Walter Hardman Project Water Use Plan

Lower Cranberry Creek: Rainbow Trout Biology/Abundance Monitoring

Implementation Year 3

Reference: WHNMON-5

Study Period: 2009-2010

Okanagan Nation Alliance Fisheries Department

October 21, 2010

Executive summary

The Walter Hardman Project is a run of the river operation on Cranberry Creek located south of Revelstoke on the eastern slope of the Monashee Mountains. The dam is part of BC Hydro's integrated generation system and produces approximately 37 gigawatt-hours (GWh) annually. The Water Use Planning Consultative Committee recommended testing operational changes that includes a year round minimum discharge flow of 0.1 m^3/s as a mitigative measure to maximize fish habitat. This report summarizes data from year three of a five year study aimed at gaining information on rainbow trout abundance and biology in the middle section of Lower Cranberry Creek. The goal of this five year project is to rationalize optimum flow conditions for rainbow trout.

In 2007 a total of seven index sites were chosen to assess rainbow trout densities, their size and age structure. Two of the original sites selected in 2007 were not monitored in 2008 or 2009 as anthropogenic and natural barriers limited fish access in 2008. To compensate for the loss of these monitoring sites, two new sites were added in 2008. In 2008, rainbow trout abundance was estimated via electrofishing and/ or snorkel surveys. In 2009 electrofishing was the only methodology used to assess the monitoring sites.

At each site wetted and bank full width, velocity, depth, and site length were measured. The substrate, cover and debris were noted. Most sites were dominated by gravel and cobble and had sufficient availability of refuge for fish. The majority of sites contained some large woody debris in the form of fallen trees. Nonetheless, pool formations were few and far between with little permanent LWD. Sites LCEF03, LCSN05 and LCSN05.5 also contained submerged vegetation and undercut banks.

This report provides an overview of observations and a data summary from the 2009 monitoring session. Higher densities of fish were observed in 2009 than in 2008 or 2007. The population estimates in the 2009 survey ranged from 318 at site LCSN01.5 to 0 at site LCSN04. Site LCSN02, LCSN05, LCSN05.5, had population estimates of 31, 246, and 24 respectively. The rainbow trout population condition factor was fair in 2009 with an average of 1.21 (N=49). In 2008 the average condition factor was 0.91 (N=15). Observed depths in 2009 were lower than in 2008, at all sites.

The rainbow trout abundance summary report in years 4 and 5 will require a more thorough investigation of the operational and seasonal flow fluctuations on the rainbow trout population. To greatly improve trout density estimates we recommend that mark-recapture experiments be conducted to determine electrofishing efficiency.

Acknowledgements

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This data report was prepared by the Okanagan Nation Alliance Fisheries Department team. The field team of Jim Clarricoates, and Cash Tonasket was led by Carla Davis. The data was compiled and synthesized by Natasha Audy and Shayla Lawrence. Carla Davis developed the methodologies, led the field component and authored the main body of the report. Additional review and revisions were conducted by Heidi McGregor, Shayla Lawrence, Rishi Sharma, Richard Bussanich, Jamie Pepper and Greg Andrusak. The final draft and senior review was completed by Howie Wright.

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1.0 Introduction

The Walter Hardman Project is located on Cranberry Creek approximately 25 kilometres south of Revelstoke, BC draining the east slope of the Monashee Mountains before entering the Arrow Lakes Reservoir. The Cranberry Creek watershed encompasses an area of 145 km^2, of which 100 km^2 lie upstream of the Walter Hardman Diversion Dam (BC Hydro 2006). The diversion is designed to direct water through a small reservoir before flowing through a tunnel to the Walter Hardman Power House located just down slope of Highway 23 on the Arrow Lakes Reservoir (Figure 1).

The dam is part of BC Hydro's integrated generation system and produces approximately 37 gigawatt-hours (GWh) annually, which is enough electricity to serve 3700 homes for one year. It is a run-of-river facility with a maximum of 4.3 m^3/s of water flow being diverted for power generation with any excess spilling back into Cranberry Creek. The stream below the diversion structure flows in a southwest direction for 13 km before entering the Arrow Lakes Reservoir.

