Okanagan Basin Monitoring and Evaluation Program

2012 Annual Report for Sites in Canada

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GLOSSARY OF OKANAGAN NAMES

N’syilx’cin Place Name	Common Name
nx̌ʷəntkʷitkʷ	Columbia River
snpinˀyaʔtkʷ	Ellis Creek
akskʷəkʷant	Inkaneep Creek
nˤaylintən	McIntyre Dam
sx̌wəx̌wnikw	Okanagan Falls
Kɬusxənitkʷ	Okanagan Lake
q̇awsitkʷ	Okanagan River
nʕaləm’xnitkʷ	Oliver
suwiẇs	Osoyoos Lake
snpintktn	Penticton
akɬxʷminaʔ	Shingle Creek
q’awst’ik’ʷt	Skaha Lake
snʕax̌əlqaxʷiyaʔ	Vaseux Creek
np’əxɬpiw’	Vaseux Lake

N’syilx’cin Salmon Names	Common Names
Xʷuminaʔ	Steelhead Salmon, Rainbow Trout (*Oncorhynchus mykiss*)
ntitiyx	Chinook Salmon (*Oncorhynchus tshawytscha*)
sćwin	Sockeye Salmon (*Oncorhynchus nerka*)

1.0 INTRODUCTION

1.1 Project Background

The Okanagan Basin Monitoring and Evaluation Program (OBMEP) is a 20-year monitoring program of anadromous salmonid abundance and habitat within the Okanagan[1] sub-basin of the Upper nx̌ʷəntkʷitkʷ (Columbia River)[2]. Initiated in 2004 by the Colville Confederated Tribes (CCT) Fish and Wildlife Department in the U.S., the program began collaborating with the Okanagan Nation Alliance (ONA) Fisheries Department in the Canadian portion of the Okanagan in 2005 due to the trans-boundary nature of the Okanagan basin (Walsh and Long, 2006a; Benson *et al,*. 2007).

The OBMEP procedures and methodology are adapted from the *Monitoring Strategy for the Upper Columbia Basin* (Hillman, 2006). Monitoring status and trends of anadromous salmonids and their habitat involves:

1. documenting present conditions of habitat attributes, water quality and species presence and abundance; and
2. quantifying changes to these conditions over time.

Status and trend data will:

1. help identify issues that require further experimental research to understand cause and effect relationships; and
2. aid in effectively monitoring management actions performed on or around streams of interest (i.e., a stream restoration project resulting in a change of abundance or quality of habitat for juvenile salmonid populations).

Thus, OBMEP strives to guide restoration and adaptive management strategies within the study area with the collection of long-term data.

Structured barriers are major constraints to present salmonid migrations in the Okanagan sub-basin. Dams exist at the outlets of all Canadian bound Okanagan main-stem lakes specifically, suwiẁs (Osoyoos Lake)[3], np'əxɬpiw' (Vaseux Lake)[4], q'awst'ik'ʷt (Skaha Lake)[5], and Kɬusxənitkʷ (Okanagan Lake)[6]. As of 2009, the outlet dam at np'əxɬpiw's - known as nˤaylintən (McIntyre Dam[7]) - is no longer a fish migration barrier for ntitiyx (Chinook Salmon; *Oncorhynchus*

[1] Spelled "Okanogan" in Washington, but spelled "Okanagan" in British Columbia.
[2] Commonly known as Columbia River but for the remainder of this report referred to as nx̌ʷəntkʷitkʷ
[3] Commonly known as Osoyoos Lake but for the remainder of this report referred to as suwiẁs
[4] Commonly known as Vaseux Lake but for the remainder of this report referred to as np'əxɬpiw'
[5] Commonly known as Skaha Lake but for the remainder of this report referred to as q'awst'ik'ʷt
[6] Commonly known as Okanagan Lake but for the remainder of this report referred to as Kɬusxənitkʷ
[7] Commonly known as McIntyre Dam but for the remainder of this report referred to as np'əxɬpiw's

tshawytscha), sc̓win (Sockeye Salmon; *O. nerka*) and Xʷuminaʔ (Steelhead Salmon; *O. mykiss*). Currently, the Kɬusxənitkʷ outlet dam at snpintktn (Penticton[8]) is the upstream barrier for all anadromous salmon species. It is generally believed that anadromous salmonids have previously occupied the entire q̓awsitkʷ headwater system (Ernst and Vedan, 2000).

Re-introduction of sc̓win fry into the q'awst'ik'ʷt system presently extends the range of anadromous salmonids to just below the Kɬusxənitkʷ outlet dam in snpintktn. Consequently, under the OBMEP mandate, the study area in Canada extends from the Kɬusxənitkʷ outlet dam south to the United States border (Figure 1).

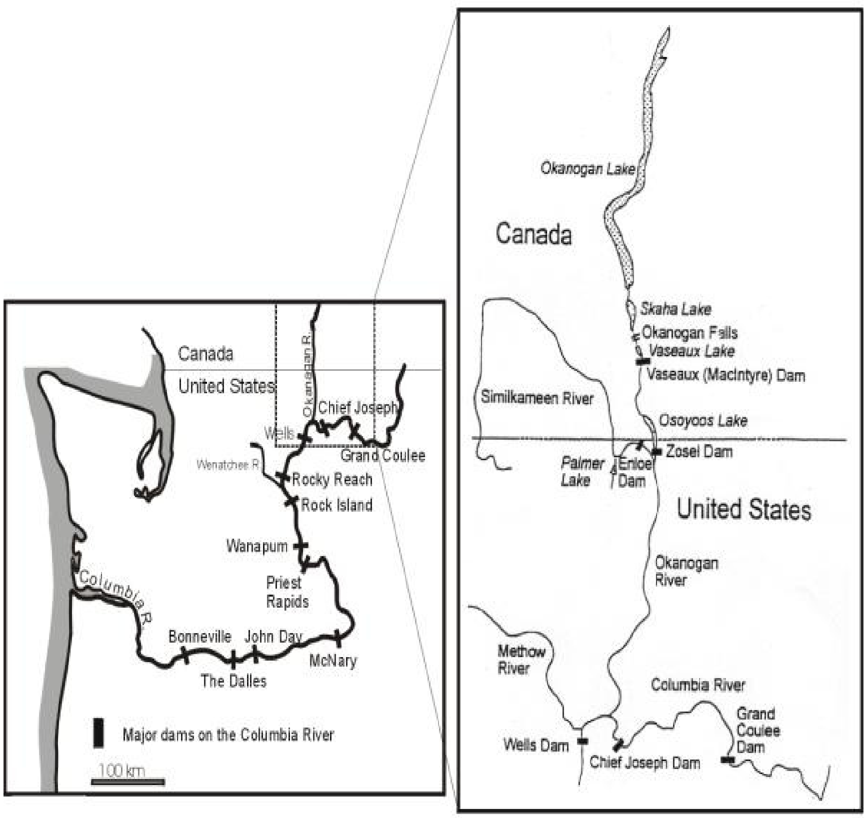


Figure 1: Map of the Okanogan Basin Monitoring and Evaluation Program (OBMEP) study area in Canada.

1.2 Study objectives

From 2005 until 2011, the OBMEP program in Canada required a total of 48 randomly generated sites divided into 5 rotating panels (sites surveyed every 5 years) and one annual panel (the same sites surveyed every year). Each panel consisted of 8 sites. In 2012, in order to speed up the ability to analyze data for rotating panels, the sampling plan was changed to a 4-panel

[8] Commonly known as Penticton but for the remainder of this report referred to as snpintktn

system where 32 sites were divided into 4 panels (Appendix I). The annual panel remained constant. Status and trend data collected, thus far, primarily include physical habitat characteristics, biological conditions, and water quality components.

The primary objectives for the Canadian OBMEP program in 2012 were to:

- survey the physical habitat at the 8 Annual Panel and 8 Panel 3 sites (following standard field protocols),
- observe on-going water discharge at established hydrometric stations in the q̓awsitkʷ main-stem, akskʷəkʷant (Inkaneep Creek[9]) and snpinˀyaʔtkʷ (Ellis Creek[10]),
- establish new water discharge hydrometric station on Shuttleworth Creek and snʕax̌əlqaxʷiyaʔ (Vaseux Creek[11]),
- monitor on-going water temperature and chemistry conditions at the 8 Annual Panel and 8 Panel 3 sites (following standard field protocols),
- survey the existing juvenile fish production at the 8 Annual Panel and 8 Panel 3 sites (following standard field protocols),
- collect invertebrates samples at the 8 Annual Panel and 8 Panel 3 sites (following standard field protocols),
- re-establish the Panel 4 sites at the end of 2012 OBMEP program in Canada.

[9] Commonly known as Inkaneep Creek but for the remainder of this report referred to as akskʷəkʷant.
[10] Commonly known as Ellis Creek but for the remainder of this report referred to as snpinˀyaʔtkʷ.
[11] Commonly known as Vaseux Creek but for the remainder of this report referred to as snʕax̌əlqaxʷiyaʔ.

2.0 METHODS

2.1 Site selection

The monitoring of salmonid abundance and habitat for status and trends involves both temporal and spatial replication and probabilistic sampling of stream reaches (Hillman, 2006). OBMEP study sites in Canada were determined using randomly selected locations generated from the Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP). EMAP is a statistically based and spatially explicit site-selection process developed for aquatic systems. For the purpose of the OBMEP study, "sites" refers to the EMAP sites and consists of q̓awsitkʷ sub-basin reaches of either the main-stem q̓awsitkʷ or its tributaries (Appendix I).

Prior to selecting the OBMEP sites, barriers to anadromous fish migration were documented to determine current range (Walsh and Long, 2006b). The 48 Canadian Okanagan EMAP sites were selected from a total of 600 possible sites above and below fish migration barriers based on accessibility with preference toward sites downstream of barriers. Reaches upstream of barriers were included as they are a source of water, nutrients, and substrate. The 48 sites were then grouped into "panels" consisting of eight sites each. One panel was considered an Annual Panel and those sites were surveyed every year. Five "rotating panels" were also created (eight sites each) and one of the five rotating panels was completed each year along with the Annual Panel (Appendix I). An additional panel of alternate (extra) sites is included if any of the Panels 1 to 5 cannot be surveyed.

In 2012, in response to requests by funding agencies for more frequent reports on panels, the rotating panel structure was changed to four rotating panels instead of five (Figure 2; Table 1). Individual sites within the rotating panels were moved around in order to facilitate this change. Due to the rearranging and shifting of sites between the different panels, three new sites were selected for 2012 within reaches that previously held EMAP selected sites. The new sites for 2012 were:

- snʕax̌əlqaxʷiyaʔ 1251 - Annual (177 replacement),
- akskʷəkʷant 1253 - Panel 3,
- snpinˀyaʔtkʷ 1254 - Panel 3.

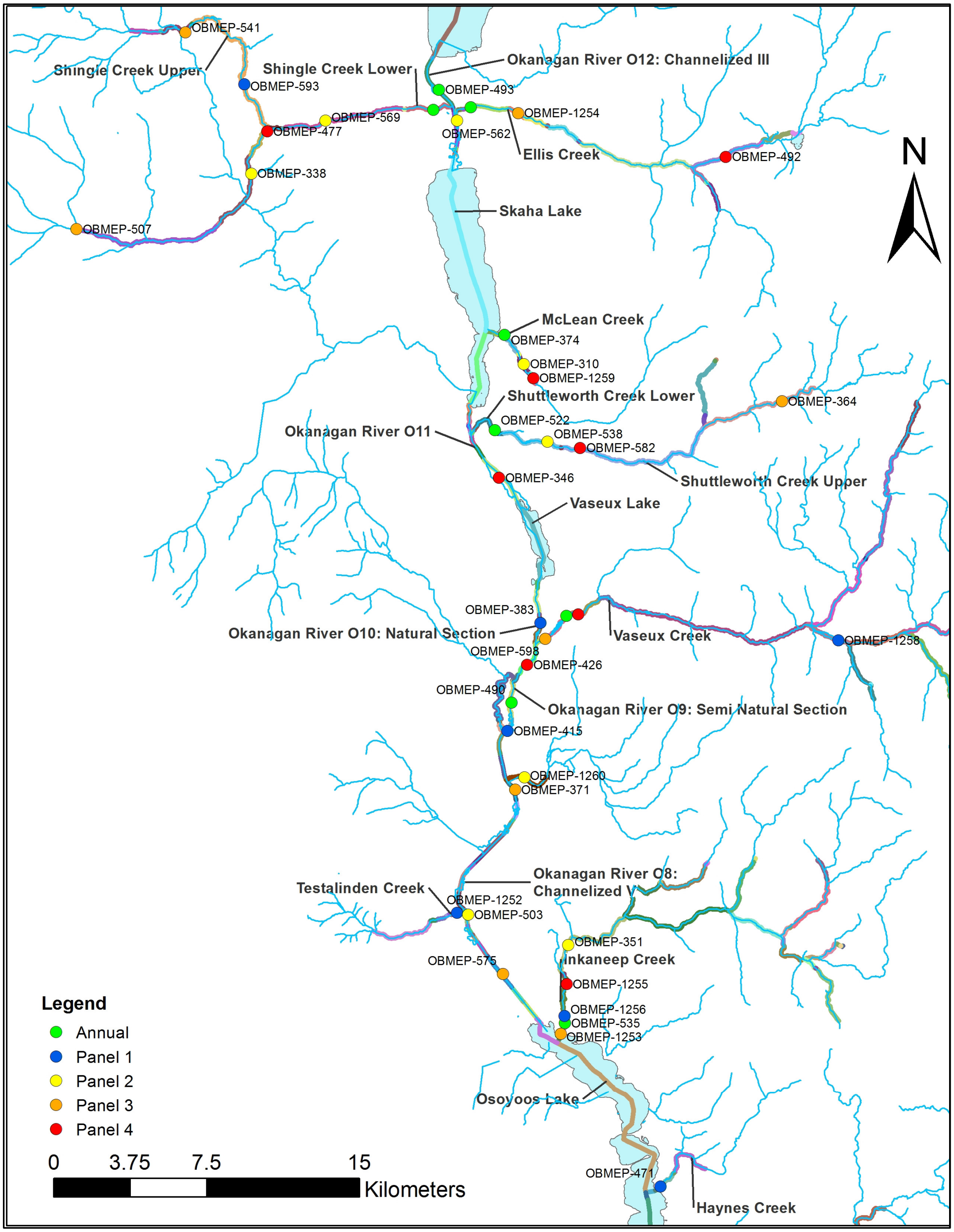


Figure 2. Map of the Four Panel design of EMAP sites for the Canadian portion of the q̓awsitkʷ basin.

Table 1: EMAP sites for the OBMEP study in the Canadian Okanagan sub-basin surveyed in 2012. Panel 3 of the rotating panels will be surveyed once every four years.

Annual Panel Sites:

Stream	Site No.
akɬxʷminaʔ	**317**
McLean	**374**
snpinʼyaʔtkʷ	**470**
q̇awsitkʷ	**490**
q̇awsitkʷ	**493**
Shuttleworth	**522**
akskʷəkʷant	**535**
snʕax̌əlqaxʷiyaʔ	**1251**

Panel 3 Sites (2012):

Stream	Site No.
Shuttleworth	**364**
q̇awsitkʷ	**371**
Shatford	**507**
akɬxʷminaʔ	**541**
q̇awsitkʷ	**575**
snʕax̌əlqaxʷiyaʔ	**598**
akskʷəkʷant	**1253**
snpinʼyaʔtkʷ	**1254**

2.2 Field protocol

In general, the OBMEP survey consists of documenting the study site, establishing transects within the site, and collecting both physical habitat and biological data related to anadromous salmonids. Surveys of the sites are generally conducted from June to September (Arterburn *et al*., 2006).Dividing the stream reach into transects creates defined increments for measuring habitat characteristics and changes (Arterburn *et al*., 2006).

Initially, a study site is located with GPS coordinates provided for all the EMAP sites – supplied by the CCT. Once the site is located, a rebar marker is placed to designate the center point of the site. The total length (or reach) of a site is determined based on an average of five bankfull width measurements (Appendix II) around the center point of the site, and then multiplied by twenty. The length of the site is then divided into ten equally spaced transects (Figure 3), flagged and consecutively labeled with letters ‘A’ through ‘K’ (with ‘A’ beginning at the downstream of the center point ‘F’ and ‘K’ ending upstream). These ten transects are again divided in half to create mid-transect points. The mid-transect point is that point exactly halfway from transect line A to transect line B, for example, and would be flagged and labeled as ‘A1’. Rebar placed at transects ‘A’ and ‘K’ also delineate the site as permanent markers.

