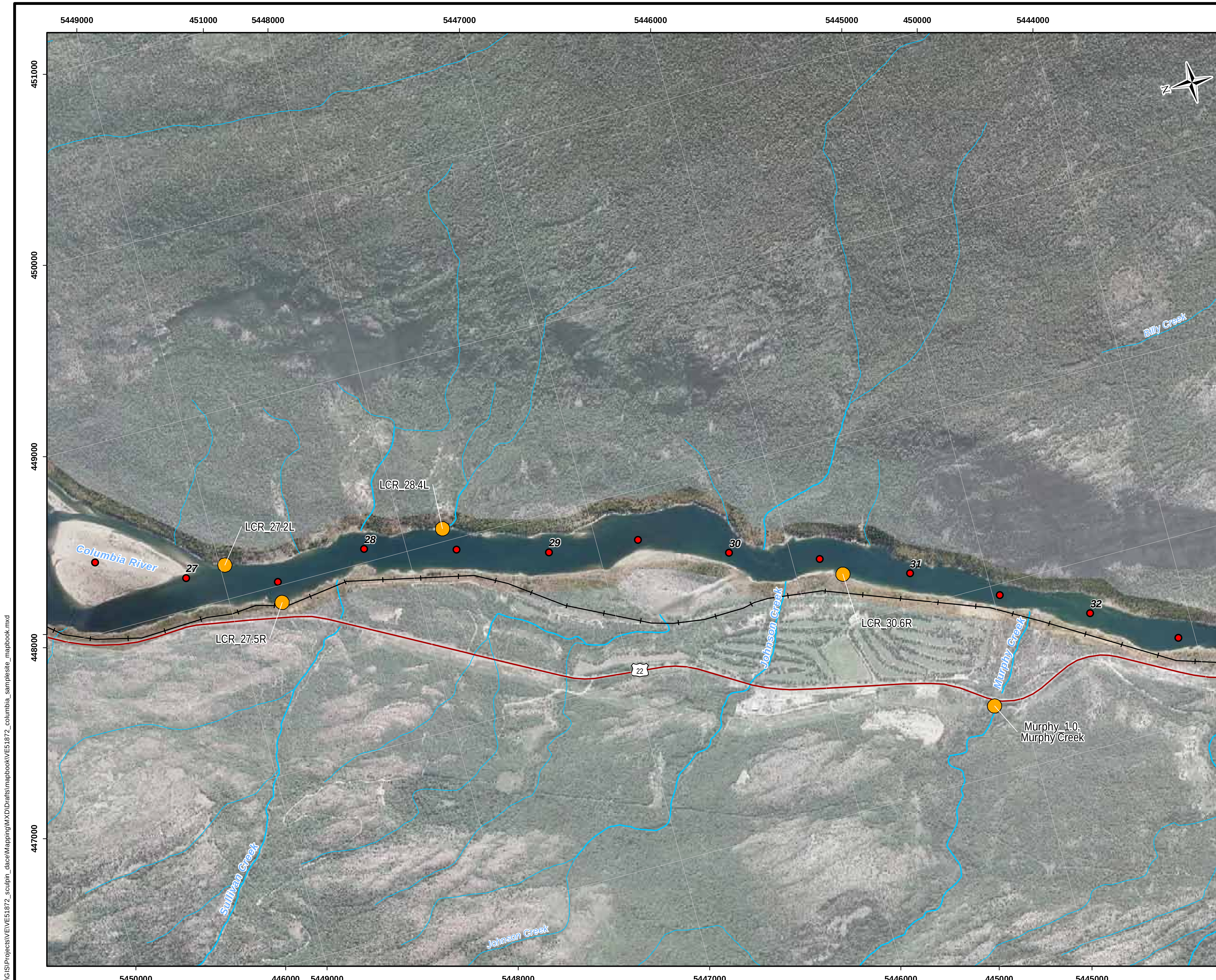

Legend

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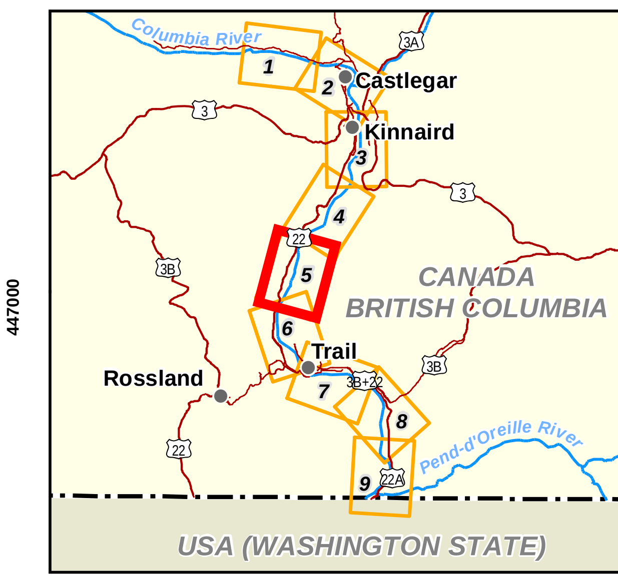

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Lower Columbia River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: January, 2014	ANALYST: WR	Figure 5 of 9
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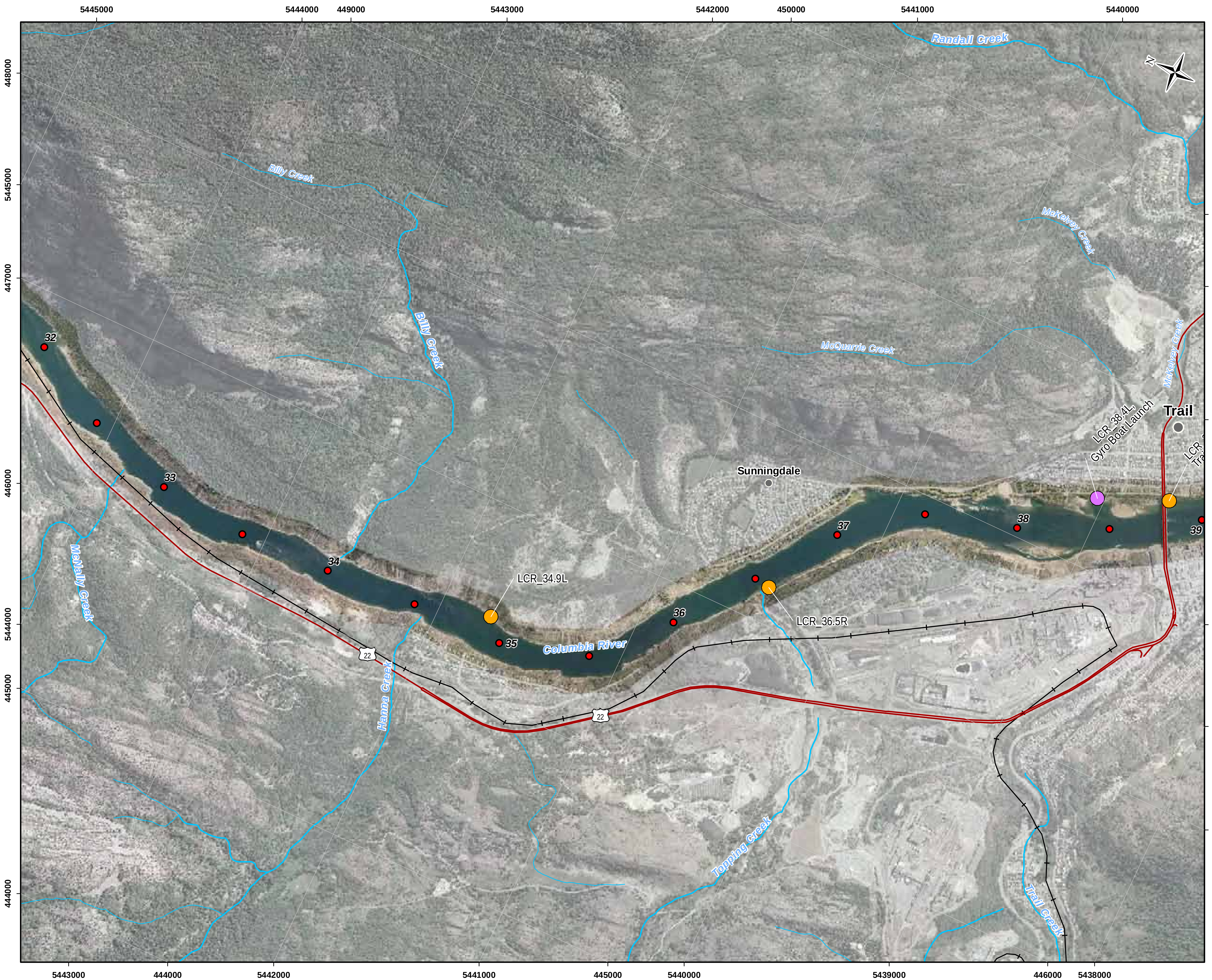

Legend

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2010-2014 Sample Locations

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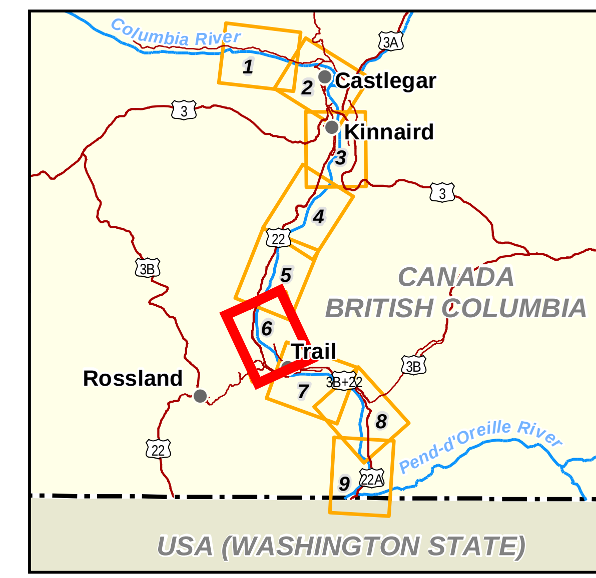

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Lower Columbia River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: January, 2014	ANALYST: WR	**Figure** 6 of 9
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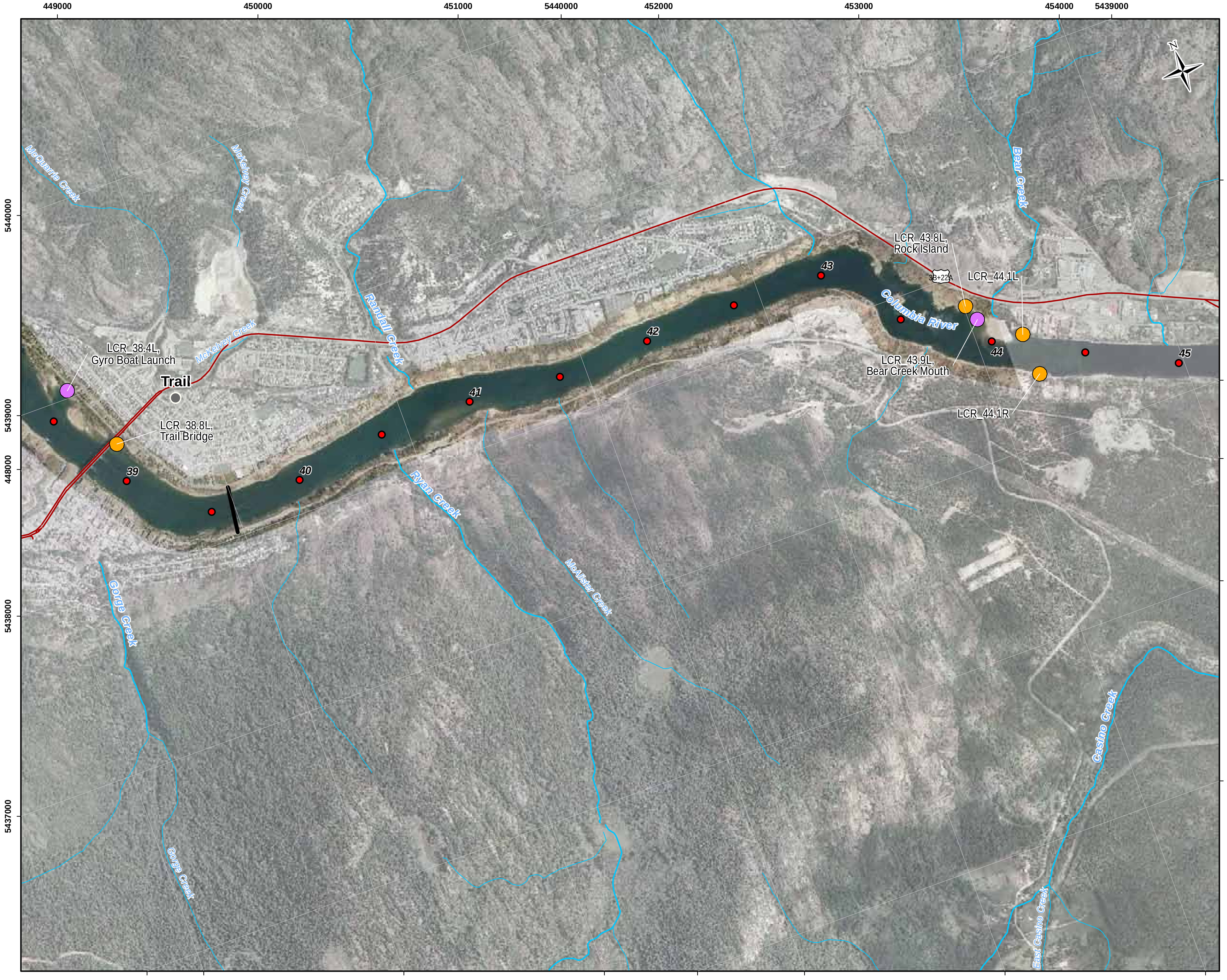

Legend
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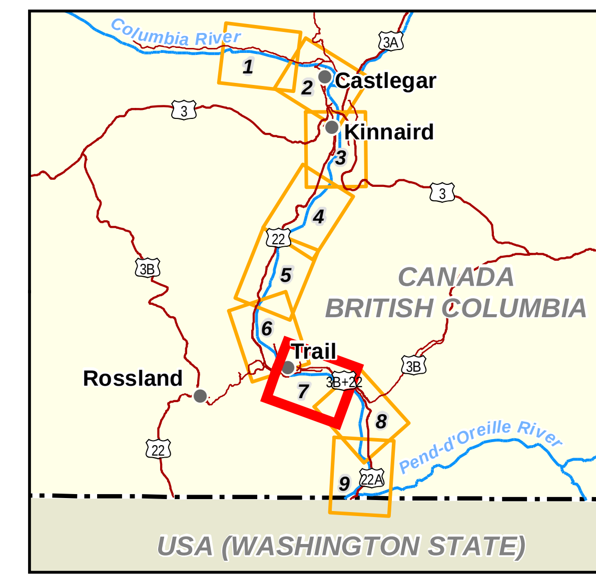

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Lower Columbia River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: January, 2014	ANALYST: WR	**Figure** 7 of 9
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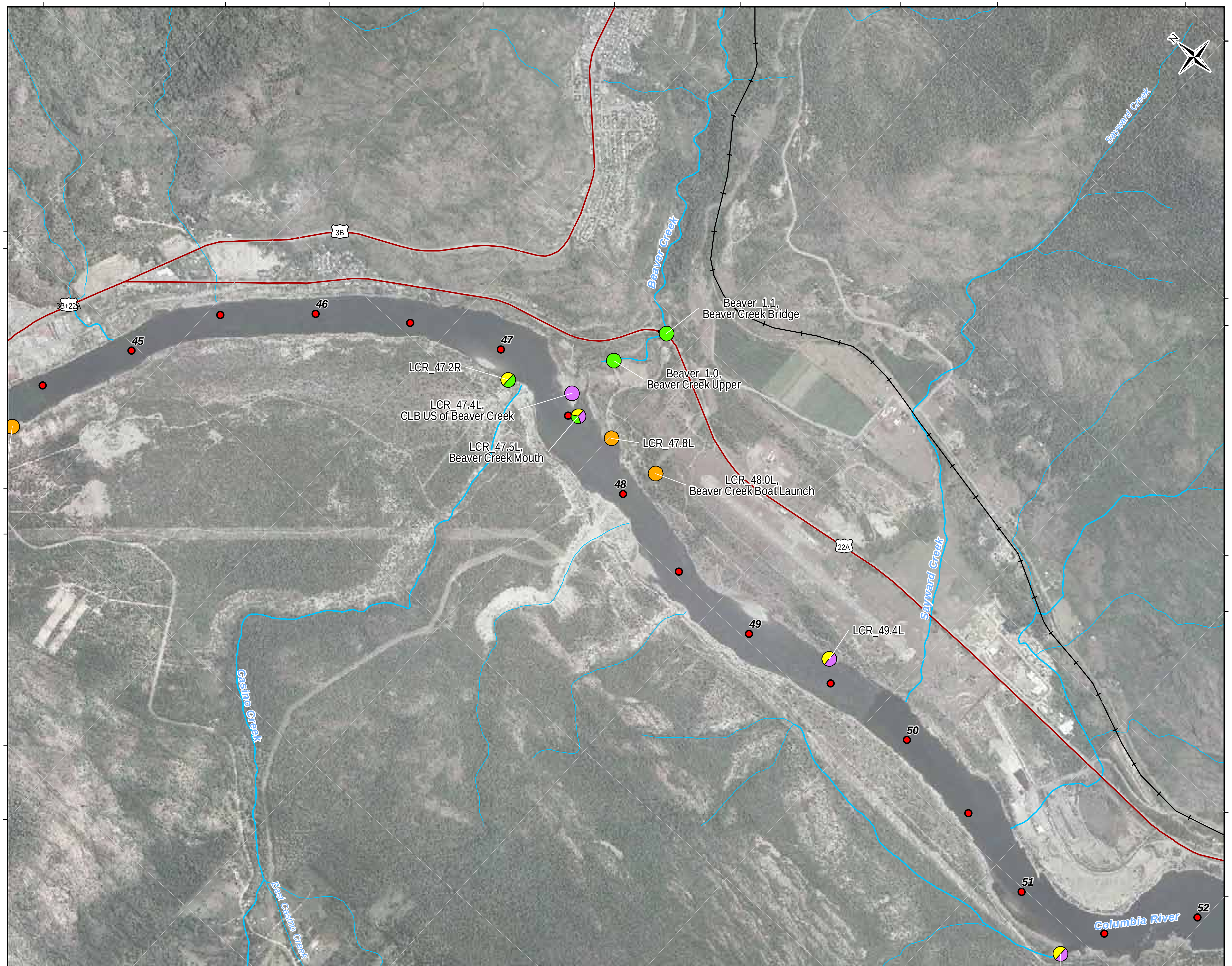

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2010-2014 Sample Locations

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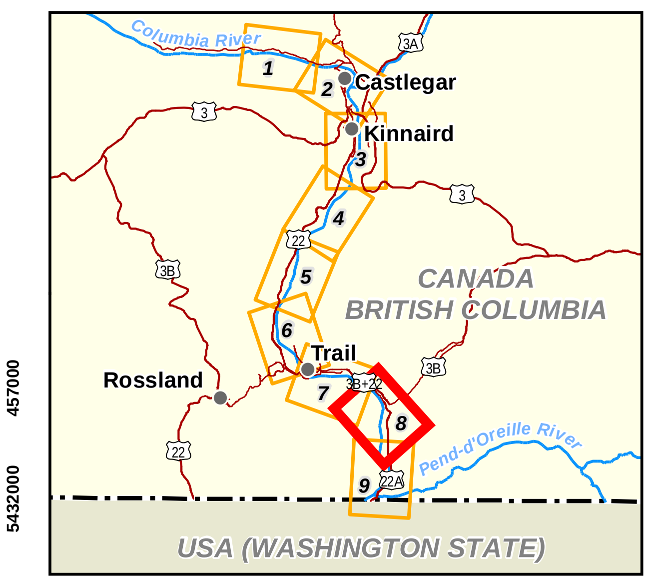

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Lower Columbia River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: January, 2014	ANALYST: WR	**Figure** 8 of 9
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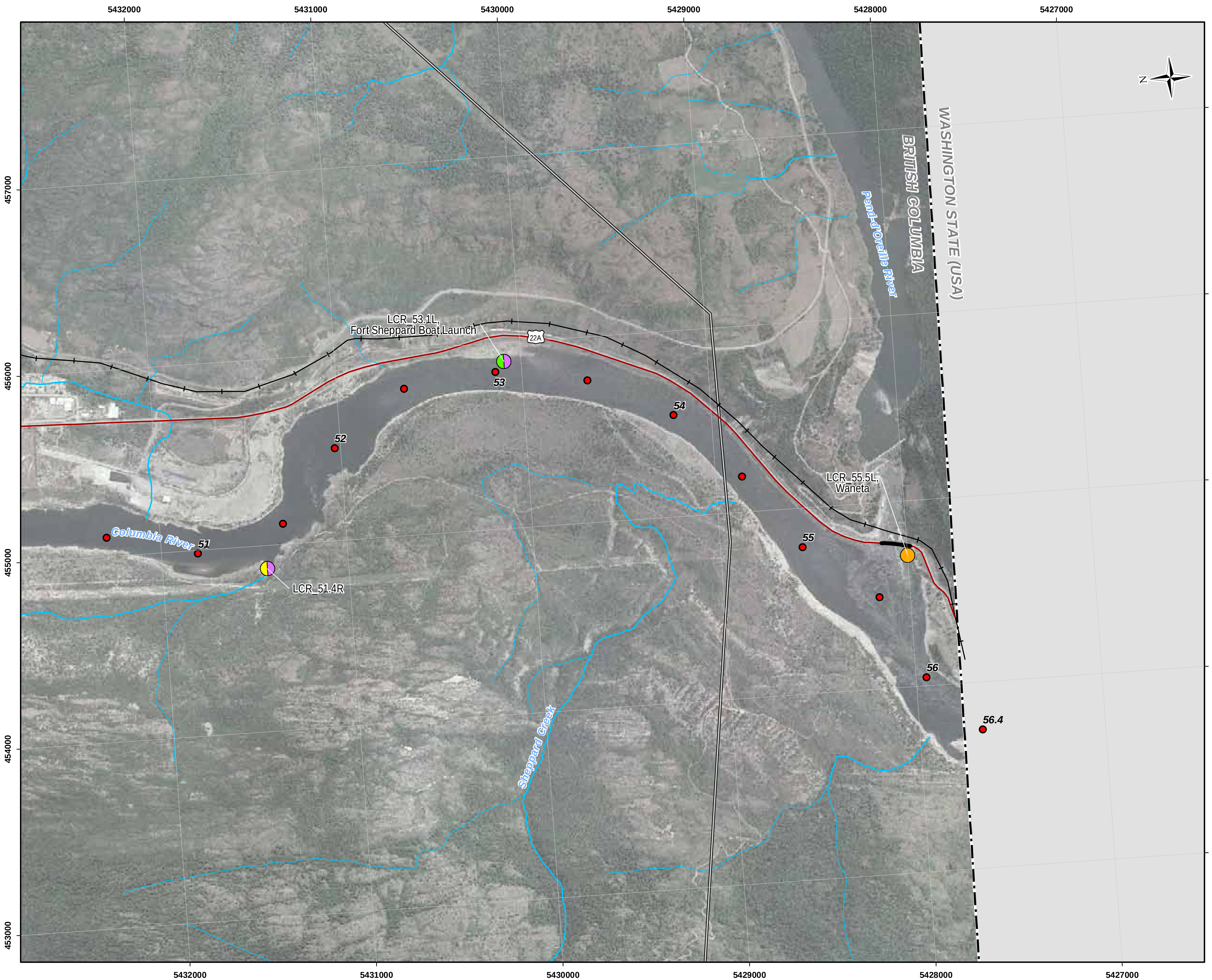

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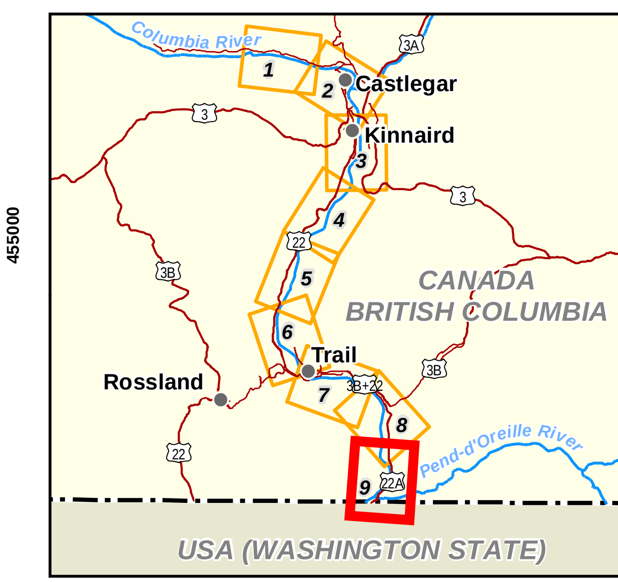

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Lower Columbia River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: January, 2014	ANALYST: WR	**Figure** 9 of 9
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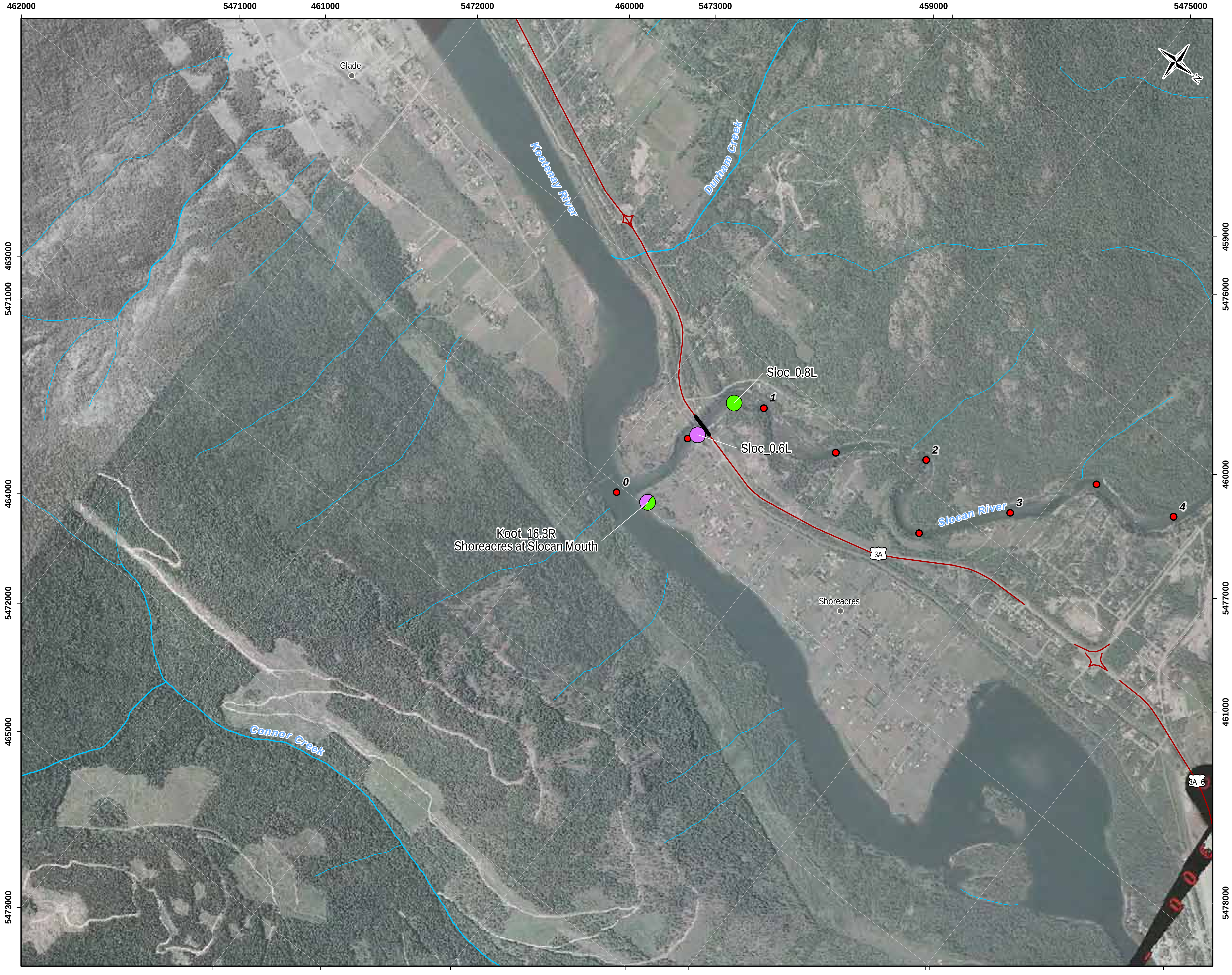

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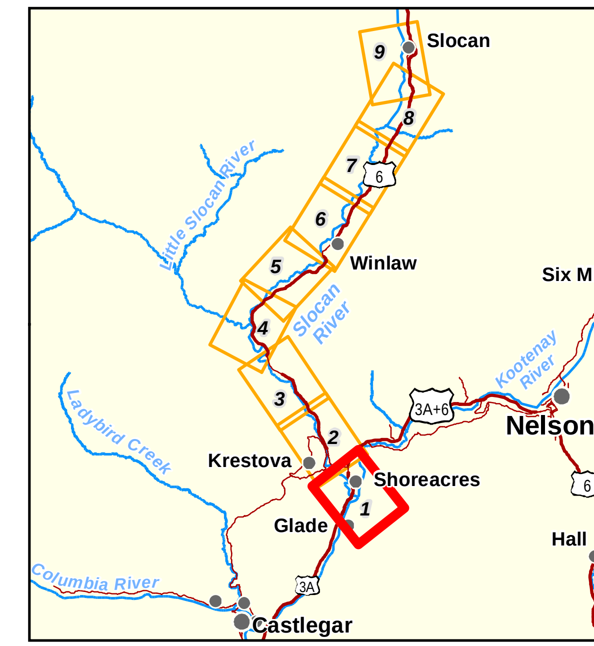

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Meters

Reference

British Columbia Imagery WMS
http://openmaps.gov.bc.ca
BC Government GeoBC Data Distribution
Natural Resources Canada Geobase

CLIENT: BC hydro

PROJECT: CLBMON-43

Slocan River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE:	ANALYST:	
September, 2014	MY	**Figure 1 of 9**
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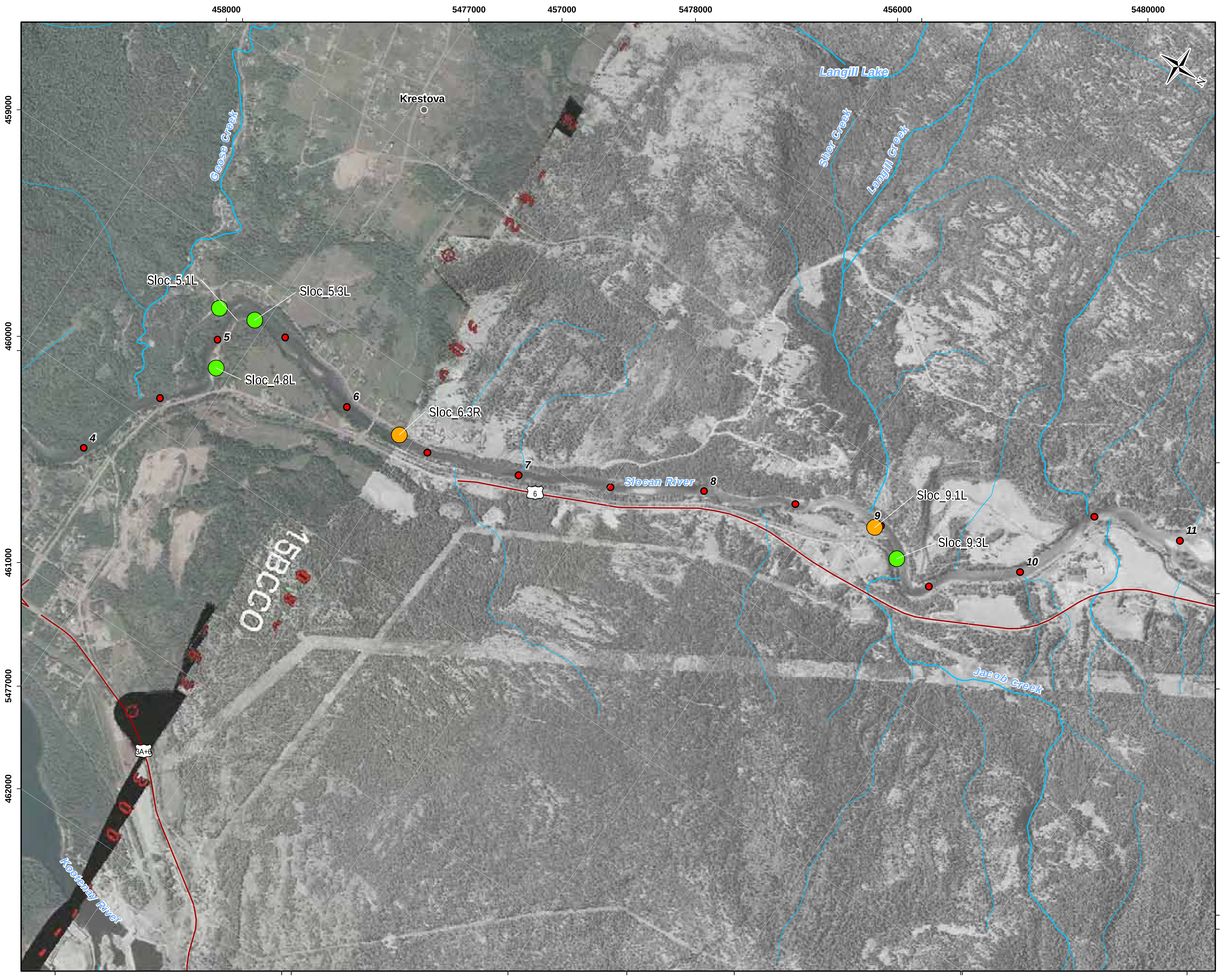

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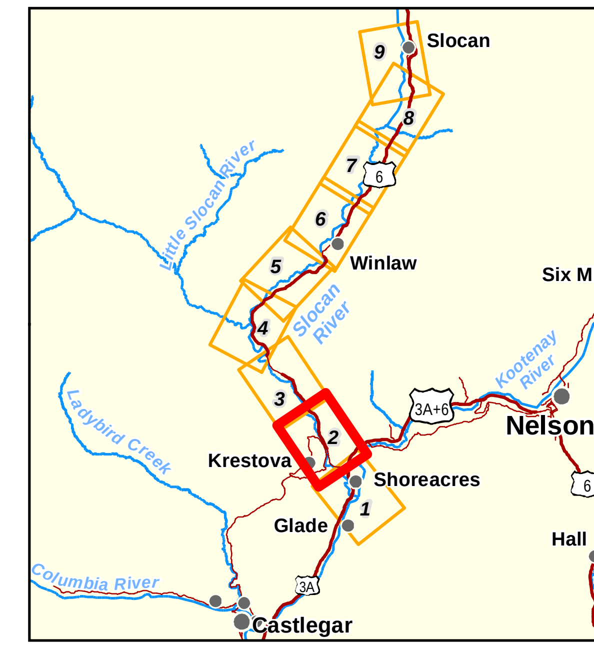

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CLIENT: BChydro

PROJECT: CLBMON-43

Slocan River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: September, 2014	ANALYST: MY	Figure 2 of 9	
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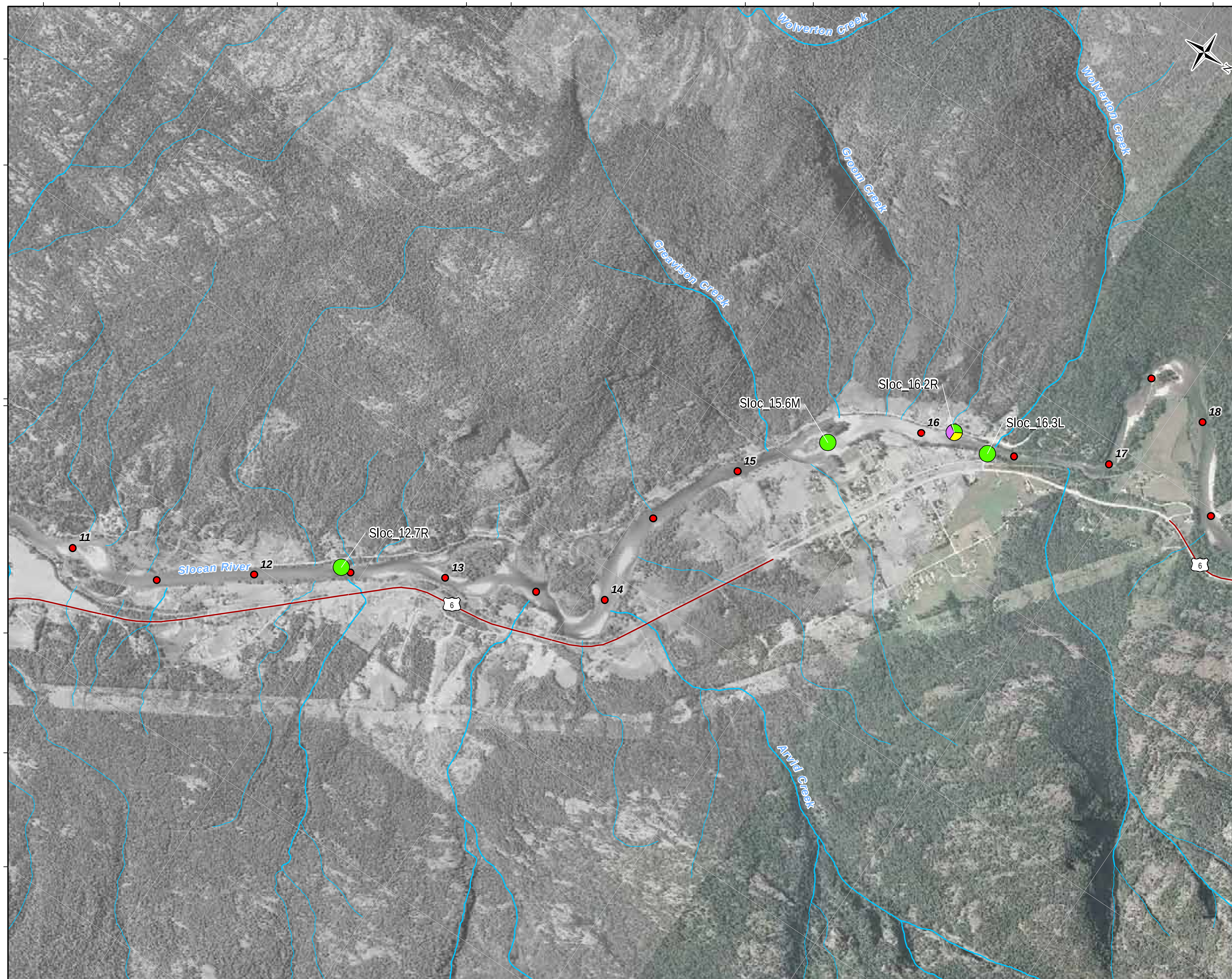

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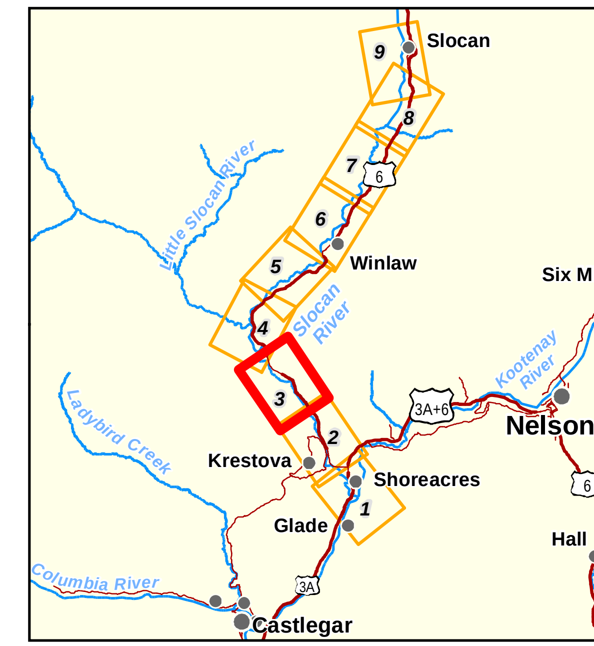
- Stream Order >= 2
- Stream Order = 1



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Meters

Reference

British Columbia Imagery WMS
http://openmaps.gov.bc.ca
BC Government GeoBC Data Distribution
Natural Resources Canada Geobase

CLIENT:

PROJECT:

CLBMON-43

Slocan River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: September, 2014	ANALYST: MY	**Figure 3 of 9**
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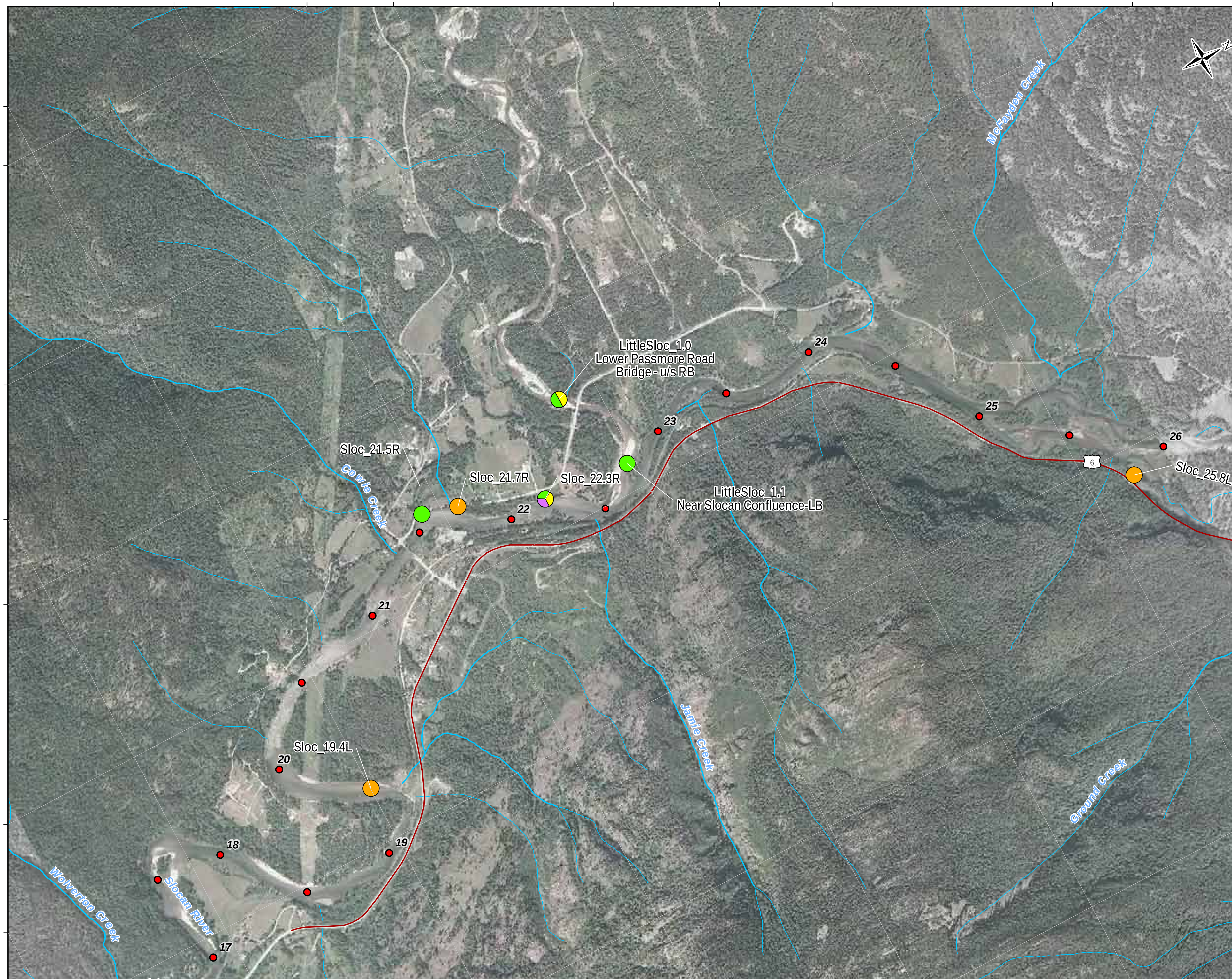
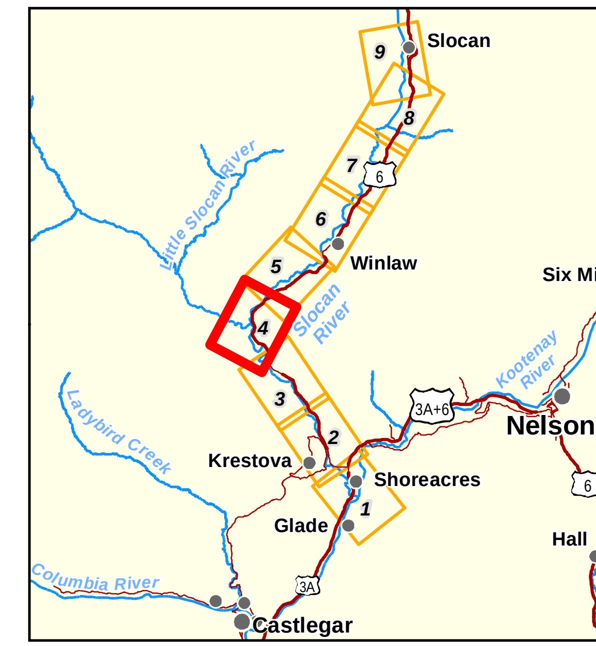