As part of a Water Use Plan (WUP) for the Walter Hardman facility, BC Hydro was instructed to undertake a fish monitoring program to provide improved information for future operating decisions (BC Hydro 2006). The WUP process requires BC Hydro to implement a monitoring program that addresses low fish flow concerns in the lower 13 km of Cranberry Creek. This issue was identified by the WUP Consultative Committee to the Comptroller of Water Rights. Consequently the Comptroller imposed a minimum flow condition and included the monitoring program a requirement of BC Hydro's license to operate.

The Consultative Committee hypothesized that flows prior to the imposition of the minimum flow order severely limited the amount of rearing habitat available for rainbow trout (*Oncorhynchus mykiss*) in lower Cranberry Creek. For example, Andrusak and Slaney (2004) noted that this section of stream was completely de-watered in September, 2003. Hence, a minimum flow of 0.1 m^3/s was imposed to improve habitat conditions for rainbow trout. The Consultative Committee believes that the resident rainbow trout population will benefit from the minimum flow requirement.

Rainbow trout have been monitored in the mid section of the Lower Cranberry Creek from 2007-2009 to quantify rainbow trout presence and abundance. This trout assessment work, in conjunction with other monitoring studies, will help in determining both the final magnitude of minimum flows as well as any potential seasonal variation in flow release.

The current monitoring program is a five year program (2007-2011) that is aimed at assessing the resident rainbow trout population in lower Cranberry Creek. During the first year of study (2007-2008), seven representative sites were selected for sub-sampling along a five kilometer section of the stream. Basic sampling techniques in the first three study years have included electroshocking and snorkel surveys. Coincidentally, the habitat in this section of stream has been assessed in detail by Andrusak and Slaney (2004) using an enhanced (WRP) fish habitat assessment procedure as described in Johnston and Slaney (1996).

Monitoring Objectives and Questions

This report documents Year-3 (2009) results of stream sampling for rainbow trout within the five kilometer section of lower Cranberry Creek. The goal of this study is to determine rainbow trout abundance estimates which can then be used to rationalize optimum fish flows. The Terms of Reference for this project states the objectives as:

1) *To provide auxiliary information on the status of the rainbow trout population in Lower Cranberry Creek to support habitat assessments of the fisheries benefits of minimum flow release from the diversion weir.*

2) *To provide baseline rainbow trout abundance data against which future monitoring studies can measure a response.*

2.0 Methods

In 2009 baseline rainbow trout abundance and biological data in lower Cranberry Creek were obtained by electrofishing. Trout density estimates were calculated using a three pass depletion method (Hayes et. al. 2007). The methods for this project followed the Resource Inventory Committee (RIC) procedures for fish collection (RIC 1997; RIC 2001). Fish habitat measurements were recorded to characterize each site such as the wetted and bank full width, velocity, depth, and site length. Substrate, cover and wood debris were noted at each site.

2.1 2007 Reconnaissance Survey

An initial reconnaissance survey was conducted along lower Cranberry creek from 0 km to 5.4 km on April 27, 2007, to identify electrofishing and snorkeling sites for the rainbow trout surveys. The 0 km mark was located at an apparent impassable falls 2.3 km upstream of the confluence of Cranberry Creek with Upper Arrow Lake. Approximately 5.4 km of stream above the barrier was assessed and seven sites representative of the habitat in the lower Cranberry Creek were selected. Sites were chosen to include both riffles and pools in similar proportions to those throughout the study area. Each site was marked with flagging tape, markers/tags (e.g., re-bar or t-bar), and geo-referenced. Sites were referenced by stream name (LC = Lower Cranberry), site number (1-10), and fish sampling method used (EF = electrofishing, SN = snorkeling).

For the 2009 study, two new sites were included to replace two sites used in 2007 and 2008. This change was required as the two previous sites were impacted by destabilized stream banks that rendered them unsuitable for sampling.