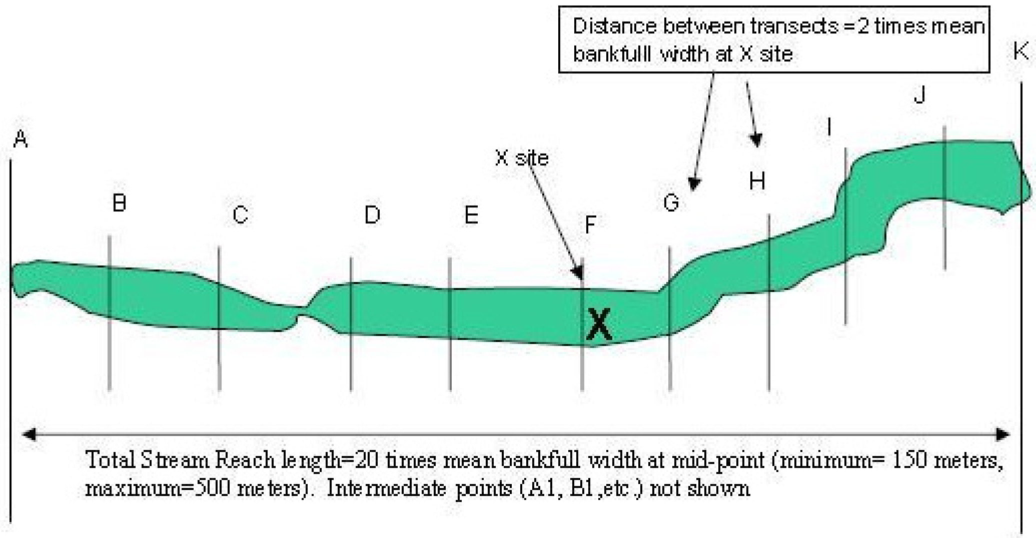


Figure 3. Depiction of a typical site setup for an EMAP site monitored within the OBMEP program.

Consistency in site location and data collection is important to the goals of the OBMEP study. Site documentation was recorded to assist in the accurate location of sites throughout the study period. GPS location of the center, upper- and lower-most transects[12], photo-documentation, and written description of the site (i.e., landmarks) are all contained in the site documentation.

2.2.1 Physical habitat surveys

A two-man crew (one constant, all well versed in OBMEP methodology) collected and recorded the physical habitat data in 2012. Physical habitat measurements included stream depth characteristics, habitat type, substrate characteristics, riparian vegetation, and human influences[13]. These measurements were collected along transects, mid-transects, and finer habitat increments. In addition, environmental conditions during the habitat survey were recorded. The physical habitat measurements, their units, and a short description are summarized in Appendix II.

In larger or more challenging streams a crew of three to five was needed. In streams too deep and deemed to be non-wadeable, a two-person kayak was used to obtain in-stream depth information. A stadia rod was used to acquire the thalweg and cross-section depths. A measuring tape was used to get bankfull width and wetted width with the exception of main-stems in which a range finder was used.

[12] Electronic data entry allowed for the collection of GPS locations of all transects (and mid-transects as explained in section 2.3).

[13] Physical Habitat survey collection protocols can be found at http://www.colvilletribes.com/media/files/2012%20obmep%20physical%20habitat%20protocols%20version%202%202.pdf.

2.2.2 Water quantity (discharge) surveys

Water quantity (discharge) data were collected in 2012 through:

- Water Survey of Canada (WSC) at their active hydrometric stations on the main-stem q̓awsitkʷ, snʕax̌əlqaxʷiyaʔ, and akskʷəkʷant (Environment Canada, 2012);
- City of Penticton at their hydrometric station on snpin'yaʔtkʷ;
- ONA staff at recently established discharge stations on Shuttleworth Creek and snʕax̌əlqaxʷiyaʔ (Figure 3).

Main-stem q̓awsitkʷ discharge data were obtained from three active WSC real-time hydrometric stations located at snpintktn (08NM050), sx̌wəx̌wnikw (08NM002), and nʕaləm'xnitkʷ (08NM085). As well, two more WSC hydrometric stations were also active on snʕax̌əlqaxʷiyaʔ (08NM171) and akskʷəkʷant (08NM200). The akskʷəkʷant hydrometric station was operated using OBMEP funding.

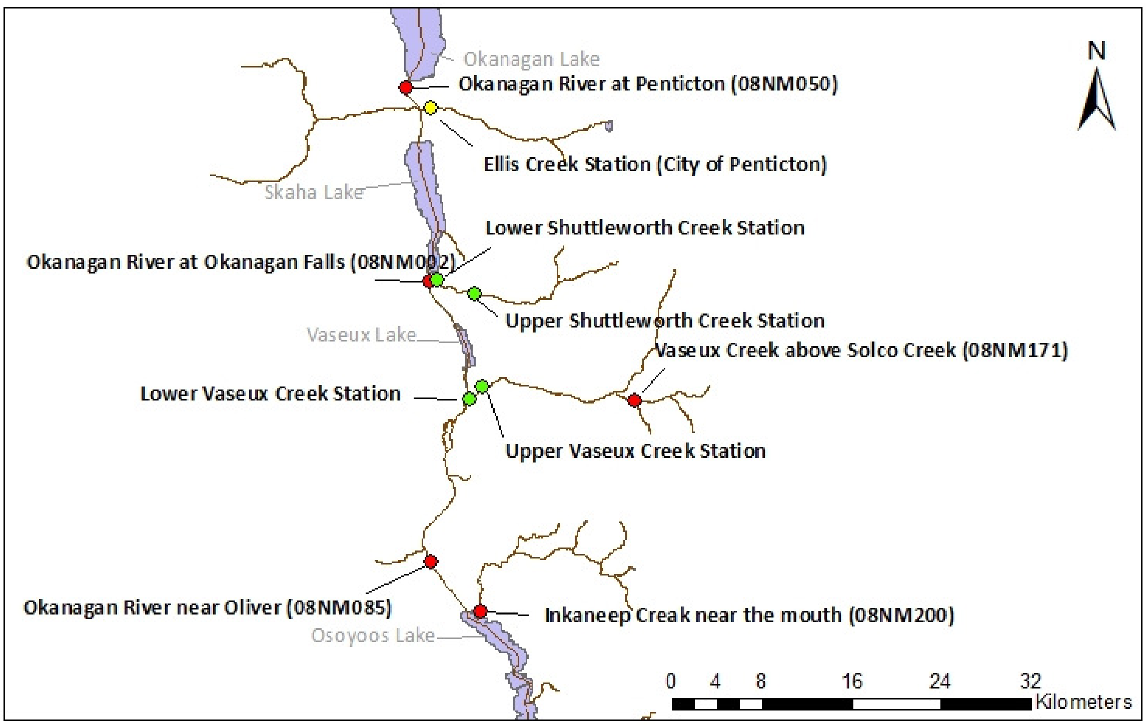


Figure 4. Map of Canadian portion of the Okanagan Basin showing locations Water Survey of Canada hydrometric stations (red), hydrometric stations operated by ONA staff (green) and the City of Penticton Ellis Creek Station (yellow).

Four established stations were operated by ONA staff. Two sites were established on Shuttleworth Creek and two on snʕax̌əlqaxʷiyaʔ (Figure 4). HOBO®U20 Water Level Loggers were installed in areas where they would be less likely to be affected during high flows but still be underwater during low flows. At the water level logger stations, a number of discharge measurements were taken at different flow levels in order to establish Stage-Discharge rating curves (Appendix III). The rating curves and logger data were then used to calculate hydrographs of discharge over time (Appendix IV).

2.2.3 Water quality surveys

Water quality was sampled three times in 2012. Samples were taken in May, July, and October/November (the first samples were delayed due to revising of the sites). The water quality was measured using the Hanna Instrument HI 9828 Multiparameter probe and the LaMotte 2020 Turbidimeter. The different parameters recorded were:

- pH,
- dissolved oxygen (DO),
- turbidity,
- conductivity,
- salinity, and
- oxygen reduction potential (ORP).

2.2.4 Water temperature

Temperature data were collected using HOBO® Water Temp Pro v2 data loggers (Onset Computer Corporation) temperature loggers. One temperature data logger was set for each of the 2012 OBMEP sites. The loggers were housed in aluminum or plastic piping (to protect from damage), secured to a land base anchor (tree stump, shrub bases, fence posts, etc), and placed within an active channel representative of the site. The installation date and a site description (i.e., transect and bank) were recorded. Loggers were retrieved after 8 to 14 weeks, the temperature data was downloaded and the loggers were reinstalled. Temperature data for the 2012 water year were first collected (late due to changes of sites) from April 2012 to July 2012 followed then by November 2012 to April 2013. Data-recording intervals for the loggers were set for every hour on the hour.

2.2.5 Snorkel surveys

Snorkel surveys were done with two people for most of the tributaries, one snorkeling and the other taking notes and watching for any fish that the snorkeler might miss. For the larger tributaries three people were used, two snorkeling and another taking notes. On the main-stem q̓awsitkʷ five snorkelers were used to survey, notes were recorded after the site was snorkeled.

Snorkeling was conducted to identify, enumerate, and classify salmonids and non-salmonids into length categories. Snorkel surveys were performed within weeks of the physical habitat surveys. Data were recorded per transect (A to K) and included start and end times, species (for salmonids), family or species where possible (for non-salmonids), number of fish (for each species or family), and length category (<100 mm, 100-300 mm, or >300 mm). The underwater visual distance, average wetted width, stream temperature and environmental conditions (at the time of the survey) were also recorded.

On the main-stem, crew members were spaced in intervals (determined by the underwater visual distance) and snorkeled downstream (from Transect K) in a straight line across the wetted width of the site. Snorkel surveys in shallower streams generally required only two or three crew members who usually began downstream (at Transect A) and finished at the upstream end of the site (Transect K). In streams too shallow to snorkel, crew members walked side by side and observed fish with the aid of polarized glasses and/ or snorkel masks for deeper pools.

Table 2: Description of the biological measurements collected during the 2012 snorkel surveys.

Measurement	General Description	Methods	Units
Fish species	Salmonids and non-salmonids are identified to species where possible	snorkel survey	species or family
Number of fish	The number of fish, of each species and family, are counted	snorkel survey	Number
Length category	Counted fish are measured and classified into one of three fish length groups (<100mm, 100-300mm, or >300mm)	snorkel survey	Millimeters

2.2.6 Benthic macroinvertebrate surveys

Benthic macroinvertebrates assemblages can be used as indicators of biological integrity and stream health and are often used to evaluate impacts from human disturbance (Hayslip, 2007). As part of OBMEP, benthic macroinvertebrate samples were taken at all 16 EMAP-generated sites in the Canadian portion of the basin unless they were completely dry. At each site, 8 transects (consecutively) were sampled by vigorously fanning and rubbing sediment in a 1ft x 1ft plot of the stream bed into a D-frame kicknet (500µm). The 8 transects were chosen by their proximity to pool-riffle-pool sequences. A total sample area of 8ft^2 is recommended in order to sample a representative portion of taxa but still remain feasible due to the patchy nature of macroinvertebrate distribution (Hayslip, 2007).

Due to laboratory requirements and budget constraints, field samples were required to undergo a secondary sorting process in order to remove debris and sediment to reduce laboratory time. In the ONA office, debris and sediment were removed from the samples and thoroughly washed and inspected for residual macroinvertebrates. Since sorting and selecting individual macroinvertebrates can be very time-consuming, and only a minimum sample size of 300 individuals was required for laboratory metrics, samples that were deemed to have a large number of individual macroinvertebrates were split and subsampled using a process where they were thoroughly mixed and randomly selected. The final samples were then sorted and selected in a well-lit place until all visible macroinvertebrates were included in the sample and the sample was void off all debris and sediment. The sample containers were filled with 95% ethanol and were shipped to a separate laboratory (EcoAnalysts Inc.) for analysis.

Decreasing taxa richness, decreasing intolerant and sediment sensitive taxa and an increased dominance of a small number of taxa are all responses that can be expected as a result of human disturbance and stressors (Jensen, 2006). Metrics of macroinvertebrate diversity that are used to assess stream health include:

- Taxa richness,
- Ephemeroptera Plechoptera Trichoptera (EPT) richness,
- Benthic Index of Biological Integrity (B-IBI) based on Jensen, 2006,

2.2.7 Adult migration and spawning surveys

In past years, spring adult Xʷuminaʔ migration and spawning surveys have included redd surveys as well as a picket-weir fish fence in akskʷəkʷant. However, due to concerns with sampling methods and the feasibility of the fish fence during high freshet flows, the surveys were discontinued for 2012.

In the fall of 2009, a Passive Integrated Transponder (PIT) detection array was installed downstream of Vertical Drop Structure (VDS) 3 near Road 18 in Oliver, BC (Figure 5). The PIT array consists of four 6.0m x 1.8m x 0.3m antennae aligned perpendicular to the river channel which covers the entire wetted width of the channel when flows are between 0-10 m^3/s. Historically, the q̓awsitkʷ has a mean peak flow of less than 50m^3/s and the array was situated such that all passing fish should have been detected by the array. Data from the PIT array can be found on the PIT Tag Information System (PTAGIS) website (http://www.ptagis.org/ptagis/) with the listing as OKC (Okanagan Channel VDS-3) small system detection arrays. The PIT array was fully monitored for the 2012 season.

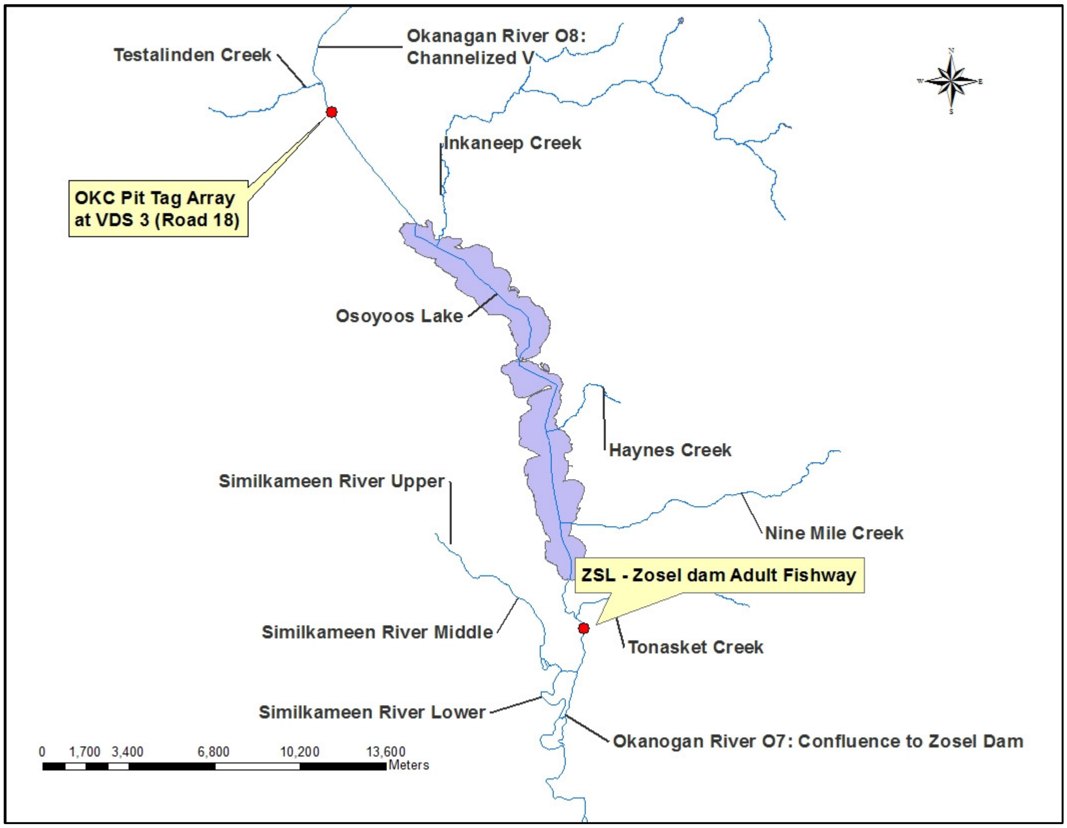


Figure 5. Map of the southern Okanagan Basin around Osoyoos Lake showing the locations of Pit Tag arrays on the Okanagan River main-stem at VDS 3 (OKC) and Zosel Dam Adult Fishway (ZSL).