Legend

- Populated Place
- Km Mark

2010-2014 Sample Locations

- Sample Location/No SARA Species Captured
- Columbia Sculpin
- Shorthead Sculpin
- Umatilla Dace
- Highway
- Bridge
- Stream Order >= 2
- Stream Order = 1



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Meters

Reference

British Columbia Imagery WMS
http://openmaps.gov.bc.ca
BC Government GeoBC Data Distribution
Natural Resources Canada Geobase

CLIENT: BC hydro

PROJECT: CLBMON-43

Slocan River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE:	ANALYST:	
September, 2014	MY	**Figure 4 of 9**
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GIS FILE: VE51872_slocan_samplesite_mapbook.mxd		
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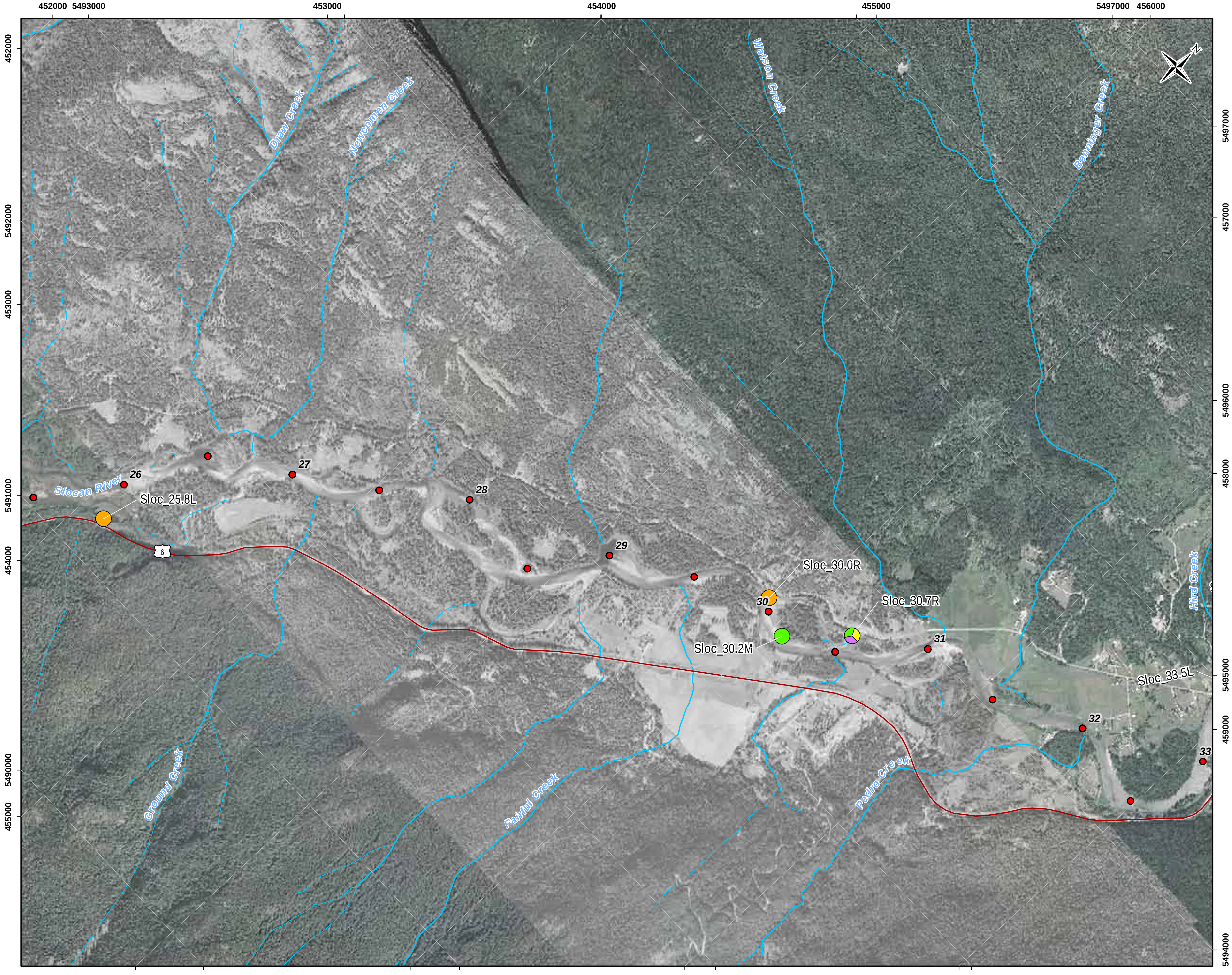
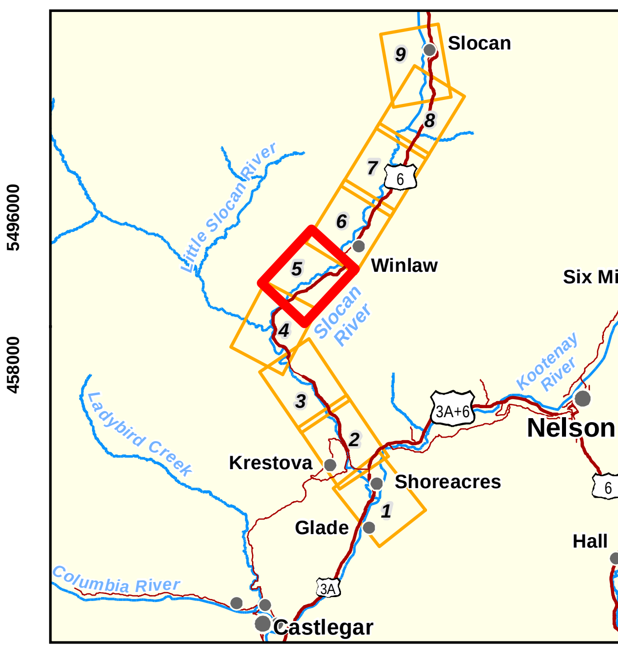


Legend

- Populated Place
- Km Mark

2010-2014 Sample Locations

- Sample Location/No SARA Species Captured
- Columbia Sculpin
- Shorthead Sculpin
- Umatilla Dace
- Highway
- Bridge
- Stream Order >= 2
- Stream Order = 1



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Meters

Reference

British Columbia Imagery WMS
http://openmaps.gov.bc.ca
BC Government GeoBC Data Distribution
Natural Resources Canada Geobase

CLIENT: BC hydro

PROJECT: CLBMON-43

Slocan River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: September, 2014	ANALYST: MY	Figure 5 of 9
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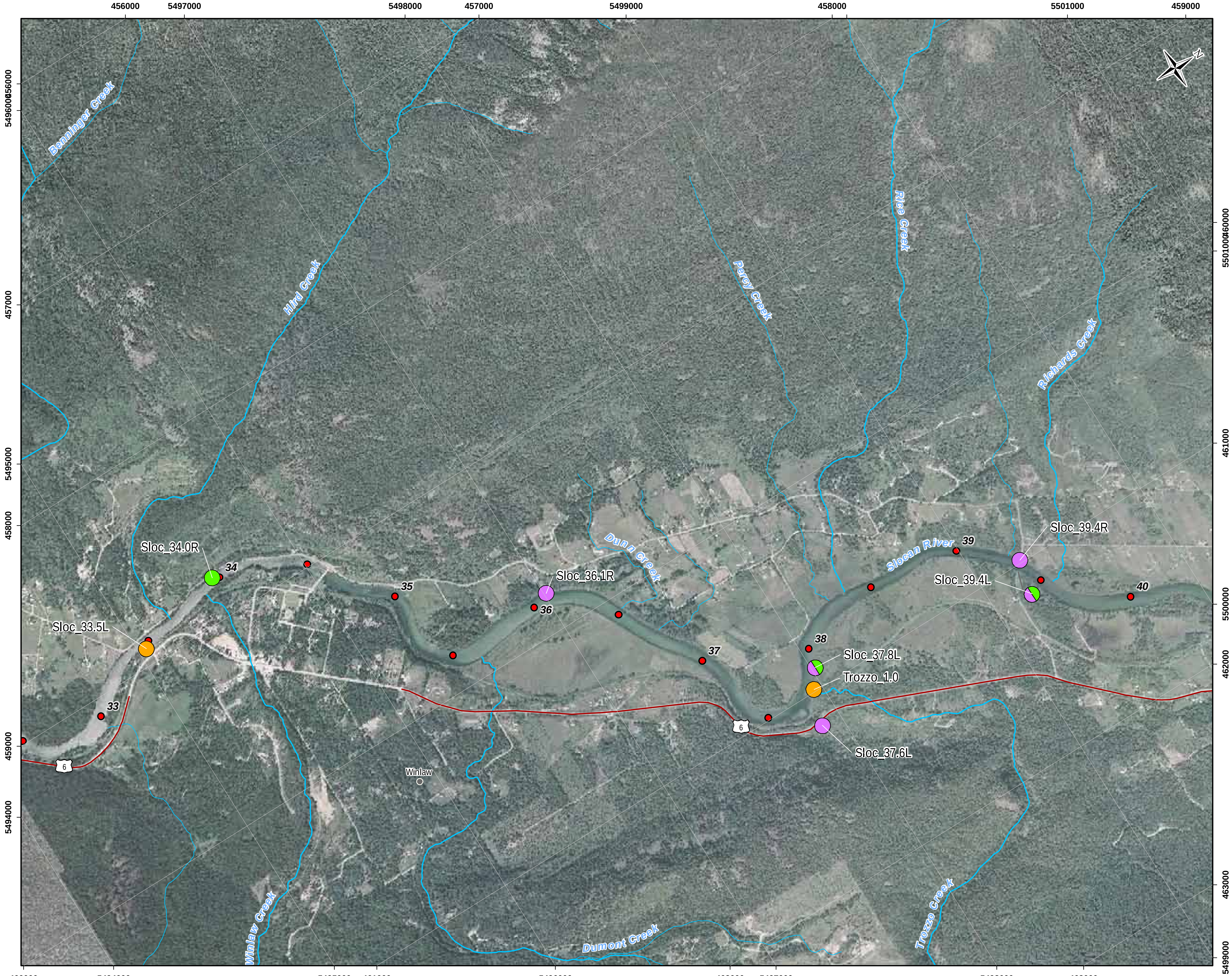
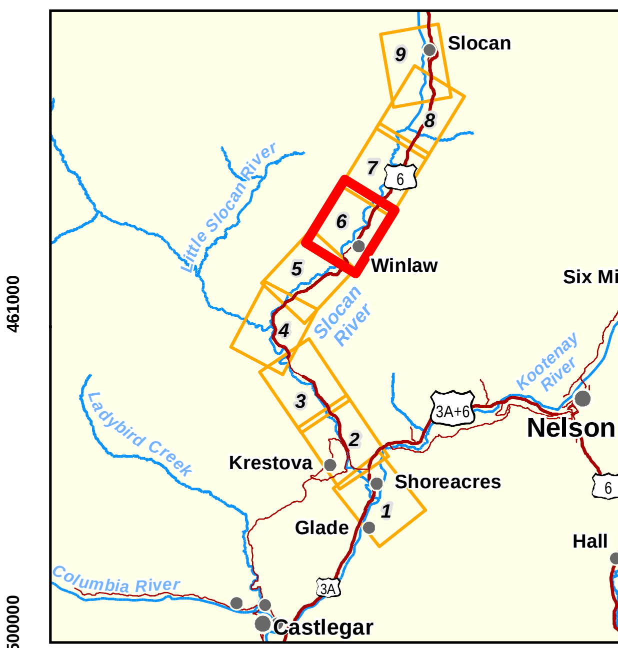


Legend

- Populated Place
- Km Mark

2010-2014 Sample Locations

- Sample Location/No SARA Species Captured
- Columbia Sculpin
- Shorthead Sculpin
- Umatilla Dace
- Highway
- Bridge
- Stream Order >= 2
- Stream Order = 1



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Meters

Reference

British Columbia Imagery WMS
http://openmaps.gov.bc.ca
BC Government GeoBC Data Distribution
Natural Resources Canada Geobase

CLIENT: BChydro

PROJECT: CLBMON-43

Slocan River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: September, 2014	ANALYST: MY	**Figure 6 of 9**
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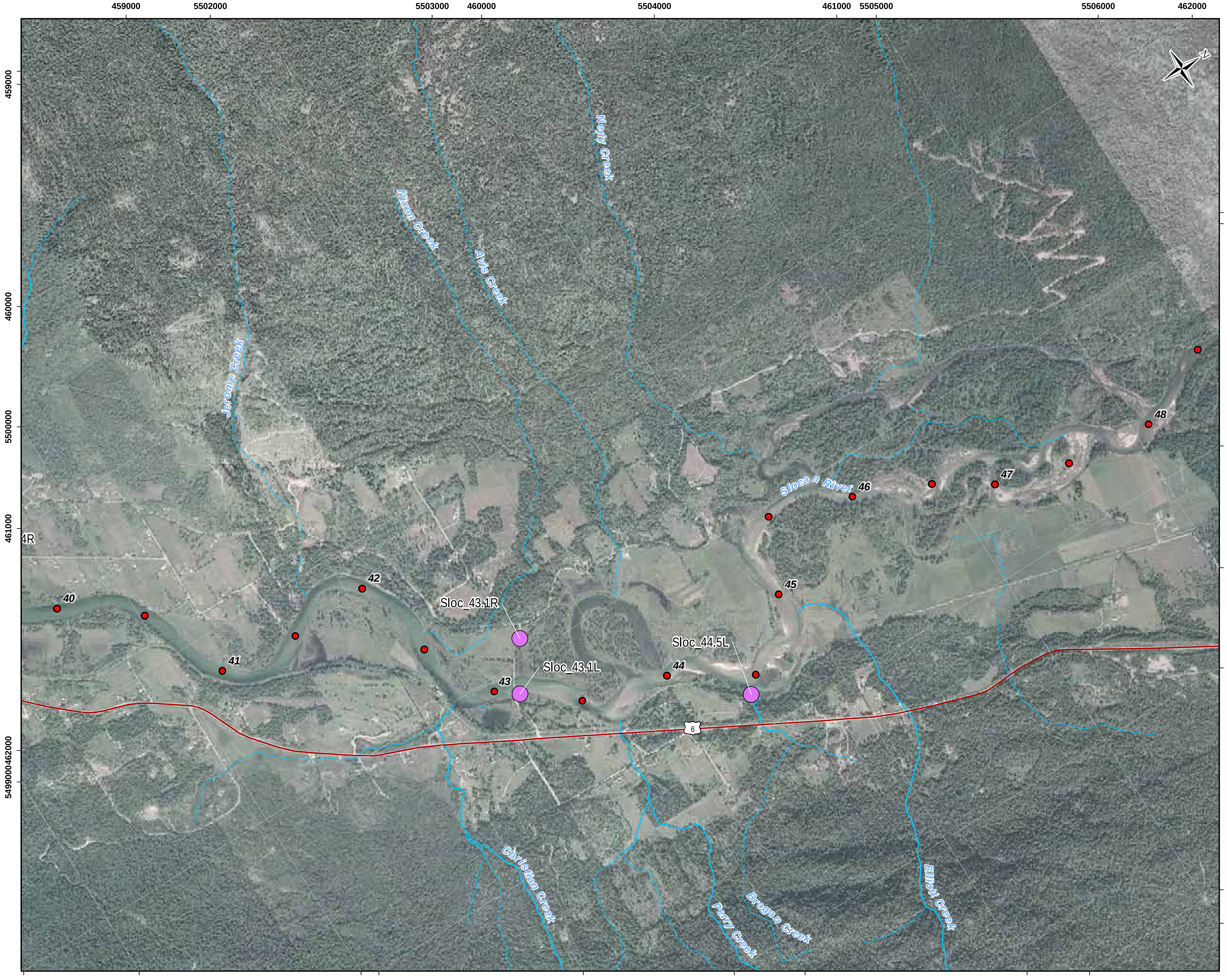
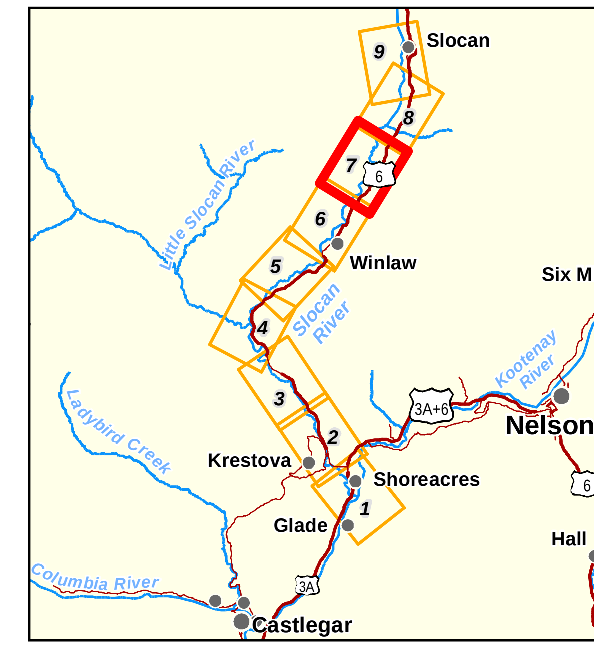


Legend

- Populated Place
- Km Mark

2010-2014 Sample Locations

- Sample Location/No SARA Species Captured
- Columbia Sculpin
- Shorthead Sculpin
- Umatilla Dace
- Highway
- Bridge
- Stream Order >= 2
- Stream Order = 1



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Meters

Reference

British Columbia Imagery WMS
http://openmaps.gov.bc.ca
BC Government GeoBC Data Distribution
Natural Resources Canada Geobase

CLIENT:

BC hydro

PROJECT:

CLBMON-43

Slocan River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE:	ANALYST:	
September, 2014	MY	**Figure 7 of 9**
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GIS FILE: VE51872_slocan_samplesite_mapbook.mxd		
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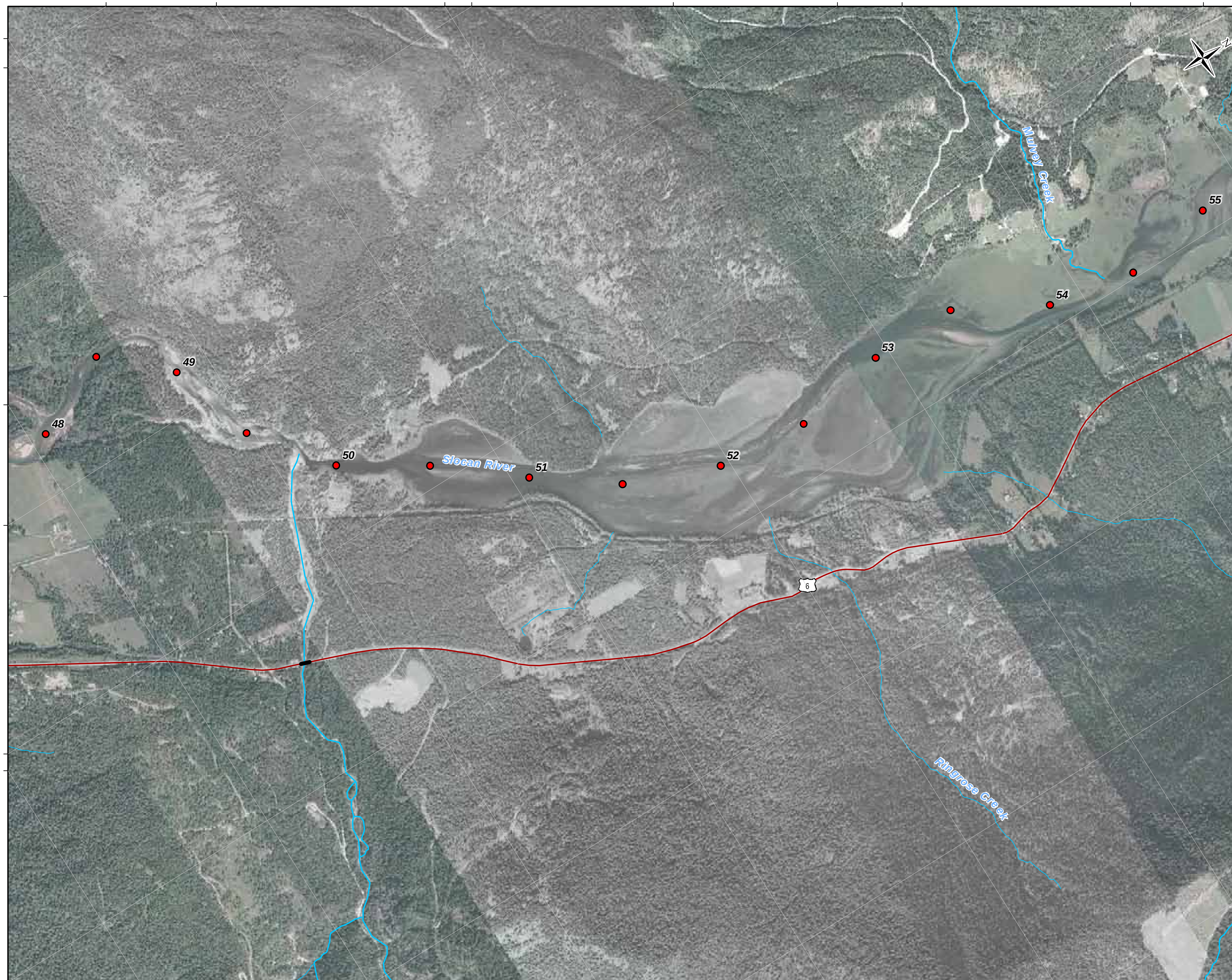
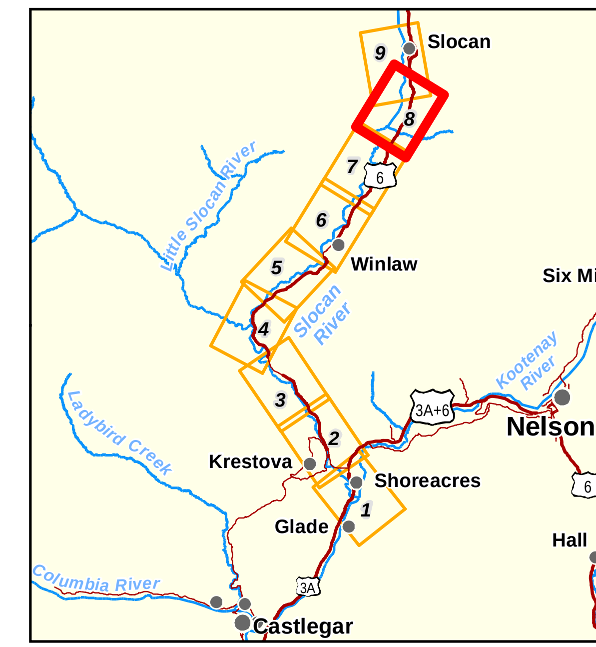


Legend

- Populated Place
- Km Mark

2010-2014 Sample Locations

- Sample Location/No SARA Species Captured
- Columbia Sculpin
- Shorthead Sculpin
- Umatilla Dace
- Highway
- Bridge
- Stream Order >= 2
- Stream Order = 1



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400 200 0 400 800

Meters

Reference

British Columbia Imagery WMS
http://openmaps.gov.bc.ca
BC Government GeoBC Data Distribution
Natural Resources Canada Geobase

CLIENT: BC hydro

PROJECT: CLBMON-43

Slocan River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: September, 2014	ANALYST: MY	**Figure 8 of 9**
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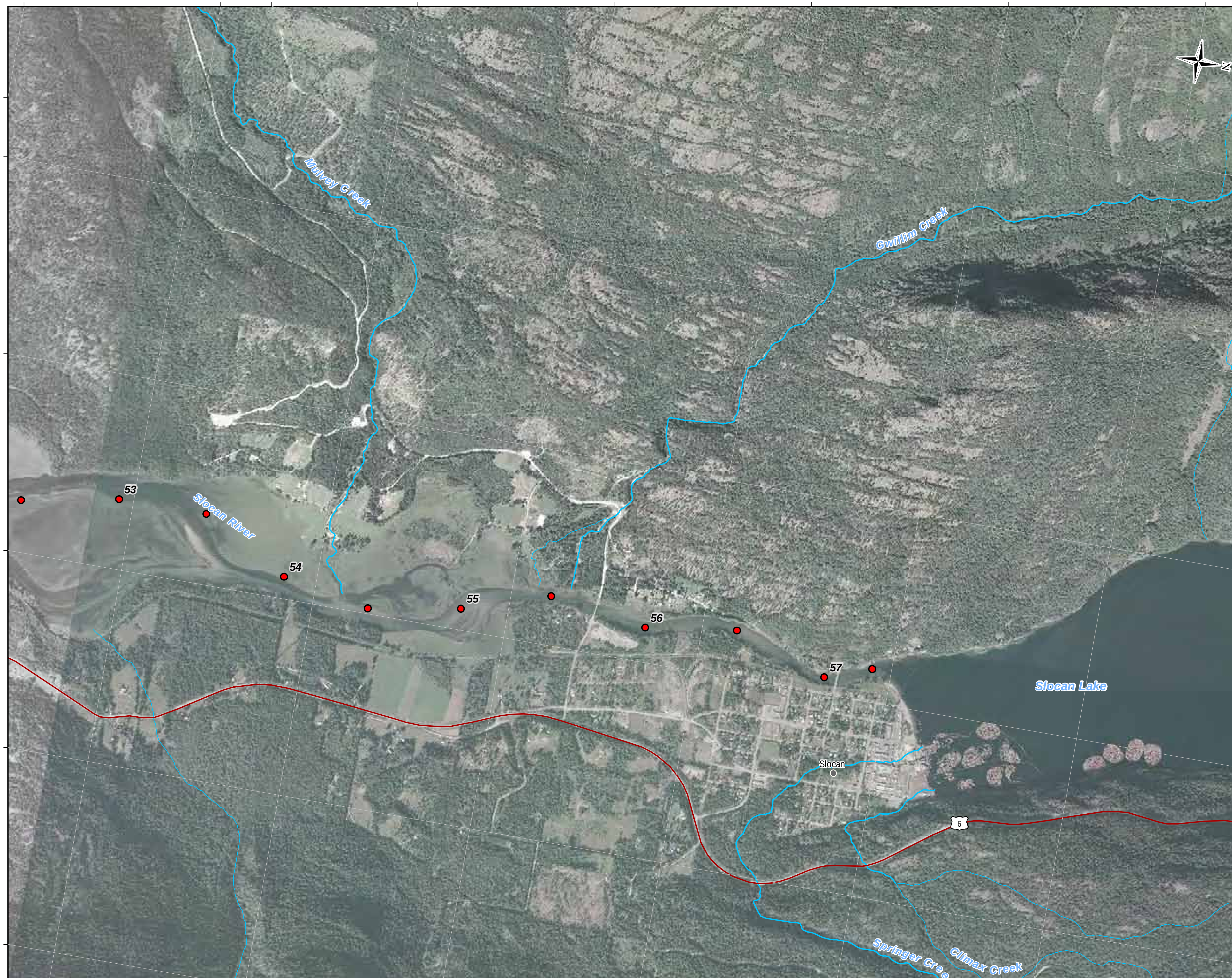
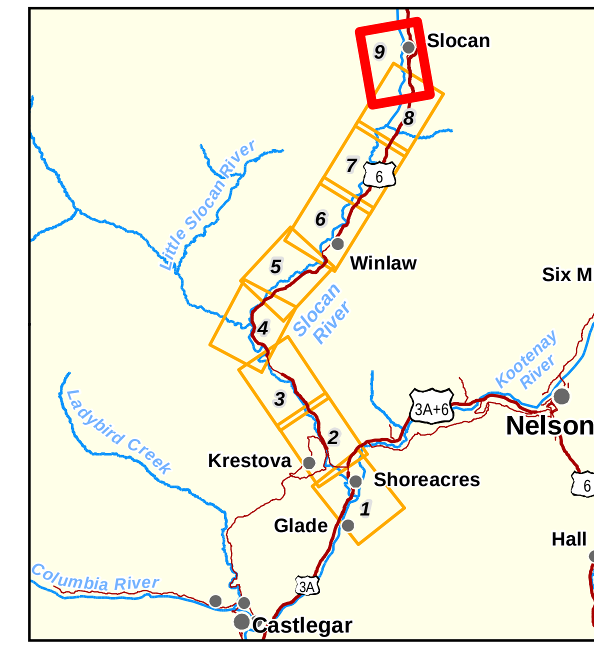


Legend

- Populated Place
- Km Mark

2010-2014 Sample Locations

- Sample Location/No SARA Species Captured
- Columbia Sculpin
- Shorthead Sculpin
- Umatilla Dace
- Highway
- Bridge
- Stream Order >= 2
- Stream Order = 1



Scale:1:20,000

400 200 0 400 800

Meters

Reference

British Columbia Imagery WMS
http://openmaps.gov.bc.ca
BC Government GeoBC Data Distribution
Natural Resources Canada Geobase

CLIENT: BC hydro

PROJECT: CLBMON-43

Slocan River Sample Locations and Observations of SARA Listed Species, 2010 - 2014

DATE: September, 2014	ANALYST: MY	**Figure 9 of 9**
JOB No: VE51872	QA/QC: CL	PDF FILE: VE51872_slocan_samplesite_mapbook.pdf
GIS FILE: VE51872_slocan_samplesite_mapbook.mxd		
PROJECTION: UTM Zone 11	DATUM: NAD83	amec

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APPENDIX C

Catch and Catch Effort Summary (Year 5)

Table C3. Summary of snorkeling, PIT tag tracking and other effort in the Lower Columbia (LCR) and Slocan river study areas, 2013-14.

Waterbody	Site[1]	River Kilometer[1]	Date	Method[2]	Set Date/Time	Pull Date/Time	Effort (Hrs)	Set Type	Site Length (m)	Site Width (m)	Site Area (m^2)	Water Temperature (°C)	Fish Captures[3]															Catch-per-unit-effort (CPUE)	Umatilla Dace CPUE	Catch per m^2	Umatilla Dace catch per m^2	Columbia Sculpin catch per m^2	Shorthead Sculpin catch per m^2
													CAS	CBA	CC	CCN	CP	CRH	DC	LNC	NSC	RB	RSC	SU	UDC	UNK	Total						
LCR	Beaver Creek Mouth	LCR_47.5L	11/07/2013	LS1				Day	30	4	120	18.8														1000	1000	0	0	8.33	0	0	0
Kootenay River	Kootenay River Mouth RB	Koot_0.2R	07/08/2013	SW1	07/08/2013 15:20	07/08/2013 15:55	0.58	Day	150	4	600	21.4	1		17	1		1	1	149						36	206	353.14	0.00	0.34	0.00	0.00	0.00
Total Snorkelling Effort (hrs), Area, Catch per Species and Average CPUE for Kootenay River, 2013							**0.58**				**600**		**1**	**0**	**17**	**1**	**0**	**1**	**1**	**149**	**0**	**0**	**0**	**0**	**0**	**36**	**206**	**353.14**	**0.00**	**0.34**			
LCR	Genelle Index Site	LCR_24.5R	24/05/2013	SW1	24/05/2013 10:00	24/05/2013 11:15	1.25	Day	100	4	400	8.8			1												1	0.80	0.00	0.00	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	24/05/2013	SW1	24/05/2013 14:00	24/05/2013 15:00	1.00	Day	100	4	400	8.9		2		1											3	3.00	0.00	0.01	0.00	0.01	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	05/06/2013	SW1	05/06/2013 11:05	05/06/2013 12:10	1.08	Day	100	4	400	12.3			4												4	3.69	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	05/06/2013	SW1	05/06/2013 13:45	05/06/2013 15:20	1.58	Day	100	4	400	11.7			3												3	1.89	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	12/06/2013	SW1	12/06/2013 11:08	12/06/2013 12:54	1.77	Day	50	3	150	13.6		2	15			5									22	12.45	0.00	0.15	0.00	0.01	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	19/06/2013	SW1	19/06/2013 9:40	19/06/2013 10:45	1.08	Day	100	5	500	13		1				1									2	1.85	0.00	0.00	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	19/06/2013	SW1	19/06/2013 13:15	19/06/2013 15:15	2.00	Day	120	4	480	12.4		2	5	1		1									9	4.50	0.00	0.02	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	27/06/2013	SW1	27/06/2013 10:10	27/06/2013 11:45	1.58	Day	100	5	500	11.9			34			1									35	22.11	0.00	0.07	0.00	0.00	0.00
LCR	Rialto Creek Mouth DS	LCR_1.6L	26/06/2013	SW1	26/07/2013 11:00	26/07/2013 11:45	0.75	Day	20	7	140	12.8			25												25	33.33	0.00	0.18	0.00	0.00	0.00
LCR	Unk Trib Mouth Robson	LCR_2.8L	26/06/2013	SW1	26/07/2013 13:10	26/07/2013 14:08	0.97	Day	40	7	280	13.4			18												18	18.62	0.00	0.06	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	27/06/2013	SW1	27/07/2013 13:30	27/07/2013 14:45	1.25	Day	120	5	600	12.5			22			1	5								28	22.40	0.00	0.05	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	07/08/2013	SW1	07/08/2013 14:18	07/08/2013 15:08	0.83	Day	75	7	525	19.8	3	1	242	7		13	4	2	2						274	328.80	0.00	0.52	0.00	0.00	0.01
LCR	Unk Trib Mouth Robson	LCR_2.8L	15/08/2013	SW1	15/08/2013 13:25	15/08/2013 14:05	0.67	Day	50	7	350	17.7	11	1	146	1		4		8		20					191	286.50	0.00	0.55	0.00	0.00	0.00
Total Snorkelling Effort (hrs), Area, Catch per Species and Average CPUE for Columbia River, 2013							**15.8**				**5125**		**14**	**9**	**515**	**10**	**0**	**26**	**9**	**10**	**2**	**20**	**0**	**0**	**0**	**0**	**615**	**38.88**	**0.00**	**0.12**	**0.00**	**0.00**	**0.00**
Total Snorkelling Effort (hrs), Area, Catch per Species and Average CPUE for the LCR Study Area, 2013							**16.4**				**5725**		**15**	**9**	**532**	**11**	**0**	**27**	**10**	**159**	**2**	**20**	**0**	**0**	**0**	**36**	**821**	**50.06**	**0.00**	**0.14**	**0.00**	**0.00**	**0.00**
Slocan River	Sloc_37.8L	Sloc_37.8L	17/07/2013	SW1	17/07/2013 10:10	17/07/2013 11:00	0.83	Day	150	7	1050	16.4													4		4	4.80	4.80	0.00	0.00	0.00	0.00
Total Snorkelling Effort (hrs), Area, Catch per Species and Average CPUE for Slocan River, 2013							**0.83**				**1050**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**4**	**4.80**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
LCR	Genelle Index Site	LCR_24.5R	08/05/2013	TR1	08/05/2013 9:20	08/05/2013 10:45	1.42	Day	100	5	500	9.1	1	2				1							1		5	3.53	0.71	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	09/05/2013	TR1	09/05/2013 10:30	09/05/2013 12:10	1.67	Day	100	4	400	9.9	1			2		7									10	6.00	0.00	0.03	0.00	0.00	0.01
LCR	CLB LB US Koot Mouth	LCR_10.5L	22/05/2013	TR1	22/05/2013 22:30	22/05/2013 23:45	1.25	Night	100	4	400	10.5						7									7	5.60	0.00	0.02	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	23/05/2013	TR1	23/05/2013 10:00	23/05/2013 11:15	1.25	Day	100	3	300	8.9	1			1											2	1.60	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	23/05/2013	TR1	23/05/2013 12:32	23/05/2013 13:51	1.32	Day	100	4	400	10.1						5									5	3.80	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	24/05/2013	TR1	24/05/2013 9:55	24/05/2013 11:15	1.33	Day	100	4	400	8.8	1														1	0.75	0.00	0.00	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	24/05/2013	TR1	24/05/2013 13:18	24/05/2013 14:20	1.03	Day	120	4	480	8.9						4									4	3.87	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	05/06/2013	TR1	05/06/2013 9:32	05/06/2013 11:45	2.22	Day	120	4	480	12.3						7									7	3.16	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	05/06/2013	TR1	05/06/2013 13:30	05/06/2013 15:00	1.50	Day	100	4	400	11.7	1					2									3	2.00	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	12/06/2013	TR1	12/06/2013 9:45	12/06/2013 11:00	1.25	Day	130	4	520	13.6	1														1	0.80	0.00	0.00	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	13/06/2013	TR1	13/06/2013 12:20	13/06/2013 14:25	2.08	Day	100	5	500	14.6						4									4	1.92	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	27/06/2013	TR1	27/06/2013 10:04	27/06/2013 11:34	1.50	Day	100	4	400	11.9	1														1	0.67	0.00	0.00	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	27/06/2013	TR1	27/06/2013 13:14	27/06/2013 14:33	1.32	Day	120	5	600	12.5						4									4	3.04	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	01/08/2013	TR1	01/08/2013 11:11	01/08/2013 12:26	1.25	Day	75	4	300	18.4						2									2	1.60	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	02/08/2013	TR1	02/08/2013 13:06	02/08/2013 14:12	1.10	Day	100	3	300	17															0	0.00	0.00	0.00	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	03/08/2013	TR1	03/08/2013 13:06	03/08/2013 14:24	1.30	Day	75	4	300	18.8						1									1	0.77	0.00	0.00	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	03/08/2013	TR1	03/08/2013 15:15	03/08/2013 16:05	0.83	Day	100	3	300	16.9															0	0.00	0.00	0.00	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	07/08/2013	TR1	07/08/2013 10:00	07/08/2013 11:30	1.50	Day	100	4	400	18.4															0	0.00	0.00	0.00	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	07/08/2013	TR1	07/08/2013 13:04	07/08/2013 14:00	0.93	Day	100	4	400	19.8						2									2	2.14	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	07/08/2013	TR1	07/08/2013 22:05	07/08/2013 23:05	1.00	Night	100	4	400	19.9						2									2	2.00	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	08/08/2013	TR1	08/08/2013 9:30	08/08/2013 10:38	1.13	Day	100	4	400	20.1						2									2	1.76	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	29/08/2013	TR1	29/08/2013 9:45	29/08/2013 11:22	1.62	Day	120	4	480	18		2				1									3	1.86	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	29/08/2013	TR1	29/08/2013 13:15	29/08/2013 14:25	1.17	Day	100	4.5	450	18						3									3	2.57	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	30/08/2013	TR1	30/08/2013 10:00	30/08/2013 11:30	1.50	Day	120	4	480	18.5		1				1									2	1.33	0.00	0.00	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	30/08/2013	TR1	30/08/2013 13:45	30/08/2013 15:15	1.50	Day	100	4.5	450	18.5						4									4	2.67	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	19/09/2013	TR1	19/09/2013 10:00	19/09/2013 11:17	1.28	Day	120	5	600	16.4						5									5	3.90	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	19/09/2013	TR1	19/09/2013 12:30	19/09/2013 14:08	1.63	Day	100	5	500	18.4	1	3		1		14									19	11.63	0.00	0.04	0.00	0.01	0.00
LCR	Genelle Index Site	LCR_24.5R	20/09/2013	TR1	20/09/2013 10:05	20/09/2013 11:23	1.30	Day	120	5	600	15.3						3									3	2.31	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	20/09/2013	TR1	20/09/2013 13:25	20/09/2013 14:48	1.38	Day	120	5	600	18.3	1	3		1		10									15	10.84	0.00	0.03	0.00	0.01	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	21/09/2013	TR1	21/09/2013 11:45	21/09/2013 13:45	2.00	Day	120	5	600	17.5		3		1		14									18	9.00	0.00	0.03	0.00	0.01	0.00
LCR	Genelle Index Site	LCR_24.5R	21/09/2013	TR1	21/09/2013 14:52	21/09/2013 16:13	1.35	Day	120	5	600	15.9						3									3	2.22	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	26/09/2013	TR1	26/09/2013 11:20	26/09/2013 12:10	0.83	Day	75	5	375	15.3						3									3	3.60	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	26/09/2013	TR1	26/09/2013 13:30	26/09/2013 15:15	1.75	Day	120	5	600	14.6		2		1		6									9	5.14	0.00	0.02	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	27/09/2013	TR1	27/09/2013 9:00	27/09/2013 10:40	1.67	Day	120	5	600	16		1		2		10									13	7.80	0.00	0.02	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	28/09/2013	TR1	28/09/2013 11:06	28/09/2013 13:00	1.90	Day	120	6	720	15.8		1		1		6									8	4.21	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	03/10/2013	TR1	03/10/2013 11:15	03/10/2013 12:15	1.00	Day	100	5	500					1		3									4	4.00	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	03/10/2013	TR1	03/10/2013 13:05	03/10/2013 14:35	1.50	Day	120	8	960					1		7									8	5.33	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	09/10/2013	TR1	09/10/2013 10:20	09/10/2013 11:30	1.17	Day	100	5	500	12.6				1		2									3	2.57	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	09/10/2013	TR1	09/10/2013 13:34	09/10/2013 15:02	1.47	Day	100	5	500	14.2		1		3		7									11	7.50	0.00	0.02	0.00	0.00	0.01
LCR	Genelle Index Site	LCR_24.5R	10/10/2013	TR1	10/10/2013 18:20	10/10/2013 19:25	1.08	Night	120	5	600	12.6						3									3	2.77	0.00	0.01	0.00	0.00	0.00