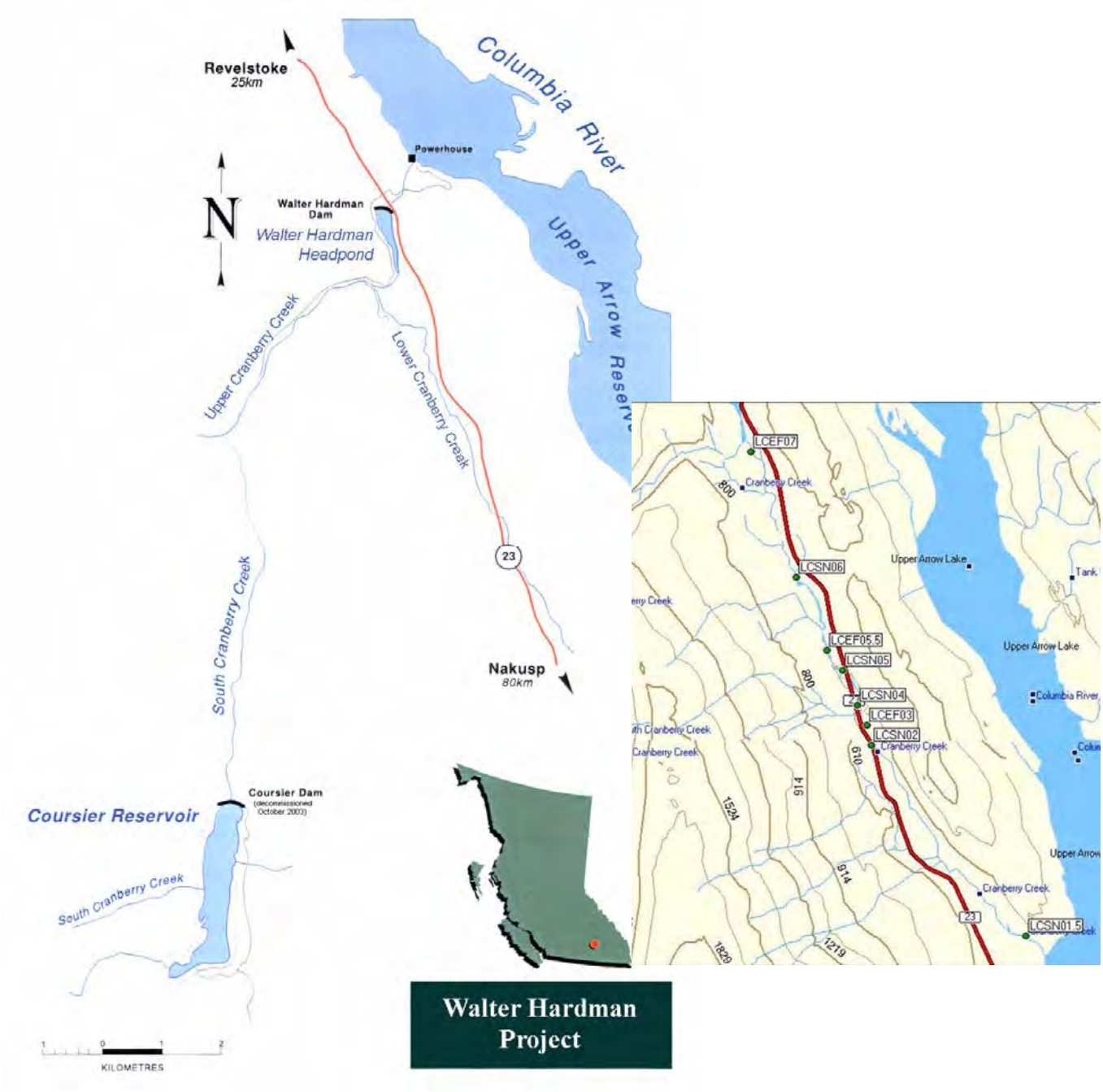

Figure 1. Map of Walter Hardman project and site locations used for fish and habitat surveys in Lower Cranberry Creek in 2009. (Source: Walter Hardman Project Use Plan, Monitoring Program Terms of Reference, 2006)

2.2 2009 Physical Habitat Survey

Fish inventory index sites were surveyed during low flow periods between August 31 and September 4, 2009. The results of these surveys can be used to determine if the operational year round minimum discharge flow of 0.1 m^3/s is appropriate for improving rainbow trout rearing habitat. There was reasonable foot access from Highway 23 for all of the sites selected.