2.3 Data collection and processing

Field data were recorded using both electronic data entry and data sheets. Most physical habitat data were collected with an electronic Trimble® YUMA® Rugged Tablet. Snorkel data were primarily collected using OBMEP data field sheets or conventional field books (where necessary). Temperature data were collected using HOBO® Water Temp Pro v2 data loggers (Onset Computer Corporation) and devices with a Panasonic CF-30 TOUGHBOOK laptop.

The Trimble® device is connected with the CCT's database. The data collected is synced up and the data is automatically saved in the CCT's database.GPS coordinates were recorded with the Trimble® during the site documentation and physical habitat survey. Collection templates for the habitat survey were programmed into the Trimble® unit by CCT (containing the same information as the data field sheets).

Snorkel field data were transferred from field notes to an OBMEP snorkel data sheet with Microsoft Excel. The temperature loggers' data were launched and read out using HOBOware® Pro Version 2.x software (Onset Computer Corporation).

3.0 RESULTS

3.1 Physical habitat surveys

Physical habitat data were collected for all 16 OBMEP sites in 2012. Data were categorized into Stream Corridor Structure (Table 3 and 4), Habitat Type (Table 5), Substrate (Table 6 and Figure 6), Riparian Vegetation (Table 7), and Human Influence (Table 8) parameters.

Table 3: Stream corridor structure parameters for eight annual EMAP sites and eight Panel 3 sites sampled in the q̓awsitkʷ Basin in 2012. Values listed are averages with the exception of Large Woody Debris (LWD) values which are totals.

		Stream Corridor Structure Parameters				
	Site Name	Bankfull Width (m)	Pool/Riffle Ratio	Bankfull Width/Depth	Small LWD >10 cm and >1m in length (#)	Large LWD >10 cm and >2m in length (#)
Annual Sites	akɬxwminaʔ-317	6.91	0.1	6.46	21	21
	McLean-374	5.00	1.2	6.45	119	95
	snpinʾyaʔtkw-470	8.13	0.0	10.42	16	16
	q̓awsitkʷ-490	45.12	2.6	28.51	38	87
	q̓awsitkʷ-493	29.36		16.86	0	0
	Shuttleworth-522	8.98	0.1	13.12	53	54
	akskʷəkʷant-535	11.04	0.2	12.92	45	19
	snʕax̌əlqaxʷiyaʔ-1251	17.44	0.2	9.46	1	9
Panel 3 Sites	Shuttleworth-364	4.48	0.3	5.33	7	12
	q̓awsitkʷ-371	33.76	24.0	10.30	1	3
	Shatford-507	9.28	0.2	8.30	10	22
	akɬxwminaʔ-541	7.12	0.2	8.08	56	54
	q̓awsitkʷ-575	33.56		13.19	1	8
	snʕax̌əlqaxʷiyaʔ-598	21.65	0.3	23.33	38	23
	akskʷəkʷant-1253	9.57	1.1	9.41	7	23
	snpinʾyaʔtkw-1254	11.65	0.1	8.46	0	2

Table 4. Stream corridor structure parameters for eight annual EMAP sites and eight Panel 3 sites sampled in the q̓awsitkʷ basin in 2012. Values listed are averages.

		Stream Corridor Structure Parameters						
	Site Name	**Thalweg Depth (m)**	**Gradient (%)**	**Wetted Width (m)**	**Bankfull Height (m)**	**Bankfull Depth (m)**	**Floodprone Depth (m)**	**Wetted Width/ Thalweg Depth**
Annual Sites	akɬxwminaʔ-317	0.39	0.68	4.27	0.68	1.07	2.14	10.94
	McLean-374	0.27	0.88	2.19	0.51	0.77	1.55	8.20
	snpinʾyaʔtkw-470	0.32	1.33	6.20	0.46	0.78	1.56	19.20
	q̓awsitkʷ-490	1.08	0.54	33.14	0.50	1.58	3.16	30.57
	q̓awsitkʷ-493	1.09	0.11	27.77	0.65	1.74	3.48	25.48
	Shuttleworth-522	0.22	2.14	4.28	0.46	0.68	1.37	19.02
	akskʷəkʷant-535	0.31	1.28	4.65	0.55	0.85	1.71	15.20
	snʕax̌əlqaxʷiyaʔ-1251	0.85	3.97	8.22	0.99	1.84	3.69	9.62
Panel 3 Sites	Shuttleworth-364	0.38	3.54	3.00	0.46	0.84	1.68	7.86
	q̓awsitkʷ-371	1.86	0.04	30.48	1.42	3.28	6.55	16.39
	Shatford-507	0.36	7.62	5.11	0.76	1.12	2.24	14.36
	akɬxwminaʔ-541	0.33	3.77	4.03	0.55	0.88	1.76	12.12
	q̓awsitkʷ-575	1.68	0.10	31.06	0.87	2.54	5.09	18.50
	snʕax̌əlqaxʷiyaʔ-598	0.31	1.34	9.54	0.62	0.93	1.86	31.11
	akskʷəkʷant-1253	0.57	0.49	5.35	0.45	1.02	2.03	9.39
	snpinʾyaʔtkw-1254	0.59	2.87	7.21	0.79	1.38	2.76	12.27

Table 5. Physical habitat types for eight annual EMAP sites and eight Panel 3 sites sampled in the q̓awsitkʷ Basin in 2012. Percentages listed are the proportion of the reach by area that consists of the listed habitat type.

		Habitat Type Parameter										
	Site Name	**Primary Pool**	**Beaver Pond**	**Pool Tailout**	**Glide**	**Large Cobble Riffle**	**Small Cobble Riffle**	**Rapids**	**Total Pools**	**Total Riffles**	**Cascade Falls**	**Dry**
Annual Sites	akɬxwminaʔ-317	8.0%	0.0%	1.0%	0.0%	37.0%	51.0%	0.0%	8.0%	92.0%	3.0%	0.0%
	McLean-374	53.6%	0.0%	11.8%	0.0%	0.0%	34.5%	0.0%	53.6%	46.4%	0.0%	0.0%
	snpinʾyaʔtkw-470	0.0%	0.0%	0.0%	0.0%	18.2%	78.2%	0.0%	0.0%	100.0%	3.6%	0.0%
	q̓awsitkʷ-490	0.0%	0.0%	0.0%	72.0%	22.0%	6.0%	0.0%	72.0%	28.0%	0.0%	0.0%
	q̓awsitkʷ-493	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
	Shuttleworth-522	10.0%	0.0%	0.9%	0.0%	7.3%	78.2%	0.0%	10.0%	90.0%	3.6%	0.0%
	akskʷəkʷant-535	17.3%	0.0%	2.7%	0.0%	0.0%	80.0%	0.0%	17.3%	82.7%	0.0%	0.0%
	snʕax̌əlqaxʷiyaʔ-1251	15.0%	0.0%	5.0%	0.0%	51.0%	0.0%	0.0%	15.0%	85.0%	29.0%	0.0%
Panel 3 Sites	Shuttleworth-364	25.0%	0.0%	6.0%	0.0%	14.0%	53.0%	0.0%	25.0%	75.0%	2.0%	0.0%
	q̓awsitkʷ-371	8.0%	0.0%	4.0%	88.0%	0.0%	0.0%	0.0%	96.0%	4.0%	0.0%	0.0%
	Shatford-507	16.0%	0.0%	5.0%	0.0%	49.0%	0.0%	0.0%	16.0%	84.0%	30.0%	0.0%
	akɬxwminaʔ-541	14.5%	0.0%	2.7%	0.0%	57.3%	4.5%	0.0%	14.5%	85.5%	20.9%	0.0%
	q̓awsitkʷ-575	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
	snʕax̌əlqaxʷiyaʔ-598	16.4%	0.0%	1.8%	9.1%	29.1%	43.6%	0.0%	25.5%	74.5%	0.0%	0.0%
	akskʷəkʷant-1253	52.0%	0.0%	6.0%	0.0%	0.0%	42.0%	0.0%	52.0%	48.0%	0.0%	0.0%
	snpinʾyaʔtkw-1254	5.0%	0.0%	3.0%	0.0%	92.0%	0.0%	0.0%	5.0%	95.0%	0.0%	0.0%

Table 6. Substrate characteristics for eight annual EMAP sites and eight panel 3 sites sampled in the q̓awsitkʷ Basin in 2012. Percentages listed are the proportion of the reach that consists of the listed substrate type.

		Substrate Parameter										
	Site Name	**Bedrock**	**Boulder**	**Large Cobble**	**Small Cobble**	**Course Gravel**	**Fine Gravel**	**Sand**	**Silt/Clay/Muck (FN)**	**Hard Pan**	**Wood**	**Other**
Annual Sites	akɬxwminaʔ-317	0.0%	4.8%	14.3%	34.3%	4.8%	0.5%	7.6%	1.4%	19.5%	4.8%	8.1%
	McLean-374	0.0%	0.0%	0.0%	0.5%	21.6%	3.7%	20.0%	2.1%	0.5%	15.3%	36.3%
	snpinˀyaʔtkw-470	0.0%	9.0%	20.0%	43.3%	5.7%	0.5%	3.3%	0.0%	3.3%	9.0%	5.7%
	q̓awsitkʷ-490	0.0%	6.7%	1.9%	47.6%	15.7%	0.5%	8.6%	2.4%	0.0%	2.4%	14.3%
	q̓awsitkʷ-493	0.0%	8.6%	20.0%	50.5%	21.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Shuttleworth-522	0.0%	2.4%	7.1%	40.5%	14.8%	2.4%	19.0%	0.5%	0.0%	6.2%	7.1%
	akskʷəkʷant-535	0.0%	2.4%	6.2%	14.3%	19.5%	2.9%	22.9%	2.4%	1.0%	19.5%	9.0%
	snʕax̌əlqaxʷiyaʔ-1251	0.0%	39.5%	26.2%	14.3%	10.5%	1.0%	4.3%	0.0%	1.0%	2.9%	0.5%
Panel Sites	Shuttleworth-364	0.0%	7.6%	21.0%	30.0%	11.0%	2.4%	8.1%	0.0%	0.0%	6.7%	13.3%
	q̓awsitkʷ-371	0.0%	4.3%	1.9%	36.2%	48.6%	0.5%	1.0%	0.0%	0.0%	0.5%	7.1%
	Shatford-507	0.0%	22.9%	21.4%	7.1%	8.1%	0.5%	6.2%	0.0%	0.0%	13.3%	20.5%
	akɬxwminaʔ-541	0.0%	21.0%	20.5%	11.4%	7.6%	4.8%	7.1%	1.0%	0.0%	13.8%	12.9%
	q̓awsitkʷ-575	0.0%	1.9%	1.4%	31.4%	20.0%	5.2%	30.5%	0.0%	0.0%	0.0%	9.5%
	snʕax̌əlqaxʷiyaʔ-598	0.0%	11.9%	24.3%	21.4%	15.7%	8.1%	7.1%	1.0%	1.9%	5.2%	3.3%
	akskʷəkʷant-1253	0.0%	0.0%	0.0%	18.6%	14.3%	4.3%	35.2%	8.6%	8.6%	6.2%	4.3%
	snpinˀyaʔtkw-1254	1.4%	37.6%	37.1%	17.1%	1.4%	0.0%	0.5%	0.0%	1.9%	1.0%	1.9%

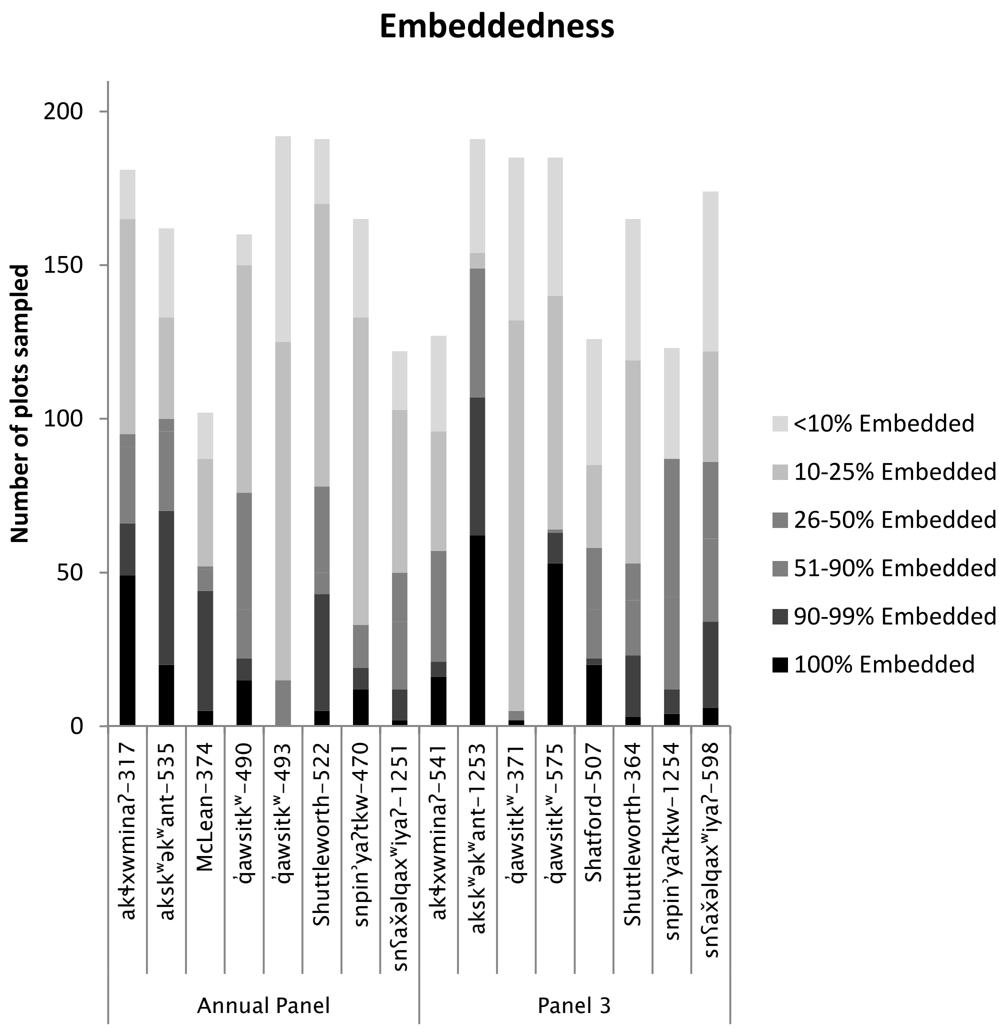


Figure 6. Graph of embeddedness coverage according to the number of substrate plots sampled per site in 2012. Darker shades represent percent coverage of area containing more embedded substrate and lighter shades represent percent coverage of area with less embedded substrate.

Table 7. Riparian vegetation attributes for eight annual EMAP sites and eight Panel 3 sites sampled in the q̓awsitkʷ Basin in 2012. Values listed are the percentages of the riparian area plots where a zero-count was not observed.