Table C3 continued

Waterbody	Site[1]	River Kilometer[1]	Date	Method[2]	Set Date/Time	Pull Date/Time	Effort (Hrs)	Set Type	Site Length (m)	Site Width (m)	Site Area (m^2)	Water Temperature (°C)	Fish Captures[3]															Catch-per-unit-effort (CPUE)	Umatilla Dace CPUE	Catch per m^2	Umatilla Dace catch per m^2	Columbia Sculpin catch per m^2	Shorthead Sculpin catch per m^2
													CAS	CBA	CC	CCN	CP	CRH	DC	LNC	NSC	RB	RSC	SU	UDC	UNK	Total						
LCR	CLB LB US Koot Mouth	LCR_10.5L	10/10/2013	TR1	10/10/2013 21:43	10/10/2013 23:00	1.28	Night	100	5	500	12.6		2		2		10									14	10.91	0.00	0.03	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	20/12/2013	TR1	20/12/2013 9:40	20/12/2013 11:05	1.42	Day	100	5	500			1				1									2	1.41	0.00	0.00	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	20/12/2013	TR1	20/12/2013 12:22	20/12/2013 13:31	1.15	Day	100	5	500																0	0.00	0.00	0.00	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	21/12/2013	TR1	21/12/2013 10:15	21/12/2013 11:55	1.67	Day	100	5	500	4.3		1				3									4	2.40	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	21/12/2013	TR1	21/12/2013 13:14	21/12/2013 14:14	1.00	Day	100	5	500	4.3															0	0.00	0.00	0.00	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	29/01/2014	TR1	29/01/2014 10:25	29/01/2014 11:45	1.33	Day	120	5	600	3.7	2	3		1		5									11	8.25	0.00	0.02	0.00	0.01	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	29/01/2014	TR1	29/01/2014 13:00	29/01/2014 14:30	1.50	Day	100	5	500	3.8		2		1		5									8	5.33	0.00	0.02	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	30/01/2014	TR1	30/01/2014 9:45	30/01/2014 10:55	1.17	Day	120	5	600	3.7	2	3		1		4									10	8.57	0.00	0.02	0.00	0.01	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	30/01/2014	TR1	30/01/2014 12:23	30/01/2014 13:48	1.42	Day	100	5	500	3.5		1		1		4									6	4.24	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	01/02/2014	TR1	01/02/2014 10:05	01/02/2014 11:34	1.48	Day	100	5	500	3.6	1			1		5									7	4.72	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	01/02/2014	TR1	01/02/2014 12:30	01/02/2014 13:45	1.25	Day	120	5	600	3.7	1	3		1		4									9	7.20	0.00	0.02	0.00	0.01	0.00
LCR	Genelle Index Site	LCR_24.5R	04/02/2014	TR1	04/02/2014 12:05	04/02/2014 12:45	0.67	Day	100	5	500	3	1	2				2									5	7.50	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	04/02/2014	TR1	04/02/2014 13:30	04/02/2014 14:25	0.92	Day	80	5	400	3						1									1	1.09	0.00	0.00	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	14/02/2014	TR1	14/02/2014 10:43	14/02/2014 11:43	1.00	Day	120	5	600	2.6	3	2													5	5.00	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	14/02/2014	TR1	14/02/2014 13:15	14/02/2014 14:30	1.25	Day	120	5	600	2.3															0	0.00	0.00	0.00	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	15/02/2014	TR1	15/02/2014 11:50	15/02/2014 12:55	1.08	Day	120	9	1080	2.5		2				1									3	2.77	0.00	0.00	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	15/02/2014	TR1	15/02/2014 14:15	15/02/2014 15:12	0.95	Day	120	7	840	2.8		2				4									6	6.32	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	20/02/2014	TR1	20/02/2014 10:45	20/02/2014 11:55	1.17	Day	120	5	600	2.9						3									3	2.57	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	20/02/2014	TR1	20/02/2014 13:05	20/02/2014 14:30	1.42	Day	120	8	960	2.9		1		2											3	2.12	0.00	0.00	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	27/03/2014	TR1	27/03/2014 9:55	27/03/2014 11:15	1.33	Day	130	5	650	4	3	1				1									5	3.75	0.00	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	27/03/2014	TR1	27/03/2014 12:30	27/03/2014 13:47	1.28	Day	125	5	625	5.2	1														1	0.78	0.00	0.00	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	28/03/2014	TR1	28/03/2014 9:45	28/03/2014 10:39	0.90	Day	100	5	500	3.3	1														1	1.11	0.00	0.00	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	28/03/2014	TR1	28/03/2014 13:00	28/03/2014 14:21	1.35	Day	130	5	650	4	2	2				1							1		6	4.44	0.74	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	29/03/2014	TR1	29/03/2014 10:05	29/03/2014 11:15	1.17	Day	100	5	500	4.3	1	1													2	1.71	0.00	0.00	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	29/03/2014	TR1	29/03/2014 13:10	29/03/2014 14:15	1.08	Day	130	5	650	4.7	2	1				2							1		6	5.54	0.92	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	31/03/2014	TR1	31/03/2014 10:08	31/03/2014 11:11	1.05	Day	100	5	500	4.7	1	1													2	1.90	0.00	0.00	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	31/03/2014	TR1	31/03/2014 12:40	31/03/2014 13:50	1.17	Day	130	5	650	4.6	2	1											1		4	3.43	0.86	0.01	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	01/04/2014	TR1	01/04/2014 10:12	01/04/2014 11:45	1.55	Day	100	5	500	4.6	2	3		1		1									7	4.52	0.00	0.01	0.00	0.01	0.00
LCR	Genelle Index Site	LCR_24.5R	01/04/2014	TR1	01/04/2014 13:20	01/04/2014 14:30	1.17	Day	130	4	520	5	2	3				5							1		11	9.43	0.86	0.02	0.00	0.01	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	02/04/2014	TR1	02/04/2014 10:00	02/04/2014 11:27	1.45	Day	100	5	500	4.6	1	4		1		1									7	4.83	0.00	0.01	0.00	0.01	0.00
LCR	Genelle Index Site	LCR_24.5R	02/04/2014	TR1	02/04/2014 14:15	02/04/2014 15:15	1.00	Day	130	4	520	5.2	4	2				4									10	10.00	0.00	0.02	0.00	0.00	0.00
Total Tracking Effort (hrs), Site Area, Catch per Species and Average CPUE for LCR Index Sites, 2013 - 2014							**92.90**				**37440**		**41**	**63**	**0**	**28**	**0**	**222**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**359**	**3.86**	**0.05**	**0.01**	**0.00**	**0.00**	**0.00**
LCR	Genelle Index Site	LCR_24.5R	12/06/2013	VO1	12/06/2013 11:20	12/06/2013 14:00	2.67	Day	75	3	225	13.6			3												3	1.12	0.00	0.01	0.00	0.00	0.00
LCR	Unk Trib Mouth Robson	LCR_2.8L	13/06/2013	VO1	13/06/2013 11:00	13/06/2013 11:05	0.08	Day	20	2	40	15.1						1									1	12.00	0.00	0.03	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	13/06/2013	VO1	13/06/2013 12:20	13/06/2013 14:45	2.42	Day	30	3	90	14.6			3			2									5	2.07	0.00	0.06	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	13/06/2013	VO1	13/06/2013 15:30	13/06/2013 16:00	0.50	Day	75	2	150	13.4			1												1	2.00	0.00	0.01	0.00	0.00	0.00
LCR	Genelle Index Site	LCR_24.5R	30/10/2013	VO1				Day																			0	0.00	0.00	0.00	0.00	0.00	0.00
LCR	CLB LB US Koot Mouth	LCR_10.5L	30/10/2013	VO1				Day																			0	0.00	0.00	0.00	0.00	0.00	0.00

Notes:

1 LB or L= left downstream bank; RB or R= right downstream bank; US= upstream; DS= downstream

2 LS= Lip Seining; SW = Snorkeling; TR= PIT Tag Tracking; VO= Visually Observed

3 CAS= Prickly sculpin; CBA= Columbia sculpin; CC= Sculpin sp.; CCN= Shorthead sculpin; CRH= Torrent sculpin; DC= Dace sp.; LNC= Longnose dace; RSC= Redside shiner; UDC= Umatilla dace; UNK= Unknown sp.

APPENDIX D

Life Stage Summary Tables

Table 1: Number (N) of target fish species captured by life stage in the LCR study area and unregulated tributaries for all years of study by all methods, 2009-2014.

Species	LCR Study Area				Unregulated Tributary[1]				
	N	Adult	Juvenile	YOY	Tributary Name	N	Adult	Juvenile	YOY
Umatilla Dace	**594**	90	212	292	Slocan River	688	497	41	150
Columbia Sculpin	**286**	232	17	37	Similkameen River system	984	706	202	76
Shorthead Sculpin	**368**	236	51	81	Pass Creek	497	245	212	40

Notes – Dace are measured by fork length while sculpins are measured by total length.
[1] – Similkameen and Pass Creek data from AMEC 2010b and AMEC 2011.

Table 2: Number (N) of Adult target fish species captured by season in the LCR study area and unregulated tributaries for all years of study by all methods, 2009-2014.

Species	LCR Study Area					Unregulated Tributary[1]					
	N	Spring	Summer	Fall	Winter	Tributary Name	N	Spring	Summer	Fall	Winter
Umatilla Dace	**90**	12	65	12	1	Slocan River	**497**	46	389	62	0
Columbia Sculpin	**232**	78	112	15	27	Similkameen River system	**706**	-	470	-	236
Shorthead Sculpin	**236**	85	110	36	5	Pass Creek	**245**	-	5	240	-

Notes – Dace are measured by fork length while sculpins are measured by total length.
[1] – Similkameen and Pass Creek data from AMEC 2010b and AMEC 2011.
- Not sampled

Table 3: Number (N) of Juvenile target fish species by season captured in the LCR study area and unregulated tributaries for all years of study combined, 2009-2014.

Species	LCR Study Area					Unregulated Tributary[1]					
	N	Spring	Summer	Fall	Winter	Tributary Name	N	Spring	Summer	Fall	Winter
Umatilla Dace	**213**	54	103	56	0	Slocan River	**41**	2	36	3	0
Columbia Sculpin	**17**	9	5	2	1	Similkameen River system	**202**	-	181	-	21
Shorthead Sculpin	**51**	14	26	11	0	Pass Creek	**212**	-	8	204	-

Notes – Dace are measured by fork length while sculpins are measured by total length.
[1] – Similkameen and Pass Creek data from AMEC 2010b and AMEC 2011.
- Not sampled

Table 4: Number (N) of Young-of-year (YOY) target fish species by season captured in the LCR study area and unregulated tributaries for all years of study combined, 2009-2014.

Species	LCR Study Area					Unregulated Tributary[1]					
	N	Spring	Summer	Fall	Winter	Tributary Name	N	Spring	Summer	Fall	Winter
Umatilla Dace	**291**	94	41	82	74	Slocan River	**150**	13	2	100	35
Columbia Sculpin	**37**	5	21	11	0	Similkameen River system	**76**	-	3	-	73
Shorthead Sculpin	**81**	17	35	29	0	Pass Creek	**40**	-	3	37	-

Notes – Dace are measured by fork length while sculpins are measured by total length.
[1] – Similkameen and Pass Creek data from AMEC 2010b and AMEC 2011.
- Not sampled

APPENDIX E

Sculpin and Dace Spawning Data (Years 1 to 5)

Table E1. Habitat characteristics of locations in which Umatilla dace displaying spawning colouration were captured in the Slocan River, 2011-13.

Location[1]	Sample Date	Set Type	Survey Method[2]	Water Temperature (°C)	Water Depth (m)	Average Velocity (m/s)	Substrate Type	Distance to Shore (m)	Fork Length (mm)	Sex[3]	Maturity	Comments
Sloc_39.4L	09/08/2011	Overnight	MT	18.5	0.4	0	Flooded Vegetation	2	110	F	Ripe	Bright red on lips, expressing eggs.
Sloc_36.1R	29/08/2011	Overnight	MT	19.3	0.8	0	Flooded Vegetation	1	95	F	Ripe	Very red on top lip, urogenital pore engorged before abdomen squeezed, 8 eggs expressed (1 mm diameter); pelvic fins do not overlap insertion of anal fin.
Sloc_36.1R	07/09/2011	Overnight	MT	18.6	1	0.01	Aquatic Macrophytes	3	97	F	Mature	Likely female; pelvics just to anal fin, fading red pigment on upper lip.
Sloc_39.4R	17/07/2013	Dusk	MT	16.6	0.8	0.3	Cobble	0.5	88	F	Ripe	Eggs expressed easily (~3), whiteish/opaque, 1 mm diameter, no colour, no tubercules noted.
Sloc_37.8L	18/07/2013	Dawn	MT	16.4	0.25	0	Flooded Vegetation	0.8	87	F	Ripe	Eggs released when squeezed, small bit of pigment on upper lip (speckling), 2 eggs (diameters: 1.5 mm- yellowish, 1 mm- white); able to squeeze out 4 of each, notably distended abdomen, no tubercles.
Sloc_37.8L	30/07/2013	Overnight	MT	20.5	1	0.05	Aquatic Macrophytes	1.3	94	F	Ripe	Ripe- average egg diameter 1.3 mm, easily squeezed 9 eggs out, bit of red/orange on upper lip and pectoral fin insertion.
Sloc_37.8L	12/08/2013	Dusk	MT	21.1	1	0.2	Silt	2	91	F	Spent	Tubercles on back, soft belly, spent female (?), tiny eggs, ripe (but with only 2 smaller eggs observed), abdomen soft and hollow, small bit of colour on nose.
Sloc_39.4L	13/08/2013	Dawn	MT	20.1	0.4	0	Aquatic Macrophytes	1	97	F	Spent	Spent female? Tiny bit of red on lips and at pectoral fin insertions, tubercles on the back, deflated stomach.
Sloc_43.1L	18/07/2011	Overnight	MT	16.2	0.6	0	Flooded Vegetation	2	70	M	Ripe	Orange on lips, base of pectoral and pelvic fins, expressing milt.
Sloc_37.8L	29/08/2011	Overnight	MT	19.2	0.5	0	Silt	1.5	72	M	Mature	Lips fading red (could be parasite or spawning colour), disected and is male with undeveloped testes.
Sloc_39.4R	08/05/2012	Overnight	MT	9.7	0.25	0	Flooded Vegetation	2	93	M	Mature	Orange coloured pelvic/lips.
Sloc_37.8L	16/08/2012	Dusk	MT	20.3	0.8	0	Silt	0.5	74	M	Ripe	Milting; slight red colour on lips and orange colour at base of pectoral and pelvic fins.
Sloc_37.8L	16/08/2012	Night	MT	20.4	0.2	0	Flooded Vegetation	2	87	M	Ripe	Milting; small amount of orange on lips.
Sloc_37.8L	17/08/2012	Dawn	MT	19.1	0.2	0	Flooded Vegetation	2	89	M	Ripe	Milting; orange at top of lips and end of pectoral and pelvic fins.
Sloc_37.8L	17/08/2012	Day	MT	18.1	0.8	0	Silt	0.5	75	M	Ripe	Milting; orange on lips and insertions of pelvic and pectoral fins.
Sloc_39.4L	13/06/2013	Overnight	MT	13	0.5	0.2	Flooded Vegetation	4	92	M	Mature	Orange at insertion of pectoral and pelvic fins, orange on upper lips and back of operculum, tubercoles on scales above lateral line, no milt.
Sloc_37.8L	09/07/2013	Overnight	MT	17	1.2	0.05	Flooded Vegetation	0.5	85	M	Ripe	Milting, pelvic fins to insertion of anal fin, orange markings on upper lip, base of operculum, anal fin; tubercoles on anterior of dorsal fin.
Sloc_39.4L	09/08/2011	Overnight	MT	18.5	0.4	0	Flooded Vegetation	2	95	UNK	Mature	Some red on lips and pelvic fin.
Sloc_39.4L	09/08/2011	Overnight	MT	18.5	0.4	0	Flooded Vegetation	2	61	UNK	Mature	
Sloc_39.4L	09/08/2011	Overnight	MT	18.5	1.2	0	Flooded Vegetation	2	75	UNK	Mature	Small amount of red on pelvic fins and lips.
Sloc_39.4L	09/08/2011	Overnight	MT	18.5	1.2	0	Flooded Vegetation	2	65	UNK	Mature	Red starting on lips.
Sloc_39.4L	09/08/2011	Overnight	MT	18.5	1.2	0	Flooded Vegetation	2	65	UNK	Mature	Some red on ventral side.
Sloc_30.7R	09/08/2011	Overnight	MT	18.7	0.5	0	Silt	0.3	64	UNK	Mature	Pink around lips, anal fin and pelvics.
Sloc_37.8L	16/08/2011	Overnight	MT	18.8	0.2	0	Silt	1	81	UNK	Mature	Red lips.
Sloc_37.8L	16/08/2011	Overnight	MT	18.8	1.2	0	Silt	1.5	75	UNK	Mature	Fat, red on top of head and starting on lips.
Sloc_37.8L	16/08/2011	Overnight	MT	18.8	1.2	0	Silt	1.5	75	UNK	Mature	Red in lips.
Sloc_36.1R	29/08/2011	Overnight	MT	19.3	0.8	0	Flooded Vegetation	1	77	UNK	Mature	Red nose, pelvic fins past insertion of anal fin.
Sloc_36.1R	29/08/2011	Overnight	MT	19.3	1.5	0	Flooded Vegetation	5	96	UNK	Mature	Small bit of red on upper lip; pelvics to insertion of anal fin.
Sloc_36.1R	29/08/2011	Overnight	MT	19.3	1.5	0	Flooded Vegetation	5	95	UNK	Mature	small bit of red on upper lip; pelvics to insertion of anal fin.
Sloc_36.1R	29/08/2011	Overnight	MT	19.3	1.5	0	Flooded Vegetation	5	78	UNK	Mature	Some red on upper lip; pelvics to insertion of anal fin.
Sloc_36.1R	07/09/2011	Overnight	MT	18.6	1.2	0	Aquatic Macrophytes	4	81	UNK	Mature	Pelvics past insertion of anal fin; slight orange at base of pectorals and along pelvic fins and upper lip ridge.
Sloc_39.4L	27/09/2011	Day	EF	14.4	-	-	-	-	84	UNK	Mature	Orange on upper lip and pelvic insertions, fins overlap anal fin origin. Vouchered.
Sloc_39.4L	29/08/2012	Overnight	MT	16.9	0.25	0	Aquatic Macrophytes	1	88	UNK	Mature	Reddish upper lips; orange at pelvic and pectoral fin insertions; soft abdomen.
Sloc_39.4L	12/08/2013	Day	MT	19.7	1	0	Aquatic Macrophytes	4	84	UNK	Mature	Slight pigment on upper lip, very soft belly, ovipositor (?), female (?), potential post-spawner.
Sloc_39.4R	12/08/2013	Day	MT	19.9	0.8	0	Aquatic Macrophytes	1	67	UNK	Mature	Mild orange on upper lip.
Sloc_39.4R	12/08/2013	Day	MT	19.9	0.8	0	Aquatic Macrophytes	1	75	UNK	Mature	Orange on upper lip.
Sloc_39.4R	12/08/2013	Dusk	MT	21	0.8	0	Aquatic Macrophytes	1	83	UNK	Spent	Small bit of red on lips, very soft abdomen, female (?), post-spawner (?).
Sloc_37.8L	13/08/2013	Dawn	MT	19.3	1.5	0.1	Aquatic Macrophytes	3	80	UNK	Mature	Bit of red on upper lip.
Sloc_39.4R	13/08/2013	Dawn	MT	20.1	0.8	0	Aquatic Macrophytes	1	55	UNK	Mature	Slight orange on upper lip.

Notes:

[1] L= left downstream bank; R= right downstream bank

[2] EF= Backpack Electrofishing; MT= Minnow Trapping

[3] F= Female; M= Male; UNK= Unknown

Table E2. Sculpin spawning habitat and nest information in Similkameen and Lower Columbia River (LCR) study areas, 2009-2013.

Waterbody	Location[1]	Location Description[1]	Sample Date	Year	Water Temperature (°C)	Survey Method[2]	UTM Zone	UTM Easting	UTM Northing	Species Code[3]	New Nest (yes/no)	Distance to Shore (m)	Habitat Type	Water Depth (m)	Average Velocity (m/s)	Substrate Type	Percent Embedded (%)	Nest Rock Axis A (mm)	Nest Rock Axis B (mm)	Nest Rock Axis C (mm)	Number of Egg Masses	Nest Stage	Number of Eggs	Egg Diameter (mm)	Nest Survival (%)	Comments[4]
LCR	LCR_1.6L	Rialto Creek Mouth DS	22/06/2011	2011	12	SW1	11	880964	5478694	CAS	Yes	12	Pool	1.3	0	Cobble	10	220	200	180	4	Eyed but not moving				Nest 1; 2 yellow clumps 2 pink- 1 pink eyed rest not eyed and yellow look fresh; few eaten eggs from newest
LCR	LCR_2.8L	Unk Trib Mouth Robson	21/06/2011	2011	11.5	SW1	11	882270	5478734	CAS	Yes	5	Pool	1.19	0.11	Cobble	0	200	150	60	5	Eyed but not moving	507	1.9	100	nest 6; varied stage from fresh/yellow to pink and eyed; few fungus in oldest clump; collect 1 clump; no fish obs; 10-13
LCR	LCR_8.2L	Robson Bridge	17/06/2010	2010	15	SW1	11			CBA	Yes	2	Run	0.4	0.05	Cobble	10	200			1	Fresh	220	2.1	100	Just deposited, captured female and observed probably male, eggs very bright mustard yellow colour, smaller than those observed in Otter Creek (possibly not fertilized yet or yet to expand), area flooded within previous ~2 weeks.
LCR	LCR_24.5R	Genelle Index Site	13/07/2011	2011	14	SW1	11	449970	5450697	CBA	Yes	2	Run	0.5	0.2	Cobble	5	180	150	80	1	Eyed but not moving	60	2.7	70	Nest2, Yellowish, some uneyed, about 30% fungused and dead. Collected
LCR	LCR_24.5R	Genelle Index Site	20/07/2011	2011	14.5	SW1	11			CBA	No	0.5	Pool	0.2	0											Nest 2 from previous; collected last time.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	SW1	11	449968	5450693	CBA	Yes	2	Run	0.66	0.19	Cobble	5	180	120	80	4	Clear/Pink (x2); eyed and moving; eyed but not moving			82	Nest 3A; CBA caught, 85 mm, 4 clumps, photos 11-12; Clump 1= 75% mort and fungus (clear/pink), Clump 2= 50% mort no fungus (clear/yolk/pink); Clump 3= few eggs remain (10), eyed and moving; Clump 4= 50 eggs eyed not moving
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	SW1	11	449968	5450693	CBA	Yes	0.5	Pool	0.25	0.04	Cobble	5	180	145	90	1	Yellow and milky	120		100	Nest 5A; CLSC (95 mm) obs; DO: 10.57 mg/L; temp: 13.8; marked and replaced; temp logger (Genelle U/S) set here at 15:00
LCR	LCR_24.5R	Genelle Index Site	13/06/2013	2013	13.4	VO1	11	449968	5450693	CBA	No	0.05	Pool	0.02	0	Cobble	5	180	145	90	1	Yellow and milky.	120		25	Nest 5A; not dewatered, a couple of mayfly nymphs, photo 68
LCR	LCR_24.5R	Genelle Index Site	13/06/2013	2013	13.4	VO1	11	449968	5450693	CBA	No	0.45	Pool	0.33	0.19	Cobble	5	180	120	80	4	Clear/Pink (x2); eyed and moving; eyed but not moving	50			Nest 3A; not dewatered.
LCR	LCR_10.5L	CLB LB US Koot Mouth	19/06/2013	2013	13	SW1	11	452636	5462905	CBA	Yes		Run	1.15	0.2						1	Eyed and moving			99	Nest 1B; CLSC observed, photos 4-10
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	VO1	11	449968	5450693	CBA	No		Run	0.75	0.36	Cobble	5	180	120	80	1	Eyed and moving	10		95	Nest 3A; 3 fungused remnants from another clump, 1 (maybe 2) clumps with 10 eyed and moving eggs left.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	VO1	11	449968	5450693	CBA	No		Run	0.26	0.01	Cobble	5	180	145	90	0	No nest	0			Nest 5A; no nest.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450011	5450713	CBA	Yes	2.5	Run	0.56	0.1	Cobble	5	170	150	80	1	Eyed and moving	60		100	Nest 1B; CLSC 70 mm observed at nest
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450018	5450721	CBA	Yes	3	Run	0.95	0.34	Boulder	5	270	250	100	1	Eyed and moving	5		100	Nest 5B; 1 CLSC observed (90 mm).
LCR	LCR_24.5R	Genelle	17/06/2010	2010	12	SW1	11			CC	Yes	3	Run	0.5	0.1	Cobble	10	230			1	Dead	15		0	Rocks covered in algae
LCR	LCR_24.5R	Genelle	17/06/2010	2010	12	SW1	11			CC	Yes	3	Run	1.1	0.1	Boulder	20	450			1	Dead	50		0	Too deep to get out of water
LCR	LCR_24.5R	Genelle	17/06/2010	2010	12	SW1	11			CC	Yes	2	Run	0.5	0.4	Boulder	20	280			1	Half dead, alive are eyed		3	25	
LCR	LCR_24.5R	Genelle	17/06/2010	2010	12	SW1	11			CC	Yes	2	Run	0.5	0.2	Boulder	20	400			1	Dead, except for 25% alive eyed but not moving	70		25	
LCR	LCR_24.5R	Genelle	17/06/2010	2010	12	SW1	11			CC	Yes	2.5	Run	0.7	0.2	Boulder	20	300			2	Dead,except for 25% eyed but not moving	150	3	25	Clutches are different colours and sizes (egg diameter yellow is 3 and darker is 4)
LCR	LCR_24.5R	Genelle	17/06/2010	2010	12	SW1	11			CC	Yes	2	Run	0.7	0.2	Boulder	20	400			1	Half dead, not eyed, appear <1 week old	85		50	
LCR	LCR_24.5R	Genelle	17/06/2010	2010	12	SW1	11			CC	Yes	2	Run	1.2	0.1	Boulder	10				1	Dead, except for a few	12	3	25	Too deep to move rock, photos underwater
LCR	LCR_24.5R	Genelle	17/06/2010	2010	12	SW1	11			CC	Yes		Run	0.75	0.5	Boulder	10	300			1	Dead,except for 10 almost eyed	40	3.1	25	
LCR	LCR_24.5R	Genelle	17/06/2010	2010	12	SW1	11			CC	Yes	2	Run	1.2	0.1	Boulder	10					Dead			0	Too deep to lift rock
LCR	LCR_24.5R	Genelle	17/06/2010	2010	12	SW1	11			CC	Yes	2	Run	1.2	0.1	Boulder	10				1	Dead, except for 3 almost at eyed stage	35	3	9	Lots of algae in area
LCR	LCR_24.5R	Genelle	17/06/2010	2010	12	SW1	11			CC	Yes	3	Run	1	0.3	Boulder	20	350			1	Dead, except for 10 eyed but not moving	50		20	
LCR	LCR_10.5L	CLB LB US Koot Mouth	07/06/2011	2011	11.2	SW1	11	888656.64	5476543.3	CC	Yes	5	Run	1.26	0.49	Cobble	5	210	170	100	1	Yellow and Milky				nest 4, replaced
LCR	LCR_10.5L	CLB LB US Koot Mouth	07/06/2011	2011	11.2	SW1	11	888648.77	5476535.71	CC	Yes	5	Run	0.95	0.28	Cobble	5	270	150	100	1	Yellow and Milky				nest 3, no fish obs, likely ~300 eggs, replaced
LCR	LCR_10.5L	CLB LB US Koot Mouth	07/06/2011	2011	11.2	SW1	11	888663.53	5476546.39	CC	Yes	6	Run	1.16	0.3	Cobble	5	250	200	180	1					nest 6, replaced, trsc seen in area
LCR	LCR_10.5L	CLB LB US Koot Mouth	07/06/2011	2011	11.2	SW1	11	888643.6	5476523.07	CC	Yes	8	Run	1.32	0.42	Cobble	0	200	150	150	2	Yellow and Milky	262	3.3		nest 1; collected; diameter 3-3.5 avg 3.3; 104 and 158 eggs
LCR	LCR_10.5L	CLB LB US Koot Mouth	07/06/2011	2011	11.2	SW1	11	888646.21	5476530.95	CC	Yes	5	Run	1.26	0.33	Cobble	5	150	150	100	1	Yellow and Milky				nest 2, clbs or shsc, replaced

Table E2 continued

Waterbody	Location[1]	Location Description[1]	Sample Date	Year	Water Temperature (°C)	Survey Method[2]	UTM Zone	UTM Easting	UTM Northing	Species Code[3]	New Nest (yes/no)	Distance to Shore (m)	Habitat Type	Water Depth (m)	Average Velocity (m/s)	Substrate Type	Percent Embedded (%)	Nest Rock Axis A (mm)	Nest Rock Axis B (mm)	Nest Rock Axis C (mm)	Number of Egg Masses	Nest Stage	Number of Eggs	Egg Diameter (mm)	Nest Survival (%)	Comments[4]
LCR	LCR_10.5L	CLB LB US Koot Mouth	07/06/2011	2011	11.2	SW1	11	888659.79	5476542.97	CC	Yes	7	Run	1.17	0.3	Cobble	5	200	120	100	1	Yellow and Milky				nest 5, no fish obs, replaced, not removed from water
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	09/06/2011	2011	11.5	SW1	11	888624.79	5476478.83	CC	Yes	2	Pool	1.17	0.06	Cobble	5	200	100	50	1	Yellow and Milky			97	nest#10; 4 dead eggs; no fish observed
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	09/06/2011	2011	11.5	SW1	11	888623.46	5476475.77	CC	Yes	2	Pool	1.4	0	Cobble	0	200	180	150	1	Yellow and Milky			98	nest#9; ~150 eggs; 2 dead eggs; photos 18-20
LCR	LCR_2.8L	Unk Trib Mouth Robson	09/06/2011	2011	11.5	SW1	11	882272.93	5478722.57	CC	Yes	8	Pool	0.92	0.08	Boulder	5	300	200	100	2	Yellow and Milky			80	nest 1, likely trsc, 20% dead eggs, photos 1-10
LCR	LCR_2.8L	Unk Trib Mouth Robson	09/06/2011	2011	11.5	SW1	11	882265.97	5478730.25	CC	Yes	5	Pool	1.2	0.02	Cobble	5	220	220	100	1	White and Milky				nest 2, white eggs, photos 13 and 17
LCR	LCR_2.8L	Unk Trib Mouth Robson	09/06/2011	2011	11.5	SW1	11	882266.19	5478730.31	CC	Yes	5	Pool	1.26	0.03	Cobble	5	180	180	150	1	Pink and Milky			90	nest 3, pink eggs, 10% dead, photos 14-16
LCR	LCR_2.8L	Unk Trib Mouth Robson	21/06/2011	2011	11.5	SW1	11			CC	No	7	Pool	1.4	0.08											nest 3 from previous; gone; likely knocked or eaten
LCR	LCR_2.8L	Unk Trib Mouth Robson	21/06/2011	2011	11.5	SW1	11			CC	No	7	Pool	1.4	0.08											nest 2 from previous; no nest anymore; likely knocked last time
LCR	LCR_24.5R	Genelle Index Site	13/07/2011	2011	14	SW1	11	449967	5450696	CC	Yes	2	Run	0.7	0.1	Cobble	10	180	100	80	1	Eyed and moving			99	Nest 3, Pinkish eggs, about 1% have hatched, <1% dead eggs
LCR	LCR_24.5R	Genelle Index Site	13/07/2011	2011	14	SW1	11	449967	5450696	CC	Yes	2	Run	0.8	0.4	Boulder	5	350	200	120	2	Eyed, Moving and Hatching	30		50	Nest 1, 1 clump hatched and fungus, other pinkish and eyed moving (Collected-5 hatched in bag; 8mm at emergence); 50% of all eggs fungused
LCR	LCR_24.5R	Genelle Index Site	13/07/2011	2011	14	SW1	11	449971	5450697	CC	Yes	3	Run	1	0.15	Boulder	0	150	180	150	1	Hatching			100	Nest 4, Pinkish eggs, no dead eggs, replaced
LCR	LCR_24.5R	Genelle Index Site	13/07/2011	2011	14	SW1	11	449978	5450697	CC	Yes	5	Run	1.3	0.2	Boulder	10	300	220	80	1	Dead	53	3	0	Nest 5, black eggs with white yolks and few yellow/white on interior of clump, one eyed egg. Some possibly viable eggs. Collected.
LCR	LCR_24.5R	Genelle Index Site	13/07/2011	2011	14	SW1	11	449985	5450697	CC	Yes	6	Run	1.3	0.3	Cobble	25	200	150	100	2	Eyed and unmoving	20		50	Nest 6, 1 clump eyed unmoving with 6 eggs remaining, other 15 eggs all fungused. Replaced but not marked.
LCR	LCR_24.5R	Genelle Index Site	13/07/2011	2011	14	SW1	11	450019	5450727	CC	Yes	4	Run	1.1	0.4	Boulder	40	300	200	80	1	Hatching			100	Nest 7, pinkish/pale eggs, half hatched, no dead eggs, replaced.
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	18/07/2011	2011	15.3	SW1	11			CC	No	1	Run	0.6	0.05	Cobble	5									Nest 10 from previous; no nest remaining
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	18/07/2011	2011	15.3	SW1	11			CC	No	4	Run	0.8	0.25	Cobble	5									Nest 5 from previous; no nest remaining
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	18/07/2011	2011	15.3	SW1	11			CC	No	5	Run	0.8	0.3	Cobble	5									Nest 4 from previous; no nest remaining
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	18/07/2011	2011	15.3	SW1	11			CC	No	4	Run	1	0.3	Cobble	5									Nest 2 from previous; no nest remaining
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	18/07/2011	2011	15.3	SW1	11			CC	No	1	Run	0.4	0.1	Cobble	5									Nest 3 from previous; no nest remaining
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	18/07/2011	2011	15.3	SW1	11			CC	No	1.5	Run	0.6	0	Cobble	0									Nest 9 from previous; no nest remaining
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	18/07/2011	2011	15.3	SW1	11			CC	No	1.5	Run	0.6	0.2	Cobble	5									Nest 6 from previous; no nest remaining
LCR	LCR_24.5R	Genelle Index Site	20/07/2011	2011	14.5	SW1	11	449960	5450685	CC	Yes	4	Run	1.15	0.33	Boulder	10	300	150	150	1	Dead			0	New for site- All dead eggs- white yolks with some fungus. Photos 56-57.
LCR	LCR_24.5R	Genelle Index Site	20/07/2011	2011	14.5	SW1	11			CC	No	1	Run	0.3	0.2											Nest 1 from previous; collected last time.
LCR	LCR_24.5R	Genelle Index Site	20/07/2011	2011	14.5	SW1	11			CC	No	1	Run	0.4	0.05											Nest 4 from previous; no nest remaining.
LCR	LCR_24.5R	Genelle Index Site	20/07/2011	2011	14.5	SW1	11			CC	No	2	Run	1	0.05											Nest 5 from previous; collected last time.
LCR	LCR_24.5R	Genelle Index Site	20/07/2011	2011	14.5	SW1	11			CC	Yes		Run	1.2	0.6	Cobble	5	150	50	100	1	Hatched	8-9			New for site- All hatched eggs, only 8-9 egg cases left. No fish observed.
LCR	LCR_24.5R	Genelle Index Site	20/07/2011	2011	14.5	SW1	11			CC	No	0.5	Pool	0.2	0.02											Nest 3 from previous; all eggs now hatched. Photos 58-61.
LCR	LCR_2.8L	Unk Trib Mouth Robson	05/06/2012	2012	12.8	SW1	11	446513	546544	CC	Yes	5	Pool	1.1	0.1	Cobble	5	150	100	100	1	Pink and milky	40		95	Nest 5; no fish observed, around 5% dead eggs
LCR	LCR_2.8L	Unk Trib Mouth Robson	05/06/2012	2012	12.8	SW1	11	446514	5465638	CC	Yes	5	Pool	1.2	0	Cobble	5	100	230	80	1	Dead	10		0	Nest 1; very few eggs observed. Possibly an abondoned nest.
LCR	LCR_2.8L	Unk Trib Mouth Robson	05/06/2012	2012	12.8	SW1	11	446513	546544	CC	Yes	5	Pool	0.9	0.1	Cobble	5	200	200	120	1	Pale orange and milky	80		100	Nest 3; fresh (few days), no dead eggs
LCR	LCR_2.8L	Unk Trib Mouth Robson	05/06/2012	2012	12.8	SW1	11	446513	546544	CC	Yes	8	Pool	1.8	0.1	Cobble	10	200	100	100	2	Pink and milky				Nest 4; no fish observed, unknown amount dead (too deep)
LCR	LCR_24.5R	Genelle Index Site	24/05/2013	2013	8.8	SW1	11	449960	5450688	CC	Yes	1.7	Run	0.67	0.47	Boulder	5	320	180	90	1	Yellow and milky	50		50	Nest 1; 1 CC observed, around half dead/eaten, egg casing remains.
LCR	LCR_24.5R	Genelle Index Site	05/06/2013	2013	11.7	SW1	11	449961	5450689	CC	Yes	2.5	Run	0.92	0.42	Cobble	5	150	180	120	1	Unknown			50	Nest 1; CC observed, nest knocked off, 1 clump, unmarked.

Table E2 continued

Waterbody	Location[1]	Location Description[1]	Sample Date	Year	Water Temperature (°C)	Survey Method[2]	UTM Zone	UTM Easting	UTM Northing	Species Code[3]	New Nest (yes/no)	Distance to Shore (m)	Habitat Type	Water Depth (m)	Average Velocity (m/s)	Substrate Type	Percent Embedded (%)	Nest Rock Axis A (mm)	Nest Rock Axis B (mm)	Nest Rock Axis C (mm)	Number of Egg Masses	Nest Stage	Number of Eggs	Egg Diameter (mm)	Nest Survival (%)	Comments[4]
LCR	LCR_24.5R	Genelle Index Site	05/06/2013	2013	11.7	SW1	11	449963	5450690	CC	Yes	2.5	Run	0.53	0.03	Boulder	5	300	200	120	1	Yellow and milky	100		95	Nest 2; CC observed, nest knocked off, 1 clump, unmarked, uneyed, fresh (<1 week), ~5% mort (eaten).
LCR	LCR_10.5L	CLB LB US Koot Mouth	05/06/2013	2013	12.3	SW1	11			CC	Yes	6	Pool	1.1	0.05	Cobble	5	120	100	80	1	Yellow, eyed, not moving	80	2.5	95	Nest 2; CC observed (likely CLSC), unmarked.
LCR	LCR_10.5L	CLB LB US Koot Mouth	05/06/2013	2013	12.3	SW1	11	452634	5462892	CC	Yes	6	Pool	1.3	0.01	Boulder	5	270	200	150	1	Unknown				Nest 3; CC observed (SHSC or CLSC), unknown stage and # of eggs, too deep, marked and replaced.
LCR	LCR_10.5L	CLB LB US Koot Mouth	05/06/2013	2013	12.3	SW1	11	452637	5462902	CC	Yes	4	Pool	0.7	0	Cobble	5	180	130	80	1	Unknown	40		50	Nest 4; ~50% dead eggs, missing eggs in middle.
LCR	LCR_10.5L	CLB LB US Koot Mouth	05/06/2013	2013	12.3	SW1	11			CC	Yes	4	Pool	0.8	0.1	Cobble	5	200	100	80	1	Eyed but not moving.	40			Nest 5; CC observed, knocked nest off.
LCR	LCR_24.5R	Genelle Index Site	05/06/2013	2013	11.7	SW1	11	450016	5450719	CC	Yes	2.5	Run	0.82	0.2	Cobble	0	200	150	100	1	Yellow and milky	150			Nest 3; 2 CC observed (dark and light), marked and replaced, fresh (<1 week)
LCR	LCR_24.5R	Genelle Index Site	05/06/2013	2013	11.7	SW1	11			CC	Yes	3	Run	0.8	0.26	Cobble	5	230	200	100	1	Unknown				Nest 4; CC observed, nest knocked off, 1 clump, unmarked.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	VO1	11	449960	5450685	CC	Yes	-0.05		0	0	Boulder	5	290	200	130	1	Hatching	80	4	85	Stranded nest; NFO, 1 clump knocked off, rock dewatered (one edge over water), 0.05 m from edge, hatched (80%), eyed and moving (5%), dessicated (15%), photos 20-22.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	VO1	11	449960	5450688	CC	Yes	0.23	Run	0.14	0.07	Cobble	10	160	130	40	1	Yellow and milky			100	Nest 1A; 1 dark CC observed, marked and replaced, temp. logger deployed, photos 3-5.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	VO1	11	449965	5450692	CC	Yes	0.35	Run	0.2	0	Boulder	5	300	280	100	1	Eyed but not moving	30	2.5		Nest 2AA; nest on adjacent rock to Nest 2A, likely same male's nest on two rocks; most of eggs eaten or displaced.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	VO1	11	449965	5450692	CC	Yes	0.35	Run	0.2	0	Cobble	5	210	180	130	2	Pale and milky	50		95	Nest 2A; adjacent to Nest 2AA; 1 CC observed, photo 9-10.; one clump slightly older with 5% morts.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	SW1	11	449967	5450694	CC	Yes	1.5	Run	0.27	0	Cobble	10	200	130	90	3	Eyed and moving; Yellow and milky				Nest 4A; NFO, 3 clumps, photos 13-14, DO: 10.52 mg/L, temp: 13.8 C; Clump 1= remnant with a few fungused eggs left, Clump 2= eyed and moving (20 eggs), Clump 3= yellow and milky with 50% mort and fungus.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	SW1	11	449971	5450693	CC	Yes	0.4	Run	0.2	0.04	Boulder	5	260	240	140	2	Eyed and moving; Uneyed	25			Nest 8A; NFO, 2 clumps, unmarked; Clump 1= 1 eyed and moving (20 eggs), Clump 2= 1 eaten and 3 uneyed alive eggs, hard to determine mortality with bits knocked off.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	VO1	11	449971	5450693	CC	Yes	0.45	Run	0.18	0.09	Cobble	5	250	210	130	1	Yellow and milky	95		100	Nest 7A; NFO, marked and replaced, photos 28-29.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	SW1	11	449992	5450697	CC	Yes	0.6	Run	0.18	0.05	Cobble	10	240	160	80	1	Eyed and moving			90	Nest 9A; NFO, 1 clump, marked, photos 30-31. Mortalities (10%) due to eating.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	VO1	11	449996	5450708	CC	Yes	0.14	Run	0.06	0	Cobble	10	140	120	70	2	Eyed and moving	180		95	Nest 12A; NFO, marked and replaced, photos 36-37, mortalities due to being eaten, pinkish eggs
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	SW1	11	449998	5450701	CC	Yes	0.6	Run	0.3	0.41	Boulder	10	320	200	100	5	5 clumps, all eyed and 4 moving			98	Nest 10A; NFO, marked and replced, 2 clumps knocked off, photos 32-33.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	VO1	11	449998	5450701	CC	Yes	0.25	Run	0.13	0.03	Cobble	5	220	160	90	1	Yellow and milky			90	Nest 11A; 1 CC observed, marked and replaced, temp. logger deployed, photos 34-35.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	VO1	11	450016	5450719	CC	No	2	Run	0.59	0.31	Cobble	0	200	150	100	1	Yellow and milky	100		95	Nest 3 (from previous survey), no CC observed, DO: 11.4 mg/L, temp. 13.9 C, photos 23-24; 2 eggs eaten
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	VO1	11			CC	Yes	-0.6	Run	0	0	Cobble	5	240	170	180	1	Yellow and milky			0	Nest 6AB; stranded nest adjacent to 6A and 6AA; starting to dessicate but apparent 100% survival prior to stranding.
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	VO1	11			CC	Yes	-0.4	Run	0	0	Cobble	5	240	180	160	1	Eyed and moving			5	Nest 6AA; stranded nest adjacent to 6A and 6AB
LCR	LCR_24.5R	Genelle Index Site	12/06/2013	2013	13.6	VO1	11			CC	Yes	-0.15		0	0	Cobble	5	190	100	70	1	Yellow and desicated			100	Nest 6A; 3 dewatered nests on 3 rocks recorded as one nest in the field, adjacent nests called 6AA and 6AB in dbs, NFO stranded, 50% of eggs fungused
LCR	LCR_24.5R	Genelle Index Site	13/06/2013	2013	13.4	VO1	11	449960	5450688	CC	No	-0.25		0	0	Cobble	10	160	130	40	1	Dead	120		0	Nest 1A; dewatered, eggs look eaten, photo 64.
LCR	LCR_10.5L	CLB LB US Koot Mouth	13/06/2013	2013	14.6	VO1	11	452639	5462902	CC	Yes	-0.6		0	0	Boulder	5	270	250	200	1	Eyed with red veins	70		0	Nest 7A; stranded nest; 1 clump, pink, eyed, red veins, NFO, photos 62-63
LCR	LCR_10.5L	CLB LB US Koot Mouth	13/06/2013	2013	14.6	VO1	11	452637	5462894	CC	Yes	-1.5		0	0	Boulder	5	260	210	100	1	Eyed	25		0	Nest 2A; no water below nest, eyed yellow eggs with red veins, NFO, marked and replaced.
LCR	LCR_10.5L	CLB LB US Koot Mouth	13/06/2013	2013	14.6	VO1	11	452637	5462902	CC	No	0.05	Pool	0.02	0	Cobble	5	180	130	80	1	Eyed and moving	20		98	Nest 4; from previous, barely wetted, body form visible through egg, in residual pocket of water, 16.1 C in pool (> 1.5 C than river), NFO.
LCR	LCR_10.5L	CLB LB US Koot Mouth	13/06/2013	2013	14.6	VO1	11	452631	5462891	CC	Yes	2.5	Pool	0.51	0.01	Boulder	5	280	270	120	1	Eyed and moving	150		95	Nest 4A; 1 clump, pinkish, mortalities due to fungus, marked and replaced, 1 CC observed, photos 56-57
LCR	LCR_10.5L	CLB LB US Koot Mouth	13/06/2013	2013	14.6	VO1	11	452633	5462894	CC	Yes	1.2	Pool	0.13	0	Boulder	5	300	200	180	1	Eyed but not moving	70		99	Nest 5A; 1 clump, yellowish, mortalities due to eating, DO: 9.29, temp: 13.8 C, marked and replaced, 1 CC observed, photos 58-59
LCR	LCR_10.5L	CLB LB US Koot Mouth	13/06/2013	2013	14.6	VO1	11	452638	5462903	CC	Yes	0.1	Pool	0.03	0	Cobble	5	150	130	100	1	Eyed and moving	70		99	Nest 6A; 1 clump, yellow, mortality due to fungus, marked and replaced, 1 CC observed, photos 60-61