2.2.1 Field Assessment Procedures

The wetted and bank full width, velocity, depth, and site length were measured at each site. Sites were surveyed immediately after fish collection. Although the aim was to monitor low flow conditions, BC Hydro operations and inclement weather conditions caused a number of flash flood events.

Site Length

Site length was measured from the furthest point upstream where the fish samples were taken to the furthest point downstream of the monitoring section. As each of the sites were sub-sampled, there has been variation in length sampled between years.

Wetted width and bank full width

Measurements were taken at five even intervals along the site length. Wetted width was measured where the dry bank met the water. The start and end points for bank full width were the edges of the active stream channel and the beginning of the zone of rooted vegetation.

Velocity and depth

One transect was chosen at the mid-point of each site and divided into five equal sections across the stream. Stream vvelocity was measured in each section with a Swoffer model 2100 current meter. Depth was recorded using the graduated rod on the meter, at 40% of total depth (measured from the bottom).

Creek Substrate, cover and debris

Substrate, cover and debris were recorded at each transect (one per site). These measurements were based on visual observations and included:

- Percent cover estimates of large woody debris, small woody debris, boulders, undercut banks, overhanging vegetation, and deep pools and
- Percentage estimates of substrate composition (boulder, cobble, gravel, sand, and fines).

Diagrams were created noting the habitat features at each site. Photographs were taken upstream and downstream of each site.

2.3 2009 Fish Surveys

Electrofishing

A three-pass depletion electrofishing methodology described by Hayes et al. (2007) was used to sample fish in 2007 and 2009 at sites: LCEF01.5, LCEF02, LCEF04, LCEF05, and LCEF05.5 (Figure 1). Sites LCEF03, and LCEF06 were not electrofished due to extreme weather conditions resulting in safety concerns. Low water levels precluded the use of snorkel surveys. A three-person crew using a Smithroot Model B-12 backpack electrofisher conducted all the sampling. All sites were enclosed using stopnets (9.5 mm mesh size). All fishes caught were placed in buckets equipped with aerators.

2008 Snorkel surveys

During the 2007 season water levels were too low to effectively snorkel the sites. All sites were thus sampled using electrofishing. In 2008 water levels were significantly higher, making electrofishing difficult at most sites. Hence snorkel surveys were the only effective alternative (Dolloff, A., J. Kershner, and R. Thurow 1996). Site LCEF05.5 was electrofished while sites LCSN02, LCSN04, LCSN05, and LCSN06 were snorkeled (Figure 1). Site LCSN03 was first snorkelled and then electrofished a half an hour later to compare methods and their results between years.

2.3.1 Biological Sampling

All captured fish were measured for fork length (mm) and wetted weight (g) at each site. All fish were anaesthetized using Aquacalm™ before measurement to minimize handling stress. A maximum of two capfuls of Aquacalm solution per 20 L of water was used (D. Southgate, DFO; personal communication 2008). Following the measurements fish were placed in a recovery container with an aerator and released when full recovery was evident.

2.3.2 Calculations

Closed population removal methods rely on sequentially removing fish from the population. The rate of decline in the population with each pass can be used to estimate the original population (Eq.1) (Hayes et al. 2007). The variance for the population estimate was calculated using Equations 2 and 3.

$$N = \frac{6x^2 - 3xy - y^2 + y(y^2 + 6xy - 3x^2)^{1/2}}{18(x-y)} \qquad \text{Eq. 1}$$

$$V(N) = \frac{N(1-q)^3 q^3}{(1-q^3)^2 - \{[t(1-q)]^2 q^2\}} \qquad \text{Eq. 2}$$

$$\text{where } q = \frac{3x-y-(y^2+6xy-3x^2)}{2x} \qquad \text{Eq. 3}$$

N = population estimate
q = proportion of random variables
$x = 2n_1 + n_2$
$y = n_1 + n_2 + n_3$
n_1 = number of fish caught on the first pass
n_2 = number of fish caught on the second pass
n_3 = number of fish caught on the third pass