		Riparian Vegetation Parameter									
	Site Name	Canopy Deciduous	Overstory Big Trees	Overstory Small Trees	Understory Deciduous	Understory Woody Shrubs and Saplings	Understory non-woody	Ground-Cover Woody shrubs/saplings	Ground cover Non-woody	Ground cover Bare Dirt/duff	Ground cover LWD
Annual Sites	akɬxwminaʔ-317	40.9%	90.9%	86.4%	36.4%	100.0%	59.1%	95.5%	100.0%	100.0%	100.0%
	McLean-374	31.8%	40.9%	45.5%	77.3%	86.4%	100.0%	100.0%	100.0%	22.7%	95.5%
	snpinʼyaʔtkw-470	81.8%	100.0%	100.0%	81.8%	100.0%	18.2%	100.0%	90.9%	100.0%	95.5%
	q̓awsitkʷ-490	90.9%	27.3%	86.4%	100.0%	95.5%	50.0%	100.0%	90.9%	81.0%	38.1%
	q̓awsitkʷ-493	31.8%	18.2%	22.7%	54.5%	13.6%	100.0%	45.5%	100.0%	31.8%	0.0%
	Shuttleworth-522	81.8%	90.9%	90.9%	68.2%	100.0%	72.7%	100.0%	100.0%	77.3%	95.5%
	akskʷəkʷant-535	95.5%	81.8%	95.5%	100.0%	95.0%	31.8%	100.0%	100.0%	100.0%	100.0%
	snʕax̌əlqaxʷiyaʔ-1251	9.1%	77.3%	81.8%	13.6%	100.0%	13.6%	100.0%	54.5%	100.0%	61.9%
Panel 3 Sites	Shuttleworth-364	4.5%	90.9%	95.5%	9.1%	100.0%	31.8%	100.0%	100.0%	100.0%	100.0%
	q̓awsitkʷ-371	59.1%	27.3%	50.0%	95.5%	90.9%	63.6%	100.0%	100.0%	77.3%	0.0%
	Shatford-507	9.1%	100.0%	100.0%	22.7%	100.0%	63.6%	100.0%	100.0%	100.0%	100.0%
	akɬxwminaʔ-541	22.7%	86.4%	95.5%	77.3%	100.0%	31.8%	95.5%	95.5%	100.0%	100.0%
	q̓awsitkʷ-575	40.9%	36.4%	27.3%	72.7%	95.5%	81.8%	100.0%	95.5%	63.6%	0.0%
	snʕax̌əlqaxʷiyaʔ-598	31.8%	54.5%	63.6%	59.1%	95.5%	36.4%	100.0%	95.5%	100.0%	90.9%
	akskʷəkʷant-1253	36.4%	18.2%	36.4%	95.5%	95.5%	90.9%	95.5%	100.0%	72.7%	72.7%
	snpinʼyaʔtkw-1254	63.6%	40.9%	100.0%	72.7%	100.0%	9.5%	100.0%	100.0%	100.0%	72.7%

Table 8: Human influence parameters for eight annual EMAP sites and eight Panel 3 sites sampled in the q̓awsitkʷ Basin in 2012. Values listed are the number of observations (both banks for each transect, maximum of 22) where the listed Human Influence Parameter was observed.

		Human Influence Parameters																	
	Site Name	Walls	Concrete Dam	Rock Dam	Buildings	River Access	Roads	Pipes	Garbage	Cleared Lot	Orchard	Pasture	Fence	Head Gate	Pump	Pump No Screen	Logging	Mining	Diversion Ditch
Annual Sites	akɬxwminaʔ-317	0	0	10	9	0	2	0	12	1	0	0	0	0	0	0	0	0	0
	McLean-374	0	0	0	0	0	0	0	1	3	0	0	1	0	0	0	0	0	0
	snpinʾyaʔtkw-470	0	0	22	17	0	17	1	20	7	0	0	0	0	0	0	0	0	0
	q̓awsitkʷ-490	11	0	1	3	0	9	2	0	2	3	0	0	0	0	0	0	0	0
	q̓awsitkʷ-493	22	0	0	0	0	22	2	0	0	0	0	0	0	0	0	0	0	0
	Shuttleworth-522	0	0	0	0	0	7	0	0	7	0	13	19	0	0	0	0	0	0
	akskʷəkʷant-535	0	0	0	0	0	2	0	0	0	0	20	12	0	0	0	0	0	0
	snʕax̌əlqaxʷiyaʔ-1251	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	4
Panel 3 Sites	Shuttleworth-364	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	q̓awsitkʷ-371	22	0	2	0	0	22	2	0	0	0	0	0	0	0	0	0	0	0
	Shatford–507	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	akɬxwminaʔ-541	0	0	0	0	0	6	0	0	0	0	22	0	0	0	0	0	0	0
	q̓awsitkʷ-575	20	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0
	snʕax̌əlqaxʷiyaʔ-598	0	0	7	1	0	14	0	1	0	0	1	6	0	0	0	0	0	0
	akskʷəkʷant-1253	0	0	0	0	0	0	0	0	0	0	22	7	0	0	0	0	0	0
	snpinʾyaʔtkw-1254	2	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0

3.2 Water quantity (discharge) surveys

The mean monthly discharges (m^3/s) for five WSC hydrometric stations are summarized below in Figure 7. The longest data set is from 1915 to 2012 for "OK River at OK Falls". Peak discharges typically occur from May to July.

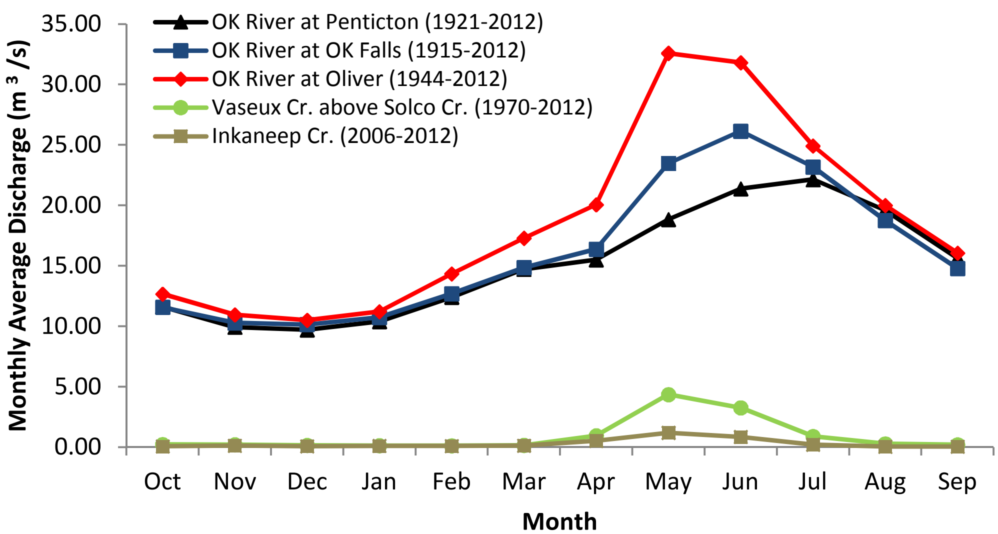


Figure 7. Historic mean monthly discharge (m^3/s) from five WSC real-time hydrometric stations in the q̓awsitkʷ sub-basin (Environment Canada, 2012).

Mean daily discharge rates for the q̓awsitkʷ main-stem are depicted in Figure 8 for the 2012 water year. Data presented are provisional and not endorsed by Environment Canada until further quality control and assurance protocols have been conducted. Discharges depicted are not the natural hydrograph as discharge is controlled at the Kɬusxənitkʷ outlet dam in snpintktn, the q̓awst'ik'ʷt outlet dam in sx̌wəx̌wnikw, and nʕaylintən at the outlet of np'əxɬpiw's (Symonds, 2000).

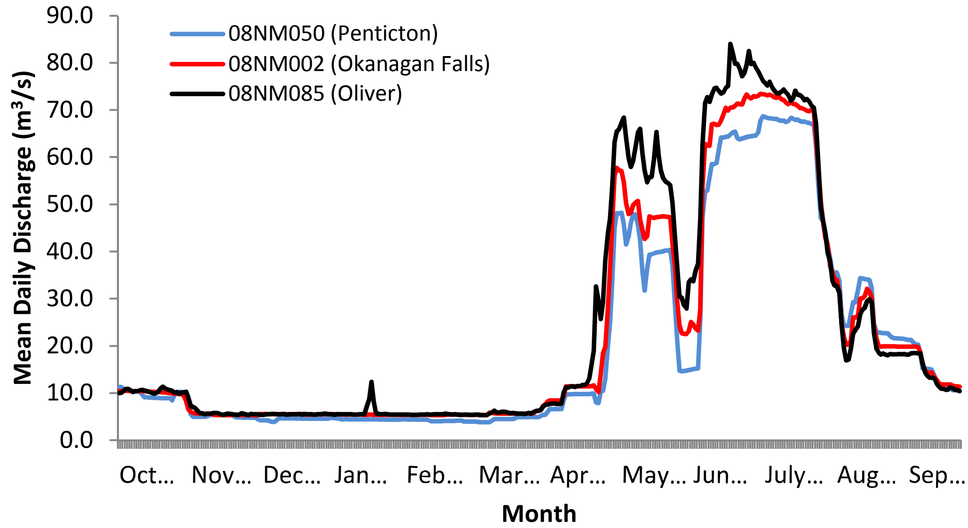


Figure 8. Mean daily discharge for the 2012 water year in the q̓awsitkʷ for the three WSC stations at snpintktn, sx̌ʷəx̌wnikw and nʕaləm'xnitkʷ (Environment Canada, 2012).

The mean daily discharge rates for the WSC hydrometric stations located at the mouth of akskʷəkʷant and at snʕax̌əlqaxʷiyaʔ are depicted below in Figure 8, as well as, the daily discharge rate from the City of Penticton for snpin'yaʔtkʷ for the 2012 water year (October 2011 to October 2012).

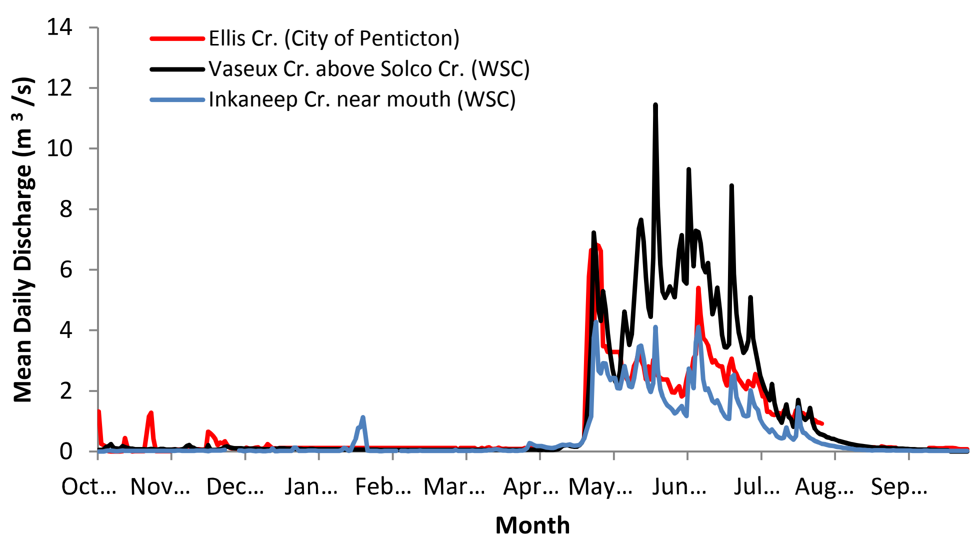


Figure 9. Mean daily discharge (m^3/s) for three tributaries to the q̓awsitkʷ; snpin'yaʔtkʷ at snpintktn, snʕax̌əlqaxʷiyaʔ and akskʷəkʷant (Environment Canada, 2012).

The hydrographs for the 4 stations monitored by ONA staff on Shuttleworth Creek and snʕax̌əlqaxʷiyaʔ are based on preliminary data and Stage-Discharge rating curves with very few points. The hydrographs are not represented here but are shown in Appendix IV. More established Stage-Discharge rating curves need to be developed in order to represent the hydrographs with a higher level of confidence.

3.3 Water quality surveys

McKean and Nagpal (1991) noted that pH values >9.0 are likely harmful to salmonids and perch during long-term exposure. In 2012, pH values in exceeding 9.0 were encountered snpinʾyaʔtkw -470, Shuttleworth-522 and akɬxwminaʔ -317 (Appendix V).

Cobel (1961) found that Xʷuminaʔ embryo survival was correlated to dissolved oxygen in redds. Cobel noted a survival rate of 62% at 9.25mg/L, and only 16% survival at 2.6mg/L. In May 2012, dissolved oxygen levels in all sites were between 8mg/L and 14mg/L (Appendix V). Higher elevation sites such as Shuttleworth-364 and Shatford-507 were at the lowest levels of dissolved oxygen at 8.8mg/L.

3.4 Water temperature surveys

Brett (1952) determined that the preferred temperature of ntitiyx fingerlings ranges from 12.2°C to 13.9°C, with an upper lethal temperature for ntitiyx fry at 25°C. The upper lethal temperature for Xʷuminaʔ fingerlings was determined to be 24°C after being acclimated down to 11°C in laboratory studies (Black, 1953). Between July and August 2012, mean daily temperatures for all the main-stem q̓awsitkʷ sites approached 25°C (Figures 10, 11 and 13).

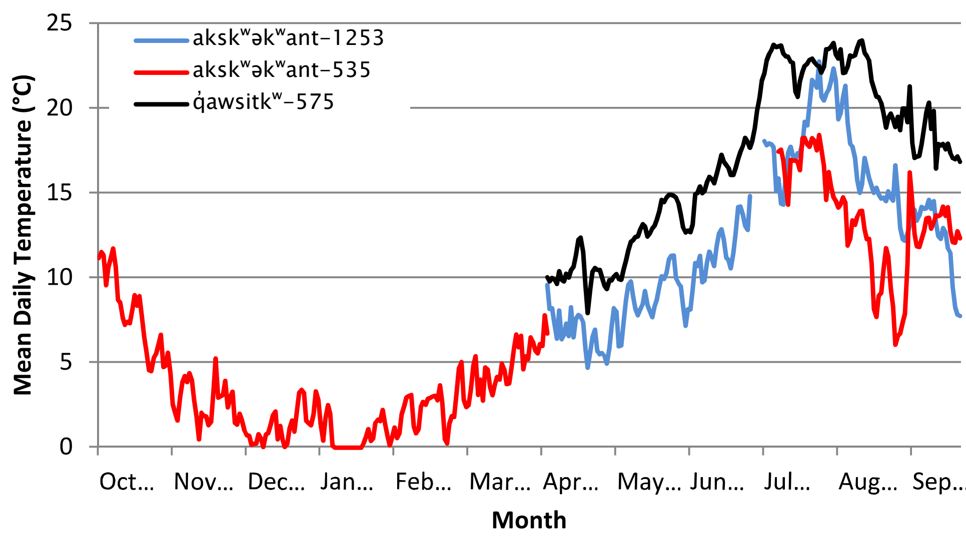


Figure 10. Mean daily temperatures observed at EMAP sites akskʷəkʷant-535, akskʷəkʷant-1253, and q̓awsitkʷ-575 for the 2012 water year.

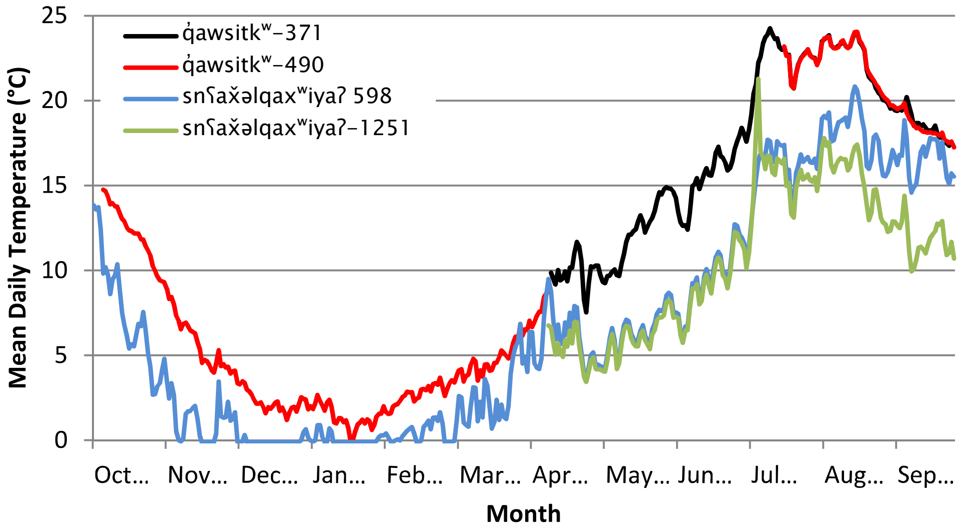


Figure 11. Mean daily temperatures observed at EMAP sites q̓awsitkʷ-371, q̓awsitkʷ-490, snʕaχ̌əlqaxʷiyaʔ-598, and snʕaχ̌əlqaxʷiyaʔ-1251 for the 2012 water year.