Table E2 continued

Waterbody	Location[1]	Location Description[1]	Sample Date	Year	Water Temperature (°C)	Survey Method[2]	UTM Zone	UTM Easting	UTM Northing	Species Code[3]	New Nest (yes/no)	Distance to Shore (m)	Habitat Type	Water Depth (m)	Average Velocity (m/s)	Substrate Type	Percent Embedded (%)	Nest Rock Axis A (mm)	Nest Rock Axis B (mm)	Nest Rock Axis C (mm)	Number of Egg Masses	Nest Stage	Number of Eggs	Egg Diameter (mm)	Nest Survival (%)	Comments[4]
LCR	LCR_10.5L	CLB LB US Koot Mouth	13/06/2013	2013	14.6	VO1	11	452632	5462884	CC	Yes	-0.8		0	0	Boulder	5	300	210	80	1	Eyed and moving	40	2.8	100	Nest 1A; stranded nest; no water below nest, still moving although eggs will likely soon die, red veins observed in eggs, NFO, marked and replaced.
LCR	LCR_24.5R	Genelle Index Site	13/06/2013	2013	13.4	VO1	11	449965	5450697	CC	No	-0.2		0	0	Cobble	10	210	180	130	2	Dead	50		0	Nest 2A; dewatered, eggs look dessicated, photo 65.
LCR	LCR_24.5R	Genelle Index Site	13/06/2013	2013	13.4	VO1	11	449967	5450694	CC	No	0.3	Pool	0.02	0	Cobble	10	200	130	90	2	Eyed and moving; Yellow and milky	20		50	Nest 4A; not dewatered, covered in mayfly nymphs, photo 66-67
LCR	LCR_24.5R	Genelle Index Site	13/06/2013	2013	13.4	VO1	11	449971	5450693	CC	No	-0.3		0	0	Cobble	5	250	210	130	1	Dead	120		0	Nest 7A; dewatered, eggs look dry/dessicated, photos 69-70.
LCR	LCR_24.5R	Genelle Index Site	13/06/2013	2013	13.4	VO1	11	449992	5450697	CC	No	-0.2		0	0	Cobble	10	240	160	80	1	Dead	120		0	Nest 9A; dewatered, looks like 5 eggs may have hatched, photo 71-72
LCR	LCR_24.5R	Genelle Index Site	13/06/2013	2013	13.4	VO1	11	449996	5450708	CC	No	-0.5		0	0	Cobble	10	140	120	70	2	Dead	180		0	Nest 12A; dewatered, photo 74
LCR	LCR_24.5R	Genelle Index Site	13/06/2013	2013	13.4	VO1	11	449998	5450701	CC	No	0.4	Pool	0	0	Boulder	10	320	200	100	5	5 clumps, all eyed and 4 moving	600		98	Nest 10A; not dewatered, 5 clumps, 1 CC observed, 2 clumps knocked off previously.
LCR	LCR_24.5R	Genelle Index Site	13/06/2013	2013	13.4	VO1	11	449998	5450701	CC	No	-0.3		0	0	Cobble	5	220	160	90	1	Dead	100		0	Nest 11A; dewatered, dessicating on edges, ~25% fungused, photo 73
LCR	LCR_2.8L	Unk Trib Mouth Robson	13/06/2013	2013	15.1	VO1	11			CC	Yes	-0.3	Pool	0	0	Boulder	5	370	250	200	1	Eyed and moving	100	3	100	New nest found stranded; unmarked, pink, NFO, photo 39.
LCR	LCR_2.8L	Unk Trib Mouth Robson	13/06/2013	2013	15.1	VO1	11			CC	Yes	-0.45	Pool	0	0	Boulder	5	270	150	150	1	Eyed and moving	150	3	100	New nest found stranded; unmarked, pink, NFO, in a very small pocket of water, photo 42, 43.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	VO1	11	449960	5450688	CC	No		Run	0.17	0.13	Cobble	5	160	130	40	0	No nest	0		0	Nest 1A; no nest, previously dewatered?
LCR	LCR_10.5L	CLB LB US Koot Mouth	19/06/2013	2013	13	SW1	11	452634	5462892	CC	No		Pool	0.8	0.04	Boulder	5	270	200	150	1	Eyed and moving			100	Nest 3; NFO.
LCR	LCR_10.5L	CLB LB US Koot Mouth	19/06/2013	2013	13	SW1	11	452646	5462935	CC	Yes		Run	0.93	0.51	Cobble	10	200	150	100	1	Eyed and moving	40		100	Nest 2B; SHSC/CLSC nest, photos 11-12
LCR	LCR_10.5L	CLB LB US Koot Mouth	19/06/2013	2013	13	SW1	11	452639	5462902	CC	No	-0.1	Pool	0.1	0		5	270	250	200	0	No nest	0		0	Nest 7A; no nest, previously observed dewatered
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	VO1	11	449965	5450692	CC	No		Run	0.13	0.01	Cobble	5	210	180	130	1	Hatched	6			Nest 2A; 6 egg casings, hatched or eaten.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	VO1	11	449967	5450694	CC	No		Run	0.35	0		5	200	130	90	0	No nest	0			Nest 4A; no nest.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	VO1	11	449971	5450693	CC	No		Run	0.1	0	Cobble	5	250	210	130	1	Dead	0		0	Nest 7A; dead remant of clump.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	VO1	11	449992	5450697	CC	No		Run	0.2	0	Cobble	5	240	160	80	0	Dead	0		0	Nest 9A; dead.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	VO1	11	449996	5450708	CC	No		Run	0.05	0	Cobble	5	140	120	70	1	Dead	8		0	Nest 12A; 8 dead eggs
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	VO1	11	449998	5450701	CC	No		Run	0.12	0.12	Cobble	5	220	160	90	0	Dead	0		0	Nest 11A; dead with maggots. Photo 16.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	VO1	11	449998	5450701	CC	No		Run	0.35	0.29	Boulder	10	320	200	100	2	Hatching; Eyed and moving			98	Nest 10A; 1 clump: eyed, moving and hatching; 2nd clump: eyed and moving, photo 17
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450012	5450720	CC	Yes	1.2	Run	0.44	0.23	Cobble	5	250	160	80	2	Eyed and moving; eyed and not moving	150		98	Nest 12B; 1 clump with 2% mortality, photos 43-44.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450012	5450722	CC	Yes	1.2	Run	0.42	0.23	Cobble	5	200	180	70	1	Eyed but not moving	100		10	Nest 10B; 1 CLSC or SHSC observed, photos 38-39
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450014	5450720	CC	Yes	2.5	Run	0.58	0.21	Cobble	5	230	200	120	2	Eyed but not moving			58	Nest 9B; 1 CC observed, Clump 1 = 80% mort and older, Clump 2= 5% mort, photos 36-37.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450014	5450720	CC	Yes	2.7	Run	0.55	0.35	Cobble	5	170	120	150	2	Eyed and moving; eyed and not moving			5	Nest 8B; 1 CC observed, 2 clumps both with 95% mortality, photos 34-35.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450016	5450719	CC	No		Run	0.63	0.11	Cobble	5	200	150	100	0	No nest	0		0	Nest 3; gone.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450016	5450721	CC	Yes	3.5	Run	0.96	0.18	Cobble	5	220	180	80	1	Eyed and moving	100		75	Nest 7B; 1 CC observed, 25% fungus covered, photos 32-33.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450017	5450722	CC	Yes	3.2	Run	0.9	0.19	Boulder	5	280	200	150	1	Eyed and moving	60		100	Nest 6B; 1 CLSC or SHSC observed, very close to hatching
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450022	5450725	CC	Yes	2.5	Run	0.85	0.24	Cobble	5	180	150	100	1	Eyed and moving	50		100	Nest 4B; eyed and moving, photos 27-28
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450025	5450726	CC	Yes	3.5	Run	1.02	0.15	Cobble	5	200	150	100	3	Unknown		3.3	100	Nest 3B; not marked as clumps were knocked off; egg diameter: 3.3 mm (preserved), photos 25-26
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	VO1	11			CC	No		Run	0	0	Cobble	5	190	100	70	2	Dead			0	Nest 6A; dead and stranded, 2 rocks have remnant nests, 100% mortality and fungused.
LCR	LCR_1.6L	Rialto Creek Mouth DS	26/06/2013	2013	12.8	SW1	11	445207	5465724	CC	Yes	4	Pool	1.03	0.01	Cobble	5	170	110	70	1	Hatching	60	3	100	Nest 1; NFO, pale peachy colour, photos 1-2.
LCR	LCR_2.8L	Unk Trib Mouth Robson	26/06/2013	2013	13.4	SW1	11	446499	5465648	CC	Yes	3.5	Pool	0.95	0.08	Cobble	5	170	110	90	1	Eyed and moving	7		100	Nest 1; NFO, photos 5-6.
LCR	LCR_24.5R	Genelle Index Site	27/06/2013	2013	11.9	SW1	11	449976	5450696	CC	Yes	1.2	Pool	0.86	0.01	Boulder	5	320	280	110	1	Hatching	100	3.1	100	Nest 1C; NFO, photos 12-13

Table E2 continued

Waterbody	Location[1]	Location Description[1]	Sample Date	Year	Water Temperature (°C)	Survey Method[2]	UTM Zone	UTM Easting	UTM Northing	Species Code[3]	New Nest (yes/no)	Distance to Shore (m)	Habitat Type	Water Depth (m)	Average Velocity (m/s)	Substrate Type	Percent Embedded (%)	Nest Rock Axis A (mm)	Nest Rock Axis B (mm)	Nest Rock Axis C (mm)	Number of Egg Masses	Nest Stage	Number of Eggs	Egg Diameter (mm)	Nest Survival (%)	Comments[4]
LCR	LCR_24.5R	Genelle Index Site	27/06/2013	2013	11.9	SW1	11	450012	5450720	CC	No	2.4	Run	0.95	0.62	Cobble	5	250	160	80	2	Hatching	150	3	100	Nest 12B; NFO, photo 15.
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	09/06/2011	2011	11.5	SW1	11	888616.09	5476461.97	CCN	Yes	5	Pool	1.32	0.01	Boulder	5	300	250	150	1	Yellow and Milky			99	nest#7; 80-100 eggs; 1 dead
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	09/06/2011	2011	11.5	SW1	11	888617.96	5476460.21	CCN	Yes	5	Pool	1.31	0.17	Boulder	5	300	200	100	1	Yellow and Milky	126	3.2	98	nest#8; 2 dead eggs; nest saved
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	18/07/2011	2011	15.3	SW1	11			CCN	No	2.5	Run	0.6	0.05	Boulder	5									Nest 8 from previous; collected last time
LCR	LCR_10.5L	CLB LB at Koot Mouth Point	18/07/2011	2011	15.3	SW1	11			CCN	No	2.5	Run	0.6	0.05	Boulder	5									Nest 7 from previous; no nest remaining
LCR	LCR_24.5R	Genelle Index Site	20/07/2011	2011	14.5	SW1	11	449948	5450680	CCN	Yes	1.5	Run	0.3	0.53	Boulder	10	300	200	100	2	Eyed, moving and hatching				New for site- 1 clump pink colour eyed and hatching, remnants of all hatched second clump. Captured fish to confirm ID. Photos 52-53
LCR	LCR_10.5L	CLB LB US Koot Mouth	24/05/2013	2013	8.9	SW1	11			CCN	Yes		Pool	1.33	0	Cobble	5	220	110	50	1	Yellow and milky	135	3	100	Nest 1; 1 CCN observed, 100% survival so far, around 5 eaten eggs, half yellow, half pale and expanded, half fertilized, spawned within the last couple of days.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450025	5450726	CCN	Yes	3.5	Run	0.95	0.05	Cobble	5	210	200	110	1	Eyed and moving	40		100	Nest 2B; SHSC 70 mm observed, photos 21-24
LCR	LCR_2.8L	Unk Trib Mouth Robson	21/06/2011	2011	11.5	SW1	11	882266.75	5478733.9	CRH	Yes	7	Pool	1.28	0.03	Cobble	0	170	120	50	1	Eyed but not moving				nest 7; white; replaced
LCR	LCR_2.8L	Unk Trib Mouth Robson	21/06/2011	2011	11.5	SW1	11	882273.43	5478725.38	CRH	No	5	Pool	1.2	0.13						2	Eyed but not moving			50	nest 1 from previous; replaced; 1 clump mainly dead/knocked other healthy
LCR	LCR_2.8L	Unk Trib Mouth Robson	05/06/2012	2012	12.8	SW1	11	446507	5465643	CRH	Yes	5	Pool	1.2	0	Cobble	5	200	120	80	3	Eyed but not moving			99	Nest 2; clump 1= eyed and pink, about 40 eggs, 0 dead, spawned 2 weeks ago; Clump 2= pink uneyed, about 200 eggs, 1% dead, 1 week old; Clump 3= yellow, fresh, about 120 eggs, 0 dead.
LCR	LCR_10.5L	CLB LB US Koot Mouth	05/06/2013	2013	12.3	TR1	11	449961	5450689	CRH	Yes	1.5	Pool	0.42	0	Cobble	20	140	100	120	1	Yellow, eyed, not moving	150		95	Nest 1; 1 CRH observed (83 mm), replaced and mark.
LCR	LCR_10.5L	CLB LB US Koot Mouth	05/06/2013	2013	12.3	TR1	11	452630	5462887	CRH	Yes	3	Pool	0.87	0	Cobble	10	200	210	80	1	Pale and milky	150			Nest 1A; CRH observed (77 mm), ~90% underside of rock covered in snail eggs (or algae), 80% have white yolks
LCR	LCR_10.5L	CLB LB US Koot Mouth	13/06/2013	2013	14.6	TR1	11	452630	5462898	CRH	Yes	3	Pool	0.56	0.02	Boulder	5	260	230	100	1	Eyed and moving	150		95	Nest 3A; 1 clump, pinkish, morts due to fungus and eating, marked and replaced, 1 PIT tagged CRH observed, photos 54-55
LCR	LCR_10.5L	CLB LB US Koot Mouth	13/06/2013	2013	14.6	VO1	11	449961	5450689	CRH	No	-1		0	0	Cobble	20	140	100	120		No nest			0	Nest 1; no nest relocated, likely knocked, location now dewatered ~1 m from wetted edge.
LCR	LCR_2.8L	Unk Trib Mouth Robson	13/06/2013	2013	15.1	VO1	11			CRH	Yes	-0.3	Pool	0	0	Boulder	10	370	300	150	1	Eyed and moving	125	3	100	Nest nest found stranded; unmarked, pink, 1 male TRSC found stranded ~25 cm from nest, photo 44, 45, 46.
LCR	LCR_24.5R	Genelle Index Site	19/06/2013	2013	12.4	SW1	11	450011	5450720	CRH	Yes	1.2	Run	0.42	0.23	Cobble	5	200	180	70	3	Eyed and moving	180		100	Nest 11B; 1 TRSC observed (85 mm), photos 41-42.
LCR	LCR_10.5L	CLB LB US Koot Mouth	19/06/2013	2013	13	SW1	11	452630	5462898	CRH	No	5	Pool	0.77	0.06	Boulder	5	260	230	100	1	Eyed and moving	100		98	Nest 3A; 1 TRSC observed, photo 2
LCR	LCR_24.5R	Genelle Index Site	27/06/2013	2013	11.9	SW1	11	450011	5450720	CRH	No	2.3	Run	0.87	0.56	Cobble	5	200	180	70	3	Eyed and moving	100	2.5	99	Nest 11B; 1 CC observed, photo 14.
LCR	LCR_2.8L	Unk Trib Mouth Robson	21/06/2011	2011	11.5	SW1	11	882270.37	5478727.54	CRH	Yes	6	Pool	1.21	0.08	Cobble	5	120	80	80	2	Eyed but not moving			99	nest 5; pinkish; one older is pinker with few moving; <1% fungused; 7-9
LCR	LCR_2.8L	Unk Trib Mouth Robson	21/06/2011	2011	11.5	SW1	11	882272.6	5478721.13	CRH	Yes	4	Pool	1.14	0.13	Cobble		200	150	100	2	Eyed but not moving			99	nest 4; marked and replaced; pink; <1% dead; photos 4-6
Pass Creek	Pass_1.0	Pass Creek Main	14/07/2010	2010	8	TR1	11	887508	5478668	CC	Yes	10	Run	0.42	0.43	Boulder	5	300	200	200	1	Hatching	62		100	All hatched just case left; none dead.
Pass Creek	Pass_1.0	Pass Creek Main	14/07/2010	2010	8	TR1	11	887501	5478671	CCN	Yes	4	Run	0.53	0.66	Cobble	5	150	200	150	1	Eyed and moving	305		99	Near hatching.
Pass Creek	Pass_1.0	Pass Creek Main	14/07/2010	2010	8	TR1	11	887512	5478680	CCN	Yes	-0.15	Other	0	0	Boulder	10	270	160	100	4	Eyed but not moving	357		97	Located in dewatered area; 0.15 m from water edge; small water pool under rock 21 deg; 12 eggs dead; male stranded.
Pass Creek	Pass_1.0	Pass Creek Main	14/07/2010	2010	8	TR1	11	887499	5478670	CCN	Yes	7	Run	0.58	0.55	Cobble	40	150	100	80	4	Eyed but not moving			99	Under bunch of other cobbles.
Pass Creek	Pass_1.0	Pass Creek Main	14/07/2010	2010	8	TR1	11	887497	5478680	CCN	Yes	7	Run	0.62	0.45	Boulder	40	350	200	100	1	Eyed and moving			99	Male observed; nest under cobble pile; only a few eggs moving.
Otter Creek (Similkameen)	Otter Creek	-	26/05/2009	2009		VO1	10	659958	5500954	CAS	Yes	1	Run	0.39	0.03	Boulder	10	360	330	270	1	Eyed, moving, close to hatching.	2520	1.5		Not tagged.
Otter Creek (Similkameen)	Otter Creek	-	25/05/2009	2009		VO1	10	659942	5500888	CBA	Yes	2	Riffle	0.40	0.66	Boulder	20				1	Yellow, milky, not eyed.	225	3		Not tagged; photos 3980-3985.
Otter Creek (Similkameen)	Otter Creek	-	09/06/2009	2009		TR1	10	659954	5500947	CBA	Yes	3	Run	0.60	0.74	Boulder	40	300	200	110	1	Eyed, moving, close to hatching.				Length: 86 mm, weight: 10.2 g, male, last 5 digits of pit tag: 1AA44.
Otter Creek (Similkameen)	Otter Creek	-	11/06/2009	2009		TR1	10	659929	5500881	CBA	Yes	1	Riffle	0.30	0.36	Cobble	20	170	100	110	1	Eyed, moving, close to hatching.	150			Length: 67 mm, weight: 3.3 g, male, last 5 digits of pit tag: 0CF36.

Table E2 continued

Waterbody	Location[1]	Location Description[1]	Sample Date	Year	Water Temperature (°C)	Survey Method[2]	UTM Zone	UTM Easting	UTM Northing	Species Code[3]	New Nest (yes/no)	Distance to Shore (m)	Habitat Type	Water Depth (m)	Average Velocity (m/s)	Substrate Type	Percent Embedded (%)	Nest Rock Axis A (mm)	Nest Rock Axis B (mm)	Nest Rock Axis C (mm)	Number of Egg Masses	Nest Stage	Number of Eggs	Egg Diameter (mm)	Nest Survival (%)	Comments[4]
Otter Creek (Similkameen)	Otter Creek	-	11/06/2009	2009		TR1	10	659959	5500943	CBA	Yes	2	Run	0.53	0.50	Boulder	30	200	80	80	1	Eyed, moving, close to hatching.	155			Length: 73 mm, weight: 5.2 g, male, last 5 digits of pit tag: 0C9D4.
Otter Creek (Similkameen)	Otter Creek	-	11/06/2009	2009		TR1	10	659955	5500949	CBA	Yes	1.5	Run	0.27	0.42	Cobble	10	160	70	70	2	Eyed, moving, close to hatching.	658			Length: 85 mm, weight: 9.1 g, unknown sex, last 5 digits of pit tag: 0CE0A; couldn't count separate clutches because they hatched.
Otter Creek (Similkameen)	Otter Creek	-	11/06/2009	2009		TR1	10	659951	5500956	CBA	Yes	3	Run	0.67	0.59	Boulder	30	350	250	150	1	Eyed, moving, close to hatching.				Length: 82 mm, weight: 8.0 g, male, last 5 digits of pit tag: 0CABE.
Otter Creek (Similkameen)	Otter Creek	-	11/06/2009	2009		VO1	10	659953	5500925	CBA	Yes	2	Run	0.35	0.73	Boulder	20				1	Eyed, moving, starting to hatch.				Not tagged.
Allison Creek (Similkameen)	Allison Creek	-	12/06/2009	2009		TR1	10	683345	5482026	CBA	Yes	2	Riffle	0.34	0.53	Boulder	20	300	150	100	3	Eyed, moving, starting to hatch.				Length: 71 mm, weight: 4.6 g, unknown sex, last 5 digits of pit tag: 1A977.
Allison Creek (Similkameen)	Allison Creek	-	12/06/2009	2009		TR1	10	683325	5482058	CBA	Yes	0.5	Riffle	0.38	0.62	Cobble	50	180	100	100	1	Eyed, moving, starting to hatch.	99			Some eggs were lost; length: 77 mm, weight: 6.3 g, male, last 5 digits of pit tag: 1AC0C.
Tulameen (Similkameen)	Tulameen	-	05/07/2009	2009		TR1	10	667320	5486404	CBA	Yes	2	Riffle	0.15	0.6	Cobble	20	230	150	60	1	Eyed, moving, close to hatching.				Length: 90 mm, weight: 9.9 g, male, last 5 digits of pit tag: ED957; photos 4188-4191.
Tulameen (Similkameen)	Tulameen	-	12/06/2009	2009		VO1	10	667295	5486396	CC	Yes	3	Riffle	0.48	1.11	Boulder	30	300	140	90	1	Yellow, milky, not eyed.	144	4		Fresh mass; not tagged.
Tulameen (Similkameen)	Tulameen	-	05/07/2009	2009		VO1	10	667318	5486405	CC	Yes	5	Riffle	0.10	0.27	Cobble	10	240	230	110	3	Eyed, not moving.				Not tagged; photos 4192-4196.
Tulameen (Similkameen)	Tulameen	-	05/07/2009	2009		VO1	10	667300	5486397	CC	Yes	3	Riffle	0.17	0.23	Cobble	20	210	140	50	2	Eyed, moving, starting to hatch.				Not tagged; photos 4197-4199.
Tulameen (Similkameen)	Tulameen	-	05/07/2009	2009		VO1	10	667371	5486434	CC	Yes	1	Riffle	0.2	0.55	Cobble	10	180	150	100	1	Eyed, not moving.				Not tagged; photos 4203-4204.
Tulameen (Similkameen)	Tulameen	-	05/07/2009	2009		VO1	10	667373	5486421	CC	Yes	1.5	Riffle	0.17	0.45	Boulder	10	330	180	120	1	Eyed, not moving.				Not tagged; photos 4205-4208.
Tulameen (Similkameen)	Tulameen	-	05/07/2009	2009		VO1	10	667367	5486423	CC	Yes	1.5	Riffle	0.26	0.67	Boulder	10	600	300	150	2	Eyed, not moving.				Not tagged; photos 4209-4212.
Tulameen (Similkameen)	Tulameen	-	05/07/2009	2009		VO1	10	667353	5486419	CC	Yes	2	Riffle	0.17	0.68	Boulder	20	300	200	100	1	Eyed, not moving.				Not tagged; photos 4215-4217.
Tulameen (Similkameen)	Tulameen	-	05/07/2009	2009		VO1	10	667325	5486410	CC	Yes	4	Riffle	0.16	0.32	Boulder	10	300	180	150	1	Eyed, not moving.				Not tagged; photos 4218-4219.
Tulameen (Similkameen)	Tulameen	-	05/07/2009	2009		VO1	10	667294	5486396	CC	Yes	3	Riffle	0.2	0.45	Cobble	20	240	190	80	2	Eyed, moving, starting to hatch.				Not tagged; photos 4220-4222.
Tulameen (Similkameen)	Tulameen	-	10/07/2009	2009		VO1	10	667468	5486475	CC	Yes	2	Riffle	0.19	0.28	Cobble	20	200	170	100	2	Eyed, not moving.				Not tagged; photos 4289-4292.
Tulameen (Similkameen)	Tulameen	-	10/07/2009	2009		VO1	10	667445	5486464	CC	Yes	2	Run	0.26	0.21	Boulder	20	300	180	150	1	Eyed, not moving.				Not tagged; photos 4293-4294.
Tulameen (Similkameen)	Tulameen	-	10/07/2009	2009		VO1	10	667370	5486428	CC	Yes	1.5	Riffle	0.20	0.50	Boulder	20	350	250	200	1	Eyed, not moving.				Not tagged; same nest found last time; still not hatched, photos 4295-4296.
Tulameen (Similkameen)	Tulameen	-	10/07/2009	2009		VO1	10	667356	5486416	CC	Yes	1.5	Riffle	0.15	0.78	Boulder	30	400	220	150	1	Eyed, not moving.				Not tagged; half hatched; photos 4297-4299.
Tulameen (Similkameen)	Tulameen	-	10/07/2009	2009		VO1	10	667342	5486422	CC	Yes	4	Riffle	0.13	0.17	Boulder	30	310	220	90	1	Eyed, not moving.				Not tagged; barely eyed; photos 4300-02.

Notes

[1] L or LB= left downstream bank, R or RB= right downstream bank, LCR= Lower Columbia River, CLB= Columbia River, US= upstream, DS= downstream, Unk= Unknown, Trib= Tributary

[2] VO= Visually observed, TR= Pit tag tracking, SW= Snorkeling

[3] CBA= Columbia Sculpin, CAS= Prickly Sculpin, CC= Sculpin sp., CCN= Shorthead Sculpin, CRH= Torrent Sculpin

[4] NFO= No fish observed

APPENDIX F

HSI Model Code

Appendix F: Sculpin and Dace Habitat Suitability Index R Code for Analysis

Project.R

```
source("header.R")
#delete_output()
library(skeleton)
source_windows("input-data.R")
source("clean-data.R")

source("manipdata-cont.R") # save to set_folders("example")
source("analysis-cont.R")
source("plot-cont.R")

source("manipdata-nests.R")
source("analysis-nests.R")
source("plot-nests.R")

source_windows("resave-plots.R")
```

input-data.R

```
source("header.R")

db<-odbcConnectAccess2007("../../data/based/CLBMON_43_23Apr14.accdb")

allfishhab<-sqlQuery(db, paste(

  "SELECT Survey.Waterbody, Survey.Site_Name, Site_Name.RiverKm, Survey.Sample_Date,
Survey.FlowReduction, SurveyMethod.SurveyMethod, Survey.Day_Night, Fish_Capture.Species_Code,
Fish_Capture.Length, Fish_Capture.Weight, Fish_Capture.Life_Stage, Fish_Capture.NestPresent,
Fish_Capture.Status, Fish_Capture.Ripe, Fish_Capture.Count, Fish_Capture.WaterDepth_m,
Fish_Capture.AvgVelocity, Fish_Capture.Substrate_Type, Fish_Capture.Embeddedness,
Fish_Capture.DistToShore_m, Fish_Capture.Habitat_Type",
  "FROM SurveyMethod INNER JOIN (Site_Name INNER JOIN (Survey INNER JOIN Fish_Capture ON
Survey.SurveyID = Fish_Capture.SurveyID) ON Site_Name.Site_Name = Survey.Site_Name) ON
(Survey.SurveyID = SurveyMethod.SurveyID) AND (SurveyMethod.SurveyMethod =
Fish_Capture.SurveyMethod) AND (SurveyMethod.SurveyID = Fish_Capture.SurveyID)",
  "WHERE (((Fish_Capture.Life_Stage) Is Not Null) AND ((Fish_Capture.Status)='Alive') AND
((Fish_Capture.WaterDepth_m) Is Not Null) AND ((Fish_Capture.AvgVelocity) Is Not Null))"
))

allfishMT<-sqlQuery(db, paste(
  "SELECT Survey.Waterbody, Survey.Site_Name, Site_Name.RiverKm, Survey.Sample_Date,
Survey.FlowReduction, SurveyMethod.SurveyMethod, Survey.Day_Night, Fish_Capture.Species_Code,
Fish_Capture.Length, Fish_Capture.Weight, Fish_Capture.Life_Stage, Fish_Capture.NestPresent,
Fish_Capture.Status, Fish_Capture.Ripe, Fish_Capture.Count, SurveyMethod.Sample_Depth,
SurveyMethod.Avg_Velocity, SurveyMethod.Substrate_Type, Fish_Capture.Embeddedness,
SurveyMethod.DistToShore_m, Fish_Capture.Habitat_Type",
  "FROM SurveyMethod INNER JOIN (Site_Name INNER JOIN (Survey INNER JOIN Fish_Capture ON
Survey.SurveyID = Fish_Capture.SurveyID) ON Site_Name.Site_Name = Survey.Site_Name) ON
```

```
(Survey.SurveyID = SurveyMethod.SurveyID) AND (SurveyMethod.SurveyMethod =
Fish_Capture.SurveyMethod) AND (SurveyMethod.SurveyID = Fish_Capture.SurveyID)",
  "WHERE (((SurveyMethod.SurveyMethod)='MT' Or (SurveyMethod.SurveyMethod)='MT0' Or
(SurveyMethod.SurveyMethod)='MT1' Or (SurveyMethod.SurveyMethod)='MT2' Or
(SurveyMethod.SurveyMethod)='MT3' Or (SurveyMethod.SurveyMethod)='MT4' Or
(SurveyMethod.SurveyMethod)='MT5' Or (SurveyMethod.SurveyMethod)='MT6' Or
(SurveyMethod.SurveyMethod)='MT7' Or (SurveyMethod.SurveyMethod)='MT8' Or
(SurveyMethod.SurveyMethod)='MT9') AND ((Fish_Capture.Length) Is Not Null) AND
((Fish_Capture.Life_Stage) Is Not Null) AND ((Fish_Capture.Status)='Alive') AND
((SurveyMethod.Sample_Depth) Is Not Null) AND ((SurveyMethod.Avg_Velocity) Is Not Null))"

))
nest<-sqlQuery(db,paste(
  "SELECT Survey.Site_Name, Site_Name.RiverKm, Survey.Sample_Date, Survey.Water_Temperature,
Nest_Information.SurveyMethod, Nest_Information.UTM_Zone, Nest_Information.UTM_Easting,
Nest_Information.UTM_Northing, Nest_Information.NewNest, Nest_Information.Species_Code,
Nest_Information.WaterDepth_m, Nest_Information.AverageVelocity, Nest_Information.SubstrateType,
Nest_Information.Embeddedness, Nest_Information.DistToShore_m, Nest_Information.HabitatType,
Nest_Information.NestRockDim1, Nest_Information.NestRockDim2, Nest_Information.NestRockDim3,
Nest_Information.NumberOfEggMasses, Nest_Information.EggStage, Nest_Information.NumberOfEggs,
Nest_Information.EggDiameter_mm, Nest_Information.Survival_percent, Nest_Information.Comments",
  "FROM SurveyMethod INNER JOIN (Site_Name INNER JOIN (Survey INNER JOIN Nest_Information ON
Survey.SurveyID = Nest_Information.SurveyID) ON Site_Name.Site_Name = Survey.Site_Name) ON
(Survey.SurveyID = SurveyMethod.SurveyID) AND (SurveyMethod.SurveyMethod =
Nest_Information.SurveyMethod) AND (SurveyMethod.SurveyID = Nest_Information.SurveyID)",
  "WHERE (((Nest_Information.Species_Code) Is Not Null))"
))
subs<-sqlQuery(db,paste(
  "SELECT Survey.Site_Name, Site_Name.RiverKm, Survey.Sample_Date, SubstrateAssessment.RockDim1,
SubstrateAssessment.RockDim2, SubstrateAssessment.RockDim3, SubstrateAssessment.Embeddedness",
  "FROM (Site_Name INNER JOIN Survey ON Site_Name.Site_Name = Survey.Site_Name) INNER JOIN
SubstrateAssessment ON Survey.SurveyID = SubstrateAssessment.SurveyID"
))

odbcCloseAll()

s(allfishhab)
s(allfishMT)
s(nest)
s(subs)

set_folders("input")
save_rdata(allfishhab,"allfishhab")
save_rdata(allfishMT, "allfishMT")
save_rdata(nest,"nest")
save_rdata(subs,"subs")
```

clean-data.R

```
source("header.r")
```

```
set_folders("input")
dat<-load_rdata("allfishhab")
mtdat<-load_rdata("allfishMT")#minnow trapping data
nest<-load_rdata("nest")
subs<-load_rdata("subs")

set_folders("clean")
print(s(dat))
print(s(mtdat))

mtdat <- rename(mtdat, c("Avg_Velocity" = "AvgVelocity"))
mtdat <- rename(mtdat, c("Sample_Depth" = "WaterDepth_m"))

dat<-rbind(dat,mtdat)

dat <- subset(dat, select = c("Waterbody", "Sample_Date", "FlowReduction", "SurveyMethod","Day_Night",
"Species_Code","Count",
                        "Length", "Weight", "Life_Stage", "WaterDepth_m","AvgVelocity", "Substrate_Type",
"Embeddedness"))

#remove the data where tracking was done during a flow reduction
dat <- subset(dat, !(FlowReduction == "Yes" & dat$SurveyMethod %in% c("TR1","TR2")))
dat<-subset(dat,(Life_Stage !="Unknown"))
dat$Life_Stage <- droplevels(dat$Life_Stage)

dat <- rename(dat, c("Sample_Date" = "Date"))
dat <- rename(dat, c("Species_Code" = "Species"))
dat <- rename(dat, c("WaterDepth_m" = "Depth"))
dat <- rename(dat, c("AvgVelocity" = "Velocity"))
dat <- rename(dat, c("Substrate_Type"="Substrate"))

dat$Date <- as.Date(dat$Date)
dat$Dayte <- dayte(dat$Date)

dat$Season <- factor(NA, levels = c("Spring", "Summer", "Fall", "Winter"))
dat$Season[dat$Dayte %in% seq(as.Date("2000-03-21"),as.Date("2000-06-21"), by = 1)] <- "Spring"
dat$Season[dat$Dayte %in% seq(as.Date("2000-06-22"),as.Date("2000-09-22"), by = 1)] <- "Summer"
dat$Season[dat$Dayte %in% seq(as.Date("2000-09-23"),as.Date("2000-12-21"), by = 1)] <- "Fall"
dat$Season[dat$Dayte %in% seq(as.Date("2000-01-01"),as.Date("2000-03-20"), by = 1)
        | dat$Dayte %in% seq(as.Date("2000-12-22"),as.Date("2000-12-31") , by = 1)] <- "Winter"

dat <- subset(dat, Species %in% c("CAS", "CBA", "CC", "CCN","CRH", "DC", "LNC", "UDC"))
dat$Species <- droplevels(dat$Species)

dat$Genus <- factor(NA, levels = c("Cottus", "Rhinichthys"))
dat$Genus[dat$Species %in% c("CAS", "CBA", "CC", "CCN","CRH")] <- "Cottus"
dat$Genus[dat$Species %in% c("DC", "LNC", "UDC")] <- "Rhinichthys"

dat$System<- factor(NA,levels=c("Slocan","Columbia"))
```

```
dat$System[dat$Waterbody %in% c("Trozzo Creek", "Slocan River")] <- "Slocan"
dat$System[dat$Waterbody %in% c("Kootenay River", "LCR", "Blueberry Creek", "Murphy Creek", "Pass
Creek")] <- "Columbia"

dat$Substrate[dat$Substrate %in% c("Aquatic Macrophytes","Woody Debris","Flooded Vegetation")]<-
"Silt"
dat$Substrate[dat$Substrate %in% c("gravel")]<-"Gravel"
dat$Substrate[dat$Substrate %in% c("Unknown","Bedrock")]<-NA
dat$Substrate<-droplevels(dat$Substrate)
dat <- dplyr::filter(dat, !is.na(Substrate))
dat$Substrate<- factor(dat$Substrate, levels=c("Silt","Sand","Gravel","Cobble","Boulder"))

dat$Day_Night[dat$Day_Night %in% c("Dawn","Day")]<-"Day"
dat$Day_Night[dat$Day_Night %in% c("Overnight","Dusk","Night")]<-"Night"
dat$Day_Night<-droplevels(dat$Day_Night)

#removing the 11 data points ranging from 2.6-7.5m in depth and ensuring no data (there were
none)exceeds
#the data cut for velocity at 2.0m/s
dat<-subset(dat,dat$Depth<=2.5)
dat<-subset(dat,dat$Velocity<=2.0)

slo<-subset (dat, System=="Slocan")
slo$System<-droplevels(slo$System)
col<-subset(dat,System=="Columbia")
col$System<-droplevels(col$System)

save_rdata (dat, "sculdace")
save_rdata(slo,"slocanSD")
save_rdata(col, "colSD")

#various plots for report and assessing data
gp <- ggplot(data=dat,aes(x=Length))
gp <- gp + geom_histogram(colour = "white", fill = "black")
gp <- gp + xlab("Length (mm)")
gp <- gp + ylab("Frequency")
gp<-gp+facet_wrap(~Genus)
gp<-gp + theme(panel.grid.minor=element_blank(),panel.grid.major=element_blank())
gwindow(3,3)
print(gp)
save_plot("LengthbyGenus",type="data")

gp <- ggplot(data=dat,aes(x=Weight))
gp <- gp + geom_histogram(colour = "white", fill = "black")
gp <- gp + xlab("Weight (g)")
gp <- gp + ylab("Frequency")
gp<-gp+facet_wrap(~Genus)
gp<-gp + theme(panel.grid.minor=element_blank(),panel.grid.major=element_blank())
gwindow(4,4)
print(gp)
```

```
save_plot("WeightbyGenus", type="data")

gp <- ggplot(data=col,aes(x=Depth))
gp <- gp + geom_density()
gp <- gp + xlab("Depth (m)")
gp <- gp + ylab("Frequency")
gp <- gp + facet_wrap(~Genus)
gp <- gp + theme(panel.grid.minor=element_blank(),panel.grid.major=element_blank())
gwindow(3,3)
print(gp)
save_plot("ColDepthbyGenus",type="data")

gp <- ggplot(data=col,aes(x=Velocity))
gp <- gp + geom_density()
gp <- gp + xlab("Velocity (m/s)")
gp <- gp + ylab("Frequency")
gp <- gp + facet_wrap(~Genus)
gp <- gp + theme(panel.grid.minor=element_blank(),panel.grid.major=element_blank())
gwindow(3,3)
print(gp)
save_plot("ColVelocitybyGenus", type="data")

gp <- ggplot(data=subset(slo, Species %in% c("CAS","CRH","LNC","UDC","CC")),aes(x=Velocity))
gp <- gp + geom_density()
gp <- gp + xlab("Velocity (m/s)")
gp <- gp + ylab("Frequency")
gp <- gp + facet_wrap(~Species, ncol=2)
gp <- gp + theme(panel.grid.minor=element_blank(),panel.grid.major=element_blank())
gwindow(4,3)
print(gp)
save_plot("SloVelocitybySp", type="data")

gp <- ggplot(data=col,aes(x=Velocity))
gp <- gp + geom_density()
gp <- gp + xlab("Velocity (m/s)")
gp <- gp + ylab("Frequency")
gp <- gp + facet_wrap(~Species, ncol=2)
gp <- gp + theme(panel.grid.minor=element_blank(),panel.grid.major=element_blank())
gwindow(4,3)
print(gp)
save_plot("ColVelocitybySp", type="data")

gp <- ggplot(data=col,aes(x=Depth))
gp <- gp + geom_density()
gp <- gp + xlab("Depth (m)")
gp <- gp + ylab("Frequency")
gp <- gp + facet_wrap(~Species, ncol=2)
gp <- gp + theme(panel.grid.minor=element_blank(),panel.grid.major=element_blank())
gwindow(4,3)
print(gp)
```

```
save_plot("ColDepthbySp", type="data")

gp <- ggplot(data=subset(slo, Species %in% c("CAS","CRH","LNC","UDC","CC")),aes(x=Depth))
gp <- gp + geom_density()
gp <- gp + xlab("Depth (m)")
gp <- gp + ylab("Frequency")
gp <- gp + facet_wrap(~Species, ncol=2)
gp <- gp + theme(panel.grid.minor=element_blank(),panel.grid.major=element_blank())
gwindow(4,3)
print(gp)
save_plot("SloDepthbySp", type="data")

#embeddedness plots for sculpin in Columbia
cc<-subset(col, Genus=="Cottus")
cc<-droplevels(cc)
gp <- ggplot(data=cc,aes(x=Embeddedness))
#gp <- gp + geom_histogram(colour = "white", fill = "black", binwidth=5)
gp<- gp+ geom_density()
gp <- gp + xlab("Embeddedness (%)")
gp<- gp + scale_x_continuous(limits=c(0,100))
gp <- gp + ylab("Frequency")
gp <- gp + theme(panel.grid.minor=element_blank(),panel.grid.major=element_blank())
gwindow(4,4)
print(gp)
save_plot("ColEmbedCCdensity", type="figures")

#embeddedness plots for shorthead (CCN) in Columbia
ccn<-subset(cc, Species=="CCN")
ccn<-droplevels(ccn)
gp <- ggplot(data=ccn,aes(x=Embeddedness))
gp <- gp + geom_histogram(colour = "white", fill = "black", binwidth=5)
gp <- gp + xlab("Embeddedness (%)")
gp<- gp + scale_x_continuous(limits=c(0,100))
gp <- gp + ylab("Frequency")
gp <- gp + theme(panel.grid.minor=element_blank(),panel.grid.major=element_blank())
gwindow(4,4)
print(gp)
save_plot("ColEmbedCCN", type="figures")

#embeddedness plots for shorthead (CCN) in Columbia
cba<-subset(cc, Species=="CBA")
cba<-droplevels(cba)
gp <- ggplot(data=cba,aes(x=Embeddedness))
gp <- gp + geom_histogram(colour = "white", fill = "black", binwidth=5)
gp <- gp + xlab("Embeddedness (%)")
gp<- gp + scale_x_continuous(limits=c(0,100))
gp <- gp + ylab("Frequency")
gp <- gp + theme(panel.grid.minor=element_blank(),panel.grid.major=element_blank())
gwindow(4,4)
print(gp)
```

```
save_plot("ColEmbedCBA", type="figures")


####Substrate and Nest data cleaning starts here.
print(s(nest))
print(s(subs))

nest<-subset(nest,NewNest!="No")
nest$NewNest<-droplevels(nest$NewNest)
nest<-subset(nest,Species_Code!="")
nest$Species_Code<-droplevels(nest$Species_Code)

nest <- subset(nest, select =
c("Site_Name","Species_Code","Embeddedness","NestRockDim1","NestRockDim2","NestRockDim3"))
nest <- rename(nest, c("NestRockDim1" = "Dim1"))
nest <- rename(nest, c("NestRockDim2" = "Dim2"))
nest <- rename(nest, c("NestRockDim3" = "Dim3"))
nest <- rename(nest, c("Site_Name" = "Site"))
nest <- rename(nest, c("Species_Code" = "Species"))
nest <- na.omit(nest)

subs<-subset(subs,select=c("Site_Name","RockDim1","RockDim2","RockDim3", "Embeddedness"))
subs <- rename(subs, c("RockDim1" = "Dim1"))
subs <- rename(subs, c("RockDim2" = "Dim2"))
subs <- rename(subs, c("RockDim3" = "Dim3"))
subs <- rename(subs, c("Site_Name" = "Site"))

nest$Genus <- factor(NA, levels = c("Cottus"))
nest$Genus[nest$Species %in% c("CAS", "CBA", "CC", "CCN","CRH")] <- "Cottus"

save_rdata(nest, "sculnest")
save_rdata(subs, "sculsub")

graphics.off()
```