If there is an instance where there were only two passes, such as in 2007, the population estimates were made using Equations 4 and 5 (Hayes et al. 2007):

$$N = \frac{n_1^2}{(n_1 - n_2)} \qquad \text{Eq. 4}$$

$$V(N) = \frac{n_1^2\, n_1^2(n_1 + n_2)}{(n_1 - n_2)^4} \qquad \text{Eq. 5}$$

where, N = population estimate
n_1 = number of fish caught on the first pass
n_2 = number of fish caught on the second pass

Fish Condition

Indices of condition were used rather than length-weight relationships (Anderson and Neumann 1996) to compare fish condition between years as outlined in the proposal and approved in the original study methods. Variations in the coefficient of condition reflect the state of maturity and degree of nourishment (Williams 2000). The condition factor was calculated using the formula (Barnham & Baxter 1998; Anderson and Neumann1996):

$$K = \frac{100{,}000W}{L^3} \qquad \text{Eq.6}$$

where K is the condition factor; W is the wet weight of the fish in grams (g); L is the fork length of the fish in millimeters (mm). The value 100,000 is a scaling constant to convert small decimals (Anderson and Neumann 1996; Barnham and Baxter 1998). For salmonids, the K values usually fall in the range of 1.20 to 1.60 for fair to excellent condition fish (Barnham and Baxter 1998).

Data from each of the electrofishing surveys and habitat assessments were compiled into a Microsoft Excel database.

3.0 Results and Discussion

3.1 Reconnaissance Survey

During the three years of assessment a number of unavoidable circumstances have resulted in changes to the study design. One of the original seven survey sites (LCEFO1) selected in 2007 had to be revised in 2008 due to a stream bank failure that eliminated a side channel that was included in the sample site. As a result, a new site 0.5 km downstream (site LCSN01.5) had to be chosen in 2008. One further adjustment in site location was made in 2009 with the exclusion of Site LCEF07, located in the overflow area of the Walter Hardman Headpond that had become overgrown with algae and was deemed inaccessible to fish. Site LCEF07 was replaced with site LCEF05 (Photo 3). Habitat assessments were conducted at all sites in 2009 but continuous poor weather events limited the field crew's ability to electrofish sites LCEF03 and LCEF06.

Table 1. Cranberry Creek site names and locations.

Site Number	Temperature Logger	Elevation [1]	Site Location	2007	2008	2009
LCSN01.5	None	*	11U 0430205E 5618141N	x	x	x
LCSN02	WH#2 & WH#5	578m	11U 0427157E 5622453N	x	x	x
LCEF03/LCSN03	None	583m	11U 0427091E 5622784N	NO	x	YES
LCSN04	None	*	11U 0426931E 5623050N	NO	x	x
LCSN05	None	592m	11U 0426647E 5623700N	NO	x	x
LCEF05.5	None	*	11U 0311505E 5524782N		YES	x
LCSN06	None	620m	11U 0425857E 5625419N	NO	x	YES

* Not recorded
[1]: taken from the GPS unit

Temperature loggers were installed and monitored within the study area as part of a separate study (WHMON4 lower Cranberry Creek Temperature Effects Monitoring). The location of the temperature loggers was established to meet the requirements of WHMON4 to evaluate the effectiveness of minimum flow releases on water temperature in the diversion reach. This study stems from the Consultative Committee's (CC) concern that warm water temperature in lower Cranberry Creek during the summer may exceed critical levels for rainbow trout. This program is also designed to investigate the Consultative Committee question of cool water temperatures affect on the rate of kokanee egg incubation during the fall and winter.

Photo 1. Site LCEF01 was used in 2007 and not in 2008 or 2009 due to the large number of trees which fell into the channel. The area was dewatered and not accessible to fish.

Photo 2. Lower Cranberry Creek, site LCEF01.5, showing habitat features including large boulders (bottom picture) and a deep pool (middle picture). The top picture is upstream of the site. The middle picture is at the site, and the bottom picture is the downstream section of the site.

Photo 3. Site LCEF07 was generally inaccessible to fish due to the spillway on the headpond (top picture) and contained extremely stagnant water with high growth of grass and algae (orange and dark green brown water in lower picture).

3.2 Physical Habitat Surveys

There are a number of characteristics that, when combined, provide suitable habitat for fish including substrate type, cover, variable water depth, suitable water velocity and migration or passage potential (Michigan Department of Environmental Quality 1997). Complex substrate and variable habitat types are more capable of supporting a large variety of fish and macroinvertebrates than a more uniform substrate or single habitat type in one area (Schlosser 1982).