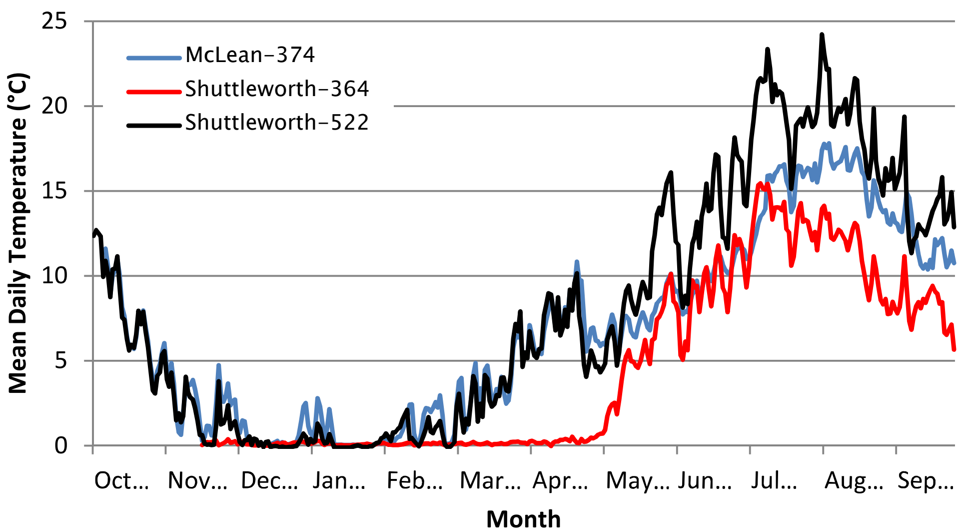


Figure 12. Mean daily temperatures observed at EMAP sites Shuttleworth-364, Shuttleworth-522, and McLean-374 for the 2012 water year.

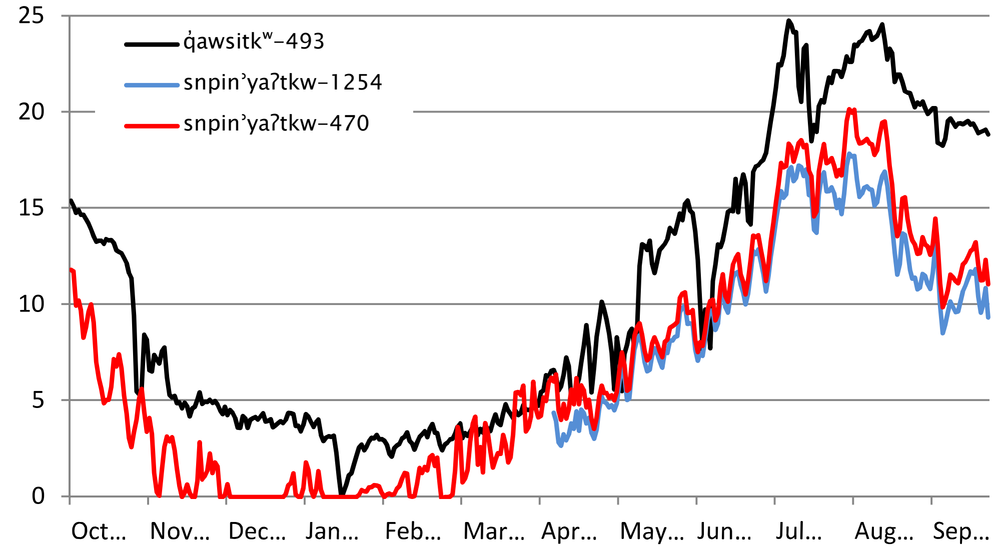


Figure 13. Mean daily temperatures observed at EMAP sites snpin'yaʔtkw-1254, snpin'yaʔtkw-470, and q̓awsitkʷ-493 for the 2012 water year.

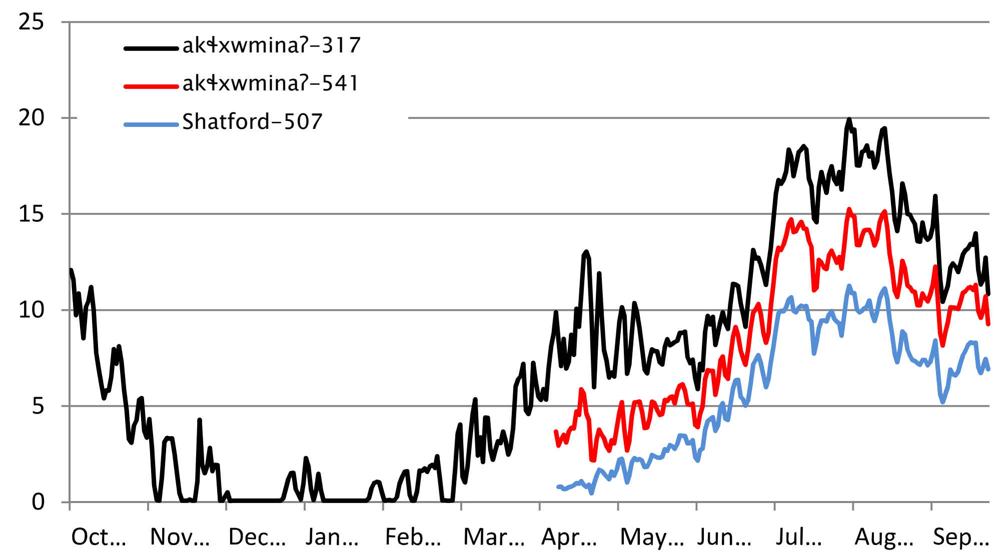


Figure 14. Mean daily temperatures observed at EMAP sites at akɬxwminaʔ-317, akɬxwminaʔ-541, and Shatford-507 for the 2012 water year.

3.5 Snorkel surveys

In 2012, snorkel surveys were completed in August and September. Most tributary sites were done from August 28 to 31. EMAP sites snpin'yaʔtkw-1254, Shuttleworth-364, and snʕax̌əlqaxʷiyaʔ–1251 were done on September 12. The main-stem sites were done in one day on September 6. In snʕax̌əlqaxʷiyaʔ, the lower site (598) was almost completely dry with the exception of one large pool and about a dozen smaller pools.

The highest number of Xwuminaʔ juveniles were observed in snʕax̌əlqaxʷiyaʔ-1251 (256 individuals) and akskʷəkʷant–1253 (221 individuals). No Xwuminaʔ juveniles were observed in q̓awsitkʷ–371 or q̓awsitkʷ–575 or snpinˀyaʔtkw-1254 (Figure 15). A total of 803 juvenile Xwuminaʔ were observed in the Canadian portion of the q̓awsitkʷ basin through snorkel counts in 2012 (Appendix VI).

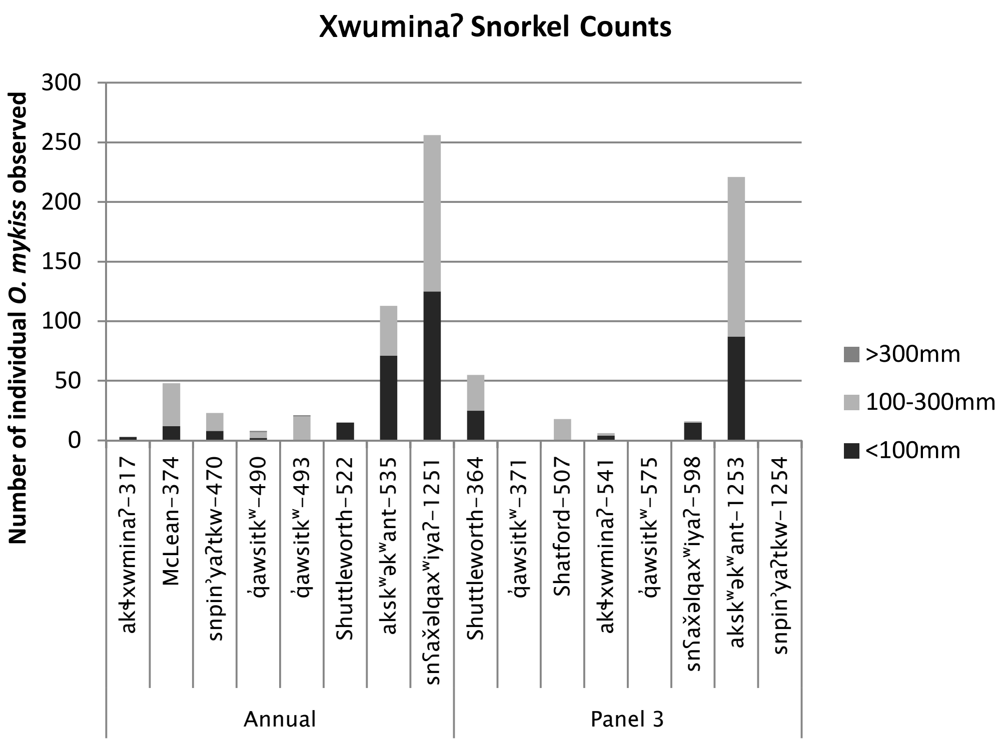


Figure 15. Number of individual Xwuminaʔ juveniles per EMAP site by size class observed through snorkel counts in 2012.

One adult ntitiyx was observed in q̓awsitkʷ–490 and one adult sćwin was observed in q̓awsitkʷ-575 (Appendix VI).

Non-salmonid fish species observed in 2012 snorkel counts include Common Carp (*Cyprinus carpio*), Longnose Dace (*Rhinichthys cataractae*), Northern Pikeminnow (*Ptychocheilus oregonensis*), Sculpins (*Cottus* sp.), Smallmouth Bass (*Micropterus dolomieu*), various Suckers (*Catostomus* sp.) and Bridgelip Sucker (*Catostomus columbianus*) (Figure 16). A total of 1498 individual non-salmonids were observed through snorkel counts in 2012 (Appendix VII).

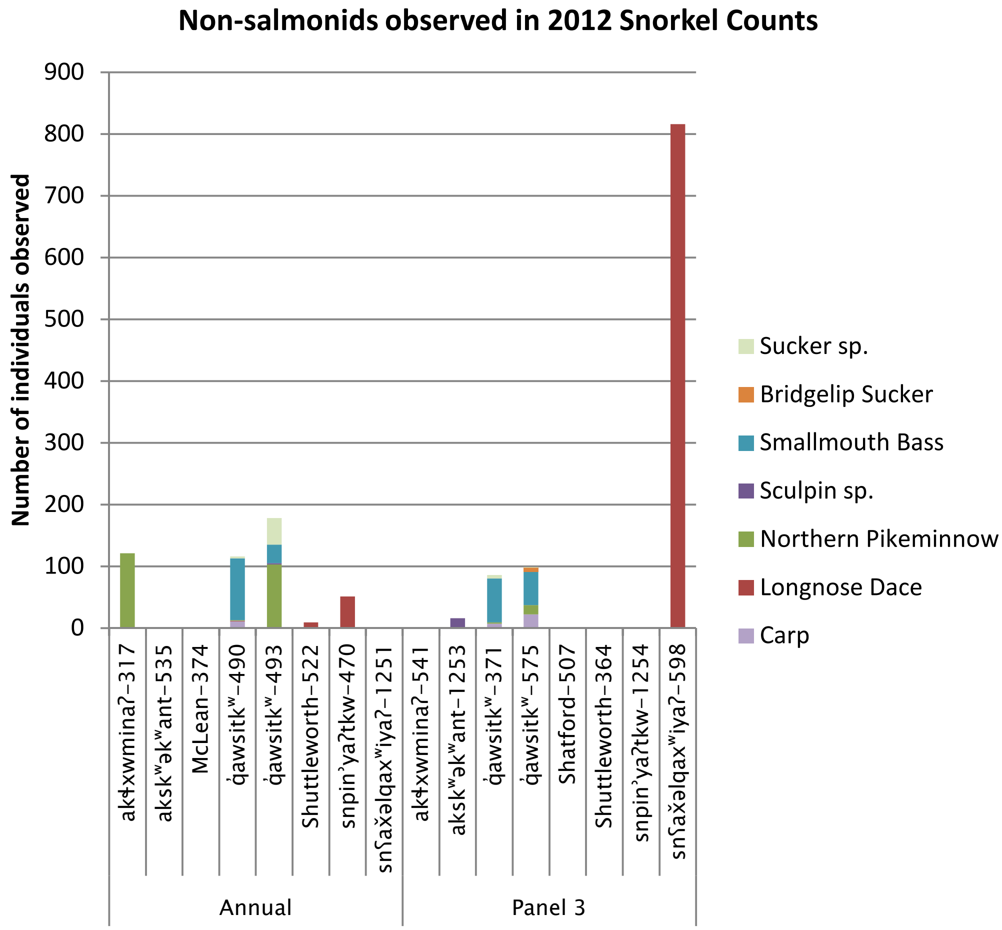


Figure 16. Number of non-salmonid individuals observed at EMAP sites through snorkel counts in 2012.

3.6 Benthic macroinvertebrate surveys

In 2012, benthic macroinvertebrate samples were collected from the Canadian portion of the q̓awsitkʷ basin between October 02 and October 12 from 14 of the 16 OBMEP sites (Shuttleworth-522 and snʕax̌əlqaxʷiyaʔ–598 were not sampled because they were completely dry). All other tributary sites were wadeable and so samples are representative of the entire cross-section; however, q̓awsitkʷ main-stem sites were not wadeable and so samples were only taken near the banks in wadeable areas. A summary of EMAP sites and biotic indices and measures are listed in Appendices VIII and IX.

Higher elevation sites such as akɬxʷminaʔ-541, Shatford-507 and Shuttleworth-364 showed relatively higher macroinvertebrate diversity and Ephemeroptera, Plecoptera and Trichoptera (EPT) diversity (Figure 17). As well, both sites on akskʷəkʷant (535 and 1253), which were lower elevation sites, showed relatively higher macroinvertebrate diversity. All four sites on the main-stem q̓awsitkʷ, as well as McLean 374, showed relatively lower macroinvertebrate and EPT diversity.

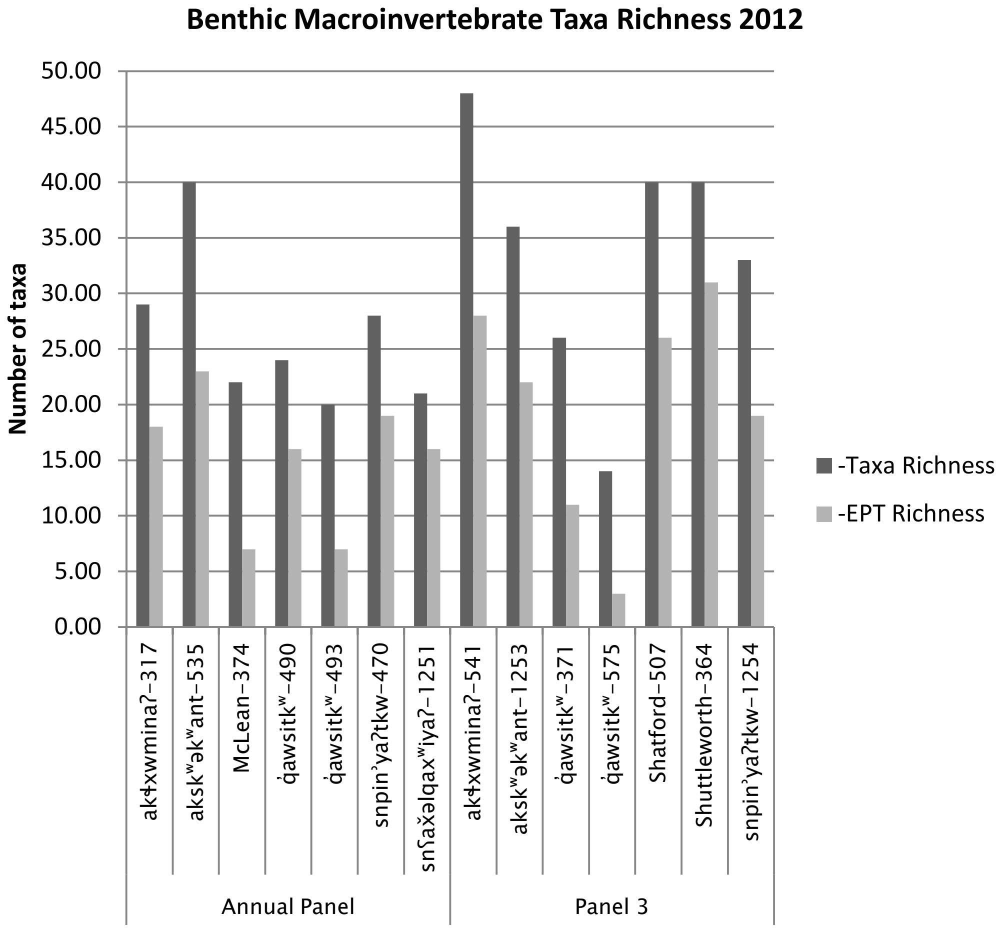


Figure 17. Comparison between EMAP sites of Taxa Richness (number of species) and EPT Richness of benthic macroinvertebrate species sampled in 2012.