manipdata-cont.r

```
source("header.r")

system <- c("Columbia", "Slocan")
genus <- c("Cottus", "Rhinichthys")

set_folders("clean")
col <- load_rdata("ColSD")
slo <- load_rdata("slocanSD")

data <- rbind(col, slo)

#levels(data$Life_Stage) <- list("Juvenile" = "YOY", "Adult" = "Adult")
levels(data$Season) <- list("Spring" = "Spring", "Summer" = "Summer", "Fall" = "Winter")
```

```
for (sys in system) {
  for (gn in genus) {

    set_folders(sys, gn)

    sdat <- subset(data, System == sys & Genus == gn)

    sdat$Genus <- droplevels(sdat$Genus)

    save_rdata(sdat, name = "data")

    if(gn == "Cottus") {
      species <- c("CCN","CBA")
    } else
      species <- "UDC"

    for (spp in species) {
      set_folders(sys, spp)

      ddat <- subset(sdat, Species == spp)
      ddat$Species <- droplevels(ddat$Species)
      save_rdata(ddat, name="data")
    }
  }
}
```

analysis-cont.R

```
source("header.r")
source("models-hsi.r")

sum_counts <- function (d) {
  if(nrow(d) == 0)
    return (data.frame(Count = 0))
  data.frame(Count = sum(d$Count))
}

system <- c("Columbia","Slocan")
species <- c("Cottus", "Rhinichthys", "UDC", "CCN", "CBA")

for (sys in system) {
  for (spp in species) {

    set_folders(sys, spp)
    #testing what is going on with UDC in Slocan
    #set_folders("Slocan", "UDC")
    #sys<-"Slocan"
    #spp<-"UDC"
    sdat <- load_rdata(name = "data")
```

```
if(nrow(sdat) > 0) {

  print(paste(sys, spp, "Substrate"))

  data <- subset(sdat,!is.na(Substrate))

  data <- ddply(data,.(Substrate), sum_counts, .drop = FALSE)
  data$Available <- 1

  analysis <- jags_analysis(model_substrate, data = data, niter = 10^4)
  print(summary(analysis))

  save_analysis(analysis, "substrate")

  print(paste(sys, spp, "Depth"))

  data <- modprep (sdat, hab = "Depth")
  data$Available <- 1

  analysis <- jags_analysis(model, data = data, niter = 10^4)
  print(summary(analysis))

  save_analysis(analysis, "depth")

  print(paste(sys, spp, "Depth - Life Stage"))

  data <- modprep (sdat, hab = "Depth", by = "Life_Stage")
  data$Available <- 1

  analysis <- jags_analysis(model_by, data = data, niter = 10^4)
  print(summary(analysis))
  save_analysis(analysis, "depth-lifestage")

  print(paste(sys, spp, "Depth - Diel Period"))

  data <- modprep (sdat, hab = "Depth", by = "Day_Night")
  data$Available <- 1

  analysis <- jags_analysis(model_by, data = data, niter = 10^4)
  print(summary(analysis))
  save_analysis(analysis, "depth-dielperiod")

  print(paste(sys, spp, "Depth - Season"))

  data <- modprep (sdat, hab = "Depth", by = "Season")
  data$Available <- 1

  analysis <- jags_analysis(model_by, data = data, niter = 10^4)
  print(summary(analysis))
```

```
    save_analysis(analysis, "depth-season")

    print(paste(sys, spp, "Velocity"))

    data <- modprep (sdat, hab = "Velocity")
    data$Available <- 1

    analysis <- jags_analysis(model, data = data, niter = 10^4)
    print(summary(analysis))
    save_analysis(analysis, "velocity")

    print(paste(sys, spp, "Velocity - Life Stage"))

    data <- modprep (sdat, hab = "Velocity", by = "Life_Stage")
    data$Available <- 1

    analysis <- jags_analysis(model_by, data = data, niter = 10^4)
    print(summary(analysis))
    save_analysis(analysis, "velocity-lifestage")

    print(paste(sys, spp, "Velocity - Diel Period"))

    data <- modprep (sdat, hab = "Velocity", by = "Day_Night")
    data$Available <- 1

    analysis <- jags_analysis(model_by, data = data, niter = 10^4)
    print(summary(analysis))
    save_analysis(analysis, "velocity-dielperiod")

    print(paste(sys, spp, "Velocity - Season"))

    data <- modprep (sdat, hab = "Velocity", by = "Season")
    data$Available <- 1

    analysis <- jags_analysis(model_by, data = data, niter = 10^4)
    print(summary(analysis))
    save_analysis(analysis, "velocity-season")
   }
  }
}
```

plot-cont.R

```
source("header.r")
source("models-hsi.r")

sum_counts <- function (d) {
  if(nrow(d) == 0)
    return (data.frame(Count = 0))
  data.frame(Count = sum(d$Count))
```

```
}

system <- c("Columbia", "Slocan")
species <- c("Cottus", "Rhinichthys",  "UDC", "CCN", "CBA")

for (sys in system) {
  for (spp in species) {
    if(sys=="Columbia" || spp!="CBA"){
      set_folders(sys, spp)
      sdat <- load_rdata(name="data")

      if(nrow(sdat) > 0) {

        print(paste(sys, spp, "Substrate"))

        analysis <- load_analysis("substrate")
        print(summary(analysis))

        prediction <- try(predict(analysis,  newdata = "Substrate"))

        if(is.data.frame(prediction)) {
          gp <- ggplot(data = prediction, aes(x = Substrate, y = estimate))
          gp <- gp + geom_bar(stat = "identity")
          gp<- gp + geom_errorbar(aes(ymax=upper,ymin=lower ),colour="grey")
          gp <- gp + scale_x_discrete(name = "Substrate")
          gp <- gp + scale_y_continuous(name = "Habitat Suitability Index", expand = c(0,0))
          gp <- gp + expand_limits(y = c(0,1))
          gwindow(4,4)
          print(gp)

          save_plot("substrate", type = ifelse(is_converged(analysis), "figures", "analyses"))
          graphics.off()
          #############

          print(paste(sys, spp, "Depth"))

          analysis <- load_analysis("depth")
          print(summary(analysis))
          prediction <- try(predict(analysis, newdata = c("Habitat", "By")))

          if(is.data.frame(prediction)) {
            gp <- ggplot(data = prediction, aes(x = Habitat, y = estimate))
            gp <- gp + geom_line()
            gp <- gp + geom_line(aes(y = lower), linetype = "dotted")
            gp <- gp + geom_line(aes(y = upper), linetype = "dotted")
            gp <- gp + scale_x_continuous(name = "Depth (m)", expand = c(0,0))
            gp <- gp + scale_y_continuous(name = "Habitat Suitability Index", expand = c(0,0))
            gp <- gp + expand_limits(x = 0, y = c(0,1))
            gwindow(4,4)
            print(gp)
```

```
save_plot("depth", type = ifelse(is_converged(analysis), "figures", "analyses"))
graphics.off()
###########

print(paste(sys, spp, "Velocity"))

analysis <- load_analysis("velocity")
print(summary(analysis))
prediction <- try(predict(analysis, newdata = c("Habitat", "By")))

if(is.data.frame(prediction)) {
 gp <- ggplot(data = prediction, aes(x = Habitat, y = estimate))
 gp <- gp + geom_line()
 gp <- gp + geom_line(aes(y = lower), linetype = "dotted")
 gp <- gp + geom_line(aes(y = upper), linetype = "dotted")
 gp <- gp + scale_x_continuous(name = "Velocity (m/s)", expand = c(0,0))
 gp <- gp + scale_y_continuous(name = "Habitat Suitability Index", expand = c(0,0))
 gp <- gp + expand_limits(x = 0, y = c(0,1))
 gwindow(4,4)
 print(gp)

 save_plot("velocity", type = ifelse(is_converged(analysis), "figures", "analyses"))
 graphics.off()
 #############

 print(paste(sys, spp, "Velocity - Life Stage"))

 analysis <- load_analysis("velocity-lifestage")
 print(summary(analysis))
 prediction <- try(predict(analysis, newdata = c("Habitat", "By")))

 if(is.data.frame(prediction)) {
  gp <- ggplot(data = prediction, aes(x = Habitat, y = estimate, group = By, color = By))
  gp <- gp + geom_line()
  gp <- gp + geom_line(aes(y = lower), linetype = "dotted")
  gp <- gp + geom_line(aes(y = upper), linetype = "dotted")
  gp <- gp + scale_x_continuous(name = "Velocity (m/s)", expand = c(0,0))
  gp <- gp + scale_y_continuous(name = "Habitat Suitability Index", expand = c(0,0))
  gp <- gp + scale_color_discrete(name = "Life Stage")
  gp <- gp + expand_limits(x = 0, y = c(0,1))
  gwindow(4,4)
  print(gp)

  save_plot("velocity-lifestage", type = ifelse(is_converged(analysis), "figures", "analyses"))
  graphics.off()
  #############

  print(paste(sys, spp, "Velocity - Diel Period"))

  analysis <- load_analysis("velocity-dielperiod")
```

```
print(summary(analysis))
prediction <- try(predict(analysis, newdata = c("Habitat", "By")))

if(is.data.frame(prediction)) {
 gp <- ggplot(data = prediction, aes(x = Habitat, y = estimate, group = By, color = By))
 gp <- gp + geom_line()
 gp <- gp + geom_line(aes(y = lower), linetype = "dotted")
 gp <- gp + geom_line(aes(y = upper), linetype = "dotted")
 gp <- gp + scale_x_continuous(name = "Velocity (m/s)", expand = c(0,0))
 gp <- gp + scale_y_continuous(name = "Habitat Suitability Index", expand = c(0,0))
 gp <- gp + scale_color_discrete(name = "Diel Period")
 gp <- gp + expand_limits(x = 0, y = c(0,1))
 gwindow(4,4)
 print(gp)

 save_plot("velocity-dielperiod", type = ifelse(is_converged(analysis), "figures", "analyses"))
 graphics.off()
 ###########
 print(paste(sys, spp, "Velocity - Season"))

 analysis <- load_analysis("velocity-season")
 print(summary(analysis))
 prediction <- try(predict(analysis, newdata = c("Habitat", "By")))

 if(is.data.frame(prediction)) {
  gp <- ggplot(data = prediction, aes(x = Habitat, y = estimate, group = By, color = By))
  gp <- gp + geom_line()
  gp <- gp + geom_line(aes(y = lower), linetype = "dotted")
  gp <- gp + geom_line(aes(y = upper), linetype = "dotted")
  gp <- gp + scale_x_continuous(name = "Velocity (m/s)", expand = c(0,0))
  gp <- gp + scale_y_continuous(name = "Habitat Suitability Index", expand = c(0,0))
  gp <- gp + scale_color_discrete(name = "Season")
  gp <- gp + expand_limits(x = 0, y = c(0,1))
  gwindow(4,4)
  print(gp)

  save_plot("velocity-season", type = ifelse(is_converged(analysis), "figures", "analyses"))
  graphics.off()
  ##############
  print(paste(sys, spp, "Depth - Lifestage"))

  analysis <- load_analysis("depth-lifestage")
  print(summary(analysis))
  prediction <- try(predict(analysis, newdata = c("Habitat", "By")))

  if(is.data.frame(prediction)) {
   gp <- ggplot(data = prediction, aes(x = Habitat, y = estimate, group = By, color = By))
   gp <- gp + geom_line()
   gp <- gp + geom_line(aes(y = lower), linetype = "dotted")
   gp <- gp + geom_line(aes(y = upper), linetype = "dotted")
```

```
gp <- gp + scale_x_continuous(name = "Depth (m)", expand = c(0,0))
gp <- gp + scale_y_continuous(name = "Habitat Suitability Index", expand = c(0,0))
gp <- gp + scale_color_discrete(name = "Life Stage")
gp <- gp + expand_limits(x = 0, y = c(0,1))
gwindow(4,4)
print(gp)

save_plot("depth-lifestage", type = ifelse(is_converged(analysis), "figures", "analyses"))
graphics.off()
############
print(paste(sys, spp, "Depth - Diel Period"))

analysis <- load_analysis("depth-dielperiod")
print(summary(analysis))
prediction <- try(predict(analysis, newdata = c("Habitat", "By")))

if(is.data.frame(prediction)) {
 gp <- ggplot(data = prediction, aes(x = Habitat, y = estimate, group = By, color = By))
 gp <- gp + geom_line()
 gp <- gp + geom_line(aes(y = lower), linetype = "dotted")
 gp <- gp + geom_line(aes(y = upper), linetype = "dotted")
 gp <- gp + scale_x_continuous(name = "Depth (m)", expand = c(0,0))
 gp <- gp + scale_y_continuous(name = "Habitat Suitability Index", expand = c(0,0))
 gp <- gp + scale_color_discrete(name = "Diel Period")
 gp <- gp + expand_limits(x = 0, y = c(0,1))
 gwindow(4,4)
 print(gp)

 save_plot("depth-dielperiod", type = ifelse(is_converged(analysis), "figures", "analyses"))
 graphics.off()
 ############

 print(paste(sys, spp, "Depth - Season"))
 analysis <- load_analysis("depth-season")
 print(summary(analysis))
 prediction <- try(predict(analysis, newdata = c("Habitat", "By")))

 if(is.data.frame(prediction)) {
  gp <- ggplot(data = prediction, aes(x = Habitat, y = estimate, group = By, color = By))
  gp <- gp + geom_line()
  gp <- gp + geom_line(aes(y = lower), linetype = "dotted")
  gp <- gp + geom_line(aes(y = upper), linetype = "dotted")
  gp <- gp + scale_x_continuous(name = "Depth (m)", expand = c(0,0))
  gp <- gp + scale_y_continuous(name = "Habitat Suitability Index", expand = c(0,0))
  gp <- gp + scale_color_discrete(name = "Season")
  gp <- gp + expand_limits(x = 0, y = c(0,1))
  gwindow(4,4)
  print(gp)

  save_plot("depth-season", type = ifelse(is_converged(analysis), "figures", "analyses"))
```

```
                  graphics.off()
                 }
                }
               }
              }
             }
            }
           }
          }
         }
        }
       }
      }
     }
```

manipdata-nests.R

```
source("header.r")

set_folders("clean")

nests <- load_rdata("sculnest")
sub <- load_rdata("sculsub")

set_folders("nests")

sort_dims <- function (d) {
  for (i in 1:nrow(d)) {
    d[i,c("Dim1","Dim2","Dim3")] <- sort(d[i,c("Dim1","Dim2","Dim3")], decreasing = TRUE)
  }
  d
}

nests <- sort_dims(nests)
sub <- sort_dims(sub)

nests$Count <- 1
sub$Count <- 1

data <- modprep (nests, hab = "Dim2", avail = sub) #
data$Available <- data$Available / sum(data$Available)

data2 <- data
data2$Available <- 1 / nrow(data)

data$By <- factor("Preference", levels = c("Use", "Preference"))
data2$By <- factor("Use", levels = c("Use", "Preference"))

data <- rbind(data, data2)
save_rdata(data, name="data")
```

analysis-nests.R

```
source("header.r")
source("models-hsi.r")

set_folders("nests")

data <- load_rdata(name="data")

analysis <- jags_analysis(model_by, data = data, niter = 10^4)
summary(analysis)
save_analysis(analysis)
```

plot-nests.R

```
source("header.r")

set_folders("nests")

analysis <- load_analysis()

prediction <- predict(analysis, newdata = c("Habitat", "By"))

gp <- ggplot(data = prediction, aes(x = Habitat, y = estimate, group = By, color = By))
gp <- gp + geom_line()
gp <- gp + scale_x_continuous(name = "Substrate Size (mm)", expand = c(0,0))
gp <- gp + scale_y_continuous(name = "Habitat Suitability Index", expand = c(0,0))
gp <- gp + scale_color_manual(name = "Type", values = palette())
gp <- gp + expand_limits(x = 0, y = c(0,1))
gwindow(4, 4)
print(gp)

save_plot("NestUsePref")
```

APPENDIX G

Flow Reduction PIT-Tracking Movements at LCR_10.5L and LCR_24.5R

Table G1. All tracking information for PIT tagged sculpins and dace relocated at least once at LCR_10.5L and LCR_24.5R, 2012-2014.

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_24.5R	17/09/2012	No	EF1	17/09/2012 10:30	3D9.1C2D239ABE	LNC	54	Alive	449984	5450695						Unknown		
LCR	LCR_24.5R	09/02/2013	Yes	TR1	09/02/2013 14:20	3D9.1C2D239ABE	LNC	54	Unknown	450022	5450721	**46**		0.4	0.05	2.6	Cobble	5	
LCR	LCR_24.5R	14/02/2013	No	TR1	14/02/2013 12:10	3D9.1C2D239ABE	LNC	54	Unknown	450022	5450719	0	None	0.63	0.08	2.8	Cobble	10	
LCR	LCR_24.5R	16/02/2013	Yes	TR1	16/02/2013 14:55	3D9.1C2D239ABE	LNC	54	Alive	450022	5450719	0	None	0.15	0.05	0.25	Cobble	10	
LCR	LCR_24.5R	17/09/2012	No	EF1	17/09/2012 10:30	3D9.1C2D23A08F	CBA	54	Alive	449984	5450695						Unknown		
LCR	LCR_24.5R	08/05/2013	No	TR1	08/05/2013 9:20	3D9.1C2D23A08F	CBA	54	Alive	449987	5450689	**7**		0.76	0.14	2	Cobble	75	
LCR	LCR_24.5R	17/09/2012	No	EF1	17/09/2012 10:30	3D9.1C2D23B289	UDC	50	Alive	449984	5450695						Unknown		
LCR	LCR_24.5R	08/05/2013	No	TR1	08/05/2013 9:20	3D9.1C2D23B289	UDC	50	Alive	449993	5450694	**9**		0.45	0.01	0.5	Cobble	5	
LCR	LCR_24.5R	08/05/2013	No	EF1		3D9.1C2D23B289	UDC	50	Alive	449967	5450692	**26**		0.2	0	0.5	Cobble	0	Recapture; lower caudal frayed; incision looks good.
LCR	LCR_10.5L	18/09/2012	No	EF2		3D9.1C2D23B9F8	CCN	50	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	14/02/2013	No	TR1	14/02/2013 9:35	3D9.1C2D23B9F8	CCN	50	Unknown	452635	5462906	**12**		0.12	0.04	0.25	Cobble	5	
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3D9.1C2D23B9F8	CCN	50	Unknown	452625	5462893	**16**		0.52	0.18	2.5	Cobble	5	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3D9.1C2D23B9F8	CCN	50	Unknown	452625	5462893	0	None	0.52	0.18	2.5	Cobble	5	
LCR	LCR_10.5L	28/09/2013	Yes	TR1	28/09/2013 11:06	3D9.1C2D23B9F8	CCN	50	Dead	452625	5462893	**0**		0.24	0.02	0.8	Cobble	5	Dead tag.
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D23C2D1	CAS	45	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D23C2D1	CAS	45	Unknown	452630	5462900	**5**		0.48	0.02	2	Cobble	10	
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D23C2D1	CAS	45	Alive	452626	5462903	6	Out	0.85	0.3	4.5	Cobble	10	
LCR	LCR_10.5L	04/10/2012	No	TR1	04/10/2012 9:50	3D9.1C2D23C2D1	CAS	45	Alive	452608	5462887	20	Downstream	0.28	0	2.5	Cobble	20	
LCR	LCR_10.5L	07/05/2012	No	EF1	07/05/2012 13:10	3D9.1C2D23C3DB	CAS	52	Dead	452642	5462915						Unknown		
LCR	LCR_10.5L	13/06/2013	No	TR1	13/06/2013 12:20	3D9.1C2D23C3DB	CAS	52	Dead	452638	5462910	**-**					Unknown		Dead tag.
LCR	LCR_24.5R	17/09/2012	No	EF1	17/09/2012 10:30	3D9.1C2D23F35C	CBA	59	Alive	449984	5450695						Unknown		
LCR	LCR_24.5R	09/02/2013	Yes	TR1	09/02/2013 14:20	3D9.1C2D23F35C	CBA	59	Alive	449994	5450695	**10**		1.1	0.5	3.2	Cobble	10	
LCR	LCR_10.5L	23/01/2014	No	EF1		3D9.1C2D248D3D	CRH	52	Alive	452636	5462905								
LCR	LCR_10.5L	29/01/2014	No	TR1	29/01/2014 13:00	3D9.1C2D248D3D	CRH	52	Unknown	452636	5462918	**13**		0.64	0.56	5	Cobble	50	
LCR	LCR_24.5R	14/08/2013	No	EF1	14/08/2013 10:30	3D9.1C2D2CB42D	CBA	46	Alive	449987	5450700						Unknown		
LCR	LCR_24.5R	20/12/2013	No	TR1	20/12/2013 12:22	3D9.1C2D2CB42D	CBA	46	Dead	449992	5450700	-		0.47	0	1.5	Boulder	20	Dead tag.
LCR	LCR_24.5R	21/12/2013	Yes	TR1	21/12/2013 13:14	3D9.1C2D2CB42D			Dead			-					Unknown		Dead tag.
LCR	LCR_24.5R	14/08/2013	No	EF1	14/08/2013 10:30	3D9.1C2D2CDE23	CRH	47	Alive	449987	5450700						Unknown		
LCR	LCR_24.5R	21/12/2013	Yes	TR1	21/12/2013 13:14	3D9.1C2D2CDE23			Dead			-					Unknown		Dead tag.
LCR	LCR_24.5R	08/05/2013	No	EF1		3D9.1C2D312C33	CAS	66	Alive	450009	5450707						Unknown		
LCR	LCR_24.5R	23/05/2013	No	TR1	23/05/2013 10:00	3D9.1C2D312C33	CAS	66	Alive	449972	5450698	**38**		0.3	0	0.4	Cobble	5	
LCR	LCR_24.5R	24/05/2013	No	TR1	24/05/2013 9:55	3D9.1C2D312C33	CAS	66	Alive	449971	5450698	1	Downstream	0.34	0.01	1	Boulder	5	
LCR	LCR_24.5R	05/06/2013	No	TR1	05/06/2013 13:30	3D9.1C2D312C33	CAS	66	Alive	449968	5450698	1	Downstream	0.25	0.01	0.5	Cobble	5	
LCR	LCR_24.5R	12/06/2013	No	TR1	12/06/2013 9:45	3D9.1C2D312C33	CAS	66	Alive	449973	5450693	2	Out	0.96	0.25	2	Cobble	0	
LCR	LCR_24.5R	27/06/2013	No	TR1	27/06/2013 10:04	3D9.1C2D312C33	CAS	66	Alive	-	-	**-**		0.31	0.15	0.8	Cobble	0	
LCR	LCR_10.5L	09/05/2013	No	EF1		3D9.1C2D312C65	CRH	80	Alive	452629	5462898						Unknown		
LCR	LCR_10.5L	22/05/2013	No	TR1	22/05/2013 22:30	3D9.1C2D312C65	CRH	80	Alive	452636	5462897	**7**		0.9	0.13	4	Cobble	5	
LCR	LCR_10.5L	23/05/2013	No	TR1	23/05/2013 12:32	3D9.1C2D312C65	CRH	80	Alive	452636	5462893	**4**		0.86	0.09	4.5	Cobble	5	
LCR	LCR_10.5L	24/05/2013	No	TR1	24/05/2013 13:18	3D9.1C2D312C65	CRH	80	Alive	452630	5462889	9	Downstream	0.78	0.06	3.2	Gravel	5	
LCR	LCR_10.5L	05/06/2013	No	TR1	05/06/2013 9:32	3D9.1C2D312C65	CRH	80	Alive	452637	5462887	4	Upstream	0.21	0	1	Cobble	10	
LCR	LCR_10.5L	13/06/2013	No	TR1	13/06/2013 12:20	3D9.1C2D312C65	CRH	80	Alive	452631	5462897	10	Upstream	0.9	0.03	4.5	Cobble	5	Previous location dewatered.
LCR	LCR_10.5L	27/06/2013	No	TR1	27/06/2013 13:14	3D9.1C2D312C65	CRH	80	Unknown	452633	5462887	**10**		0.23	0	1.3	Boulder	5	
LCR	LCR_10.5L	01/08/2013	No	TR1	01/08/2013 11:11	3D9.1C2D312C65	CRH	80	Unknown	452634	5462885	**2**		0.48	0.24	2.25	Cobble	5	
LCR	LCR_10.5L	30/08/2013	Yes	TR1	30/08/2013 13:45	3D9.1C2D312C65	CRH	80	Alive	452626	5462890	**9**		0.68	0.23	3.4	Cobble	10	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3D9.1C2D312C65	CRH	80	Alive	452624	5462894	**4**		0.23	0.14	1.5	Cobble	5	
LCR	LCR_10.5L	28/09/2013	Yes	TR1	28/09/2013 11:06	3D9.1C2D312C65	CRH	80	Alive	452624	5462893	2	Downstream	0.26	0.2	1.5	Cobble	10	
LCR	LCR_10.5L	03/10/2013	No	TR1	03/10/2013 13:05	3D9.1C2D312C65	CRH	80	Alive	452619	5462908	20	Upstream	0.7	0.43	7	Cobble	5	
LCR	LCR_10.5L	09/10/2013	No	TR1	09/10/2013 13:34	3D9.1C2D312C65	CRH	80	Unknown	452628	5462913	**10**		0.44	0.15	4.5	Cobble	0	
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3D9.1C2D312C65	CRH	80	Unknown	452629	5462898	0	None	0.37	0.31	4.5	Cobble	0	

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_10.5L	01/02/2014	Yes	TR1	01/02/2014 10:05	3D9.1C2D312C65	CRH	80	Alive	452623	5462891	**9**		0.13	0.06	0.6	Cobble	10	
LCR	LCR_10.5L	15/02/2014	Yes	TR1	15/02/2014 11:50	3D9.1C2D312C65	CRH	80	Alive	452625	5462913	**22**		0.56	0.34	5	Cobble	10	
LCR	LCR_10.5L	25/03/2013	No	EF1	25/03/2013 13:50	3D9.1C2D312CC3	CRH	87	Alive	452624	5462896						Unknown		Milting.
LCR	LCR_10.5L	09/05/2013	No	TR1	09/05/2013 10:30	3D9.1C2D312CC3	CRH	87	Unknown	452628	5462897	**4**		0.93	0.14	4	Boulder	10	
LCR	LCR_10.5L	05/06/2013	No	TR1	05/06/2013 9:32	3D9.1C2D312CC3	CRH	87	Unknown	452648	5462923	**33**		0.35	0	4	Cobble	5	
LCR	LCR_10.5L	14/08/2013	No	EF1		3D9.1C2D312D0E	CRH	63	Alive	452636	5462902						Unknown		
LCR	LCR_10.5L	29/08/2013	No	TR1	29/08/2013 13:15	3D9.1C2D312D0E	CRH	63	Alive	452634	5462909	**7**		1	0.28	4	Cobble	10	
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3D9.1C2D312D0E	CRH	63	Alive	452638	5462913	6	Upstream	0.4	0.02	2.5	Cobble	5	
LCR	LCR_24.5R	07/02/2013	No	EF1	07/02/2013 9:20	3D9.1C2D312D15	CRH	85	Alive	450000	5450706						Unknown		
LCR	LCR_24.5R	08/02/2013	No	TR1	08/02/2013 11:50	3D9.1C2D312D15	CRH	85	Alive	450001	5450701	0	None	0.58	0.19	1.8	Cobble	10	
LCR	LCR_24.5R	14/02/2013	No	TR1	14/02/2013 12:10	3D9.1C2D312D15	CRH	85	Unknown	450001	5450701	**0**		0.58	0.19	1.8	Cobble	10	
LCR	LCR_24.5R	16/02/2013	Yes	TR1	16/02/2013 14:55	3D9.1C2D312D15	CRH	85	Alive	450001	5450701	0	None	0.05	0	0.1	Cobble	5	
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D312D35	CRH	60	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D312D35	CRH	60	Unknown	452637	5462921	**24**		0.55	0.02	3	Cobble	10	Dewatered- not relocated day 2.
LCR	LCR_10.5L	26/10/2012	No	TR1	26/10/2012 12:45	3D9.1C2D312D35	CRH	60	Unknown	452634	5462912	**9**		0.72	0.07	2.2	Cobble	5	
LCR	LCR_10.5L	27/10/2012	Yes	TR1	27/10/2012 11:35	3D9.1C2D312D35	CRH	60	Alive	452633	5462915	0	None	0.17	0.02	0.8	Cobble	5	
LCR	LCR_10.5L	09/02/2013	Yes	TR1	09/02/2013 11:30	3D9.1C2D312D35	CRH	60	Unknown	452632	5462915	**1**		1.1	0.05	5	Cobble	5	
LCR	LCR_10.5L	14/02/2013	No	TR1	14/02/2013 9:35	3D9.1C2D312D35	CRH	60	Alive	452633	5462911	2	Downstream	0.81	0.03	3	Gravel	5	
LCR	LCR_10.5L	09/05/2013	No	TR1	09/05/2013 10:30	3D9.1C2D312D35	CRH	60	Alive	452638	5462910	**5**		0.31	0	1.5	Cobble	5	
LCR	LCR_10.5L	22/05/2013	No	TR1	22/05/2013 22:30	3D9.1C2D312D35	CRH	60	Alive	452651	5462921	**17**		0.5	0	1.8	Cobble	5	
LCR	LCR_10.5L	13/06/2013	No	TR1	13/06/2013 12:20	3D9.1C2D312D35	CRH	60	Alive	452643	5462916	**9**		0.74	0	4	Cobble	5	
LCR	LCR_10.5L	18/09/2012	No	EF2		3D9.1C2D312DA8	CRH	69	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D312DA8	CRH	69	Alive	452623	5462888	**12**		0.55	0.05	2	Cobble	10	
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D312DA8	CRH	69	Alive	452617	5462885	8	Downstream	0.55	0.01	3	Cobble	10	
LCR	LCR_10.5L	27/10/2012	Yes	TR1	27/10/2012 11:35	3D9.1C2D312DA8	CRH	69	Alive	452612	5462882	**6**		0.35	0.02	2	Cobble	5	
LCR	LCR_10.5L	08/11/2012	No	TR1	08/11/2012 13:20	3D9.1C2D312DA8	CRH	69	Alive	452613	5462880	1	Out	0.4	0.02	3	Cobble	10	
LCR	LCR_10.5L	08/11/2012	No	TR1	08/11/2012 19:35	3D9.1C2D312DA8	CRH	69	Unknown	452613	5462880	**0**		0.4	0.02	3	Cobble	10	
LCR	LCR_10.5L	09/02/2013	Yes	TR1	09/02/2013 11:30	3D9.1C2D312DA8	CRH	69	Unknown	452620	5462889	**11**		0.95	0.3	4.5	Cobble	5	
LCR	LCR_10.5L	14/02/2013	No	TR1	14/02/2013 9:35	3D9.1C2D312DA8	CRH	69	Alive	452617	5462891	2	Out	0.8	0.39	5	Cobble	25	
LCR	LCR_10.5L	16/02/2013	Yes	TR1	16/02/2013 11:25	3D9.1C2D312DA8	CRH	69	Alive	452617	5462891	0	None	0.4	0.13	3	Cobble	24	
LCR	LCR_10.5L	22/05/2013	No	TR1	22/05/2013 22:30	3D9.1C2D312DA8	CRH	69	Alive	452635	5462897	**19**		0.95	0	4	Cobble	5	
LCR	LCR_10.5L	23/05/2013	No	TR1	23/05/2013 12:32	3D9.1C2D312DA8	CRH	69	Alive	452633	5462889	**8**		0.7	0.03	2.5	Cobble	10	
LCR	LCR_10.5L	05/06/2013	No	TR1	05/06/2013 9:32	3D9.1C2D312DA8	CRH	69	Alive	452638	5462890	3	Upstream	0.23	0	1.5	Boulder	10	
LCR	LCR_10.5L	25/03/2013	No	EF1	25/03/2013 13:50	3D9.1C2D312EB5	CRH	71	Alive	452624	5462896						Unknown		
LCR	LCR_10.5L	09/05/2013	No	TR1	09/05/2013 10:30	3D9.1C2D312EB5	CRH	71	Unknown	452635	5462909	**17**		0.65	0	3.5	Cobble	10	
LCR	LCR_10.5L	05/06/2013	No	TR1	05/06/2013 9:32	3D9.1C2D312EB5	CRH	71	Unknown	452647	5462904	**13**		0.2	0	0.2	Boulder	10	
LCR	LCR_10.5L	07/08/2013	No	TR1	07/08/2013 13:04	3D9.1C2D312EB5	CRH	71	Unknown	452643	5462907	**5**		0.27	0.01	0.9	Cobble	5	
LCR	LCR_10.5L	07/08/2013	No	TR1	07/08/2013 22:05	3D9.1C2D312EB5	CRH	71	Alive	452644	5462913	3.5	Upstream	0.21	0.04	0.8	Cobble	5	
LCR	LCR_10.5L	08/08/2013	No	TR1	08/08/2013 9:30	3D9.1C2D312EB5	CRH	71	Alive	452643	5462911	2.5	Downstream	0.32	0.05	1	Boulder	5	
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3D9.1C2D312EB5	CRH	71	Alive	452639	5462914	**5**		0.05	0	0.2	Gravel	5	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3D9.1C2D312EB5	CRH	71	Alive	452633	5462912	**6**		0.81	0.01	3.5	Cobble	10	Not tracked yesterday during previous track.
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3D9.1C2D312EB5	CRH	71	Alive	452631	5462907	0	None	0.67	0.05	3.5	Cobble	5	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3D9.1C2D312EB5	CRH	71	Unknown	452631	5462910	0	None	0.67	0.05	3.5	Cobble	5	
LCR	LCR_10.5L	28/09/2013	Yes	TR1	28/09/2013 11:06	3D9.1C2D312EB5	CRH	71	Alive	452631	5462910	0	None	0.37	0.01	2.2	Cobble	5	
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3D9.1C2D312EB5	CRH	71	Alive	452620	5462906	**12**		0.68	0.3	6	Cobble	5	
LCR	LCR_10.5L	21/12/2013	Yes	TR1	21/12/2013 10:15	3D9.1C2D312EB5	CRH	71	Alive	452638	5462922	**24**		0.55	0.2	5	Cobble	5	
LCR	LCR_10.5L	29/01/2014	No	TR1	29/01/2014 13:00	3D9.1C2D312EB5	CRH	71	Alive	452640	5462918	**4**		0.21	0.04	1.2	Cobble	5	
LCR	LCR_10.5L	30/01/2014	No	TR1	30/01/2014 12:23	3D9.1C2D312EB5	CRH	71	Alive	452640	5462918	0	None	0.21	0.04	1.2	Cobble	5	
LCR	LCR_10.5L	01/02/2014	Yes	TR1	01/02/2014 10:05	3D9.1C2D312EB5	CRH	71	Alive	452634	5462912	7	Downstream	0.42	0	1.8	Cobble	5	
LCR	LCR_10.5L	04/02/2014	No	TR1	04/02/2014 13:30	3D9.1C2D312EB5	CRH	71	Alive	452634	5462919	10	Upstream	0.48	0.47	3	Cobble	10	
LCR	LCR_24.5R	17/09/2012	No	EF2	17/09/2012 14:00	3D9.1C2D312EE0	UDC	55	Alive	449999	5450702						Unknown		
LCR	LCR_24.5R	04/10/2012	No	TR1	04/10/2012 13:00	3D9.1C2D312EE0	UDC	55	Unknown	450005	5450702	**6**		0.31	0	0.5	Cobble	20	

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3D9.1C2D312EEA	CBA	58	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	20/12/2013	No	TR1	20/12/2013 9:40	3D9.1C2D312EEA	CBA	58	Dead	452631	5462898	-		0.51	0.01	2	Cobble	10	Dead tag.
LCR	LCR_10.5L	21/12/2013	Yes	TR1	21/12/2013 10:15	3D9.1C2D312EEA	CBA	58	Dead			-					Unknown		Dead tag.
LCR	LCR_10.5L	09/05/2013	No	EF1		3D9.1C2D312EF2	CRH	81	Alive	452629	5462898						Unknown		
LCR	LCR_10.5L	13/06/2013	No	TR1	13/06/2013 12:20	3D9.1C2D312EF2	CRH	81	Alive	452630	5462898	**1**		0.56	0.02	3	Boulder	5	
LCR	LCR_10.5L	13/06/2013	No	VO1	13/06/2013 12:20	3D9.1C2D312EF2	CRH	81	Alive	452629	5462898	**1**		0.56	0.2	3	Boulder	5	Found under nest 3A.
LCR	LCR_10.5L	19/06/2013	No	SW1	19/06/2013 9:40	3D9.1C2D312EF2	CRH	81	Alive	452630	5462898	**1**		0.77	0.06	5	Boulder	5	1 CRH observed under nest 3A.
LCR	LCR_10.5L	27/06/2013	No	TR1	27/06/2013 13:14	3D9.1C2D312EF2	CRH	81	Alive	452635	5462889	**10**		0.55	0.13	2.5	Cobble	5	
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3D9.1C2D312EF2	CRH	91	Alive	452634	5462906	**17**					Unknown		Recapture: length increased from 81 to 91 mm and weight from 7.2 to 10.2 g.
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3D9.1C2D312EF2	CRH	91	Unknown	452632	5462898	**8**		0.19	0.07	1	Cobble	10	Grown from 81 to 91 mm; previously recaptured.
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3D9.1C2D312EF2	CRH	91	Unknown	452632	5462898	0	None	0.19	0.07	1	Cobble	10	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3D9.1C2D312EF2	CRH	91	Alive	452628	5462897	3	Out	0.32	0.05	1.2	Cobble	10	Previous location dewatered.
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3D9.1C2D312EF2	CRH	91	Unknown	452626	5462896	**2**		0.35	0.03	1.5	Gravel	5	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3D9.1C2D312EF2	CRH	91	Alive	452626	5462896	0	None	0.35	0.03	1.5	Gravel	5	
LCR	LCR_24.5R	07/02/2013	No	EF1	07/02/2013 9:20	3D9.1C2D312F14	CBA	94	Alive	450000	5450706						Unknown		
LCR	LCR_24.5R	08/02/2013	No	TR1	08/02/2013 11:50	3D9.1C2D312F14	CBA	94	Alive	450000	5450703	**3**		0.2	0.2	2	Cobble	10	
LCR	LCR_24.5R	08/02/2013	Yes	TR1	08/02/2013 17:00	3D9.1C2D312F14	CBA	94	Unknown	450001	5450705	0.2	Out	0.15	0.05	1.2	Cobble	10	
LCR	LCR_24.5R	14/02/2013	No	TR1	14/02/2013 12:10	3D9.1C2D312F14	CBA	94	Unknown	450004	5450701	**5**		0.95	0.23	2.3	Cobble	10	
LCR	LCR_24.5R	16/02/2013	Yes	TR1	16/02/2013 14:55	3D9.1C2D312F14	CBA	94	Unknown	450004	5450701	0	None	0.35	0	1.5	Cobble	5	
LCR	LCR_10.55L	07/02/2013	No	EF1	07/02/2013 13:00	3D9.1C2D312F3F	CRH	75	Alive	452637	5462898								
LCR	LCR_10.5L	14/02/2013	No	TR1	14/02/2013 9:35	3D9.1C2D312F3F	CRH	75	Unknown	452617	5462870	**34**		0.65	0.01	4	Cobble	40	
LCR	LCR_10.5L	16/02/2013	Yes	TR1	16/02/2013 11:25	3D9.1C2D312F3F	CRH	75	Unknown	452617	5462870	0	None	0.24	0.02	1	Cobble	40	
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D313036	CCN	86	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	04/10/2012	No	TR1	04/10/2012 9:50	3D9.1C2D313036	CCN	86	Unknown	452621	5462901	**4**		0.71	0.6	4	Cobble	10	
LCR	LCR_10.5L	09/10/2013	No	TR1	09/10/2013 13:34	3D9.1C2D313036	CCN	86	Unknown	452612	5462892	**13**		0.75	0.26	3.5	Cobble	5	
LCR	LCR_10.5L	25/03/2013	No	EF1	25/03/2013 13:50	3D9.1C2D313092	CRH	83	Alive	452624	5462896						Unknown		
LCR	LCR_10.5L	22/05/2013	No	TR1	22/05/2013 22:30	3D9.1C2D313092	CRH	83	Unknown	452628	5462878	**18**		0.8	0.09	2	Boulder	5	
LCR	LCR_10.5L	23/05/2013	No	TR1	23/05/2013 12:32	3D9.1C2D313092	CRH	83	Unknown	452628	5462878	**0**		0.75	0.07	2	Boulder	5	
LCR	LCR_10.5L	24/05/2013	No	TR1	24/05/2013 13:18	3D9.1C2D313092	CRH	83	Alive	452628	5462878	0	None	0.56	0.07	2	Boulder	5	
LCR	LCR_10.5L	05/06/2013	No	TR1	05/06/2013 9:32	3D9.1C2D313092	CRH	83	Alive	452628	5462879	**1**		0.42	0	1.5	Cobble	20	Nest #1.
LCR	LCR_24.5R	07/02/2013	No	EF1	07/02/2013 9:20	3D9.1C2D31317A	CBA	95	Alive	450000	5450706						Unknown		
LCR	LCR_24.5R	08/02/2013	No	TR1	08/02/2013 11:50	3D9.1C2D31317A	CBA	95	Alive	450002	5450708	**3**		0.15	0.1	3.8	Cobble	10	
LCR	LCR_24.5R	08/02/2013	Yes	TR1	08/02/2013 17:00	3D9.1C2D31317A	CBA	95	Unknown	450002	5450708	0	None	0.15	0.1	1.8	Cobble	10	
LCR	LCR_24.5R	09/02/2013	Yes	TR1	09/02/2013 14:20	3D9.1C2D31317A	CBA	95	Alive	450001	5450704	1.5	Out	0.2	0.25	1	Cobble	10	
LCR	LCR_24.5R	14/02/2013	No	TR1	14/02/2013 12:10	3D9.1C2D31317A	CBA	95	Alive	449998	5450699	4	Downstream	0.1	0.24	0.4	Cobble	5	
LCR	LCR_24.5R	16/02/2013	Yes	TR1	16/02/2013 14:55	3D9.1C2D31317A	CBA	95	Alive	449999	5450699	3	Downstream	0.15	0	0.2	Cobble	5	
LCR	LCR_24.5R	21/02/2013	No	TR1	21/02/2013 12:15	3D9.1C2D31317A	CBA	95	Alive	449999	5450699	0	None	0.15	0	0.2	Cobble	5	
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D3131F2	CCN	52	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	04/10/2012	No	TR1	04/10/2012 9:50	3D9.1C2D3131F2	CCN	52	Unknown	452615	5462892	**13**		0.8	0.6	4	Cobble	5	
LCR	LCR_10.5L	20/02/2014	No	TR1	20/02/2014 13:05	3D9.1C2D3131F2	CCN	52	Unknown	452602	5462878	**19**		0.67	0	7	Boulder	10	
LCR	LCR_10.55L	07/02/2013	No	EF1	07/02/2013 13:00	3D9.1C2D3131FB	CRH	75	Alive	452637	5462898								
LCR	LCR_10.5L	08/02/2013	No	TR1	08/02/2013 9:40	3D9.1C2D3131FB	CRH	75	Alive	452631	5462901	**7**					Unknown		
LCR	LCR_10.5L	16/02/2013	Yes	TR1	16/02/2013 11:25	3D9.1C2D3131FB	CRH	75	Alive	452616	5462871	**34**		0.12	0.01	1	Boulder	10	
LCR	LCR_24.5R	11/09/2013	No	EF1		3D9.1C2D313266	CRH	73	Alive	449998	5450702						Unknown		
LCR	LCR_24.5R	03/10/2013	No	TR1	03/10/2013 11:15	3D9.1C2D313266	CRH	73	Alive	450007	5450698	**10**		0.52	0	3.2	Cobble	0	
LCR	LCR_24.5R	09/10/2013	No	TR1	09/10/2013 10:20	3D9.1C2D313266	CRH	73	Unknown	450007	5450698	0	None	0.52	0	3.2	Cobble	0	
LCR	LCR_24.5R	10/10/2013	No	TR1	10/10/2013 18:20	3D9.1C2D313266	CRH	73	Alive	450005	5450697	1.5	In	0.32	0	1.7	Cobble	5	
LCR	LCR_24.5R	15/02/2014	Yes	TR1	15/02/2014 14:15	3D9.1C2D313266	CRH	73	Alive	450006	5450706	**9**		0.54	0	2.1	Boulder	10	
LCR	LCR_24.5R	20/02/2014	No	TR1	20/02/2014 10:45	3D9.1C2D313266	CRH	73	Alive	450006	5450706	0	None	0.54	0	2.1	Boulder	10	
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3D9.1C2D3132B9	CRH	68	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3D9.1C2D3132B9	CRH	68	Alive	452641	5462933	**28**		0.83	0.72	3.5	Cobble	10	