To understand habitat suitability for rainbow trout, bottom substrate was assessed and recorded at all seven study sites within the Cranberry Creek study area. Most sites were dominated by gravel and cobble (Table 2). In general, rock and gravel are considered the most desirable cover habitat for rainbow trout (Michigan Department of Environmental Quality 1997). There was a limited amount of fines within all sites (Table 2). The proportion of each of these components varied among sites. Site LCEN01.5 was the only site dominated by bedrock and boulders.

Most sites offered suitable cover for trout with the majority of sites containing some large woody debris in the form of fallen trees. The amount of large woody debris in the stream was variable with LCEF05.5 having the largest quantity (Photo 5; Table 2). Sites LCEF03, LCSN05 and LCSN05.5 contained submerged vegetation and undercut banks. Undercutting provides excellent cover for fish (Platts et al. 1983). Site LCSN01.5 had 25% to 50% canopy cover and 25% submerged woody debris. The riparian zone along all study sites had well-vegetated banks.

At the same location on lower Cranberry Creek, Andrusak and Slaney (2004) surveyed a total distance of 1.86 km from the upstream end of the lower canyon reach to the Highway 23 Bridge. They have kindly permitted reproduction of their findings with the following excerpts:

Twenty-one habitat units, dominated by riffles, were surveyed, and mean channel and wetted widths were 21.0 m (range 10-37m) and 16.9 m (range 10-27 m), respectively. The assessment was conducted throughout rising flows during a rainfall event at an estimated variable flow of about 5-10 m^3/sec on October 28, 2003. By stream length, riffle, glide and pool habitat comprised 90.7%, 3.1% and 6.1%, respectively. Almost all glides, except two, were converted to riffles at near bank-full flows during the survey on October 28, 2003.

Habitat depths were typically high as a result of near-bank full flows, but were still low because of limited pool development. Overall, mean depth was only 0.54 m. Mean depths of riffles, glides and pools were 0.43, 0.55 and 0.83 m, respectively. Mean maximum depths of riffles, glides and pools were 0.85 m, 0.85 m and 1.4 m, respectively, or 0.96 m on average. Mean bank full depth of all habitat units was 0.82 m, and ranged from 0.4 to 1.4 m.

Substrates were dominated by cobbles throughout the Highway Reach, with a few boulders in steeper riffles. Mean dominant substrate size in all habitat units was 0.20 m and ranged from 0.15 to 0.25 m. Mean sub-dominant size was 0.14 m and ranged from 0.05 m to 0.25 m. Small gravels and sands were limited in the evaluated reach. Upstream of the Highway Reach below

the upper barrier (~2 km downstream from the upper barrier) there was evidence of sediment deposition on bars that appeared to decrease downstream to the Highway 23 Bridge). The estimated range of gradients varied highly from 0.01% (pool) to 0.8% (riffle), and averaged 0.45%. Estimated average velocity in mid-September was 0.83 m/sec.

Primary pools were poorly developed at the Highway Reach of Cranberry Creek. Percent primary pool was low or 6.1% by length and area, and therefore, rated as poor. In addition, if all glides are included as equivalent to shallow pools; "pools" were 9.2%. Thus, with glides included as shallow pools, percent pool was <40%, and therefore, from the habitat diagnostics provided in Table 5 in Johnston and Slaney (1996), percent pool + glide is rated as poor. Similarly, pool frequency was low because there were 22 channel widths per primary pool. If glides are included there are 14.7 channel widths per pool + glide which still rated as poor (>4 channel widths per pool). Further, if the 15 small pocket pools in riffles are included, there were 4.2 channel widths per pool, and pool frequency is again rated as poor. Thus, an overall pool rating of poor was assigned for habitat pool development (Table 2).