According to the five metrics utilized by Jensen (2006), the Benthic Index of Biological Integrity (B-IBI) shows that eight of the ten tributary sites were rated as having “Excellent” stream conditions (Table 9). The main-stem q̓awsitkʷ sites were ranked between “Good” and “Fair” with the exception of q̓awsitkʷ-575 which was “Very Poor” (Table 9).

Table 9. List of EMAP sites showing the multimetric biotic index (B-IBI) scoring for benthic macroinvertebrates (Jensen, 2006) sampled in 2012.

		PARAMETER							
	EMAP Sites	**Total # of taxa**	**Number of Plecoptera (stonefly) taxa**	**Number of Ephemeroptera (mayfly) taxa**	**Number of Trichoptera (caddisfly) taxa**	**Number of intolerant taxa**	**Number of clinger taxa**	**B-IBI score[1]**	**Stream Condition**
Annual Sites	akɬxwminaʔ-317	29.00	3.00	8.00	7.00	12.00	19.00	23	Excellent
	McLean-374	22.00	2.00	2.00	3.00	5.00	9.00	15	Fair
	snpinʾyaʔtkw-470	28.00	6.00	9.00	4.00	12.00	19.00	25	Excellent
	q̓awsitkʷ-490	24.00	3.00	6.00	7.00	7.00	16.00	21	Good
	q̓awsitkʷ-493	20.00	0.00	3.00	4.00	4.00	9.00	15	Fair
	akskʷəkʷant-535	40.00	8.00	8.00	7.00	16.00	22.00	25	Excellent
	snʕax̌əlqaxʷiyaʔ-1251	21.00	1.00	9.00	6.00	12.00	15.00	19	Good
Panel 3 Sites	Shuttleworth-364	40.00	9.00	12.00	10.00	25.00	28.00	25	Excellent
	q̓awsitkʷ-371	26.00	2.00	4.00	5.00	4.00	15.00	21	Good
	Shatford-507	40.00	12.00	6.00	8.00	24.00	26.00	25	Excellent
	akɬxwminaʔ-541	48.00	6.00	11.00	11.00	22.00	28.00	25	Excellent
	q̓awsitkʷ-575	14.00	0.00	2.00	1.00	0.00	4.00	5	Very Poor
	akskʷəkʷant-1253	36.00	8.00	7.00	7.00	15.00	22.00	25	Excellent
	snpinʾyaʔtkw-1254	33.00	4.00	10.00	5.00	18.00	20.00	25	Excellent

3.7 Adult migration

A total of five tagged Xʷuminaʔ were detected at the PIT array on the q̓awsitkʷ channel at VDS 3 (Figure 18, Appendix X). Of the five tags detected, two were wild Xʷuminaʔ and three were hatchery Xʷuminaʔ. Four of the fish were tagged and released at Priest Rapids Dam in mid-August to mid-September 2011 while one fish was released in Omak Creek, WA in April 2010. All five tags were detected between April 1 -28, 2012.

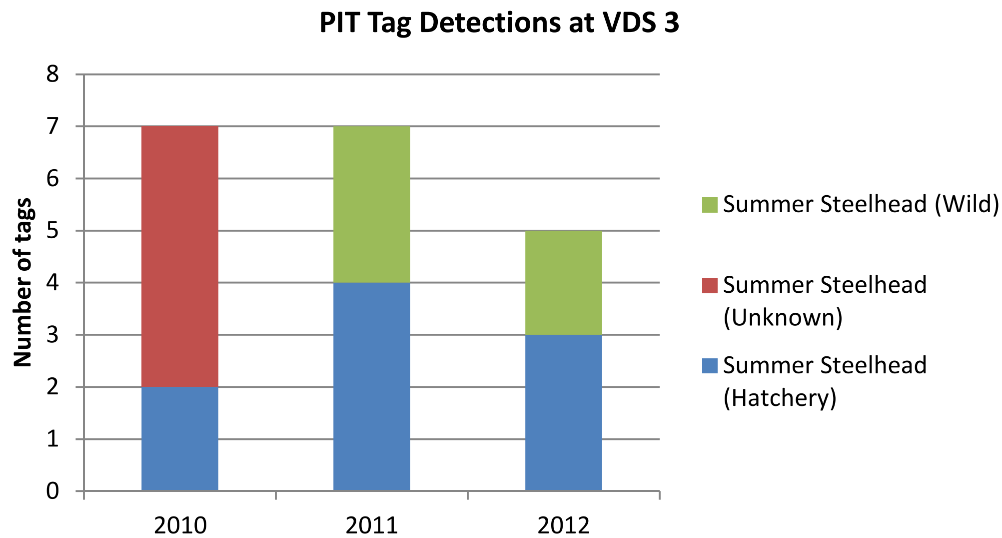


Figure 18. Summary of the number of tagged Xʷuminaʔ detected on the q̓awsitkʷ channel at VDS 3 for 2011 and 2012.

The PIT array at Zosel Dam detects fish entering suwiw̓s (Figure 5). In 2012, a total of 60 Xʷuminaʔ entered suwiw̓s (Table 10). Of these fish, 8.33% entered the q̓awsitkʷ upriver of the lake while in 2011, 16.67% of the fish detected migrated upriver. However, of the proportion migrating upriver of suwiw̓s, a larger proportion of wild Xʷuminaʔ were detected (33.33% in 2011 and 28.57% in 2012). These proportions are based on an extremely small sample sizes and a larger data set over a longer period of time is needed.

Table 10. Summary of tagged Xʷuminaʔ detections at Zosel Dam and q̓awsitkʷ channel at VDS 3 for 2011 and 2012.

	Detection Site		
	OKC	Zosel Dam	% of tagged fish past OKC from Zosel
2011			
Summer Steelhead (Hatchery)	4	31	12.90%
Summer Steelhead (Unknown)		2	0.00%
Summer Steelhead (Wild)	3	9	33.33%
2011 Total	**7**	**42**	**16.67%**
2012			
Summer Steelhead (Hatchery)	3	50	6.00%
Summer Steelhead (Unknown)		3	0.00%
Summer Steelhead (Wild)	2	7	28.57%
2012 Total	**5**	**60**	**8.33%**

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 Physical Habitat Data Analysis

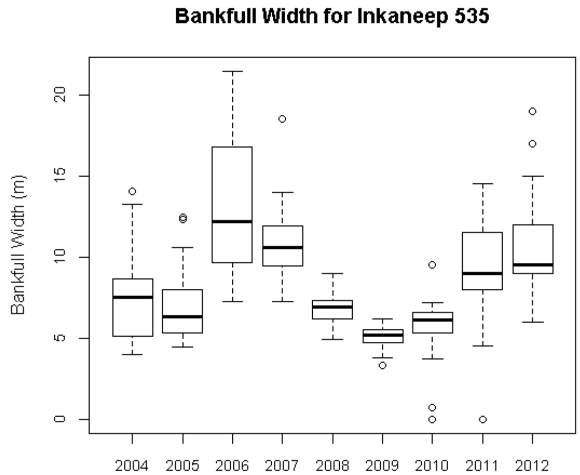
In order to infer status and trend conditions from long-term monitoring data, methodology and sample sizes must be designed spatially and temporally in such a way that statistical difference can be recognized if it occurs or recognized as not occurring if there is no difference. Sampling error including systematic errors are inherent in every study and must be identified and quantified in order for a study to be scientifically defensible. Non-sampling errors including human errors must be identified through Quality Assurance/Quality Control (QA/QC) measures in order to ensure that data collected are as accurate as possible.

In 2012, eight years of previous data were available to analyze, therefore an analysis was done to look at the viability of OBMEP physical habitat data collected in Canada. In order to do this, data were assessed for variability, precision and consistency.

4.1.1 Variability and precision

A number of the physical habitat parameters assessed through OBMEP should not change drastically in one site from year to year in reality. Stream corridor structure parameters especially should not see drastic change unless unusual and considerable geological or climatic factors were present. However, the results from data gathered through OBMEP show a number of parameters with variability that is too high to be considered a natural process but instead must be attributed to the methods of data collection.

Bankfull width is the width that corresponds to a discharge return interval from 1.4 to 1.6 years. This is indicated by the topographic break between channel bank and floodplain in low gradient, meandering streams and indicated by features such as scour lines of roots and banks or height of depositional features in steeper, mountain streams (Hillman, 2006). The average bankfull width should not change drastically from year to year at a site. As an example, bankfull width is shown for aksk^{w}ək^{w}ant – 535 for all years (Figure 19). The average bankfull width ranges from 5.08m (2009) to 13.20m (2006). Since average bankfull width would not realistically change that much in that amount of time and measurements were taken by a variety of technicians, the reason for the high range of averages must be the methods used or the different interpretations of literature on the methods.

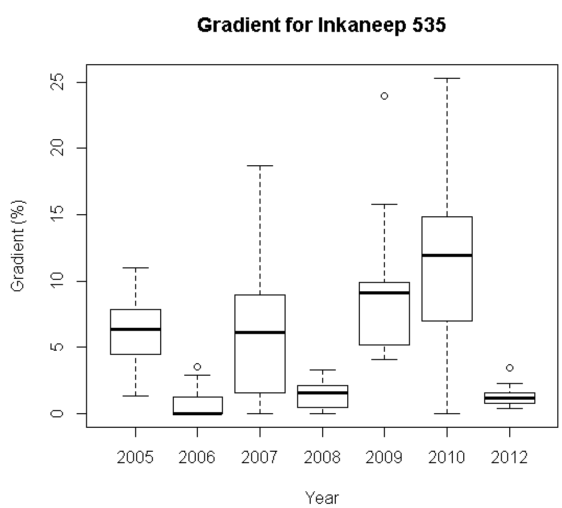


Descriptive Statistics for akskʷəkʷant -535 Bankfull Width			
Year	Mean ± 95% Confidence Intervals (m)	Standard Error $\widehat{SE} = \frac{s}{\sqrt{n}}$	Coefficient of Variation $\widehat{CV} = \frac{s}{\bar{x}}$
2004	7.52 ± 1.26	0.60	0.37 (37%)
2005	7.00 ± 1.10	0.53	0.34 (34%)
2006	13.20 ± 2.09	1.00	0.34 (34%)
2007	10.87 ± 1.12	0.54	0.23 (23%)
2008	6.82 ± 0.42	0.20	0.14 (14%)
2009	5.08 ± 0.33	0.16	0.14 (14%)
2010	5.61 ± 0.90	0.43	0.36 (36%)
2011	9.13 ± 1.38	0.66	0.34 (34%)
2012	10.90 ± 1.58	0.76	0.33 (33%)

Figure 19. Descriptive statistics represented for bankfull width data collection on akskʷəkʷant - 535.

Bankfull width measurements, used as a factor for stream size, influence most other measurements involved in OBMEP physical habitat collection. The length of the site, distance between transects and cross-sectional measurements are all influenced by bankfull width measurements.

Similarly, average stream gradient should not vary from year to year. Gradient data gathered for akskʷəkʷant – 535 (Figure 20) show that the average can range from 0.73% (2006) to 11.86% (2010). This is not realistically possible and must be related to the methods used to collect the data. Gradient data were not collected in 2011 due to concerns about the methods and a new method was used in 2012. The validity of the previous years' data should be questioned.



Descriptive Statistics for akskʷəkʷant -535 Gradients			
Year	Mean ± 95% Confidence Intervals (%)	Standard Error $\widehat{SE} = \frac{s}{\sqrt{n}}$	Coefficient of Variation $\widehat{CV} = \frac{s}{\bar{x}}$
2005	6.33 ± 1.25	0.60	0.43 (43%)
2006	0.73 ± 0.79	0.36	1.70 (170%)
2007	6.63 ± 2.59	1.24	0.86 (86%)
2008	1.40 ± 0.46	0.22	0.70 (70%)
2009	9.82 ± 4.31	1.91	0.61 (61%)
2010	11.86 ± 3.02	1.45	0.57 (57%)
2012	1.28 ± 0.32	0.15	0.54 (54%)

Figure 20. Descriptive statistics represented for gradient data collected on akskʷəkʷant - 535.

4.1.2 Consistency and non-sampling error

Human error, or non-sampling error, can occur when measurement mistakes are made or when field crews collect data inconsistently from year to year. As an example, ground cover parameters are listed (Figure 21) for riparian zone coverage in all Annual Panel sites for each year. The data represented are the number of plots (10m by 10m area on both banks at each transect) per site (a maximum of 22) where zero coverage was recorded.

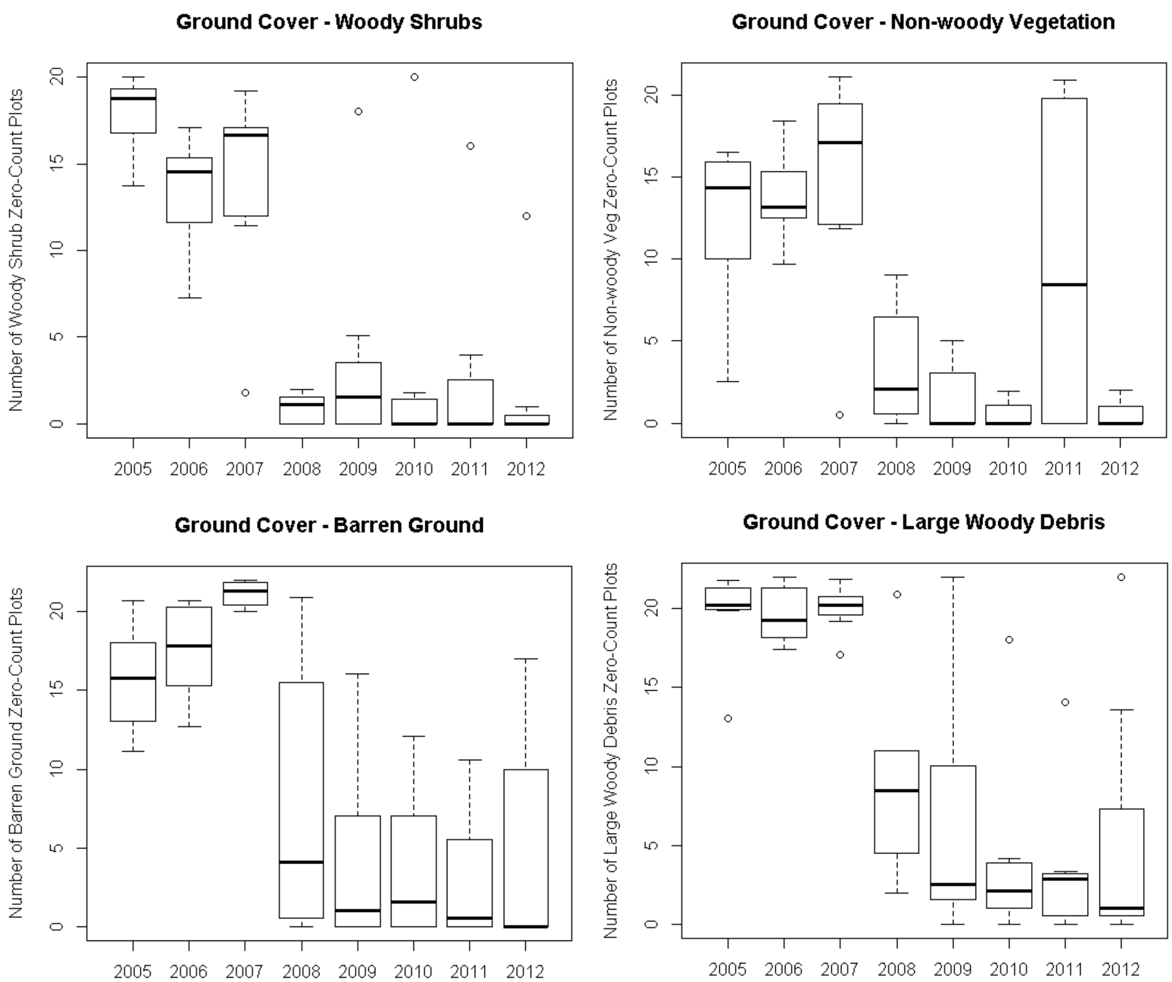


Figure 21. Ground cover parameters collected for riparian zone coverage in all Annual Panel sites for each year.