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3D9.1C2D3132B9	CRH	68	Alive	452644	5462937	5	Upstream	0.66	0.57	2.5	Cobble	10	
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D3132D6	CRH	66	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D3132D6	CRH	66	Unknown	452636	5462917	**20**		0.6	0.12	3	Cobble	10	
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D3132D6	CRH	66	Alive	452635	5462914	2	Out	0.2	0.05	1.2	Cobble	5	
LCR	LCR_24.5R	11/09/2013	No	EF1		3D9.1C2D313338	CCN	84	Alive	449998	5450702						Unknown		
LCR	LCR_24.5R	09/10/2013	No	TR1	09/10/2013 10:20	3D9.1C2D313338	CCN	84	Unknown	450002	5450696	**7**		0.57	0	1.8	Cobble	10	
LCR	LCR_10.5L	14/08/2013	No	EF1		3D9.1C2D313365	CRH	62	Alive	452636	5462902						Unknown		
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3D9.1C2D313365	CRH	62	Alive	452633	5462911	**9**		0.58	0.05	3	Gravel	5	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3D9.1C2D313365	CRH	62	Unknown	452630	5462908	**4**		0.77	0.09	5	Cobble	5	
LCR	LCR_10.5L	28/09/2013	Yes	TR1	28/09/2013 11:06	3D9.1C2D313365	CRH	62	Alive	452630	5462908	0	None	0.58	0.01	3.5	Cobble	5	
LCR	LCR_24.5R	14/08/2013	No	EF1	14/08/2013 10:30	3D9.1C2D31338E	CRH	61	Alive	449987	5450700						Unknown		
LCR	LCR_24.5R	29/08/2013	No	TR1	29/08/2013 9:45	3D9.1C2D31338E	CRH	61	Alive	449991	5450697	**5**		0.8	0	2.5	Cobble	10	
LCR	LCR_24.5R	30/08/2013	Yes	TR1	30/08/2013 10:00	3D9.1C2D31338E	CRH	61	Alive	449994	5450696	1	Out	0.93	0	3	Cobble	10	
LCR	LCR_24.5R	19/09/2013	No	TR1	19/09/2013 10:00	3D9.1C2D31338E	CRH	61	Alive	449991	5450696	**3**		1.2	0.12	5	Cobble	0	
LCR	LCR_24.5R	03/10/2013	No	TR1	03/10/2013 11:15	3D9.1C2D31338E	CRH	61	Alive	450001	5450696	**10**		0.85	0	4	Cobble	0	
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D3133F4	CRH	63	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D3133F4	CRH	63	Unknown	452636	5462917	**20**		0.6	0.12	3	Cobble	10	
LCR	LCR_10.5L	27/06/2013	No	TR1	27/06/2013 13:14	3D9.1C2D3133F4	CRH	63	Alive	452635	5462893	**24**		0.97	0.14	4	Boulder	0	
LCR	LCR_10.5L	18/09/2012	No	EF2		3D9.1C2D313439	CCN	64	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D313439	CCN	64	Unknown	452634	5462898	**9**		0.28	0.02	0.8	Cobble	5	
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D313439	CCN	64	Alive	452630	5462903	1.5	Out	0.02	0	0.1	Boulder	0	
LCR	LCR_10.5L	27/10/2012	Yes	TR1	27/10/2012 11:35	3D9.1C2D313439	CCN	64	Unknown	452623	5462903	**7**		0.62	0.26	3	Gravel	5	
LCR	LCR_10.5L	08/11/2012	No	TR1	08/11/2012 13:20	3D9.1C2D313439	CCN	64	Alive	452624	5462907	0.5	Downstream	0.53	0.03	4	Cobble	5	
LCR	LCR_10.5L	18/09/2012	No	EF2		3D9.1C2D31348E	CRH	88	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D31348E	CRH	88	Alive	452604	5462871	**36**		1.03	0.03	12	Boulder	5	
LCR	LCR_10.5L	27/10/2012	Yes	TR1	27/10/2012 11:35	3D9.1C2D31348E	CRH	88	Alive	452607	5462878	**8**		0.56	0.02	6	Cobble	10	
LCR	LCR_10.5L	18/09/2012	No	EF2		3D9.1C2D31350B	CRH	64	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D31350B	CRH	64	Unknown	452634	5462913	**16**		0.28	0	0.8	Cobble	10	
LCR	LCR_24.5R	17/09/2012	No	EF2	17/09/2012 14:00	3D9.1C2D313548	CBA	59	Alive	449999	5450702						Unknown		
LCR	LCR_24.5R	16/02/2013	Yes	TR1	16/02/2013 14:55	3D9.1C2D313548	CBA	59	Unknown	449990	5450693	**13**		0.65	0.03	1.8	Cobble	5	
LCR	LCR_24.5R	07/02/2013	No	EF1	07/02/2013 9:20	3D9.1C2D3135AB	CBA	63	Alive	450000	5450706						Unknown		
LCR	LCR_24.5R	08/02/2013	No	TR1	08/02/2013 11:50	3D9.1C2D3135AB	CBA	63	Alive	450002	5450705	**2**		0.6	0.5	1.2	Cobble	10	
LCR	LCR_24.5R	09/02/2013	Yes	TR1	09/02/2013 14:20	3D9.1C2D3135AB	CBA	63	Alive	450003	5450703	5	Out	0.75	0.4	3	Cobble	5	
LCR	LCR_24.5R	07/02/2013	No	EF1	07/02/2013 9:20	3D9.1C2D313615	CBA	72	Alive	450000	5450706						Unknown		
LCR	LCR_24.5R	09/02/2013	Yes	TR1	09/02/2013 14:20	3D9.1C2D313615	CBA	72	Alive	450001	5450707	**1**		0.05	0	0.1	Cobble	10	
LCR	LCR_24.5R	17/09/2012	No	EF2	17/09/2012 14:00	3D9.1C2D313629	CRH	69	Alive	449999	5450702						Unknown		
LCR	LCR_24.5R	08/11/2012	No	TR1	08/11/2012 17:30	3D9.1C2D313629	CRH	69	Unknown	450003	5450697	**6**		0.8	0.17	2.5	Cobble	10	
LCR	LCR_24.5R	16/02/2013	Yes	TR1	16/02/2013 14:55	3D9.1C2D313629	CRH	69	Alive	449985	5450693	**18**		0.25	0	0.2	Cobble	5	
LCR	LCR_24.5R	11/09/2013	No	EF1		3D9.1C2D313698	CRH	80	Alive	449998	5450702						Unknown		
LCR	LCR_24.5R	19/09/2013	No	TR1	19/09/2013 10:00	3D9.1C2D313698	CRH	80	Alive	449996	5450704	**3**		0.16	0.2	0.6	Cobble	0	
LCR	LCR_24.5R	09/10/2013	No	TR1	09/10/2013 10:20	3D9.1C2D313698	CRH	80	Alive	450007	5450706	**11**		0.1	0	0.15	Cobble	5	
LCR	LCR_24.5R	10/10/2013	No	TR1	10/10/2013 18:20	3D9.1C2D313698	CRH	80	Alive	450007	5450697	4.5	Downstream	0.56	0	4.2	Cobble	10	
LCR	LCR_24.5R	17/09/2012	No	EF2	17/09/2012 14:00	3D9.1C2D3136DD	CBA	90	Alive	449999	5450702						Unknown		
LCR	LCR_24.5R	29/08/2013	No	TR1	29/08/2013 9:45	3D9.1C2D3136DD	CBA	90	Alive	449995	5450702	**4**		0.4	0.38	1.8	Cobble	10	
LCR	LCR_10.55L	07/02/2013	No	EF1	07/02/2013 13:00	3D9.1C2D313787	CRH	86	Alive	452637	5462898								
LCR	LCR_10.5L	09/02/2013	Yes	TR1	09/02/2013 11:30	3D9.1C2D313787	CRH	86	Alive	452621	5462884	**21**		0.34	0	1.5	Cobble	5	
LCR	LCR_10.5L	09/05/2013	No	TR1	09/05/2013 10:30	3D9.1C2D313787	CRH	86	Unknown	452622	5462886	**2**		0.61	0.01	3	Cobble	5	
LCR	LCR_10.5L	29/08/2013	No	TR1	29/08/2013 13:15	3D9.1C2D313787	CRH	86	Alive	452629	5462898	**14**		0.78	0.22	4	Cobble	10	
LCR	LCR_10.5L	30/08/2013	Yes	TR1	30/08/2013 13:45	3D9.1C2D313787	CRH	86	Alive	452629	5462898	0	None	0.78	0.22	4	Cobble	10	
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3D9.1C2D313787	CRH	86	Unknown	452629	5462897	0	None	0.74	0.15	2	Cobble	0	

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3D9.1C2D313787	CRH	86	Unknown	452629	5462897	0	None	0.74	0.15	2	Cobble	0	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3D9.1C2D313787	CRH	86	Dead	452629	5462897	-					Unknown		Dead tag.
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3D9.1C2D313787	CRH	86	Unknown	452628	5462896	-		0.15	0.05	0.8	Cobble	10	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3D9.1C2D313787	CRH	86	Unknown	452628	5462896	0	None	0.15	0.05	0.8	Cobble	10	
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3D9.1C2D3137E1	CRH	70	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3D9.1C2D3137E1	CRH	70	Unknown	452629	5462901	**7**		0.98	0.28	4	Cobble	5	
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3D9.1C2D3137E1	CRH	70	Unknown	452629	5462901	0	None	0.98	0.28	4	Cobble	5	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3D9.1C2D3137E1	CRH	70	Alive	452629	5462901	0	None	0.45	0.01	1.8	Cobble	5	
LCR	LCR_10.5L	03/10/2013	No	TR1	03/10/2013 13:05	3D9.1C2D3137E1	CRH	70	Alive	452608	5462897	**21**		0.75	0.41	8	Cobble	5	
LCR	LCR_10.5L	09/10/2013	No	TR1	09/10/2013 13:34	3D9.1C2D3137E1	CRH	70	Alive	452610	5462896	0.5	In	0.76	0.54	8	Boulder	25	
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3D9.1C2D3137E1	CRH	70	Alive	452610	5462897	1	Downstream	0.78	0.57	8	Cobble	10	
LCR	LCR_24.5R	07/02/2013	No	EF1	07/02/2013 9:20	3D9.1C2D31384A	CRH	77	Alive	450000	5450706						Unknown		
LCR	LCR_24.5R	05/06/2013	No	TR1	05/06/2013 13:30	3D9.1C2D31384A	CRH	77	Alive	449988	5450696	**16**		0.82	0.17	4	Unknown	0	
LCR	LCR_24.5R	07/02/2013	No	EF1	07/02/2013 9:20	3D9.1C2D313880	CBA	73	Alive	450000	5450706						Unknown		
LCR	LCR_24.5R	08/05/2013	No	TR1	08/05/2013 9:20	3D9.1C2D313880	CBA	73	Alive	450014	5450707	**14**		0.68	0.36	2.2	Cobble	10	
LCR	LCR_24.5R	08/05/2013	No	EF1		3D9.1C2D313880	CBA	74	Alive	449967	5450692	**49**					Unknown		Recapture; stomach dispended due to eggs; no scar; tag visible.
LCR	LCR_10.5L	18/09/2012	No	EF2		3D9.1C2D313899	CCN	83	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D313899	CCN	83	Unknown	452639	5462923	**27**		0.18	0.03	1.5	Cobble	5	
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D313899	CCN	83	Alive	452637	5462925	6	Upstream	0.2	0	0.5	Cobble	0	
LCR	LCR_10.5L	26/10/2012	No	TR1	26/10/2012 12:45	3D9.1C2D313899	CCN	83	Alive	452642	5462928	**6**		0.15	0.14	0.5	Cobble	10	
LCR	LCR_10.5L	27/10/2012	Yes	TR1	27/10/2012 11:35	3D9.1C2D313899	CCN	83	Alive	452638	5462931	1	Out	0.18	0.17	1	Cobble	5	
LCR	LCR_10.5L	09/02/2013	Yes	TR1	09/02/2013 11:30	3D9.1C2D313899	CCN	83	Unknown	452622	5462888	**46**		0.42	0	2.5	Cobble	10	
LCR	LCR_10.5L	14/02/2013	No	TR1	14/02/2013 9:35	3D9.1C2D313899	CCN	83	Alive	452620	5462888	0.25	Out	0.49	0.01	2	Cobble	10	
LCR	LCR_10.5L	16/02/2013	Yes	TR1	16/02/2013 11:25	3D9.1C2D313899	CCN	83	Alive	452620	5462889	1.5	Out	0.2	0.01	1.5	Cobble	5	
LCR	LCR_10.5L	09/05/2013	No	TR1	09/05/2013 10:30	3D9.1C2D313899	CCN	83	Alive	452621	5462887	**2**		0.94	0.1	4.5	Cobble	10	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3D9.1C2D313899	CCN	83	Alive	452620	5462884	**3**		0.27	0.01	1.7	Boulder	5	
LCR	LCR_10.5L	25/03/2013	No	EF1	25/03/2013 13:50	3D9.1C2D3138CD	CAS	66	Alive	452624	5462896						Unknown		
LCR	LCR_10.5L	09/05/2013	No	TR1	09/05/2013 10:30	3D9.1C2D3138CD	CAS	66	Alive	452628	5462895	**4**		0.5	0.03	2	Cobble	10	
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D3139A5	CCN	54	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D3139A5	CCN	54	Unknown	452627	5462902	**3**		0.53	0.2	3.5	Cobble	5	
LCR	LCR_24.5R	17/09/2012	No	EF2	17/09/2012 14:00	3D9.1C2D3139BC	CCN	85	Alive	449999	5450702						Unknown		
LCR	LCR_24.5R	23/05/2013	No	TR1	23/05/2013 10:00	3D9.1C2D3139BC	CCN	85	Alive	449969	5450696	**31**		0.86	0.46	2.3	Cobble	5	
LCR	LCR_24.5R	17/09/2012	No	EF2	17/09/2012 14:00	3D9.1C2D3139E1	CRH	68	Alive	449999	5450702						Unknown		
LCR	LCR_24.5R	09/02/2013	Yes	TR1	09/02/2013 14:20	3D9.1C2D3139E1	CRH	68	Unknown	450017	5450717	**23**		0.4	0.5	2.5	Cobble	15	
LCR	LCR_24.5R	14/02/2013	No	TR1	14/02/2013 12:10	3D9.1C2D3139E1	CRH	68	Unknown	450016	5450713	0	None	0.68	0.19	2.5	Cobble	10	
LCR	LCR_24.5R	16/02/2013	Yes	TR1	16/02/2013 14:55	3D9.1C2D3139E1	CRH	68	Alive	450016	5450713	0.25	Out	0.15	0.1	0.3	Cobble	10	
LCR	LCR_24.5R	21/02/2013	No	TR1	21/02/2013 12:15	3D9.1C2D3139E1	CRH	68	Alive	450016	5450710	1	Downstream	0.15	0	0.3	Cobble	10	
LCR	LCR_10.5L	14/08/2013	No	EF1		3D9.1C2D313A53	CRH	60	Alive	452636	5462902						Unknown		
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3D9.1C2D313A53	CRH	60	Alive	452630	5462901	**6**		0.73	0.2	3	Cobble	0	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3D9.1C2D313A53	CRH	60	Alive	452631	5462908	10	Upstream	0.84	0.01	3.5	Gravel	5	
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3D9.1C2D313A53	CRH	60	Unknown	452616	5462902	**16**		0.66	0.5	6	Gravel	5	
LCR	LCR_24.5R	11/09/2013	No	EF1		3D9.1C2D313ACC	CRH	105	Alive	449998	5450702						Unknown		
LCR	LCR_24.5R	03/10/2013	No	TR1	03/10/2013 11:15	3D9.1C2D313ACC	CRH	105	Alive	450010	5450700	**12**		0.96	0	4.5	Cobble	0	
LCR	LCR_24.5R	20/02/2014	No	TR1	20/02/2014 10:45	3D9.1C2D313ACC	CRH	105	Alive	450020	5450715	**18**		0.38	0	1.6	Cobble	5	
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D313AF6	CRH	72	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3D9.1C2D313AF6	CRH	72	Alive	452603	5462891	**24**		0.57	0.53	10	Cobble	5	
LCR	LCR_24.5R	11/09/2013	No	EF1		3D9.1C2D313B25	CRH	84	Alive	449998	5450702						Unknown		
LCR	LCR_24.5R	19/09/2013	No	TR1	19/09/2013 10:00	3D9.1C2D313B25	CRH	84	Alive	450016	5450716	**23**		0.9	0.25	4.5	Cobble	5	
LCR	LCR_24.5R	20/09/2013	No	TR1	20/09/2013 10:05	3D9.1C2D313B25	CRH	84	Alive	450018	5450713	3	Downstream	0.72	0.28	3	Cobble	5	
LCR	LCR_24.5R	21/09/2013	Yes	TR1	21/09/2013 14:52	3D9.1C2D313B25	CRH	84	Alive	450019	5450710	2	Upstream	0.72	0.33	3.5	Cobble	5	
LCR	LCR_24.5R	26/09/2013	No	TR1	26/09/2013 11:20	3D9.1C2D313B25	CRH	84	Alive	450019	5450714	1	In	0.32	0.32	1	Cobble	5	
LCR	LCR_10.5L	18/09/2012	No	EF2		3D9.1C2D313B3E	CCN	55	Alive	452625	5462900						Unknown		

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_10.5L	27/10/2012	Yes	TR1	27/10/2012 11:35	3D9.1C2D313B3E	CCN	55	Alive	452609	5462883	**23**		0.68	0.04	5	Cobble	5	
LCR	LCR_10.5L	09/05/2013	No	EF1		3D9.1C2D313BCE	CRH	77	Alive	452629	5462898						Unknown		
LCR	LCR_10.5L	22/05/2013	No	TR1	22/05/2013 22:30	3D9.1C2D313BCE	CRH	77	Alive	452633	5462888	**11**		0.37	0	1.2	Boulder	0	
LCR	LCR_10.5L	24/05/2013	No	TR1	24/05/2013 13:18	3D9.1C2D313BCE	CRH	77	Alive	452634	5462888	1	Out	0.39	0.05	1.8	Cobble	0	
LCR	LCR_10.5L	05/06/2013	No	TR1	05/06/2013 9:32	3D9.1C2D313BCE	CRH	77	Alive	452630	5462885	5	Downstream	0.87	0.07	3	Cobble	10	Nest #2.
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D313C1F	CCN	65	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D313C1F	CCN	65	Unknown	452632	5462907	**10**		0.5	0.06	2	Cobble	5	
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D313C1F	CCN	65	Alive	452632	5462908	2.5	Out	0.21	0	0.5	Gravel	5	
LCR	LCR_10.5L	04/10/2012	No	TR1	04/10/2012 9:50	3D9.1C2D313C1F	CCN	65	Dead	452632	5462908	-					Unknown		Dead tag.
LCR	LCR_10.5L	26/10/2012	No	TR1	26/10/2012 12:45	3D9.1C2D313C1F	CCN	65	Dead	452625	5462900	-					Unknown		Likely dead.
LCR	LCR_10.5L	09/02/2013	Yes	TR1	09/02/2013 11:30	3D9.1C2D313C1F	CCN	65	Unknown	452631	5462907	-		1.02	0.1	5	Gravel	40	
LCR	LCR_10.5L	14/02/2013	No	TR1	14/02/2013 9:35	3D9.1C2D313C1F	CCN	65	Unknown	452632	5462908	0	None	0.8	0.01	3	Gravel	50	
LCR	LCR_10.5L	16/02/2013	Yes	TR1	16/02/2013 11:25	3D9.1C2D313C1F	CCN	65	Dead	452632	5462908	-		0.21	0.01	1	Sand	75	Dead tag.
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3D9.1C2D313C1F	CCN	65	Unknown	452630	5462905	-		0.78	0	3.5	Gravel	5	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3D9.1C2D313C1F	CCN	65	Unknown	452630	5462905	0	None	0.78	0	3.5	Gravel	5	
LCR	LCR_10.5L	21/12/2013	Yes	TR1	21/12/2013 10:15	3D9.1C2D313C1F	CCN	65	Dead			-					Unknown		Dead tag.
LCR	LCR_10.55L	07/02/2013	No	EF1	07/02/2013 13:00	3D9.1C2D313C6E	CRH	81	Alive	452637	5462898				Unknown				
LCR	LCR_10.5L	09/02/2013	Yes	TR1	09/02/2013 11:30	3D9.1C2D313C6E	CRH	81	Unknown	452630	5462904	**9**		0.57	0	2.5	Cobble	5	
LCR	LCR_10.5L	16/02/2013	Yes	TR1	16/02/2013 11:25	3D9.1C2D313C6E	CRH	81	Alive	452615	5462885	**24**		0.59	0.01	2.5	Cobble	50	
LCR	LCR_10.5L	21/02/2013	No	TR1	21/02/2013 10:10	3D9.1C2D313C6E	CRH	81	Alive	452607	5462876	**12**		0.56	0.03	6	Cobble	30	
LCR	LCR_10.5L	09/05/2013	No	TR1	09/05/2013 10:30	3D9.1C2D313C6E	CRH	81	Alive	452622	5462883	**17**		0.58	0	3.5	Gravel	5	
LCR	LCR_10.5L	23/05/2013	No	TR1	23/05/2013 12:32	3D9.1C2D313C6E	CRH	81	Unknown	452630	5462886	**9**		0.84	0.04	3	Cobble	5	
LCR	LCR_10.5L	01/08/2013	No	TR1	01/08/2013 11:11	3D9.1C2D313C6E	CRH	81	Alive	452627	5462878	**9**		0.76	0.11	2.5	Boulder	0	
LCR	LCR_10.5L	03/08/2013	Yes	TR1	03/08/2013 13:06	3D9.1C2D313C6E	CRH	81	Alive	452627	5462878	0	None	0.25	0.01	1	Boulder	0	
LCR	LCR_10.5L	07/08/2013	No	TR1	07/08/2013 13:04	3D9.1C2D313C6E	CRH	81	Alive	452626	5462881	**3**		0.37	0	1.5	Boulder	5	
LCR	LCR_10.5L	08/08/2013	No	TR1	08/08/2013 9:30	3D9.1C2D313C6E	CRH	81	Alive	452626	5462881	0	None	0.37	0	1.5	Boulder	5	
LCR	LCR_10.5L	29/08/2013	No	TR1	29/08/2013 13:15	3D9.1C2D313C6E	CRH	81	Alive	452620	5462877	**7**		0.44	0.08	4.5	Boulder	10	
LCR	LCR_10.5L	30/08/2013	Yes	TR1	30/08/2013 13:45	3D9.1C2D313C6E	CRH	81	Alive	452623	5462876	2.2	In	0.24	0.08	1.5	Boulder	10	
LCR	LCR_10.5L	12/09/2013	No	EF1		3D9.1C2D313C6E	CRH	98	Alive	452634	5462906						Unknown		Recapture.
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3D9.1C2D313C6E	CRH	98	Alive	452620	5462867	**41**		0.73	0.01	3.5	Boulder	10	
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3D9.1C2D313C6E	CRH	98	Alive	452617	5462866	0.3	Upstream	0.77	0	3.5	Boulder	0	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3D9.1C2D313C6E	CRH	98	Alive	452617	5462866	0	None	0.33	0.03	1.5	Boulder	0	
LCR	LCR_24.5R	11/09/2013	No	EF1		3D9.1C2D313CBF	CCN	84	Alive	449998	5450702						Unknown		
LCR	LCR_24.5R	03/10/2013	No	TR1	03/10/2013 11:15	3D9.1C2D313CBF	CCN	84	Alive	450003	5450697	**7**		0.4	0	1.5	Cobble	10	
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D313CC6	CCN	58	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	04/10/2012	No	TR1	04/10/2012 9:50	3D9.1C2D313CC6	CCN	58	Unknown	452619	5462902	**6**		0.63	0.6	4	Cobble	5	
LCR	LCR_10.5L	27/10/2012	Yes	TR1	27/10/2012 11:35	3D9.1C2D313CC6	CCN	58	Alive	452620	5462902	**1**		0.62	0.62	4	Gravel	5	
LCR	LCR_10.5L	08/11/2012	No	TR1	08/11/2012 13:20	3D9.1C2D313CC6	CCN	58	Alive	452622	5462902	0.1	In	0.63	0.37	5	Cobble	10	
LCR	LCR_10.5L	16/02/2013	Yes	TR1	16/02/2013 11:25	3D9.1C2D313CC6	CCN	58	Alive	452623	5462903	**1**		0.67	0.1	3	Cobble	5	
LCR	LCR_10.5L	21/02/2013	No	TR1	21/02/2013 10:10	3D9.1C2D313CC6	CCN	58	Alive	452628	5462908	6	Upstream	0.45	0.01	4	Cobble	5	
LCR	LCR_10.5L	09/10/2013	No	TR1	09/10/2013 13:34	3D9.1C2D313CC6	CCN	58	Unknown	452626	5462903	**5**		0.3	0.04	2.5	Cobble	5	
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3D9.1C2D313CC6	CCN	58	Unknown	452625	5462900	0	None	0.32	0.11	2.5	Cobble	5	
LCR	LCR_10.5L	20/02/2014	No	TR1	20/02/2014 13:05	3D9.1C2D313CC6	CCN	58	Alive	452624	5462906	**6**		0.28	0.04	2.5	Cobble	10	
LCR	LCR_10.5L	18/09/2012	No	EF2		3D9.1C2D313D12	CCN	68	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D313D12	CCN	68	Unknown	452623	5462893	**7**		0.8	0.27	3.5	Cobble	10	
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D313D12	CCN	68	Alive	452622	5462894	0.75	Out	0.3	0.1	1.2	Cobble	5	
LCR	LCR_10.5L	04/10/2012	No	TR1	04/10/2012 9:50	3D9.1C2D313D12	CCN	68	Unknown	452615	5462892	**7**		0.78	0.05	3	Cobble	10	
LCR	LCR_10.5L	18/09/2012	No	EF2		3D9.1C2D313D5F	CRH	94	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	08/11/2012	No	TR1	08/11/2012 19:35	3D9.1C2D313D5F	CRH	94	Unknown	452618	5462895	**9**		0.78	0.36	6	Cobble	10	
LCR	LCR_24.5R	07/02/2013	No	EF1	07/02/2013 9:20	3D9.1C2D313D91	CBA	80	Alive	450000	5450706						Unknown		
LCR	LCR_24.5R	09/02/2013	Yes	TR1	09/02/2013 14:20	3D9.1C2D313D91	CBA	80	Alive	450002	5450703	**4**		0.5	0.4	2	Cobble	5	

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_24.5R	14/02/2013	No	TR1	14/02/2013 12:10	3D9.1C2D313D91	CBA	80	Alive	450001	5450699	2	Downstream	0.62	0.37	2.5	Cobble	10	
LCR	LCR_10.5L	14/08/2013	No	EF1		3D9.1C2D3147BC	CRH	58	Alive	452636	5462902						Unknown		
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3D9.1C2D3147BC	CRH	58	Alive	452631	5462907	**7**		0.64	0.08	3	Gravel	5	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3D9.1C2D3147BC	CRH	58	Alive	452632	5462911	0.5	Out	0.75	0.11	3.4	Cobble	5	
LCR	LCR_10.5L	14/08/2013	No	EF1		3D9.1C2D314836	CCN	55	Alive	452636	5462902						Unknown		
LCR	LCR_10.5L	28/09/2013	Yes	TR1	28/09/2013 11:06	3D9.1C2D314836	CCN	55	Alive	452625	5462902	**11**		0.7	0.21	5	Cobble	10	
LCR	LCR_10.5L	03/10/2013	No	TR1	03/10/2013 13:05	3D9.1C2D314836	CCN	55	Alive	452622	5462901	2	Downstream	0.28	0.1	2	Cobble	5	
LCR	LCR_10.5L	09/10/2013	No	TR1	09/10/2013 13:34	3D9.1C2D314836	CCN	55	Alive	452622	5462905	4	Out	0.5	0.36	5.5	Gravel	5	
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3D9.1C2D314836	CCN	55	Unknown	452636	5462902	0	None	0.43	0.35	5	Gravel	5	
LCR	LCR_24.5R	07/02/2013	No	EF1	07/02/2013 9:20	3D9.1C2D314B8E	CRH	87	Alive	450000	5450706						Unknown		
LCR	LCR_24.5R	08/05/2013	No	TR1	08/05/2013 9:20	3D9.1C2D314B8E	CRH	87	Alive	450027	5450722	**31**		0.48	0	2.1	Cobble	10	
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D314BA3	CCN	53	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D314BA3	CCN	53	Unknown	452629	5462903	**5**		0.91	0.31	4	Cobble	5	
LCR	LCR_10.5L	04/10/2012	No	TR1	04/10/2012 9:50	3D9.1C2D314BA3	CCN	53	Unknown	452621	5462901	**8**		0.71	0.6	4	Cobble	10	
LCR	LCR_10.5L	27/10/2012	Yes	TR1	27/10/2012 11:35	3D9.1C2D314BA3	CCN	53	Unknown	452623	5462905	**4**		0.7	0.57	4	Cobble	5	
LCR	LCR_10.5L	25/03/2013	No	EF1	25/03/2013 13:50	3D9.1C2D314C59	CRH	79	Alive	452624	5462896						Unknown		
LCR	LCR_10.5L	09/05/2013	No	TR1	09/05/2013 10:30	3D9.1C2D314C59	CRH	79	Alive	452623	5462890	**6**		0.61	0.08	3	Cobble	5	
LCR	LCR_10.5L	09/05/2013	No	EF1		3D9.1C2D314C59	CRH	81	Alive	452629	5462898	**10**					Unknown		
LCR	LCR_24.5R	11/09/2013	No	EF1		3D9.1C2D314C5B	CRH	65	Alive	449998	5450702						Unknown		
LCR	LCR_24.5R	19/09/2013	No	TR1	19/09/2013 10:00	3D9.1C2D314C5B	CRH	65	Alive	450020	5450723	**30**		0.76	0.22	3	Cobble	5	
LCR	LCR_24.5R	20/09/2013	No	TR1	20/09/2013 10:05	3D9.1C2D314C5B	CRH	65	Alive	450023	5450720	0.75	Out	0.78	0.31	3.75	Cobble	5	
LCR	LCR_24.5R	21/09/2013	Yes	TR1	21/09/2013 14:52	3D9.1C2D314C5B	CRH	65	Alive	450024	5450717	1	Out	0.4	0.01	1.7	Cobble	5	
LCR	LCR_24.5R	26/09/2013	No	TR1	26/09/2013 11:20	3D9.1C2D314C5B	CRH	65	Alive	450022	5450720	3	In	0.59	0	3	Cobble	5	
LCR	LCR_24.5R	10/10/2013	No	TR1	10/10/2013 18:20	3D9.1C2D314C5B	CRH	65	Alive	450024	5450711	**9**		0.8	0	5	Boulder	20	
LCR	LCR_24.5R	07/02/2013	No	EF1	07/02/2013 9:20	3D9.1C2D315976	CBA	92	Alive	450000	5450706						Unknown		
LCR	LCR_24.5R	08/02/2013	Yes	TR1	08/02/2013 17:00	3D9.1C2D315976	CBA	92	Unknown	450001	5450704	**2**		0.15	0.05	0.2	Cobble	10	
LCR	LCR_24.5R	09/02/2013	Yes	TR1	09/02/2013 14:20	3D9.1C2D315976	CBA	92	Alive	450002	5450705	2.5	Out	0.2	0.05	1.1	Cobble	5	
LCR	LCR_24.5R	21/02/2013	No	TR1	21/02/2013 12:15	3D9.1C2D315976	CBA	92	Alive	450027	5450716	**27**		0.15	0	1.3	Boulder	0	
LCR	LCR_10.5L	14/08/2013	No	EF1		3D9.1C2D3159CE	CRH	64	Alive	452636	5462902						Unknown		
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3D9.1C2D3159CE	CRH	64	Alive	452633	5462914	**12**		0.94	0.12	5	Gravel	5	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3D9.1C2D3159CE	CRH	64	Alive	452634	5462916	1.5	Out	0.7	0.04	3.5	Cobble	5	
LCR	LCR_10.5L	03/10/2013	No	TR1	03/10/2013 13:05	3D9.1C2D3159CE	CRH	64	Alive	452626	5462914	**8**		0.3	0.2	3.5	Cobble	5	
LCR	LCR_10.5L	09/10/2013	No	TR1	09/10/2013 13:34	3D9.1C2D3159CE	CRH	64	Unknown	452636	5462902	0	None	0.33	0.2	3	Cobble	5	
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3D9.1C2D3159CE	CRH	64	Unknown	452636	5462902	0	None	0.29	0.25	3	Cobble	5	
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D315A4C	CRH	60	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D315A4C	CRH	60	Unknown	452632	5462903	**8**		0.47	0.03	2	Cobble	10	
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D315A54	CRH	60	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D315A54	CRH	60	Unknown	452641	5462929	**33**		0.16	0.02	0.2	Cobble	5	Dewatered- not relocated day 2.
LCR	LCR_10.5L	08/11/2012	No	TR1	08/11/2012 13:20	3D9.1C2D315A54	CRH	60	Alive	452633	5462927	**8**		0.63	0.16	3	Cobble	5	
LCR	LCR_10.5L	08/11/2012	No	TR1	08/11/2012 19:35	3D9.1C2D315A54	CRH	60	Unknown	452623	5462894	**34**		0.5	0.04	2	Cobble	10	
LCR	LCR_10.5L	09/02/2013	Yes	TR1	09/02/2013 11:30	3D9.1C2D315A54	CRH	60	Alive	452620	5462879	**15**		0.45	0	2.5	Cobble	5	
LCR	LCR_10.5L	14/02/2013	No	TR1	14/02/2013 9:35	3D9.1C2D315A54	CRH	60	Alive	452618	5462883	2	Upstream	0.47	0.03	3	Cobble	5	
LCR	LCR_10.5L	07/08/2013	No	TR1	07/08/2013 22:05	3D9.1C2D315A54	CRH	60	Alive	452649	5462921	**49**		0.22	0.11	1.7	Cobble	5	
LCR	LCR_10.5L	30/08/2013	Yes	TR1	30/08/2013 13:45	3D9.1C2D315A54	CRH	60	Alive	452629	5462895	**33**		0.64	0.25	3.5	Cobble	10	
LCR	LCR_10.5L	09/05/2013	No	EF1		3D9.1C2D315A5D	CRH	81	Alive	452629	5462898						Unknown		
LCR	LCR_10.5L	22/05/2013	No	TR1	22/05/2013 22:30	3D9.1C2D315A5D	CRH	81	Unknown	452628	5462881	**17**		0.83	0.04	2	Cobble	5	
LCR	LCR_10.5L	23/05/2013	No	TR1	23/05/2013 12:32	3D9.1C2D315A5D	CRH	81	Alive	452628	5462880	1	In	0.52	0	1.5	Boulder	5	
LCR	LCR_10.5L	24/05/2013	No	TR1	24/05/2013 13:18	3D9.1C2D315A5D	CRH	81	Alive	452629	5462881	1	Downstream	0.48	0	2	Boulder	5	
LCR	LCR_10.5L	05/06/2013	No	TR1	05/06/2013 9:32	3D9.1C2D315A5D	CRH	81	Alive	452628	5462879	1.5	Downstream	0.4	0	1.5	Cobble	20	
LCR	LCR_24.5R	14/08/2013	No	EF1	14/08/2013 10:30	3D9.1C2D315A79	CCN	57	Alive	449987	5450700						Unknown		
LCR	LCR_24.5R	29/01/2014	No	TR1	29/01/2014 10:25	3D9.1C2D315A79	CCN	57	Alive	449994	5450695	**9**		0.78	0.01	3.2	Cobble	5	
LCR	LCR_24.5R	30/01/2014	No	TR1	30/01/2014 9:45	3D9.1C2D315A79	CCN	57	Unknown	449994	5450695	0	None	0.78	0.01	3.2	Cobble	5	

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_24.5R	01/02/2014	Yes	TR1	01/02/2014 12:30	3D9.1C2D315A79	CCN	57	Unknown	449994	5450695	**0**		0.78	0.01	3.2	Cobble	5	
LCR	LCR_10.55L	07/02/2013	No	EF1	07/02/2013 13:00	3D9.1C2D315B3D	CRH	73	Alive	452637	5462898				Unknown				
LCR	LCR_10.5L	08/02/2013	Yes	TR1	08/02/2013 15:20	3D9.1C2D315B3D	CRH	73	Unknown	452628	5462897	**9**		1.3	0.3	3.5	Cobble	10	
LCR	LCR_10.5L	09/02/2013	Yes	TR1	09/02/2013 11:30	3D9.1C2D315B3D	CRH	73	Unknown	452628	5462897	**0**		0.32	0.1	1	Cobble	5	
LCR	LCR_10.5L	14/02/2013	No	TR1	14/02/2013 9:35	3D9.1C2D315B3D	CRH	73	Unknown	452626	5462897	**2**		0.42	0.05	2	Cobble	25	
LCR	LCR_10.5L	16/02/2013	Yes	TR1	16/02/2013 11:25	3D9.1C2D315B3D	CRH	73	Alive	452626	5462898	0.5	Out	0.15	0.01	0.5	Cobble	5	
LCR	LCR_24.5R	07/02/2013	No	EF1	07/02/2013 9:20	3D9.1C2D315B85	CRH	71	Alive	450000	5450706						Unknown		
LCR	LCR_24.5R	08/02/2013	Yes	TR1	08/02/2013 17:00	3D9.1C2D315B85	CRH	71	Alive	450003	5450707	**3**		0.2	0.05	0.2	Cobble	15	
LCR	LCR_24.5R	09/02/2013	Yes	TR1	09/02/2013 14:20	3D9.1C2D315B85	CRH	71	Alive	450003	5450705	2.8	Out	0.3	0.05	1.2	Cobble	10	
LCR	LCR_24.5R	14/02/2013	No	TR1	14/02/2013 12:10	3D9.1C2D315B85	CRH	71	Unknown	450003	5450705	0	None	0.23	0.07	1.1	Cobble	5	
LCR	LCR_24.5R	16/02/2013	Yes	TR1	16/02/2013 14:55	3D9.1C2D315B85	CRH	71	Alive	450004	5450703	3	Downstream	0.2	0	0.6	Cobble	5	
LCR	LCR_24.5R	21/02/2013	No	TR1	21/02/2013 12:15	3D9.1C2D315B85	CRH	71	Alive	450004	5450700	1.5	Upstream	0.22	0	1.1	Cobble	5	
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D315BB3	CCN	62	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	04/10/2012	No	TR1	04/10/2012 9:50	3D9.1C2D315BB3	CCN	62	Unknown	452623	5462910	**10**		0.83	0.6	4	Cobble	5	
LCR	LCR_10.5L	27/10/2012	Yes	TR1	27/10/2012 11:35	3D9.1C2D315BB3	CCN	62	Alive	452623	5462910	**0**		0.87	0.53	6	Cobble	5	
LCR	LCR_24.5R	11/09/2013	No	EF1		3D9.1C2D315CC4	CRH	70	Alive	449998	5450702						Unknown		
LCR	LCR_24.5R	19/09/2013	No	TR1	19/09/2013 10:00	3D9.1C2D315CC4	CRH	70	Alive	450025	5450726	**36**		0.45	0	1.7	Cobble	5	
LCR	LCR_24.5R	20/09/2013	No	TR1	20/09/2013 10:05	3D9.1C2D315CC4	CRH	70	Alive	450025	5450726	1	Downstream	0.41	0	1.7	Cobble	5	
LCR	LCR_24.5R	21/09/2013	Yes	TR1	21/09/2013 14:52	3D9.1C2D315CC4	CRH	70	Alive	450026	5450717	4.5	Out	0.44	0	3	Cobble	5	
LCR	LCR_24.5R	26/09/2013	No	TR1	26/09/2013 11:20	3D9.1C2D315CC4	CRH	70	Alive	450024	5450719	0.5	Downstream	0.56	0	3.5	Cobble	5	
LCR	LCR_24.5R	08/05/2013	No	EF1		3D9.1C2D315D1B	CCN	89	Alive	450009	5450707						Unknown		
LCR	LCR_24.5R	09/10/2013	No	TR1	09/10/2013 10:20	3D9.1C2D315D1B	CCN	89	Dead			-					Unknown		Dead tag.
LCR	LCR_10.5L	18/09/2012	No	EF1	18/09/2012 10:15	3D9.1C2D315D93	CCN	62	Alive	452625	5462900						Unknown		
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D315D93	CCN	63	Unknown	452625	5462901	**1**		0.67	0.2	4	Cobble	10	
LCR	LCR_24.5R	26/04/2011	No	EF1		3D9.1C2D61158B	CAS	79	Alive	450033	5450719						Unknown		
LCR	LCR_24.5R	12/05/2011	No	TR1	12/05/2011 10:00	3D9.1C2D61158B	CAS	79	Alive	886941.986	5464077.045			0.52	0.02	1	Cobble	40	
LCR	LCR_24.5R	26/04/2011	No	EF2		3D9.1C2D61A7A4	CRH	68	Alive	449997	5450698						Unknown		
LCR	LCR_24.5R	12/05/2011	No	TR1	12/05/2011 10:00	3D9.1C2D61A7A4	CRH	68	Alive	886928.538	5464070.92			0.25	0	0.2	Cobble	10	Moved into recently flooded area; no didymo.
LCR	LCR_10.5L	28/03/2012	No	EF1	28/03/2012 15:00	3D9.1C2D62CCD7	CCN	64	Alive	452624	5462884						Unknown		Dropped tag- collected.
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D62CCD7	CCN	64	Unknown	452622	5462895	**11**		0.43	0.3	4	Cobble	10	
LCR	LCR_10.5L	09/05/2013	No	TR1	09/05/2013 10:30	3D9.1C2D62CCD7	CCN	64	Unknown	452646	5462939	**50**		0.68	0.25	2	Cobble	10	
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3D9.1C2D62CCD7	CCN	64	Unknown	452646	5462943	**4**		0.83	0.78	2.5	Boulder	5	
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3D9.1C2D62CCD7	CCN	64	Unknown	452646	5462943	0	None	0.83	0.78	2.5	Boulder	5	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3D9.1C2D62CCD7	CCN	64	Alive	452646	5462943	0	None	0.32	0.18	0.75	Boulder	5	
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3D9.1C2D62CCD7	CCN	64	Unknown	452644	5462938	0	None	0.2	0.11	1	Cobble	5	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3D9.1C2D62CCD7	CCN	64	Unknown	452644	5462938	0	None	0.2	0.11	1	Cobble	5	
LCR	LCR_24.5R	28/03/2012	No	EF1	28/03/2012 9:30	3D9.1C2D62D425	LNC	57	Alive	450011	5450713						Unknown		
LCR	LCR_24.5R	29/03/2012	No	TR2	29/03/2012 12:12	3D9.1C2D62D425	LNC	57	Alive	450010	5450707	**6**		0.52	0.25	1.9	Cobble	5	
LCR	LCR_24.5R	30/03/2012	Yes	TR1	30/03/2012 14:15	3D9.1C2D62D425	LNC	57	Alive	450009	5450714	0.4	Out	0.24	0.01	1.2	Cobble	5	
LCR	LCR_24.5R	31/03/2012	Yes	TR1	31/03/2012 13:35	3D9.1C2D62D425	LNC	57	Alive	450009	5450709	1.5	Out	0.38	0.16	1.3	Cobble	5	
LCR	LCR_24.5R	31/03/2012	Yes	TR2	31/03/2012 14:35	3D9.1C2D62D425	LNC	57	Alive	450009	5450709	0	None	0.35	0.1	1.3	Cobble	5	
LCR	LCR_24.5R	01/04/2012	Yes	TR1	01/04/2012 12:02	3D9.1C2D62D425	LNC	57	Alive	450011	5450707	1	Upstream	0.19	0.14	0.6	Cobble	0	
LCR	LCR_24.5R	13/04/2012	No	TR1	13/04/2012 12:43	3D9.1C2D62D425	LNC	57	Alive	450015	5450716	**10**		0.82	0.21	2.5	Cobble	5	
LCR	LCR_24.5R	13/04/2012	No	TR2	13/04/2012 14:23	3D9.1C2D62D425	LNC	57	Alive	450012	5450712	1	Out	1.05	0.16	3	Cobble	20	
LCR	LCR_24.5R	28/03/2012	No	EF1	28/03/2012 9:30	3D9.1C2D62E081	CRH	69	Alive	450011	5450713						Unknown		
LCR	LCR_24.5R	13/04/2012	No	TR1	13/04/2012 12:43	3D9.1C2D62E081	CRH	69	Alive	450008	5450711	**4**		0.32	0.11	1	Cobble	5	
LCR	LCR_24.5R	13/04/2012	No	TR2	13/04/2012 14:23	3D9.1C2D62E081	CRH	69	Alive	450009	5450707	1	Out	0.5	0.01	2.5	Cobble	5	
LCR	LCR_24.5R	26/04/2011	No	EF1		3D9.1C2D6366E6	CRH	76	Alive	450033	5450719						Unknown		
LCR	LCR_24.5R	12/05/2011	No	TR1	12/05/2011 10:00	3D9.1C2D6366E6	CRH	76	Alive	886980.069	5464108.818	**-**		0.26	0.22	1	Cobble	40	Swam away after disturbed.
LCR	LCR_24.5R	26/04/2011	No	EF1		3D9.1C2D63698E	CRH	77	Alive	450033	5450719						Unknown		
LCR	LCR_24.5R	05/09/2012	No	TR1	05/09/2012 9:35	3D9.1C2D63698E	CRH	77	Alive	450012	5450721	**21**		0.45	0.19	1.5	Cobble	0	