Large wood in the channel of Cranberry Creek was in low abundance (Table 2), and LWD jams were largely associated with the middle sub-reach (680 m to 1,371 m) where the channel bends away from the Highway. Total LWD in the 1.86 km length of mainstem and side-channels equated to 1.37 pieces per channel width, of which 1.06 per channel width were functional, thereby affecting the channel geomorphology and or providing fish habitat cover. Most woody debris was small (<30 cm) in diameter with only 0.37 pieces per channel width >30 cm. Thus, functional LWD was rated as low fair. This condition reflected limited recruitment from a young riparian forest, except in the middle sub-reach where some mature timber has created a few active log jams.

Fish habitat cover was also sparse throughout the Highway reach (Table 2). Total cover averaged only 7.1%, which is rated as poor quality. Of this, boulder cover in riffles as a diagnostic averaged 1.1% and was rated as poor quality. Mean percent woody cover in pools as another cover diagnostic was low fair or only 5.8%, and with glide units included was 3.0%, and thus rated as poor to fair quality habitat (Table 1). Finally, overstream vegetative and woody cover averaged 3.6% and thus was rated as poor quality.

Interstices of stream substrates were not overly in-filled with fines but sandbars were evident at bends. Therefore, substrate condition was rated as fair. Some spawning gravels were evident in the Highway reach of Cranberry Creek, particularly in the middle sub-reach where jams caused more sorting of sediments. Side-channel development rated as only fair because the Highway encroached on the channel except in one large meander where jams and side-channels were more frequent.

Table 2. Instream fish habitat characteristics and ratings for Cranberry Creek in late October 2003 (targets from Table 5 of Johnston and Slaney 1996).*

HABITAT PARAMETER	REACH AMOUNT	RATING	TARGET (GOOD)
Percent Pool+Glide	9.2	Poor	>55
Pool plus Glide Frequency	14.7	Poor	<2
% Pools + Frequency		Poor	
Pieces of Functional LWD per Channel Width	1.06	Low-fair	>2
Percent Woody Cover in Pools + Glides	3.0	Poor	>20
Percent Boulder Cover in Riffles	1.1	Poor	>30
% Overhead Cover	3.6	Poor	>20

* Table 2 provided by Andrusak and Slaney (2004)

Estimated useable trout fry habitat averaged 3% and ranged from 0% to 10% (Appendix A). Mean trout parr habitat was 5.5% and ranged from 1% to 20%. Most habitat units (86%) only provided 10% or less useable trout parr habitat. This is because LWD cover features were relatively sparse as summarized above.

The primary disturbance indicator in the Highway Reach was de-watering by the BC Hydro diversion of Cranberry Creek at 13 km during mid to late summer and in winter.). In the lower canyon reach, there was some minor flow in late summer (0.05-0.1 m^3/sec) as a result of contributions from small tributaries, but the stream was dry (aside from trace groundwater seepage) in the Highway reach for 3 km, as well as, upstream of the Highway 23 bridge for 6 km to the BC Hydro diversion. Kokanee were observed over a distance of at least 1.5 km in the lower portion of Cranberry Creek. Further, several large mountain whitefish were observed in a pool at about 2 km at the downstream end of the lower partial (chute) barrier; therefore, kokanee can potentially migrate upstream nearly 2 km.

A secondary disturbance indictor, other than past logging within the riparian zone was a series (3) of landslides located 0.5 km downstream of the BC Hydro diversion. As well, disturbance in the form of highway encroachment at km 4 in the lower Highway Reach was evident where the channel was realigned using rip-rap.

The 2009 habitat assessment generally concurs with the results of Andrusak and Slaney (2004) especially the absence of pools and LWD. The latter feature was < 25% at all sites (Table 2).

Photo 4. Site LCEF03 showing the large woody debris over the stream site along the right bank facing downstream (top), upstream of site (middle right) and the right bank facing upstream (bottom).

Photo 5. Large woody debris (LWD) and overhanging vegetation at site LCSN05.5. The top photo is the LWD upstream of the site, while the middle photo is the upstream section the site. The bottom photo shows the overhanging vegetation facing downstream of the site.

Table 3. Physical habitat features of rainbow trout sampling sites at Cranberry Creek, 2009.