For all four ground cover parameters, the first three years show a relatively high number of plots with zero coverage for all Annual Panel sites. However, in 2008, the number of plots with zero coverage changes drastically and a relatively low number of plots show zero coverage. This would indicate that the ground cover increased in 2008 for all parameters including Barren Ground. As this is technically impossible, the data do not represent natural factors but instead a change in field methods used to determine riparian coverage. This is an example where the subjectivity of the data collected results in inconsistencies over time.

4.2 Recommendations

The following is a list of recommendations for future years:

- Keep a consistent crew responsible for physical habitat data collection in the field.
- Cross-train crews frequently between Canada and the U.S. to maintain consistency of methods on both sides of the border and to maintain consistency of methods over time.
- Develop and maintain Quality Assurance/Quality Control techniques to ensure that data are complete and accurate.
- Ensure that staff are trained in the use of the Trimble® YUMA® to reduce errors that may take time and resources to fix later.
- Research possible opportunities for integrating Traditional Ecological Knowledge (TEK) into OBMEP.
- Collect flow and water level measurements during high water events to develop better rating curves at water stations.
- Develop methods for collecting discharge during high water events when stream are unwadeable.
- Collect water quality data for attributes when those attributes are actually a limiting factor for salmonids (e.g. collect DO in August and collect Turbidity during spring freshet).
- Coordinate tributary snorkel crews between Canada and the U.S. to ensure consistent intensity of sampling.
- Continue to develop benthic macroinvertebrate methods to incorporate Canadian Aquatic Biomonitoring Network (CABIN) parameters in order to make data comparable to Environment Canada programs.
- Assess the difference in benthic macroinvertebrate collection methods between years in the U.S. and Canada and develop a consistent methodology.
- Develop more confident methods of enumerating adult abundance and spawning activity at low densities.

5.0 REFERENCES

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APPENDICES

Appendix I. Summary of the OBMEP sites in the Canadian portion of the Okanagan sub-basin in the Four Panel setup

Annual Panel	Panel 1 (2010)	Panel 2 (2011)	Panel 3 (2012)	Panel 4 (2013)
q̇awsitkʷ 490	q̇awsitkʷ 383	q̇awsitkʷ 562	**q̇awsitkʷ 371**	q̇awsitkʷ 346
q̇awsitkʷ 493	q̇awsitkʷ 415	q̇awsitkʷ 503	**q̇awsitkʷ 575**	q̇awsitkʷ 426
akskʷəkʷant 535	Haynes 471	akskʷəkʷant 351	**akɬxʷminaʔ 541**	Shatford 477
snʕax̌əlqaxʷiyaʔ 1251[14]	Testalinden 1252	McLean 310	**snpinʼyaʔtkʷ 1254**	Shuttleworth 582
Shuttleworth 522	akskʷəkʷant 1256	Shatford 338	**Shatford 507**	snʕax̌əlqaxʷiyaʔ 1257
akɬxʷminaʔ 317	snʕax̌əlqaxʷiyaʔ 1258	akɬxʷminaʔ 569	**akskʷəkʷant 1253**	snpinʼyaʔtkʷ 492
snpinʼyaʔtkʷ 470	TBD	Shuttleworth 538	**Shuttleworth 364**	McLean 1259
McLean 374[a]	akɬxʷminaʔ 593	Wolfcub 1260	**snʕax̌əlqaxʷiyaʔ 598**	akskʷəkʷant 1255

Panel	Year									
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Annual	x	x	x	x	x	x	x	x	x	x
Panel 1	x					x				x
Panel 2		x					x			
Panel 3			x					x		
Panel 4				x					x	
Panel 5					x			Discontinued		

Panel	Year									
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Annual	x	x	x	x	x	x	x	x	x	x
Panel 1				x				x		
Panel 2	x				x				x	
Panel 3		x				x				x
Panel 4			x				x			

Note: X' denotes a physical and biological survey will be performed.

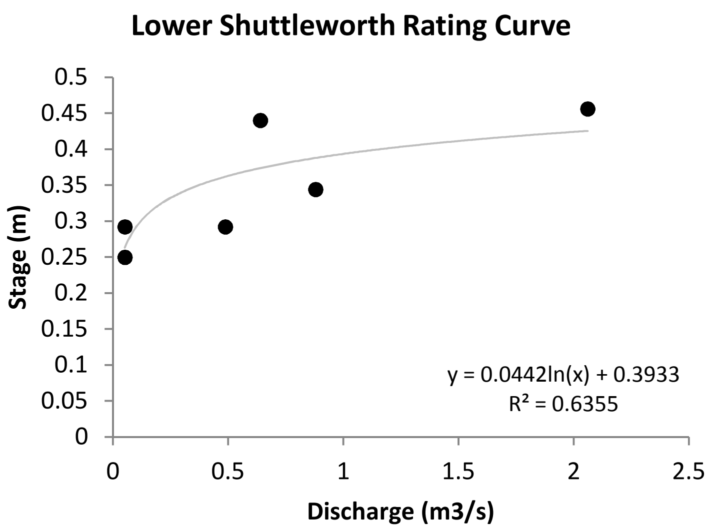
[14] In the Annual Panel, Vaseux 177 has been move and renamed Vaseux 1251.

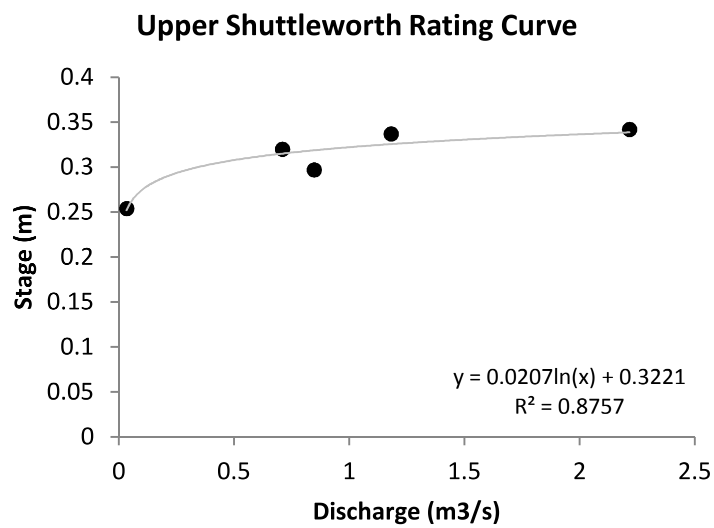
Appendix II. OBMEP physical habitat measurements collected and recorded in the field.

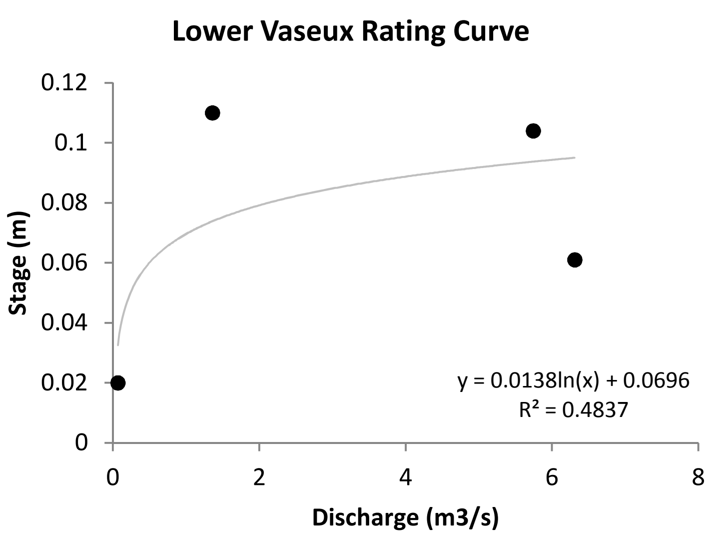
Measurement	General Description	Equipment	Units
Thalweg depth	Deepest depth of a channel cross-section	stadia rod	meters
Entrenchment ratio	Entrenched, moderately entrenched, or slightly entrenched	n/a	no units
Wetted width	Width of water surface measured perpendicular to the direction of flow at a specific discharge*	stadia rod or laser ranging instrument	meters
Bankfull width	Channel width between the tops of the most pronounced banks on either side of a stream reach*	stadia rod or laser ranging instrument	meters
Bankfull heights	Vertical distance from the water surface at the wetted edge to the point of maximum flow elevation occurring on a 1.5 year cycle	stadia rod and a level	meters
Sediment	Unconsolidated, loose deposits with diameter <16 mm i.e. fine gravel, sand, silt, clay or muck	n/a	presence or absence
Habitat types	Glide, primary pool, dry, falls, small cobble riffle, large cobble riffle, pool tailout, beaver pond, rapid, or cascade	n/a	habitat type code
Mid channel bar	Width of mid channel bar if present	stadia rod or laser ranging instrument	meters
Substrate	Classify particle by its median diameter i.e. coarse gravel, boulder, bedrock. Estimate embeddedness as the average % that substrate are surrounded by fine sediments	n/a	substrate size class and embeddedness (%)
Large Woody Debris	Dead trees with diameter >0.1 m in the active channel or spanning the channel	n/a	no. of pieces of each length category (>1 m or >2 m)
Human influence	Pipes, buildings, dikes, pasture, river access site, pavement, garbage piles, cleared lots, orchards, logging or mining operations, diversion structures	n/a	presence or absence, proximity to channel
Canopy cover	Measure riparian vegetation structure in mid-channel, and facing the left and right bank	concave spherical densitometer	number of grid intersection points
Riparian vegetation	Dominant vegetation type and aerial coverage for: canopy layer, understory, and ground cover layer	n/a	vegetation type, % aerial coverage
Side channel	LWD, Thalweg, and substrate	stadia rod	units for each described above
Backwaters	Quiescent off-channel aquatic habitats i.e. sloughs, alcoves, backwater ponds, or oxbows	n/a	presence or absence
Gradients	Gradients between the transects and mid-transects (i.e. A to A1, J1 to K) collected while standing in the thalweg of the stream	Laser Technology, Inc Impulse 200™ laser ranging instrument	percentage

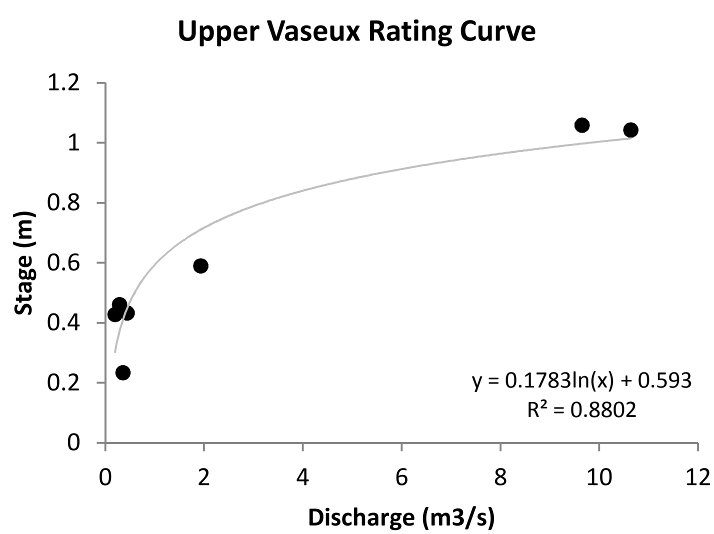
Note: Units are measured to the nearest 0.01m where applicable.
*Armantrout, N.B., Compiler. 1998. Glossary of Aquatic Habitat Inventory Terminology. American Fisheries Society, Bethesda, Maryland.

Appendix III – Rating curves for Shuttleworth Creek and snʕax̌əlqaxʷiyaʔ









Appendix IV – Preliminary hydrographs of 2012 water year for Shuttleworth Creek and snʕax̌əlqaxʷiyaʔ

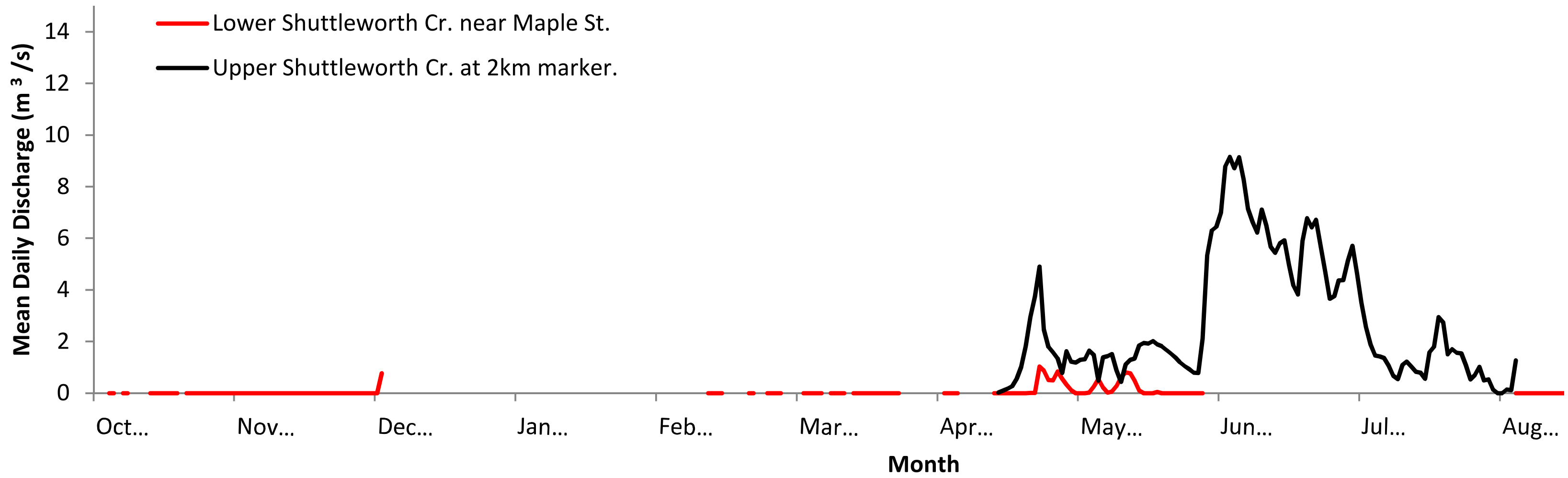


Figure 22. Hydrograph for 2012 water year of two stations on Shuttleworth Creek using preliminary data from ONA rating curve.