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_24.5R	14/09/2012	No	TR1	14/09/2012 9:45	3D9.1C2D63698E	CRH	77	Dead	450033	5450719	-					Unknown		
LCR	LCR_24.5R	23/05/2013	No	TR1	23/05/2013 10:00	3D9.1C2D63698E	CRH		Dead	450012	5450717	-					Unknown		Dead, tag found above water in September.
LCR	LCR_10.5L	28/03/2012	No	EF1	28/03/2012 15:00	3D9.1C2D637704	CBA	83	Alive	452624	5462884						Unknown		
LCR	LCR_10.5L	31/03/2012	Yes	TR1	31/03/2012 9:00	3D9.1C2D637704	CBA	83	Alive	452620	5462887	**5**		0.79	0.07	7	Cobble	5	
LCR	LCR_10.5L	31/03/2012	Yes	TR2	31/03/2012 10:40	3D9.1C2D637704	CBA	83	Alive	452620	5462887	**0**		0.6	0.01	6.8	Cobble	5	
LCR	LCR_10.5L	01/04/2012	Yes	TR1	01/04/2012 8:32	3D9.1C2D637704	CBA	83	Alive	452620	5462887	0	None	0.3	0	2.1	Cobble	5	
LCR	LCR_24.5R	26/04/2011	No	EF2		3D9.1C2D639B53	CAS	84	Alive	449997	5450698						Unknown		
LCR	LCR_24.5R	12/05/2011	No	TR1	12/05/2011 10:00	3D9.1C2D639B53	CAS	84	Alive	886953.117	5464073.722	**-**		0.87	0.7	3	Cobble	30	Didymo.
LCR	LCR_24.5R	26/04/2011	No	EF1		3D9.1C2D63A22D	CRH	60	Alive	450033	5450719						Unknown		
LCR	LCR_24.5R	05/09/2012	No	TR1	05/09/2012 9:35	3D9.1C2D63A22D	CRH	60	Unknown	450016	5450716	**17**		0.57	0.44	1.5	Cobble	5	
LCR	LCR_24.5R	14/09/2012	No	TR1	14/09/2012 9:45	3D9.1C2D63A22D	CRH	60	Dead	450016	5450721	0	None	0.15	0.08	0.3	Cobble	5	
LCR	LCR_24.5R	17/12/2012	No	TR1	17/12/2012 10:45	3D9.1C2D63A22D	CRH	60	Dead	450016	5450721	-		0.36	0.29	1.5	Cobble	5	
LCR	LCR_24.5R	08/02/2013	Yes	TR1	08/02/2013 17:00	3D9.1C2D63A22D	CRH	60	Dead	450016	5450721	-					Unknown		Missed fish. In pit tag reader file, but no habitat info.
LCR	LCR_24.5R	23/05/2013	No	TR1	23/05/2013 10:00	3D9.1C2D63A22D	CRH	60	Dead	450015	5450720	-		1.11	0.57	3	Cobble	10	
LCR	LCR_24.5R	24/05/2013	No	TR1	24/05/2013 9:55	3D9.1C2D63A22D	CRH	60	Dead	450015	5450720	0	None	1.05	0.64	3	Cobble	10	
LCR	LCR_24.5R	20/12/2013	No	TR1	20/12/2013 12:22	3D9.1C2D63A22D	CRH	60	Dead	450016	5450720	-		0.03	0	0.1	Cobble	5	Dead tag.
LCR	LCR_24.5R	21/12/2013	Yes	TR1	21/12/2013 13:14	3D9.1C2D63A22D	CRH	60	Dead			-					Unknown		Dead tag.
LCR	LCR_10.5L	28/03/2012	No	EF1	28/03/2012 15:00	3D9.1C2D63A57B	CCN	76	Alive	452624	5462884						Unknown		
LCR	LCR_10.5L	29/03/2012	No	TR2	29/03/2012 16:12	3D9.1C2D63A57B	CCN	76	Alive	452625	5462895	**11**		0.59	0.28	3.2	Cobble	5	
LCR	LCR_10.5L	30/03/2012	Yes	TR1	30/03/2012 9:15	3D9.1C2D63A57B	CCN	76	Alive	452626	5462895	0.6	Upstream	0.54	0.31	2.2	Cobble	0	
LCR	LCR_10.5L	30/03/2012	Yes	TR2	30/03/2012 11:45	3D9.1C2D63A57B	CCN	76	Alive	452624	5462892	0.5	Out	0.64	0.26	3	Cobble	5	
LCR	LCR_10.5L	31/03/2012	Yes	TR1	31/03/2012 9:00	3D9.1C2D63A57B	CCN	76	Alive	452624	5462892	0	None	0.42	0.17	1.8	Cobble	5	
LCR	LCR_10.5L	31/03/2012	Yes	TR2	31/03/2012 10:40	3D9.1C2D63A57B	CCN	76	Alive	452624	5462892	0	None	0.26	0.08	0.9	Cobble	5	
LCR	LCR_10.5L	01/04/2012	Yes	TR1	01/04/2012 8:32	3D9.1C2D63A57B	CCN	76	Alive	452623	5462895	**3**		0.46	0.23	2.3	Cobble	5	Marker removed- field movement n/a.
LCR	LCR_10.5L	28/09/2012	No	TR1	28/09/2012 15:15	3D9.1C2D63A57B	CCN	76	Alive	452623	5462886	**9**		0.45	0.02	1.5	Cobble	5	
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D63A57B	CCN	76	Alive	452620	5462887	2	Out	0.18	0.03	0.5	Cobble	10	
LCR	LCR_24.5R	28/03/2012	No	EF1	28/03/2012 9:30	3D9.1C2D63A591	CBA	73	Alive	450011	5450713						Unknown		
LCR	LCR_24.5R	01/04/2012	Yes	TR1	01/04/2012 12:02	3D9.1C2D63A591	CBA	73	Alive	450012	5450703	**10**		0.98	0.13	4.6	Cobble	5	
LCR	LCR_24.5R	28/03/2012	No	EF1	28/03/2012 9:30	3D9.1C2D63A5DD	CRH	68	Alive	450011	5450713						Unknown		
LCR	LCR_24.5R	29/03/2012	No	TR1	29/03/2012 9:51	3D9.1C2D63A5DD	CRH	68	Alive	450009	5450714	**2**		0.09	0	0.5	Cobble	5	
LCR	LCR_24.5R	29/03/2012	No	TR2	29/03/2012 12:12	3D9.1C2D63A5DD	CRH	68	Alive	450010	5450709	1.2	Upstream	0.39	0.28	1.7	Cobble	5	
LCR	LCR_24.5R	31/03/2012	Yes	TR2	31/03/2012 14:35	3D9.1C2D63A5DD	CRH	68	Alive	450011	5450706	4.5	Out	0.78	0.28	4.4	Cobble	5	
LCR	LCR_24.5R	01/04/2012	Yes	TR1	01/04/2012 12:02	3D9.1C2D63A5DD	CRH	68	Alive	450014	5450706	1.5	Out	0.93	0.23	4.1	Cobble	5	
LCR	LCR_24.5R	13/04/2012	No	TR1	13/04/2012 12:43	3D9.1C2D63A5DD	CRH	68	Alive	450010	5450711	**6**		0.35	0.11	1.5	Cobble	5	
LCR	LCR_24.5R	13/04/2012	No	TR2	13/04/2012 14:23	3D9.1C2D63A5DD	CRH	68	Alive	450010	5450711	0	None	0.35	0.11	1.5	Cobble	5	
LCR	LCR_10.5L	28/03/2012	No	EF1	28/03/2012 15:00	3D9.1C2D63A8B7	CAS	86	Alive	452624	5462884						Unknown		
LCR	LCR_10.5L	30/03/2012	Yes	TR1	30/03/2012 9:15	3D9.1C2D63A8B7	CAS	86	Alive	452623	5462885	**1**		0.37	0.01	1.6	Cobble	0	
LCR	LCR_10.5L	30/03/2012	Yes	TR2	30/03/2012 11:45	3D9.1C2D63A8B7	CAS	86	Alive	452623	5462885	0	None	0.25	0.01	1.4	Cobble	0	
LCR	LCR_10.5L	31/03/2012	Yes	TR1	31/03/2012 9:00	3D9.1C2D63A8B7	CAS	86	Alive	452623	5462885	0	None	0.21	0	0.6	Cobble	5	
LCR	LCR_10.5L	31/03/2012	Yes	TR2	31/03/2012 10:40	3D9.1C2D63A8B7	CAS	86	Alive	452621	5462885	1	Out	0.15	0.01	1	Cobble	5	
LCR	LCR_10.5L	01/04/2012	Yes	TR1	01/04/2012 8:32	3D9.1C2D63A8B7	CAS	86	Alive	452618	5462886	**3**		0.17	0	1.1	Cobble	5	Marker removed- field movement n/a.
LCR	LCR_10.5L	13/04/2012	No	TR1	13/04/2012 8:55	3D9.1C2D63A8B7	CAS	86	Alive	452618	5462887	**1**		0.83	0.16	5	Cobble	40	
LCR	LCR_10.5L	13/04/2012	No	TR2	13/04/2012 10:45	3D9.1C2D63A8B7	CAS	86	Alive	452618	5462887	0	None	0.83	0.16	5	Cobble	40	
LCR	LCR_24.5R	26/04/2011	No	EF2		3D9.1C2D63AAAF	CRH	64	Alive	449997	5450698						Unknown		
LCR	LCR_24.5R	12/05/2011	No	TR1	12/05/2011 10:00	3D9.1C2D63AAAF	CRH	64	Alive	886923	5464071			0.14	0.03	0.2	Cobble	10	
LCR	LCR_24.5R	05/09/2012	No	TR1	05/09/2012 9:35	3D9.1C2D63AAAF	CRH	64	Alive	449964	5450691			0.92	0.54	2	Cobble	10	
LCR	LCR_24.5R	14/09/2012	No	TR1	14/09/2012 9:45	3D9.1C2D63AAAF	CRH	64	Dead	449965	5450690	0	None	0.43	0.43	1.5	Cobble	5	

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_24.5R	08/02/2013	No	TR1	08/02/2013 11:50	3D9.1C2D63AAAF	CRH	64	Dead	449965	5450690	-		0.3	0.3	1.2	Cobble	5	
LCR	LCR_24.5R	28/03/2012	No	EF1	28/03/2012 9:30	3D9.1C2D63AABE	CCN	79	Alive	450011	5450713						Unknown		
LCR	LCR_24.5R	29/03/2012	No	TR1	29/03/2012 9:51	3D9.1C2D63AABE	CCN	79	Alive	450013	5450711	**3**		0.59	0.2	2.8	Cobble	5	
LCR	LCR_24.5R	29/03/2012	No	TR2	29/03/2012 12:12	3D9.1C2D63AABE	CCN	79	Alive	450013	5450711	0	None	0.59	0.2	2.8	Cobble	5	
LCR	LCR_24.5R	30/03/2012	Yes	TR1	30/03/2012 14:15	3D9.1C2D63AABE	CCN	79	Alive	450013	5450711	0	None	0.39	0.14	1.3	Cobble	0	
LCR	LCR_24.5R	31/03/2012	Yes	TR1	31/03/2012 13:35	3D9.1C2D63AABE	CCN	79	Alive	450012	5450711	2	Out	0.39	0.19	1.3	Cobble	0	
LCR	LCR_24.5R	31/03/2012	Yes	TR2	31/03/2012 14:35	3D9.1C2D63AABE	CCN	79	Alive	450012	5450711	0	None	0.5	0.19	1.4	Cobble	0	
LCR	LCR_24.5R	01/04/2012	Yes	TR1	01/04/2012 12:02	3D9.1C2D63AABE	CCN	79	Alive	450012	5450706	0.8	Downstream	0.25	0.04	0.5	Cobble	0	
LCR	LCR_24.5R	13/04/2012	No	TR1	13/04/2012 12:43	3D9.1C2D63AABE	CCN	79	Alive	450010	5450711	**5**		0.45	0.33	2	Cobble	5	
LCR	LCR_24.5R	13/04/2012	No	TR2	13/04/2012 14:23	3D9.1C2D63AABE	CCN	79	Alive	450010	5450711	0	None	0.45	0.33	2	Cobble	5	
LCR	LCR_24.5R	04/10/2012	No	TR1	04/10/2012 13:00	3D9.1C2D63AABE	CCN	79	Unknown	449960	5450680	**59**		0.16	0	0.5	Cobble	5	Likely dead.
LCR	LCR_24.5R	08/11/2012	No	TR1	08/11/2012 9:45	3D9.1C2D63AABE	CCN	79	Alive	449958	5450677	**4**		0.05	0.01	0.25	Gravel	5	
LCR	LCR_24.5R	07/05/2012	No	EF1	07/05/2012 9:45	3D9.1C2D63AE41	CRH	67	Alive	450008	5450708						Unknown		
LCR	LCR_24.5R	05/06/2013	No	TR1	05/06/2013 13:30	3D9.1C2D63AE41	CRH	67	Alive	450027	5450730	**29**		0.13	0.12	0.3	Cobble	5	
LCR	LCR_10.5L	07/05/2012	No	EF1	07/05/2012 13:10	3D9.1C2D63B050	CBA	84	Alive	452642	5462915						Unknown		Milting.
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3D9.1C2D63B050	CBA	84	Unknown	452646	5462942	**27**		0.65	0.59	2	Cobble	10	
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3D9.1C2D63B050	CBA	84	Unknown	452646	5462942	0	None	0.65	0.59	2	Cobble	10	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3D9.1C2D63B050	CBA	84	Unknown	452646	5462942	0	None	0.27	0.09	0.5	Cobble	10	
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3D9.1C2D63B050	CBA	84	Unknown	452644	5462938	0	None	0.18	0.1	0.7	Cobble	5	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3D9.1C2D63B050	CBA	84	Unknown	452644	5462938	0	None	0.18	0.1	0.7	Cobble	5	
LCR	LCR_10.5L	28/09/2013	Yes	TR1	28/09/2013 11:06	3D9.1C2D63B050	CBA	84	Dead	452644	5462938						Unknown		Dead tag; tag found on shore.
LCR	LCR_24.5R	28/03/2012	No	EF1	28/03/2012 9:30	3D9.1C2D63B0EF	CRH	74	Alive	450011	5450713						Unknown		
LCR	LCR_24.5R	29/03/2012	No	TR1	29/03/2012 9:51	3D9.1C2D63B0EF	CRH	74	Alive	450014	5450715	**4**		0.39	0.27	2.1	Cobble	5	
LCR	LCR_24.5R	29/03/2012	No	TR2	29/03/2012 12:12	3D9.1C2D63B0EF	CRH	74	Alive	450014	5450715	0	None	0.39	0.27	2.1	Cobble	5	
LCR	LCR_24.5R	30/03/2012	Yes	TR1	30/03/2012 14:15	3D9.1C2D63B0EF	CRH	74	Alive	450015	5450716	2.6	Out	0.61	0.13	3	Cobble	5	
LCR	LCR_24.5R	31/03/2012	Yes	TR1	31/03/2012 13:35	3D9.1C2D63B0EF	CRH	74	Alive	450012	5450713	1	In	0.01	0	0.2	Cobble	0	
LCR	LCR_24.5R	31/03/2012	Yes	TR2	31/03/2012 14:35	3D9.1C2D63B0EF	CRH	74	Alive	450013	5450711	1.4	Out	0.22	0	4	Cobble	0	
LCR	LCR_24.5R	01/04/2012	Yes	TR1	01/04/2012 12:02	3D9.1C2D63B0EF	CRH	74	Alive	450013	5450711	0	None	0.1	0	0.1	Cobble	0	
LCR	LCR_24.5R	13/04/2012	No	TR1	13/04/2012 12:43	3D9.1C2D63B0EF	CRH	74	Alive	450015	5450715	**4**		0.8	0.23	2.5	Cobble	20	
LCR	LCR_24.5R	13/04/2012	No	TR2	13/04/2012 14:23	3D9.1C2D63B0EF	CRH	74	Alive	450015	5450715	0	None	0.8	0.23	2.5	Cobble	20	
LCR	LCR_24.5R	28/03/2012	No	EF1	28/03/2012 9:30	3D9.1C2D692F51	CBA	75	Alive	450011	5450713						Unknown		
LCR	LCR_24.5R	29/03/2012	No	TR1	29/03/2012 9:51	3D9.1C2D692F51	CBA	75	Alive	450011	5450714	**1**		0.35	0.06	2.4	Cobble	5	
LCR	LCR_24.5R	29/03/2012	No	TR2	29/03/2012 12:12	3D9.1C2D692F51	CBA	75	Alive	450011	5450714	0	None	0.35	0.06	2.4	Cobble	5	
LCR	LCR_24.5R	28/03/2012	No	EF1	28/03/2012 9:30	3D9.1C2D6932D3	CRH	68	Alive	450011	5450713						Unknown		
LCR	LCR_24.5R	29/03/2012	No	TR1	29/03/2012 9:51	3D9.1C2D6932D3	CRH	68	Alive	450011	5450713	**0**		0.27	0.07	1.6	Cobble	5	
LCR	LCR_24.5R	29/03/2012	No	TR2	29/03/2012 12:12	3D9.1C2D6932D3	CRH	68	Alive	450011	5450713	0	None	0.27	0.07	1.6	Cobble	5	
LCR	LCR_24.5R	31/03/2012	Yes	TR1	31/03/2012 13:35	3D9.1C2D6932D3	CRH	68	Alive	450009	5450709	3.5	Out	0.5	0.22	1.8	Cobble	5	
LCR	LCR_24.5R	31/03/2012	Yes	TR2	31/03/2012 14:35	3D9.1C2D6932D3	CRH	68	Alive	450009	5450709	0	None	0.5	0.22	1.8	Cobble	5	
LCR	LCR_24.5R	01/04/2012	Yes	TR1	01/04/2012 12:02	3D9.1C2D6932D3	CRH	68	Alive	450009	5450709	0	None	0.33	0.19	1.1	Cobble	5	
LCR	LCR_24.5R	13/04/2012	No	TR1	13/04/2012 12:43	3D9.1C2D6932D3	CRH	68	Alive	450003	5450707	**6**		0.2	0	1	Cobble	5	
LCR	LCR_24.5R	13/04/2012	No	TR2	13/04/2012 14:23	3D9.1C2D6932D3	CRH	68	Alive	450003	5450707	0	None	0.2	0	1	Cobble	5	
LCR	LCR_24.5R	28/03/2012	No	EF1	28/03/2012 9:30	3D9.1C2D693325	CRH	78	Alive	450011	5450713						Unknown		
LCR	LCR_24.5R	01/04/2012	Yes	TR1	01/04/2012 12:02	3D9.1C2D693325	CRH	78	Alive	450010	5450700	**13**		1	0.11	4.1	Cobble	5	
LCR	LCR_24.5R	13/04/2012	No	TR1	13/04/2012 12:43	3D9.1C2D693325	CRH	78	Alive	450021	5450722	**25**		0.5	0	2.5	Cobble	5	
LCR	LCR_24.5R	13/04/2012	No	TR2	13/04/2012 14:23	3D9.1C2D693325	CRH	78	Alive	450021	5450722	0	None	0.5	0	2.5	Cobble	5	
LCR	LCR_24.5R	28/03/2012	No	EF1	28/03/2012 9:30	3D9.1C2D693329	CRH	84	Alive	450011	5450713						Unknown		
LCR	LCR_24.5R	31/03/2012	Yes	TR1	31/03/2012 13:35	3D9.1C2D693329	CRH	84	Alive	450007	5450709	**6**		0.57	0.01	2.7	Cobble	5	
LCR	LCR_24.5R	31/03/2012	Yes	TR2	31/03/2012 14:35	3D9.1C2D693329	CRH	84	Alive	450007	5450709	0	None	0.58	0.1	2.5	Cobble	5	
LCR	LCR_24.5R	01/04/2012	Yes	TR1	01/04/2012 12:02	3D9.1C2D693329	CRH	84	Alive	450007	5450709	0	None	0.45	0.13	1.5	Cobble	5	
LCR	LCR_24.5R	13/04/2012	No	TR1	13/04/2012 12:43	3D9.1C2D693329	CRH	84	Alive	450007	5450706	**3**		1	0.13	3	Cobble	20	
LCR	LCR_24.5R	13/04/2012	No	TR2	13/04/2012 14:23	3D9.1C2D693329	CRH	84	Alive	450007	5450703	1	Upstream	0.76	0.12	2.5	Cobble	10	
LCR	LCR_24.5R	28/03/2012	No	EF1	28/03/2012 9:30	3D9.1C2D693734	CRH	79	Alive	450011	5450713						Unknown		

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_24.5R	29/03/2012	No	TR1	29/03/2012 9:51	3D9.1C2D693734	CRH	79	Alive	450012	5450713	**1**		0.44	0.23	2.5	Cobble	5	
LCR	LCR_24.5R	29/03/2012	No	TR2	29/03/2012 12:12	3D9.1C2D693734	CRH	79	Alive	450012	5450713	0	None	0.44	0.23	2.5	Cobble	5	
LCR	LCR_24.5R	30/03/2012	Yes	TR1	30/03/2012 14:15	3D9.1C2D693734	CRH	79	Alive	450009	5450713	0.25	Downstream	0.2	0	0.8	Cobble	0	
LCR	LCR_10.5L	28/03/2012	No	EF1	28/03/2012 15:00	3D9.1C2D69390B	CRH	81	Alive	452624	5462884						Unknown		
LCR	LCR_10.5L	29/03/2012	No	TR1	29/03/2012 14:04	3D9.1C2D69390B	CRH	81	Alive	452622	5462886	**3**		0.66	0.04	2.6	Cobble	5	
LCR	LCR_10.5L	29/03/2012	No	TR2	29/03/2012 16:12	3D9.1C2D69390B	CRH	81	Alive	452622	5462886	0	None	0.66	0.04	2.6	Cobble	5	
LCR	LCR_10.5L	30/03/2012	Yes	TR2	30/03/2012 11:45	3D9.1C2D69390B	CRH	81	Alive	452622	5462887	0	None	0.36	0.35	2.2	Cobble	0	
LCR	LCR_10.5L	31/03/2012	Yes	TR2	31/03/2012 10:40	3D9.1C2D69390B	CRH	81	Alive	452622	5462887	0	None	0.25	0.01	1.4	Cobble	5	
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D69390B	CRH	81	Unknown	452617	5462873	**15**		0.18	0.01	1.8	Cobble	10	
LCR	LCR_10.5L	09/05/2013	No	TR1	09/05/2013 10:30	3D9.1C2D69390B	CRH	81	Alive	452627	5462894	**23**		0.5	0.01	2.8	Boulder	5	
LCR	LCR_10.5L	22/05/2013	No	TR1	22/05/2013 22:30	3D9.1C2D69390B	CRH	81	Alive	452626	5462875	**19**		0.78	0	3	Boulder	10	Moved overnight.
LCR	LCR_10.5L	13/06/2013	No	TR1	13/06/2013 12:20	3D9.1C2D69390B	CRH	81	Alive	452626	5462879	**4**		0.13	0	1	Cobble	5	
LCR	LCR_10.5L	27/06/2013	No	TR1	27/06/2013 13:14	3D9.1C2D69390B	CRH	81	Unknown	452627	5462874	**5**		0.72	0.02	2.1	Boulder	15	
LCR	LCR_10.5L	28/03/2012	No	EF1	28/03/2012 15:00	3D9.1C2D6939AB	CCN	88	Alive	452624	5462884						Unknown		
LCR	LCR_10.5L	29/03/2012	No	TR1	29/03/2012 14:04	3D9.1C2D6939AB	CCN	88	Alive	452624	5462888	**4**		0.5	0.03	2.8	Cobble	0	
LCR	LCR_10.5L	31/03/2012	Yes	TR1	31/03/2012 9:00	3D9.1C2D6939AB	CCN	88	Alive	452632	5462905	**19**		0.29	0.02	1.2	Cobble	5	Tracked on 28 March, no movement measured in field.
LCR	LCR_10.5L	31/03/2012	Yes	TR2	31/03/2012 10:40	3D9.1C2D6939AB	CCN	88	Alive	452632	5462905	0.1	Upstream	0.13	0.06	0.4	Cobble	5	
LCR	LCR_10.5L	29/09/2012	Yes	TR1	29/09/2012 10:30	3D9.1C2D6939AB	CCN	88	Alive	452616	5462885	**26**		0.61	0.04	3.5	Cobble	10	
LCR	LCR_10.5L	09/02/2013	Yes	TR1	09/02/2013 11:30	3D9.1C2D6939AB	CCN	88	Unknown	452624	5462891	**10**		0.34	0.15	1	Boulder	5	
LCR	LCR_24.5R	17/09/2012	No	EF1	17/09/2012 10:30	3D9.1C2D693A54	CAS	70	Alive	449984	5450695						Unknown		
LCR	LCR_24.5R	04/10/2012	No	TR1	04/10/2012 13:00	3D9.1C2D693A54	CAS	70	Alive	450034	5450726	**59**		0.38	0.2	1.5	Cobble	0	
LCR	LCR_24.5R	08/11/2012	No	TR1	08/11/2012 17:30	3D9.1C2D693A54	CAS	70	Unknown	450033	5450726	**1**		0.2	0.15	0.5	Cobble	5	
LCR	LCR_24.5R	09/02/2013	Yes	TR1	09/02/2013 14:20	3D9.1C2D693A54	CAS	70	Unknown	450034	5450725	**1**		0.35	0.05	2.2	Cobble	10	
LCR	LCR_24.5R	14/02/2013	No	TR1	14/02/2013 12:10	3D9.1C2D693A54	CAS	70	Alive	450034	5450724	1	Out	0.68	0.01	3.2	Cobble	10	
LCR	LCR_24.5R	16/02/2013	Yes	TR1	16/02/2013 14:55	3D9.1C2D693A54	CAS	70	Alive	450034	5450724	0	None	0.2	0.05	0.3	Cobble	10	
LCR	LCR_24.5R	21/02/2013	No	TR1	21/02/2013 12:15	3D9.1C2D693A54	CAS	70	Alive	450034	5450724	0	None	0.2	0.05	0.3	Cobble	10	
LCR	LCR_24.5R	08/05/2013	No	TR1	08/05/2013 9:20	3D9.1C2D693A54	CAS	70	Unknown	450035	5450723	**1**		0.95	0.34	3.2	Boulder	10	
LCR	LCR_24.5R	17/09/2012	No	EF1	17/09/2012 10:30	3D9.1C2D693B54	UDC	52	Alive	449984	5450695						Unknown		
LCR	LCR_24.5R	16/02/2013	Yes	TR1	16/02/2013 14:55	3D9.1C2D693B54	UDC	52	Unknown	449983	5450692	**3**		0.46	0	1.5	Cobble	10	
LCR	LCR_24.5R	21/02/2013	No	TR1	21/02/2013 12:15	3D9.1C2D693B54	UDC	52	Unknown	449983	5450692	0	None	0.46	0	1.5	Cobble	10	
LCR	LCR_24.5R	17/09/2012	No	EF1	17/09/2012 10:30	3D9.1C2D693DF2	CBA	96	Alive	444998	5450695						Unknown		
LCR	LCR_24.5R	29/08/2013	No	TR1	29/08/2013 9:45	3D9.1C2D693DF2	CBA	96	Alive	444997	5450699	**4**		0.65	0.56	2.75	Cobble	5	
LCR	LCR_24.5R	30/08/2013	Yes	TR1	30/08/2013 10:00	3D9.1C2D693DF2	CBA	96	Alive	444997	5450699	0	None	0.65	0.56	2.75	Cobble	5	
LCR	LCR_24.5R	28/03/2012	No	EF1	28/03/2012 9:30	3D9.1C2D693F34	CBA	79	Alive	450011	5450713						Unknown		
LCR	LCR_24.5R	01/04/2012	Yes	TR1	01/04/2012 12:02	3D9.1C2D693F34	CBA	79	Alive	450005	5450700	**14**		0.81	0.04	3.6	Cobble	5	
LCR	LCR_24.5R	13/04/2012	No	TR1	13/04/2012 12:43	3D9.1C2D693F34	CBA	79	Alive	450003	5450704	**4**		1.2	0.42	6	Cobble	40	
LCR	LCR_24.5R	13/04/2012	No	TR2	13/04/2012 14:23	3D9.1C2D693F34	CBA	79	Alive	450003	5450704	0	None	1.2	0.42	6	Cobble	40	
LCR	LCR_24.5R	17/09/2012	No	EF1	17/09/2012 10:30	3D9.1C2D69409C	CBA	79	Alive	449984	5450695						Unknown		
LCR	LCR_24.5R	21/02/2013	No	TR1	21/02/2013 12:15	3D9.1C2D69409C	CBA	79	Unknown	449983	5450685	**10**		0.78	0.01	1	Boulder	5	
LCR	LCR_24.5R	07/05/2012	No	EF1	07/05/2012 9:45	3D9.1C2D69441D	CCN	67	Alive	450008	5450708						Unknown		
LCR	LCR_24.5R	08/02/2013	Yes	TR1	08/02/2013 17:00	3D9.1C2D69441D	CCN	67	Unknown	450003	5450706	**5**		1.4	0.3	2.5	Cobble	10	
LCR	LCR_24.5R	09/02/2013	Yes	TR1	09/02/2013 14:20	3D9.1C2D69441D	CCN	67	Alive	450003	5450706	0	None	0.2	0.25	1.5	Cobble	10	
LCR	LCR_24.5R	14/02/2013	No	TR1	14/02/2013 12:10	3D9.1C2D69441D	CCN	67	Unknown	450002	5450703	0	None	0.34	0.09	1.1	Cobble	5	
LCR	LCR_24.5R	16/02/2013	Yes	TR1	16/02/2013 14:55	3D9.1C2D69441D	CCN	67	Dead	450002	5450703	-					Unknown		Dead tag.
LCR	LCR_24.5R	20/12/2013	No	TR1	20/12/2013 12:22	3D9.1C2D69441D	CCN	67	Unknown	450002	5450706	-		1	0.53	5	Cobble	5	
LCR	LCR_24.5R	21/12/2013	Yes	TR1	21/12/2013 13:14	3D9.1C2D69441D	CCN	67	Unknown	450002	5450706	0	None	0.52	0.2	2.5	Cobble	5	
LCR	LCR_10.5L	28/03/2012	No	EF1	28/03/2012 15:00	3D9.1C2D694421	CRH	60	Alive	452624	5462884						Unknown		
LCR	LCR_10.5L	29/03/2012	No	TR1	29/03/2012 14:04	3D9.1C2D694421	CRH	60	Alive	452623	5462886	**2**		0.31	0.03	2	Cobble	0	
LCR	LCR_10.5L	30/03/2012	Yes	TR2	30/03/2012 11:45	3D9.1C2D694421	CRH	60	Alive	452619	5462890	**6**		0.95	0.48	4.2	Cobble	5	
LCR	LCR_10.5L	31/03/2012	Yes	TR1	31/03/2012 9:00	3D9.1C2D694421	CRH	60	Alive	452622	5462890	2	Out	0.58	0.34	2.5	Cobble	5	
LCR	LCR_10.5L	31/03/2012	Yes	TR2	31/03/2012 10:40	3D9.1C2D694421	CRH	60	Alive	452622	5462890	0.1	Upstream	0.42	0.27	2.4	Cobble	5	
LCR	LCR_10.5L	01/04/2012	Yes	TR1	01/04/2012 8:32	3D9.1C2D694421	CRH	60	Alive	452622	5462891	0.3	Upstream	0.2	0.08	1.4	Cobble	5	

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_10.5L	13/04/2012	No	TR1	13/04/2012 8:55	3D9.1C2D694421	CRH	60	Alive	452640	5462929	**42**		0.23	0.14	1.5	Cobble	60	
LCR	LCR_10.5L	13/04/2012	No	TR2	13/04/2012 10:45	3D9.1C2D694421	CRH	60	Alive	452640	5462929	0	None	0.23	0.14	1.5	Cobble	60	
LCR	LCR_24.5R	07/05/2012	No	EF1	07/05/2012 9:45	3D9.1C2D694B0E	CRH	68	Alive	450008	5450708						Unknown		
LCR	LCR_24.5R	05/09/2012	No	TR1	05/09/2012 9:35	3D9.1C2D694B0E	CRH	68	Unknown	449988	5450699	**22**		0.58	0.09	2	Cobble	10	
LCR	LCR_24.5R	14/09/2012	No	TR1	14/09/2012 9:45	3D9.1C2D694B0E	CRH	68	Unknown	449989	5450700	0	None	0.23	0	0.5	Sand	100	
LCR	LCR_24.5R	08/02/2013	No	TR1	08/02/2013 11:50	3D9.1C2D694B0E	CRH	68	Alive	449990	5450696	**4**		0.15	0	0.5	Cobble	2	
LCR	LCR_24.5R	08/02/2013	Yes	TR1	08/02/2013 17:00	3D9.1C2D694B0E	CRH	68	Unknown	449990	5450696	0	None	1.15	0	1.5	Cobble	2	
LCR	LCR_10.5L	12/09/2013	No	EF1		3DD.00774077B5	CAS	85	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3DD.00774077B5	CAS	85	Alive	452640	5462928	**23**		0.35	0.33	3	Cobble	5	
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3DD.00774077B5	CAS	85	Unknown	452640	5462928	0	None	0.35	0.33	3	Cobble	5	
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3DD.0077407E45	CRH	69	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3DD.0077407E45	CRH	69	Alive	452624	5462892	**17**		0.84	0.31	4	Boulder	5	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3DD.0077407E45	CRH	69	Alive	452617	5462884	12	Downstream	0.69	0.01	4	Boulder	5	Not a flow reduction movement, fish was not there yesterday.
LCR	LCR_10.5L	12/09/2013	No	EF1		3DD.0077408368	CBA	81	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3DD.0077408368	CBA	81	Unknown	452630	5462902	**6**		0.61	0.03	3	Cobble	5	
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3DD.0077408368	CBA	81	Unknown	452630	5462902	0	None	0.61	0.03	3	Cobble	5	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3DD.0077408368	CBA	81	Alive	452629	5462899	3	Downstream	0.31	0.01	1.5	Cobble	5	
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3DD.0077408368	CBA	81	Unknown	452626	5462896	**4**		0.2	0.07	1	Gravel	5	
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3DD.007740D6EE	CBA	74	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3DD.007740D6EE	CBA	74	Unknown	452622	5462907	**12**		0.5	0.33	7	Cobble	0	
LCR	LCR_10.5L	12/09/2013	No	EF1		3DD.007740D7B5	CRH	70	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3DD.007740D7B5	CRH	70	Unknown	452626	5462894	**14**		0.6	0.21	2.5	Cobble	5	
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3DD.007740D7B5	CRH	70	Unknown	452626	5462894	0	None	0.6	0.21	2.5	Cobble	5	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3DD.007740D7B5	CRH	70	Unknown	452626	5462892	0	None	0.12	0.1	0.5	Cobble	5	
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3DD.007740D7B5	CRH	70	Alive	452623	5462892	**3**		0.22	0.11	1	Cobble	5	
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3DD.007740D7B5	CRH	70	Alive	452620	5462906	**14**		0.68	0.3	6	Cobble	5	
LCR	LCR_10.5L	12/09/2013	No	EF1		3DD.007740E0B5	CRH	92	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3DD.007740E0B5	CRH	92	Unknown	452630	5462902	**6**		0.48	0.05	2.5	Cobble	20	
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3DD.007740E0B5	CRH	92	Alive	452628	5462899	0.3	Out	0.64	0.03	2.5	Cobble	10	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3DD.007740E0B5	CRH	92	Alive	452628	5462899	0	None	0.1	0.05	0.4	Cobble	20	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3DD.007740E0B5	CRH	92	Unknown	452630	5462902	**4**		0.18	0.04	0.3	Cobble	5	
LCR	LCR_10.5L	28/09/2013	Yes	TR1	28/09/2013 11:06	3DD.007740E0B5	CRH	92	Alive	452630	5462903	1.5	Out	0.16	0.01	0.5	Cobble	10	
LCR	LCR_10.5L	20/12/2013	No	TR1	20/12/2013 9:40	3DD.007740E0B5	CRH	92	Alive	452635	5462902	**5**		0.76	0.04	3	Cobble	5	
LCR	LCR_10.5L	21/12/2013	Yes	TR1	21/12/2013 10:15	3DD.007740E0B5	CRH	92	Alive	452633	5462905	1	Upstream	0.27	0.3	1.2	Cobble	5	
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3DD.007740F056	CRH	68	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3DD.007740F056	CRH	68	Unknown	452627	5462897	**11**		0.4	0.12	2.3	Cobble	5	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3DD.007740F056	CRH	68	Unknown	452627	5462897	0	None	0.4	0.12	2.3	Cobble	5	
LCR	LCR_10.5L	28/09/2013	Yes	TR1	28/09/2013 11:06	3DD.007740F056	CRH	68	Alive	452627	5462897	0	None	0.17	0.01	0.5	Cobble	5	
LCR	LCR_10.5L	09/10/2013	No	TR1	09/10/2013 13:34	3DD.007740F056	CRH	68	Unknown	452617	5462902	**11**		0.76	0.62	7	Cobble	5	
LCR	LCR_24.5R	23/01/2014	No	EF1	23/01/2014 12:00	3DD.007740F977	CBA	74	Alive	449993	5450695								
LCR	LCR_24.5R	29/01/2014	No	TR1	29/01/2014 10:25	3DD.007740F977	CBA	74	Alive	449992	5450695	**1**		0.97	0.02	4.6	Boulder	10	
LCR	LCR_24.5R	30/01/2014	No	TR1	30/01/2014 9:45	3DD.007740F977	CBA	74	Unknown	449992	5450695	0	None	0.97	0.02	4.6	Boulder	10	
LCR	LCR_24.5R	04/02/2014	No	TR1	04/02/2014 12:05	3DD.007740F977	CBA	74	Unknown	449992	5450695	0	None	0.66	0.01	2.1	Cobble	5	
LCR	LCR_24.5R	14/02/2014	No	TR1	14/02/2014 10:43	3DD.007740F977	CBA	74	Alive	449994	5450693	2.5	Out	0.8	0.12	3.75	Cobble	10	
LCR	LCR_24.5R	15/02/2014	Yes	TR1	15/02/2014 14:15	3DD.007740F977	CBA	74	Alive	449993	5450692	0.5	Out	0.6	0	3	Cobble	10	
LCR	LCR_10.5L	22/01/2014	No	EF1		3DD.007740F9EC	CCN	85	Alive	452636	5462905								
LCR	LCR_10.5L	29/01/2014	No	TR1	29/01/2014 13:00	3DD.007740F9EC	CCN	85	Alive	452631	5462902	**6**		0.27	0.04	1.2	Cobble	25	
LCR	LCR_10.5L	30/01/2014	No	TR1	30/01/2014 12:23	3DD.007740F9EC	CCN	85	Alive	452631	5462902	0	None	0.27	0.04	1.2	Cobble	25	
LCR	LCR_10.5L	01/02/2014	Yes	TR1	01/02/2014 10:05	3DD.007740F9EC	CCN	85	Alive	452631	5462901	2	Downstream	0.09	0.07	0.5	Cobble	10	
LCR	LCR_10.5L	20/02/2014	No	TR1	20/02/2014 13:05	3DD.007740F9EC	CCN	85	Alive	452622	5462902	**9**		0.25	0	2	Cobble	5	
LCR	LCR_10.5L	22/01/2014	No	EF1		3DD.0077411570	CRH	69	Alive	452636	5462905								
LCR	LCR_10.5L	29/01/2014	No	TR1	29/01/2014 13:00	3DD.0077411570	CRH	69	Unknown	452641	5462931	**26**		0.5	0.27	2	Boulder	5	