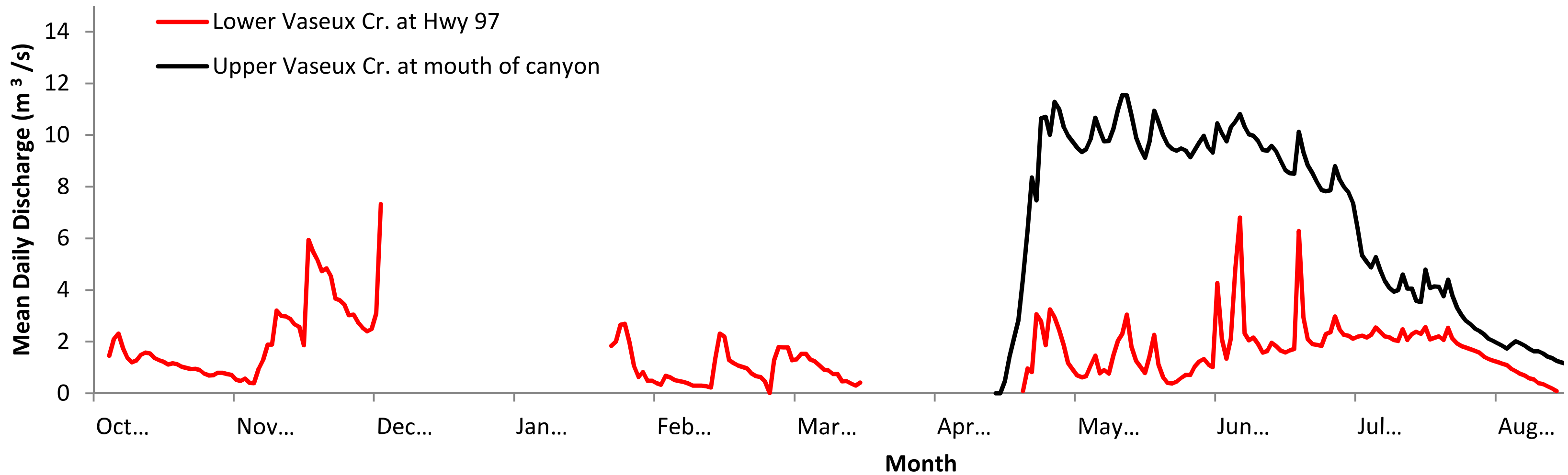
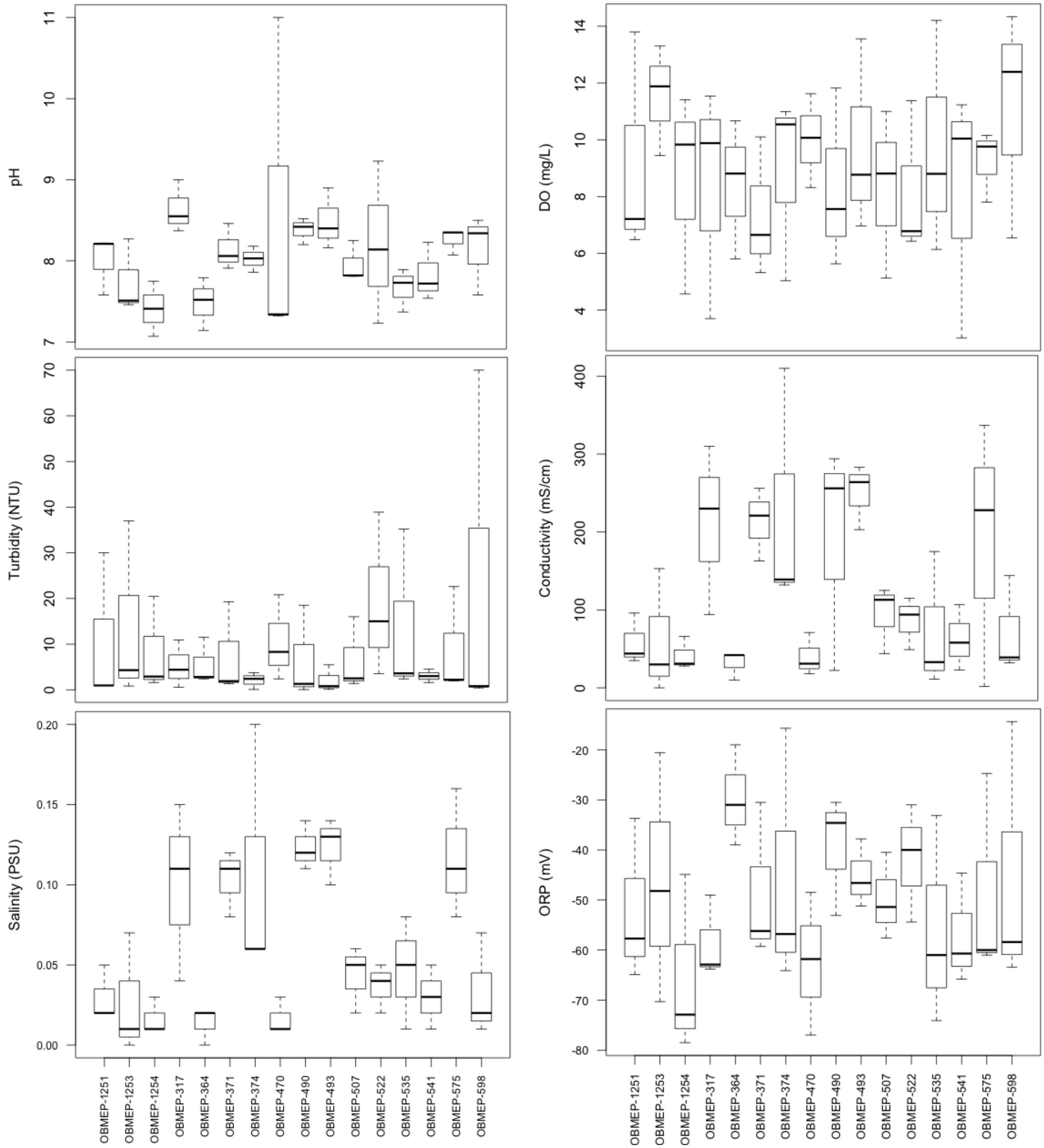


Figure 23. Hydrograph for 2012 water year of two stations on snʕax̌əlqaxʷiyaʔ using preliminary data from ONA rating curves.

Appendix V – Water Quality Results



Appendix VI. Summary of snorkel survey data for Salmonids collected in 2012.

	Salmonid Species				
Site	**ntitiyx**	**Mountain Whitefish**	**Xʷuminaʔ**	**sćwin**	**Site Total**
Annual					
akɬxwminaʔ-317			3		3
akskʷəkʷant-535			113		113
McLean-374			48		48
q̇awsitkʷ-490	1	1	8		10
q̇awsitkʷ-493			21		21
Shuttleworth-522			15		15
snpinʾyaʔtkw-470			23		23
snʕax̌əlqaxʷiyaʔ-1251			256		256
Panel 3					
akɬxwminaʔ-541			6		6
akskʷəkʷant-1253		67	221		288
q̇awsitkʷ-371		1	0		1
q̇awsitkʷ-575		1	0	1	2
Shatford-507			18		18
Shuttleworth-364			55		55
snpinʾyaʔtkw-1254			0		0
snʕax̌əlqaxʷiyaʔ-598			16		16
Total	**1**	**70**	**803**	**1**	**875**

Appendix VII. Summary of snorkel survey data for non-salmonids collected in 2013.

	Non-salmonids									
Site	**Carp**	**Longnose Dace**	**Northern Pikeminnow**	**Sculpin Unknown**	**Smallmouth Bass**	**Sucker Bridgelip**	**Sucker Unknown**	**Turtle**	**Unknown**	**Grand Total**
Annual										
akɬxwminaʔ-317			121						2	123
akskʷəkʷant-535		0								0
McLean-374			0							0
q̓awsitkʷ-490	11	1	1		100		3			116
q̓awsitkʷ-493			103	2	30		43			178
Shuttleworth-522		9								9
snpin’yaʔtkw-470		51							1	52
snʕax̌əlqaxʷiyaʔ-1251									1	1
Panel 3										
akɬxwminaʔ-541					0					0
akskʷəkʷant-1253				16						16
q̓awsitkʷ-371	7		2		71		6	1		87
q̓awsitkʷ-575	22		15		54	7	1			99
Shatford-507					0					0
Shuttleworth-364		0								0
snpin’yaʔtkw-1254									1	1
snʕax̌əlqaxʷiyaʔ-598		816								816
Grand Total	**40**	**877**	**242**	**18**	**255**	**7**	**53**	**1**	**5**	**1498**

Appendix VIII – Summary of benthic macroinvertebrate data for seven EMAP annual sites in 2012.

	Annual Sites						
	akɬxwminaʔ–317	McLean–374	snpinʼyaʔtkw–470	akskʷəkʷant–535	snʕax̌əlqaxʷiyaʔ–1251	q̓awsitkʷ–490	q̓awsitkʷ–493
Collection Date	**3-Oct**	**4-Oct**	**3-Oct**	**9-Oct**	**5-Oct**	**5-Oct**	**12-Oct**
Abundance Measures							
Corrected Abundance	646.00	881.10	249.00	367.08	252.00	449.54	254.00
EPT Abundance	412.00	267.00	159.00	183.54	201.00	332.50	124.00
Richness Measures							
Species Richness	29.00	22.00	28.00	40.00	21.00	24.00	20.00
EPT Richness	18.00	7.00	19.00	23.00	16.00	16.00	7.00
Ephemeroptera Richness	8.00	2.00	9.00	8.00	9.00	6.00	3.00
Plecoptera Richness	3.00	2.00	6.00	8.00	1.00	3.00	0.00
Trichoptera Richness	7.00	3.00	4.00	7.00	6.00	7.00	4.00
Chironomidae Richness	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Oligochaeta Richness	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Non-Chiro. Non-Olig. Richness	27.00	20.00	26.00	38.00	20.00	22.00	18.00
Rhyacophila Richness	0.00	0.00	0.00	1.00	1.00	0.00	0.00
Functional Group Composition							
% Filterers	47.06	3.33	18.88	15.53	7.54	18.05	61.02
% Gatherers	24.15	50.61	31.73	47.20	20.24	43.49	4.33
% Predators	3.41	17.58	7.23	15.53	2.38	8.58	31.89
% Scrapers	15.48	27.88	8.84	12.73	7.14	28.11	2.76
% Shredders	9.60	0.30	30.52	8.70	61.11	1.48	0.00
% Piercer-Herbivores	0.00	0.30	0.40	0.00	0.00	0.00	0.00
% Unclassified	0.00	0.00	0.00	0.31	0.00	0.30	0.00
Filterer Richness	4.00	1.00	3.00	5.00	2.00	2.00	3.00
Gatherer Richness	9.00	6.00	7.00	7.00	5.00	7.00	4.00
Predator Richness	5.00	9.00	6.00	15.00	3.00	7.00	8.00
Scraper Richness	5.00	4.00	4.00	6.00	6.00	4.00	5.00
Shredder Richness	5.00	1.00	5.00	6.00	3.00	3.00	0.00
Piercer-Herbivore Richness	0.00	1.00	1.00	0.00	0.00	0.00	0.00
Unclassified	0.00	0.00	0.00	1.00	0.00	1.00	0.00
Biotic Indices							
% Indiv. w/ HBI Value	97.52	97.27	97.59	95.65	100.00	99.70	85.83
Hilsenhoff Biotic Index	4.33	4.64	3.99	3.74	2.37	3.59	4.77
% Indiv. w/ MTI Value	79.26	39.09	67.87	40.68	81.35	72.19	81.10
Metals Tolerance Index	4.37	3.80	3.12	3.30	2.44	3.57	4.68
% Indiv. w/ FSBI Value	82.66	56.97	55.42	60.56	60.71	57.10	62.99
Fine Sediment Biotic Index	96.00	42.00	93.00	105.00	90.00	57.00	18.00
FSBI - average	3.31	1.91	3.32	2.62	4.29	2.38	0.90
FSBI - weighted average	4.77	3.48	4.32	3.52	4.45	4.50	3.26
% Indiv. w/ TPM Value	88.85	68.79	68.67	70.19	96.43	60.36	64.96
Temp. Pref. Metric - average	3.66	2.68	2.86	3.20	4.48	2.00	1.10
TPM - weighted average	3.33	4.78	4.12	5.27	5.29	3.12	2.48

Appendix IX – Summary of benthic macroinvertebrate data for seven EMAP Panel 3 sites in 2012.

	Panel 3 Sites						
	Shuttleworth–364	**Shatford–507**	**akɬxwminaʔ–541**	**akskʷəkʷant–1253**	**snpinʼyaʔtkw–1254**	**q̓awsitkʷ–371**	**q̓awsitkʷ–575**
Collection Date	**4-Oct**	**2-Oct**	**2-Oct**	**9-Oct**	**3-Oct**	**10-Oct**	**10-Oct**
Abundance Measures							
Corrected Abundance	875.76	160.00	913.14	384.18	336.00	123.00	59.00
EPT Abundance	691.53	118.00	718.23	181.26	264.00	55.00	5.00
Richness Measures							
Species Richness	40.00	40.00	48.00	36.00	33.00	26.00	14.00
EPT Richness	31.00	26.00	28.00	22.00	19.00	11.00	3.00
Ephemeroptera Richness	12.00	6.00	11.00	7.00	10.00	4.00	2.00
Plecoptera Richness	9.00	12.00	6.00	8.00	4.00	2.00	0.00
Trichoptera Richness	10.00	8.00	11.00	7.00	5.00	5.00	1.00
Chironomidae Richness	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Oligochaeta Richness	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Non-Chiro. Non-Olig. Richness	38.00	39.00	46.00	34.00	31.00	24.00	12.00
Rhyacophila Richness	3.00	4.00	1.00	1.00	0.00	0.00	0.00
Functional Group Composition							
% Filterers	7.62	0.00	2.05	23.74	9.52	21.14	5.08
% Gatherers	40.55	16.25	20.18	25.82	31.55	56.91	69.49
% Predators	12.80	42.50	11.11	19.88	5.36	10.57	23.73
% Scrapers	12.20	19.38	46.78	19.58	19.05	5.69	1.69
% Shredders	25.30	16.88	13.45	10.98	33.04	5.69	0.00
% Piercer-Herbivores	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Unclassified	0.00	0.62	0.00	0.00	0.00	0.00	0.00
Filterer Richness	4.00	0.00	4.00	5.00	3.00	5.00	1.00
Gatherer Richness	9.00	9.00	12.00	8.00	11.00	10.00	6.00
Predator Richness	10.00	17.00	15.00	13.00	7.00	8.00	6.00
Scraper Richness	7.00	3.00	8.00	4.00	6.00	2.00	1.00
Shredder Richness	8.00	9.00	7.00	6.00	4.00	1.00	0.00
Piercer-Herbivore Richness	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unclassified	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Biotic Indices							
% Indiv. w/ HBI Value	96.95	87.50	94.44	97.92	98.21	96.75	96.61
Hilsenhoff Biotic Index	2.81	1.39	1.55	4.04	2.61	4.97	6.11
% Indiv. w/ MTI Value	65.24	37.50	83.92	61.72	84.52	61.79	23.73
Metals Tolerance Index	2.93	1.17	1.92	3.92	2.42	3.82	3.93
% Indiv. w/ FSBI Value	77.13	65.62	79.82	69.14	61.01	52.03	1.69
Fine Sediment Biotic Index	146.00	109.00	126.00	103.00	116.00	39.00	4.00
FSBI - average	3.65	2.72	2.62	2.86	3.52	1.50	0.29
FSBI - weighted average	4.42	5.28	5.58	3.89	4.85	4.36	4.00
% Indiv. w/ TPM Value	80.18	81.88	87.43	85.16	83.63	62.60	15.25
Temp. Pref. Metric - average	4.72	4.97	3.92	3.42	4.27	1.31	0.57
TPM - weighted average	5.60	7.20	6.23	5.22	5.22	2.39	2.89

Appendix X – PIT Tag Detections at OKC (VDS 3) and Zosel Dam in 2012

Tag Number	Stock	OKC Observation Date	Release Site	Release Date
3D9.1C2D28010C	Summer Steelhead (Hatchery)	April 18, 2012	Omak Creek, WA	April 12, 2010
3D9.1C2D8CFDD3	Summer Steelhead (Hatchery)	April 14, 2012	Priest Rapids Dam, WA	August 25, 2011
3D9.1C2D8E79B0	Summer Steelhead (Wild)	April 9, 2012	Priest Rapids Dam, WA	September 13, 2011
3D9.1C2D8FDCED	Summer Steelhead (Wild)	April 1, 2012	Priest Rapids Dam, WA	August 18, 2011
3D9.1C2D8FF877	Summer Steelhead (Hatchery)	April 28, 2012	Priest Rapids Dam, WA	August 16, 2011