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_10.5L	01/02/2014	Yes	TR1	01/02/2014 10:05	3DD.0077411570	CRH	69	Alive	452641	5462934	3	Upstream	0.25	0.24	0.7	Cobble	10	
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3DD.007741188E	CRH	85	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3DD.007741188E	CRH	85	Alive	452620	5462890	**21**		0.37	0.24	2	Boulder	5	
LCR	LCR_24.5R	22/01/2014	No	EF1		3DD.0077412636	CBA	88	Alive	449993	5450695								Milting.
LCR	LCR_24.5R	29/01/2014	No	TR1	29/01/2014 10:25	3DD.0077412636	CBA	88	Alive	450003	5450702	**12**		0.52	0.24	1.7	Cobble	5	
LCR	LCR_24.5R	30/01/2014	No	TR1	30/01/2014 9:45	3DD.0077412636	CBA	88	Alive	450003	5450702	0	None	0.52	0.24	1.7	Cobble	5	
LCR	LCR_24.5R	22/01/2014	No	EF1		3DD.0077415EA7	CRH	77	Alive	449993	5450695								
LCR	LCR_24.5R	29/01/2014	No	TR1	29/01/2014 10:25	3DD.0077415EA7	CRH	77	Alive	450005	5450705	**16**		0.71	0.21	4.5	Cobble	10	
LCR	LCR_24.5R	30/01/2014	No	TR1	30/01/2014 9:45	3DD.0077415EA7	CRH	77	Alive	450019	5450717	20	Upstream	0.26	0.26	1.1	Cobble	5	
LCR	LCR_24.5R	01/02/2014	Yes	TR1	01/02/2014 12:30	3DD.0077415EA7	CRH	77	Alive	450020	5450715	2	Out	0.18	0	0.6	Boulder	10	Previous location dewatered.
LCR	LCR_24.5R	15/02/2014	Yes	TR1	15/02/2014 14:15	3DD.0077415EA7	CRH	77	Alive	450019	5450715	**1**		0.54	0	2.8	Cobble	10	
LCR	LCR_10.5L	22/01/2014	No	EF1		3DD.007741A639	CRH	95	Alive	452636	5462905								
LCR	LCR_10.5L	01/02/2014	Yes	TR1	01/02/2014 10:05	3DD.007741A639	CRH	95	Alive	452638	5462929	**24**		0.43	0.27	2	Boulder	5	
LCR	LCR_10.5L	12/09/2013	No	EF1		3DD.007741C8D6	CRH	80	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	03/10/2013	No	TR1	03/10/2013 13:05	3DD.007741C8D6	CRH	80	Alive	452621	5462912	**14**		0.95	0.41	9	Cobble	5	
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3DD.007741C8E0	CRH	73	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	03/10/2013	No	TR1	03/10/2013 13:05	3DD.007741C8E0	CRH	73	Alive	452621	5462908	**13**		0.76	0.33	8	Cobble	0	
LCR	LCR_10.5L	09/10/2013	No	TR1	09/10/2013 13:34	3DD.007741C8E0	CRH	73	Unknown	452621	5462908	0	None	0.81	0.47	8	Cobble	5	
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3DD.007741C8E0	CRH	73	Unknown	452634	5462906	0	None	0.73	0.4	7.5	Cobble	5	
LCR	LCR_10.5L	12/09/2013	No	EF1		3DD.007741C9C6	CBA	59	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	28/09/2013	Yes	TR1	28/09/2013 11:06	3DD.007741C9C6	CBA	59	Alive	452634	5462906	**0**		0.63	0.02	3.4	Cobble	5	
LCR	LCR_24.5R	22/01/2014	No	EF1		3DD.007741E2C7	CBA	78	Alive	449993	5450695								
LCR	LCR_24.5R	29/01/2014	No	TR1	29/01/2014 10:25	3DD.007741E2C7	CBA	78	Alive	450001	5450698	**9**		0.61	0.59	3.2	Cobble	5	
LCR	LCR_24.5R	30/01/2014	No	TR1	30/01/2014 9:45	3DD.007741E2C7	CBA	78	Alive	450001	5450698	**0**		0.61	0.59	3.2	Cobble	5	
LCR	LCR_24.5R	01/02/2014	Yes	TR1	01/02/2014 12:30	3DD.007741E2C7	CBA	78	Alive	449999	5450692	5	Out	1.05	0.34	5	Cobble	5	
LCR	LCR_10.5L	23/01/2014	No	EF1		3DD.007741F239	CBA	85	Alive	452636	5462905								
LCR	LCR_10.5L	20/02/2014	No	TR1	20/02/2014 13:05	3DD.007741F239			Dead					0.5		5			Dead tag.
LCR	LCR_24.5R	22/01/2014	No	EF1		3DD.007741F283	CAS	60	Alive	449993	5450695								
LCR	LCR_24.5R	29/01/2014	No	TR1	29/01/2014 10:25	3DD.007741F283	CAS	60	Alive	449994	5450695	**1**		0.78	0.01	3.2	Cobble	5	
LCR	LCR_24.5R	30/01/2014	No	TR1	30/01/2014 9:45	3DD.007741F283	CAS	60	Alive	449994	5450695	0	None	0.78	0.01	3.2	Cobble	5	
LCR	LCR_24.5R	30/01/2014	No	TR1	30/01/2014 9:45	3DD.007741F283	CAS	60	Alive	449994	5450695	0	None	0.78	0.01	3.2	Cobble	5	
LCR	LCR_24.5R	01/02/2014	Yes	TR1	01/02/2014 12:30	3DD.007741F283	CAS	60	Unknown	449995	5450694	**1**		0.37	0	2	Boulder	10	
LCR	LCR_24.5R	01/02/2014	Yes	TR1	01/02/2014 12:30	3DD.007741F283	CAS	60	Unknown	449995	5450694	**0**		0.37	0	2	Boulder	10	
LCR	LCR_24.5R	04/02/2014	No	TR1	04/02/2014 12:05	3DD.007741F283	CAS	60	Unknown	449999	5450692	3	Upstream	0.73	0.27	4	Cobble	5	
LCR	LCR_24.5R	04/02/2014	No	TR1	04/02/2014 12:05	3DD.007741F283	CAS	60	Unknown	449999	5450692	3	Upstream	0.73	0.27	4	Cobble	5	
LCR	LCR_24.5R	14/02/2014	No	TR1	14/02/2014 10:43	3DD.007741F283	CAS	60	Alive	449997	5450693	0.5	In	0.48	0	3	Cobble	5	
LCR	LCR_24.5R	14/02/2014	No	TR1	14/02/2014 10:43	3DD.007741F283	CAS	60	Alive	449997	5450693	0.5	In	0.48	0	3	Cobble	5	
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3DD.0077420FD4	CBA	55	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3DD.0077420FD4	CBA	55	Alive	452643	5462938	**33**		0.9	0.65	2	Cobble	5	
LCR	LCR_10.5L	22/01/2014	No	EF1		3DD.007742111B	CBA	69	Alive	452636	5462905								
LCR	LCR_10.5L	15/02/2014	Yes	TR1	15/02/2014 11:50	3DD.007742111B	CBA	69	Alive	452639	5462933	**28**		0.41	0	1.7	Cobble	5	
LCR	LCR_10.5L	20/02/2014	No	TR1	20/02/2014 13:05	3DD.007742111B	CBA	69	Alive	452639	5462993	0	None	0.41	0	1.7	Cobble	5	
LCR	LCR_10.5L	12/09/2013	No	EF1		3DD.0077422419	CRH	76	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3DD.0077422419	CRH	76	Alive	452641	5462931	**26**		0.3	0.15	1.5	Cobble	10	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3DD.0077422419	CRH	76	Alive	452638	5462929	3	Out	0.42	0.3	2	Cobble	10	Previous location dewatered.
LCR	LCR_24.5R	23/01/2014	No	EF1	23/01/2014 12:00	3DD.0077422E3C	CAS	94	Alive	449993	5450695								
LCR	LCR_24.5R	14/02/2014	No	TR1	14/02/2014 10:43	3DD.0077422E3C	CAS	94	Alive	450003	5450701	**12**		0.24	0	1.5	Cobble	15	
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3DD.00774235A0	CRH	71	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3DD.00774235A0	CRH	71	Alive	452640	5462923	**18**		0.36	0.04	2.5	Cobble	10	
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3DD.00774235A0	CRH	71	Alive	452636	5462918	3	Downstream	0.54	0.01	2.5	Cobble	5	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3DD.00774235A0	CRH	71	Alive	452636	5462926	7	Out	0.43	0.36	3	Cobble	5	Previous location dewatered.
LCR	LCR_10.5L	23/01/2014	No	EF1		3DD.00774238F6	CBA	76	Alive	452636	5462905								

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_10.5L	29/01/2014	No	TR1	29/01/2014 13:00	3DD.00774238F6	CBA	76	Alive	452633	5462905	**3**		0.16	0.06	0.8	Gravel	25	
LCR	LCR_24.5R	22/01/2014	No	EF1		3DD.0077424701	CRH	58	Alive	449993	5450695								
LCR	LCR_24.5R	29/01/2014	No	TR1	29/01/2014 10:25	3DD.0077424701	CRH	58	Alive	449994	5450695	**1**		0.78	0.01	3.2	Cobble	5	
LCR	LCR_24.5R	01/02/2014	Yes	TR1	01/02/2014 12:30	3DD.0077424701	CRH	58	Alive	449995	5450692	2.5	Out	0.84	0.07	5	Cobble	5	
LCR	LCR_24.5R	04/02/2014	No	TR1	04/02/2014 12:05	3DD.0077424701	CRH	58	Unknown	449962	5450690	2	Downstream	0.41	0.04	3.3	Cobble	5	
LCR	LCR_24.5R	22/01/2014	No	EF1		3DD.007742528F	CRH	66	Alive	449993	5450695								
LCR	LCR_24.5R	15/02/2014	Yes	TR1	15/02/2014 14:15	3DD.007742528F	CRH	66	Dead										Dead tag.
LCR	LCR_24.5R	23/01/2014	No	EF1	23/01/2014 12:00	3DD.0077426B4A	CBA	89	Alive	449993	5450695								
LCR	LCR_24.5R	15/02/2014	Yes	TR1	15/02/2014 14:15	3DD.0077426B4A	CBA	89	Alive	450010	5450706	**20**		0.28	0	0.8	Cobble	15	
LCR	LCR_24.5R	22/01/2014	No	EF1		3DD.0077426CAE	CBA	88	Alive	449993	5450695								Milting.
LCR	LCR_24.5R	01/02/2014	Yes	TR1	01/02/2014 12:30	3DD.0077426CAE	CBA	88	Alive	450030	5450718	**44**		0.07	0	0.15	Cobble	0	
LCR	LCR_10.5L	12/09/2013	No	EF1		3DD.007742768D	CRH	70	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3DD.007742768D	CRH	70	Unknown	452643	5462931	**27**		0.24	0.1	1	Cobble	5	
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3DD.007742768D	CRH	70	Unknown	452643	5462931	0	None	0.24	0.1	1	Cobble	5	
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3DD.007742768D	CRH	70	Alive	452641	5462935	3	Out	0.17	0.21	0.8	Cobble	5	
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3DD.007742768D	CRH	70	Alive	452640	5462932	0.5	Out	0.28	0.18	1.5	Cobble	10	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3DD.007742768D	CRH	70	Alive	452640	5462932	0	None	0.28	0.18	1.5	Cobble	10	
LCR	LCR_10.5L	28/09/2013	Yes	TR1	28/09/2013 11:06	3DD.007742768D	CRH	70	Alive	452641	5462934	0.7	Out	0.15	0.04	0.5	Cobble	10	Previous location dewatered.
LCR	LCR_10.5L	22/01/2014	No	EF1		3DD.0077427EB0	CRH	89	Alive	452636	5462905								
LCR	LCR_10.5L	29/01/2014	No	TR1	29/01/2014 13:00	3DD.0077427EB0	CRH	89	Alive	452640	5462918	**14**		0.2	0.03	1	Cobble	10	
LCR	LCR_10.5L	30/01/2014	No	TR1	30/01/2014 12:23	3DD.0077427EB0	CRH	89	Alive	452640	5462918	0	None	0.2	0.03	1	Cobble	10	
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3DD.00774286CA	CRH	81	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	03/10/2013	No	TR1	03/10/2013 13:05	3DD.00774286CA	CRH	81	Alive	452624	5462910	**11**		0.46	0.31	6	Cobble	0	
LCR	LCR_10.5L	09/10/2013	No	TR1	09/10/2013 13:34	3DD.00774286CA	CRH	81	Alive	452627	5462912	1	Downstream	0.42	0.22	5	Cobble	5	
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3DD.00774286CA	CRH	81	Unknown	452634	5462906	0	None	0.53	0.24	5	Cobble	5	
LCR	LCR_10.5L	22/01/2014	No	EF1		3DD.0077429C27	CAS	61	Alive	452636	5462905								
LCR	LCR_10.5L	01/02/2014	Yes	TR1	01/02/2014 10:05	3DD.0077429C27	CAS	61	Alive	452638	5462929	**24**		0.43	0.27	2	Boulder	5	
LCR	LCR_24.5R	22/01/2014	No	EF1		3DD.0077429D16	CRH	92	Alive	449993	5450695								
LCR	LCR_24.5R	29/01/2014	No	TR1	29/01/2014 10:25	3DD.0077429D16	CRH	92	Alive	450033	5450726	**51**		0.28	0.13	1.5	Cobble	5	
LCR	LCR_24.5R	30/01/2014	No	TR1	30/01/2014 9:45	3DD.0077429D16	CRH	92	Alive	450033	5450726	0	None	0.28	0.13	1.5	Cobble	5	
LCR	LCR_10.5L	12/09/2013	No	EF1		3DD.007742A283	CRH	83	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3DD.007742A283	CRH	83	Alive	452627	5462896	**12**		0.07	0.09	0.4	Cobble	5	
LCR	LCR_10.5L	09/10/2013	No	TR1	09/10/2013 13:34	3DD.007742A283	CRH	83	Unknown	452608	5462876	**28**		0.12	0.02	1.5	Gravel	5	
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3DD.007742A283	CRH	83	Alive	452610	5462879	2	Upstream	0.05	0	0.75	Cobble	0	
LCR	LCR_24.5R	22/01/2014	No	EF1		3DD.007742C030	CRH	66	Alive	449993	5450695								
LCR	LCR_24.5R	01/02/2014	Yes	TR1	01/02/2014 12:30	3DD.007742C030	CRH	66	Unknown	449993	5450691	**4**		1.1	0.13	5.5	Cobble	5	
LCR	LCR_24.5R	04/02/2014	No	TR1	04/02/2014 12:05	3DD.007742C030	CRH	66	Unknown	449993	5450691	0	None	1.1	0.13	5.5	Cobble	5	
LCR	LCR_24.5R	15/02/2014	Yes	TR1	15/02/2014 14:15	3DD.007742C030	CRH	66	Alive	449993	5450691	0	None	0.54	0	2	Cobble	5	
LCR	LCR_24.5R	20/02/2014	No	TR1	20/02/2014 10:45	3DD.007742C030	CRH	66	Unknown	449993	5450691	0	None	0.46	0	1.5	Cobble	5	
LCR	LCR_24.5R	22/01/2014	No	EF1		3DD.007742C732	CRH	78	Alive	449993	5450695								
LCR	LCR_24.5R	29/01/2014	No	TR1	29/01/2014 10:25	3DD.007742C732	CRH	78	Alive	449994	5450698	**3**		0.43	0	1.8	Cobble	5	
LCR	LCR_24.5R	30/01/2014	No	TR1	30/01/2014 9:45	3DD.007742C732	CRH	78	Alive	449994	5450698	0	None	0.43	0	1.8	Cobble	5	
LCR	LCR_24.5R	01/02/2014	Yes	TR1	01/02/2014 12:30	3DD.007742C732	CRH	78	Alive	449996	5450695	**4**		0.1	0	0.1	Cobble	5	
LCR	LCR_24.5R	15/02/2014	Yes	TR1	15/02/2014 14:15	3DD.007742C732	CRH	78	Alive	450011	5450706	**19**		0.47	0	3	Boulder	5	
LCR	LCR_10.5L	11/09/2013	No	EF1	11/09/2013 14:10	3DD.007742C782	CRH	74	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	21/09/2013	Yes	TR1	21/09/2013 11:45	3DD.007742C782	CRH	74	Alive	452635	5462918	**12**		0.63	0.23	3	Cobble	5	
LCR	LCR_10.5L	21/12/2013	Yes	TR1	21/12/2013 10:15	3DD.007742C782	CRH	74	Alive	452636	5462915	**3**		0.74	0.1	5	Cobble	5	
LCR	LCR_10.5L	30/01/2014	No	TR1	30/01/2014 12:23	3DD.007742C782	CRH	74	Alive	452634	5462916	**2**		0.74	0.07	3	Cobble	5	
LCR	LCR_10.5L	12/09/2013	No	EF1		3DD.007742D163	CRH	70	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	03/10/2013	No	TR1	03/10/2013 13:05	3DD.007742D163	CRH	70	Alive	452631	5462922	**16**		0.23	0.19	1	Cobble	5	
LCR	LCR_10.5L	22/01/2014	No	EF1		3DD.007742DF80	CBA	76	Alive	452636	5462905								
LCR	LCR_10.5L	29/01/2014	No	TR1	29/01/2014 13:00	3DD.007742DF80	CBA	76	Alive	452626	5462897	**13**		0.28	0.15	1.5	Boulder	10	

Table G1 continued

Waterbody[1]	Site Name[1]	Sample Date	Flow Reduction	Method[2]	Start Time	PIT Number	Species Code[3]	Length (mm)	Alive/Dead	Easting	Northing	Move From Last (m)[4]	Move Direction	Water Depth (m)	Average Velocity (m/s)	River Meter (m)	Substrate Type	Embeddedness (%)	Comments
LCR	LCR_10.5L	30/01/2014	No	TR1	30/01/2014 12:23	3DD.007742DF80	CBA	76	Alive	452626	5462897	0	None	0.28	0.15	1.5	Boulder	10	
LCR	LCR_10.5L	12/09/2013	No	EF1		3DD.007742E462	CBA	78	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	09/10/2013	No	TR1	09/10/2013 13:34	3DD.007742E462	CBA	78	Unknown	452634	5462906	0	None	0.72	0.34	7	Cobble	5	
LCR	LCR_10.5L	10/10/2013	No	TR1	10/10/2013 21:43	3DD.007742E462	CBA	78	Alive	452622	5462907	0.5	In	0.5	0.33	7	Cobble	0	
LCR	LCR_10.5L	20/12/2013	No	TR1	20/12/2013 9:40	3DD.007742E462	CBA	78	Alive	452635	5462902	**14**		0.76	0.04	3	Cobble	5	
LCR	LCR_10.5L	21/12/2013	Yes	TR1	21/12/2013 10:15	3DD.007742E462	CBA	78	Alive	452635	5462902	0	None	0.2	0.01	1.2	Cobble	5	
LCR	LCR_24.5R	23/01/2014	No	EF1	23/01/2014 12:00	3DD.007742ECF4	CRH	83	Alive	449993	5450695								
LCR	LCR_24.5R	29/01/2014	No	TR1	29/01/2014 10:25	3DD.007742ECF4	CRH	83	Alive	449991	5450696	**2**		0.65	0.05	3.1	Boulder	10	
LCR	LCR_24.5R	30/01/2014	No	TR1	30/01/2014 9:45	3DD.007742ECF4	CRH	83	Alive	449991	5450696	0	None	0.65	0.05	3.1	Boulder	10	
LCR	LCR_10.5L	12/09/2013	No	EF1		3DD.00774327D7	CBA	70	Alive	452634	5462906						Unknown		
LCR	LCR_10.5L	19/09/2013	No	TR1	19/09/2013 12:30	3DD.00774327D7	CBA	70	Alive	452640	5462928	**23**		0.52	0.46	3.2	Cobble	5	
LCR	LCR_10.5L	20/09/2013	No	TR1	20/09/2013 13:25	3DD.00774327D7	CBA	70	Unknown	452640	5462928	0	None	0.52	0.46	3.2	Cobble	5	
LCR	LCR_10.5L	26/09/2013	No	TR1	26/09/2013 13:30	3DD.00774327D7	CBA	70	Alive	452648	5462941	**15**		0.14	0.04	0.4	Cobble	10	
LCR	LCR_10.5L	27/09/2013	No	TR1	27/09/2013 9:00	3DD.00774327D7	CBA	70	Alive	452645	5462943	3.5	Downstream	0.6	0.41	3.1	Cobble	5	
LCR	LCR_24.5R	23/01/2014	No	EF1	23/01/2014 12:00	3DD.007743357A	CBA	68	Alive	449993	5450695								
LCR	LCR_24.5R	01/02/2014	Yes	TR1	01/02/2014 12:30	3DD.007743357A	CBA	68	Unknown	450000	5450694	**7**		0.46	0.22	1.7	Cobble	5	
LCR	LCR_24.5R	04/02/2014	No	TR1	04/02/2014 12:05	3DD.007743357A	CBA	68	Unknown	450000	5450694	0	None	0.46	0.22	1.7	Cobble	5	
LCR	LCR_24.5R	14/02/2014	No	TR1	14/02/2014 10:43	3DD.007743357A	CBA	68	Alive	450000	5450694	0	None	0.46	0.22	1.7	Cobble	5	
LCR	LCR_10.5L	22/01/2014	No	EF1		3DD.007743363E	CBA	76	Alive	452636	5462905								
LCR	LCR_10.5L	15/02/2014	Yes	TR1	15/02/2014 11:50	3DD.007743363E	CBA	76	Alive	452625	5462913	**14**		0.44	0.42	4.5	Cobble	5	
LCR	LCR_24.5R	22/01/2014	No	EF1		3DD.0077434120	CAS	60	Alive	449993	5450695								
LCR	LCR_24.5R	22/01/2014	No	EF1		3DD.0077434120	CAS	60	Alive	449993	5450695								
LCR	LCR_24.5R	29/01/2014	No	TR1	29/01/2014 10:25	3DD.0077434120	CAS	60	Alive	449987	5450695	**6**		0.31	0.08	1.6	Cobble	5	
LCR	LCR_24.5R	29/01/2014	No	TR1	29/01/2014 10:25	3DD.0077434120	CAS	60	Alive	449987	5450695	**0**		0.31	0.08	1.6	Cobble	5	
LCR	LCR_24.5R	30/01/2014	No	TR1	30/01/2014 9:45	3DD.0077434120	CAS	60	Alive	449992	5450696	1.5	Out	0.85	0.05	4.6	Cobble	5	
LCR	LCR_24.5R	14/02/2014	No	TR1	14/02/2014 10:43	3DD.0077434120	CAS	60	Alive	449992	5450695	1	Out	0.38	0	1.6	Cobble	0	
LCR	LCR_24.5R	14/02/2014	No	TR1	14/02/2014 10:43	3DD.0077434120	CAS	60	Alive	449992	5450695	1	Out	0.38	0	1.6	Cobble	0	
LCR	LCR_10.5L	22/01/2014	No	EF1		3DD.0077435051	CRH	96	Alive	452636	5462905								
LCR	LCR_10.5L	29/01/2014	No	TR1	29/01/2014 13:00	3DD.0077435051	CRH	96	Alive	452620	5462885	**26**		0.4	0.02	2	Cobble	5	
LCR	LCR_10.5L	30/01/2014	No	TR1	30/01/2014 12:23	3DD.0077435051	CRH	96	Alive	452620	5462886	1	Out	0.68	0.03	3	Cobble	5	
LCR	LCR_10.5L	01/02/2014	Yes	TR1	01/02/2014 10:05	3DD.0077435051	CRH	96	Alive	452619	5462885	2	Upstream	0.41	0	2.5	Cobble	5	

Notes

[1] LCR= Lower Columbia River; R= right downstream bank; L= left downstream bank

[2] EF= Backpack Electrofishing; TR= Pit Tag Tracking; VO= Visually Observed; SW= Snorkeling

[3] LNC= Longnose dace; CBA= Columbia sculpin; UDC= Umatilla dace; CCN= Shorthead sculpin; CAS= Prickly sculpin; CRH= Torrent sculpin

[4] Bold text represents distance derived from UTMs while plain text represent distance measured in the field.

APPENDIX H

Flow Reduction Movement Maps (Year 5)

Legend

- 20/09/2013 PIT Tag Location
- 21/09/2013 PIT Tag Location
- 26/09/2013 PIT Tag Location
- Movement of Relocated PIT Tag

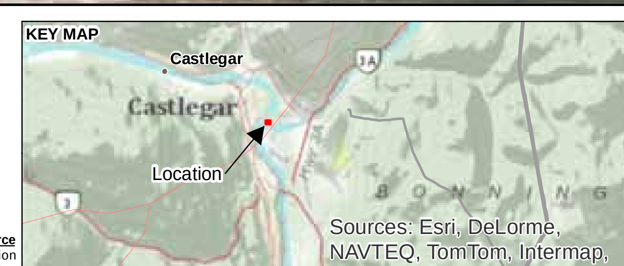
CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

Wetted Edge

- 19-SEP-13
- 21-SEP-13

0 5 10
Metres
Scale:1:350

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map



CLIENT: BC hydro

PROJECT: **LCR Sculpin and Dace**

TITLE: Locations of PIT Tagged Sculpins at LCR_10.5L Before, Immediately Following and One Week After a HLK Flow Reduction on September 21, 2013

DATE: March, 2014	ANALYST: PK	Figure
JOB No: VE52219	QA/QC: CL	PDF FILE: 001_10.5L_survey_130920_130926.pdf
GIS FILE: 001_10.5L_survey_130920_130926.mxd		amec
PROJECTION: UTM 11	DATUM: NAD83	

Y:\GIS\Projects\VE\VE51872_sculpin_dace\Mapping\MXD\Drafts\20140317\001_10.5L_survey_130920_130926.mxd

Legend

- 20/09/2013 PIT Tag Location
- 21/09/2013 PIT Tag Location
- 26/09/2013 PIT Tag Location
- Movement of Relocated PIT Tag

CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

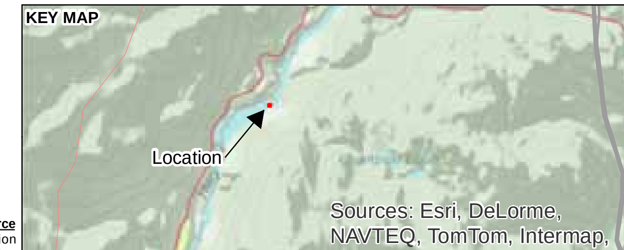
Wetted Edge

- 19-SEP-13
- 21-SEP-13

0 5 10
Metres
Scale:1:200

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map

KEY MAP



CLIENT: BC hydro

PROJECT:

LCR Sculpin and Dace

TITLE:

Locations of PIT Tagged Sculpins at LCR_24.5R Before, Immediately Following and One Week After a HLK Flow Reduction on September 21, 2013

DATE: March, 2014	ANALYST: PK	Figure
JOB No: VE52219	QA/QC: CL	PDF FILE: 002_24.5R_survey_130920_130926.pdf
GIS FILE: 002_24.5R_survey_130920_130926.mxd		
PROJECTION: UTM 11	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE51872_sculpin_dace\Mapping\MXD\Drafts\20140317\002_24.5R_survey_130920_130926.mxd

Legend

- 27/09/2013 PIT Tag Location
- 28/09/2013 PIT Tag Location
- 03/10/2013 PIT Tag Location
- Movement of Relocated PIT Tag

CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

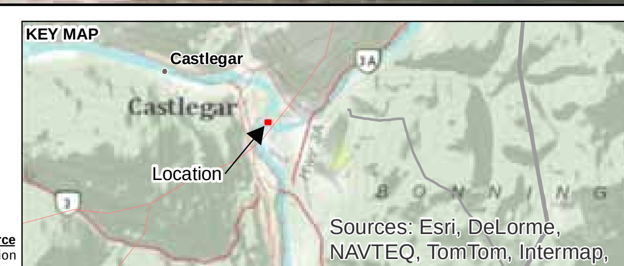
Wetted Edge

- 27-SEP-13
- 28-SEP-13

0 5 10
Metres
Scale:1:350

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map

KEY MAP



CLIENT: BC hydro		PROJECT: **LCR Sculpin and Dace**	
TITLE: Locations of PIT Tagged Sculpins at LCR_10.5L Before, Immediately Following and One Week After a HLK Flow Reduction on September 28, 2013	DATE: March, 2014	ANALYST: PK	Figure
	JOB No: VE52219	QA/QC: CL	PDF FILE: 003_10.5L_survey_130927_131003.pdf
	GIS FILE: 003_10.5L_survey_130927_131003.mxd		amec
	PROJECTION: UTM 11	DATUM: NAD83	

Y:\GIS\Projects\VE\VE51872_sculpin_dace\Mapping\MXD\Drafts\20140317\003_10.5L_survey_130927_131003.mxd

Legend

- 26/09/2013 PIT Tag Location
- 03/10/2013 PIT Tag Location

Wetted Edge

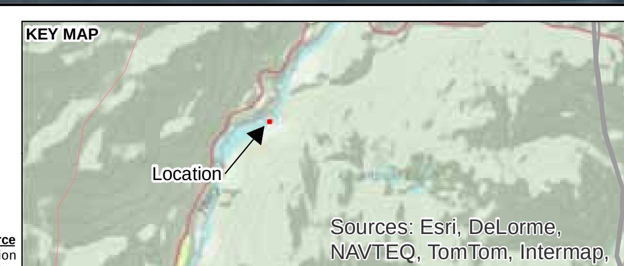
- 21-SEP-13
- 03-OCT-13

CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

0 5 10
Metres
Scale:1:200

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map

KEY MAP



CLIENT: BC hydro		PROJECT: **LCR Sculpin and Dace**	
TITLE: Locations of PIT Tagged Sculpins at LCR_24.5R Before and One Week After a HLK Flow Reduction on September 28, 2013	DATE: March, 2014	ANALYST: PK	Figure
	JOB No: VE52219	QA/QC: CL	PDF FILE: 004_24.5R_survey_130927_131003.pdf
	GIS FILE: 004_24.5R_survey_130927_131003.mxd		
	PROJECTION: UTM 11	DATUM: NAD83	amec

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Legend

- 20/12/2013 PIT Tag Location
- 21/12/2013 PIT Tag Location
- Movement of Relocated PIT Tag
- CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

Wetted Edge

- 20-DEC-13
- 21-DEC-13

0 5 10
Metres
Scale:1:350

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map

KEY MAP

CLIENT: BC hydro	PROJECT: **LCR Sculpin and Dace**
TITLE: Locations of PIT Tagged Sculpins at LCR_10.5L Before and Immediately Following a HLK Flow Reduction on December 21, 2013	DATE: March, 2014
	ANALYST: PK
	Figure
	JOB No: VE52219
	QA/QC: CL
	PDF FILE: 005_10.5L_survey_131220_131221.pdf
	GIS FILE: 005_10.5L_survey_131220_131221.mxd
	PROJECTION: UTM 11
	DATUM: NAD83

amec

Y:\GIS\Projects\VE\VE51872_sculpin_dace\Mapping\MXD\Drafts\20140317\005_10.5L_survey_131220_131221.mxd

Legend

- 30/01/2014 PIT Tag Location
- 01/02/2014 PIT Tag Location
- 04/02/2014 PIT Tag Location
- Movement of Relocated PIT Tag

CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

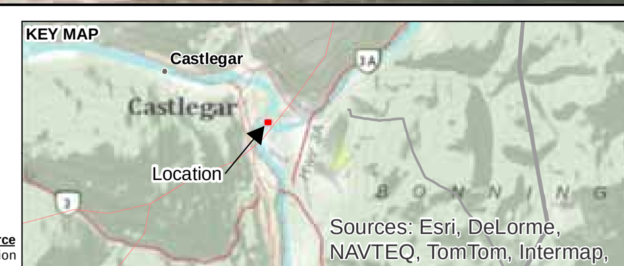
Wetted Edge

- 30-JAN-14
- 01-FEB-14

0 5 10
Metres
Scale:1:350

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map

KEY MAP



CLIENT: BC hydro	PROJECT: LCR Sculpin and Dace		
TITLE: Locations of PIT Tagged Sculpins at LCR_10.5L Before, Immediately Following and One Week After a HLK Flow Reduction on February 01, 2014	DATE: March, 2014	ANALYST: PK	Figure
	JOB No: VE52219	QA/QC: CL	PDF FILE: 006_10.5L_survey_140130_140204.pdf
	GIS FILE: 006_10.5L_survey_140130_140204.mxd		amec
	PROJECTION: UTM 11	DATUM: NAD83	

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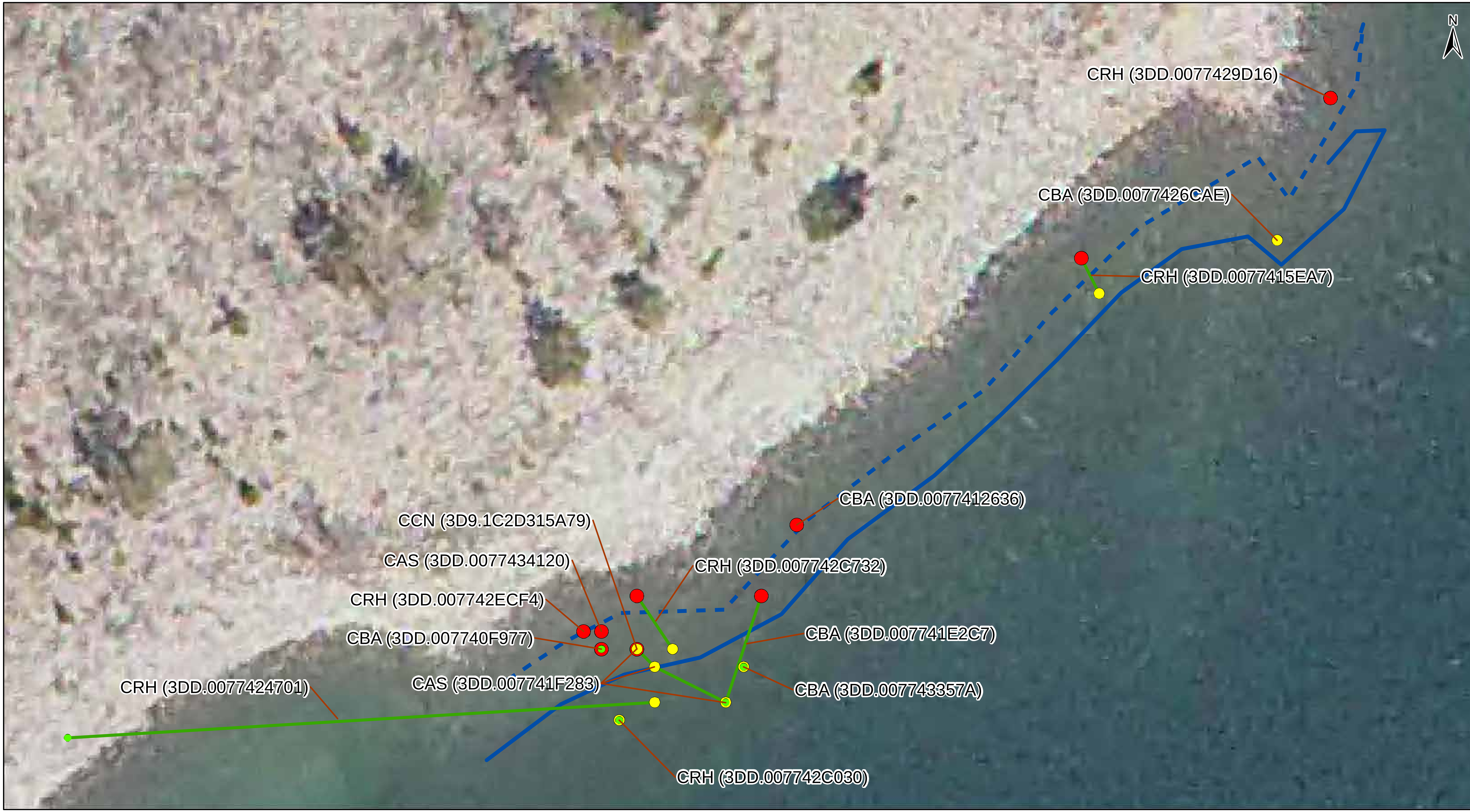


Legend

- 30/01/2014 PIT Tag Location
- 01/02/2014 PIT Tag Location
- 04/02/2014 PIT Tag Location
- Movement of Relocated PIT Tag
- CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

Wetted Edge

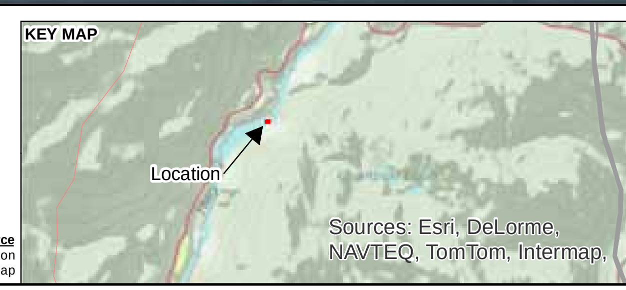
- 30-JAN-14
- 01-FEB-14

0 5 10

Metres

Scale:1:200

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map



CLIENT: BC hydro

PROJECT: **LCR Sculpin and Dace**

TITLE: Locations of PIT Tagged Sculpins at LCR_24.5R Before, Immediately Following and One Week After a HLK Flow Reduction on February 01, 2014

DATE: March, 2014	ANALYST: PK	Figure
JOB No: VE52219	QA/QC: CL	PDF FILE: 007_24.5R_survey_140130_140204.pdf
GIS FILE: 007_24.5R_survey_140130_140204.mxd		amec
PROJECTION: UTM 11	DATUM: NAD83	

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Legend

- 15/02/2014 PIT Tag Location
- 20/02/2014 PIT Tag Location

Wetted Edge

- 14-FEB-14
- 15-FEB-14

CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

0 5 10
Metres
Scale:1:500

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map

KEY MAP

CLIENT:
BC hydro

PROJECT:
LCR Sculpin and Dace

TITLE:
Locations of PIT Tagged Sculpins at LCR_10.5L Before, Immediately Following and One Week After a HLK Flow Reduction on February 15, 2014

DATE: April, 2014	ANALYST: PK	Figure
JOB No: VE52219	QA/QC: CL	PDF FILE: 008_10.5L_survey_140214_140220.pdf
GIS FILE: 008_10.5L_survey_140214_140220.mxd		
PROJECTION: UTM 11	DATUM: NAD83	

amec

Y:\GIS\Projects\VE\VE51872_sculpin_dace\Mapping\MXD\Drafts\20140317\008_10.5L_survey_140214_140220.mxd

Legend

- 14/02/2014 PIT Tag Location
- 15/02/2014 PIT Tag Location
- 20/02/2014 PIT Tag Location
- Movement of Relocated PIT Tag

CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

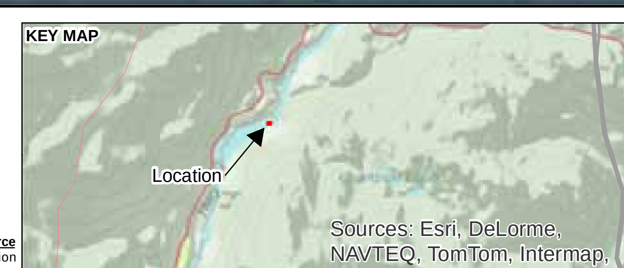
Wetted Edge

- 14-FEB-14
- 15-FEB-14

0 5 10
Metres
Scale:1:200

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map

KEY MAP



CLIENT: BC hydro

PROJECT:

LCR Sculpin and Dace

TITLE:

Locations of PIT Tagged Sculpins at LCR_24.5R Before, Immediately Following and One Week After a HLK Flow Reduction on February 15, 2014

DATE: March, 2014	ANALYST: PK	Figure
JOB No: VE52219	QA/QC: CL	PDF FILE: 009_24.5R_survey_140214_140220.pdf
GIS FILE: 009_24.5R_survey_140214_140220.mxd		amec
PROJECTION: UTM 11	DATUM: NAD83	

Y:\GIS\Projects\VE\VE51872_sculpin_dace\Mapping\MXD\Drafts\20140317\009_24.5R_survey_140214_140220.mxd

Legend

- 28/03/2014 PIT Tag Location
- 29/03/2014 PIT Tag Location
- 31/03/2014 PIT Tag Location
- Movement of Relocated PIT Tag

CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

Wetted Edge

- 27-MAR-14
- 29-MAR-14

0 5 10
Metres
Scale:1:350

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map

KEY MAP

CLIENT:

TITLE:
Locations of PIT Tagged Sculpins at LCR_10.5L Before, Immediately Following and One Week After a HLK Flow Reduction on March 29, 2014

PROJECT:
LCR Sculpin and Dace

DATE: April, 2014	ANALYST: PK	Figure
JOB No: VE52219	QA/QC: CL	PDF FILE: 001_10.5L_survey_140327_140329.pdf
GIS FILE: 001_10.5L_survey_140327_140329.mxd		
PROJECTION: UTM 11	DATUM: NAD83	

Y:\GIS\Projects\VE\VE51872_sculpin_dace\Mapping\MXD\Drafts\20140408\001_10.5L_survey_140327_140329.mxd

Legend

- 28/03/2014 PIT Tag Location
- 29/03/2014 PIT Tag Location
- 31/03/2014 PIT Tag Location
- Movement of Relocated PIT Tag
- CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

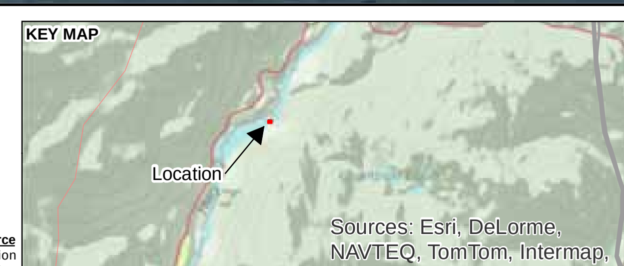
Wetted Edge

- 27-MAR-14
- 29-MAR-14

0 5 10
Metres
Scale:1:200

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map

KEY MAP



CLIENT:	BC hydro
PROJECT:	LCR Sculpin and Dace
TITLE:	Locations of PIT Tagged Sculpins at LCR_24.5R Before, Immediately Following and One Week After a HLK Flow Reduction on March 29, 2014
DATE:	April, 2014
ANALYST:	PK
JOB No:	VE52219
QA/QC:	CL
Figure	
PDF FILE:	002_24.5R_survey_140327_140329.pdf
GIS FILE:	002_24.5R_survey_140327_140329.mxd
PROJECTION:	UTM 11
DATUM:	NAD83

amec

Y:\GIS\Projects\VE\VE51872_sculpin_dace\Mapping\MXD\Drafts\20140408\002_24.5R_survey_140327_140329.mxd

Legend

- 31/03/2014 PIT Tag Location
- 01/04/2014 PIT Tag Location
- 02/04/2014 PIT Tag Location
- Movement of Relocated PIT Tag

CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

Wetted Edge

- 31-MAR-14
- 01-APR-14

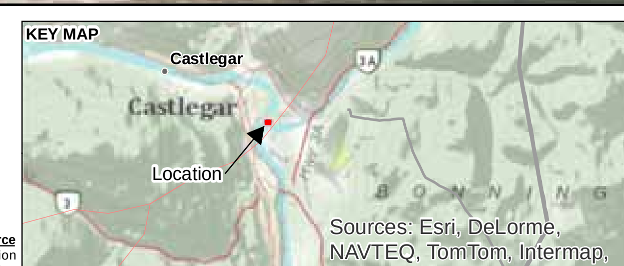
0 5 10

Metres

Scale:1:350

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map

KEY MAP



CLIENT: BC hydro

TITLE:
Locations of PIT Tagged Sculpins at LCR_10.5L Before, Immediately Following and One Week After a HLK Flow Reduction on April 01, 2014

PROJECT:
LCR Sculpin and Dace

DATE: April, 2014	ANALYST: PK	Figure
JOB No: VE52219	QA/QC: CL	PDF FILE: 003_10.5L_survey_140331_140401.pdf
GIS FILE: 003_10.5L_survey_140331_140401.mxd		
PROJECTION: UTM 11	DATUM: NAD83	

Y:\GIS\Projects\VE\VE51872_sculpin_dace\Mapping\MXD\Drafts\20140408\003_10.5L_survey_140331_140401.mxd

Legend

- 31/03/2014 PIT Tag Location
- 01/04/2014 PIT Tag Location
- 02/04/2014 PIT Tag Location
- Movement of Relocated PIT Tag
- CAS (3D9.1C2D23C2D1) - Species and PIT Tag Number

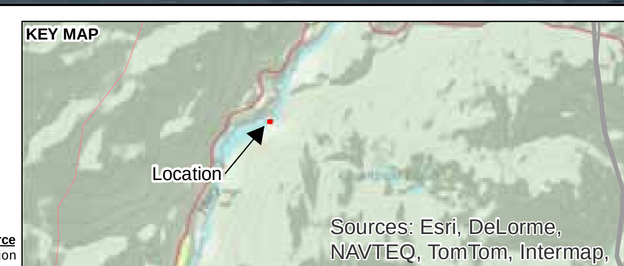
Wetted Edge

- 31-MAR-14
- 01-APR-14

0 5 10
Metres
Scale:1:200

Source
BC Government GeoBC Data Distribution
Microsoft Bing Map

KEY MAP



CLIENT: BC hydro

TITLE: Locations of PIT Tagged Sculpins at LCR_24.5R Before, Immediately Following and One Week After a HLK Flow Reduction on April 01, 2014

PROJECT: **LCR Sculpin and Dace**

DATE: April, 2014	ANALYST: PK	Figure
JOB No: VE52219	QA/QC: CL	PDF FILE: 004_24.5R_survey_140331_140401.pdf
GIS FILE: 004_24.5R_survey_140331_140401.mxd		
PROJECTION: UTM 11	DATUM: NAD83	amec

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