Site	LCSN01.5	LCSN02	LCEF03	LCSN04	LCSN05	LCSN05.5	LCSN06
Date	1-Sep-09	Sept 2 & 4 2009	31-Aug-09	Sept 1 & 4 2009	Sept 1 & 2 2009	Sept 2 & 4 2009	2-Sep-09
Time (h)	10:30	10:31	16:53	15:53	11:49	13:23	15:07
Water Temp (ºC)	15	13.7	*	19	16.8	14.5	17.3
Air Temp (ºC)	20	20.0	24.2	30	21.5	18.6	22.5
Site length (m)	95.6	66.5	120	105	148	62.5	74.9
Wetted Width average m N=5 (Serror)	9.4 (1.6)	12.0 (6.7)	6.2 (1.0)	7.9 (1.2)	7.3 (0.9)	4.0 (0.9)	8.9 (1.0)
Bank full width m (Serror)N=5	16.2 (1.8)	19.2 (6.7)	28.9 (3.3)	16.8 (1.5)	25.0 (2.6)	9.0 (0.7)	12.6 (1.1)
Average Velocities m/s (Serror)	0.06 (0.01)	0.19 (0.39)	0.13 (0.05)	0.11 (0.11)	0.8 (0.04)	0.03 (0.04)	0.15 (0.05)
Average Depth m (Serror)	0.30 (0.04)	0.19 (0.54)	0.19 (0.04)	0.06 (0.03)	0.26 (0.10)	0.19 (0.04)	0.42 (0.10)
Substrate	large cobble, boulders, large pebbles	large pebbles, small cobble, sand	large cobbles, small cobbles, small pebbles	small cobbles, large cobbles, sand	gravel, cobble, sand	cobble, gravel, sand	boulders, large cobbles, sand
Cover	10% LWD, clumped 25% SWD submerged canopy coverage: 25-50%	<5% LWD clumped <5% SWD submerged LWD, <5% undercut banks canopy coverage: 0-25%	5-10% LWD clumped 0-5% SWD undercut banks, rip-rap along highway canopy coverage: 0-25%	<5% LWD clumped <5% SWD submerged, undercut banks canopy coverage: 0-25%	20-25% LWD clumped <5% SWD submerged, undercut bank canopy coverage: 25-50%	20-25% LWD clumped 5-10% SWD submerged, undercut banks canopy coverage: 50-75%	0% LWD 0% SWD submerged boulders, undercut bank canopy coverage: 0-25%

Instream Vegetation	algae	none	none	none	none	none	none
Site gradient	1-5%	1-5%	1-5%	1-5%	1-5%	1-5%	1-5%

LWD –Large woody debris
SWD –Small woody debris
*not recorded

3.3 Fish Surveys

Rainbow trout were captured by electrofishing at four sites in 2009 (Table 3). Site LCSN01.5 yielded the highest numbers of rainbow trout (21 fish, mean length = 76 mm, standard error 8. At site LCSN02, 9 rainbow trout were captured (mean length = 105 mm, standard error 21). Sites LCSNO5 and LCSNO5.5 yielded 11 and 7 rainbow trout with a mean length of 37mm, standard error 1 and mean length 45 mm, standard error 3, respectively. Most rainbow trout caught were observed at site LCSN01.5 concealed in spaces between boulders.

The largest rainbow trout caught in 2009 was at site LCSN02. It measured 20.8 cm, weighted 123 g, and was caught during the third electrofishing pass. For comparison, the largest rainbow trout caught in 2007 was at site LCSN03 (12.8 cm, 15.4 g), and the largest rainbow trout seen in 2008 was estimated at 30 cm. In 2008 small minnows (Cyprinid family) were also observed but not captured at this site in a calm pool with reduced flow.

Table 4. Electrofishing survey at Cranberry Creek, September 2009.

Site	Species	Size class (mm)	Fish collected (#)	Area (m^2)	Density (fish/m^2)
LCSN01.5	RBT	0-100	15	902.46	0.0166
	RBT	100-150	6	902.46	0.0066
LCSN02	RBT	0-100	5	796.67	0.0063
	RBT	100-150	1	796.67	0.0013
	RBT	150-200	2	796.67	0.0025
	RBT	200-250	1	796.67	0.0013
LCSF03	*		*	739.92	*
LCSN04	No fish observed		0	825.30	0
LCSN05	RBT	0-100	11	1074	0.0102
LCSF05.5	RBT	0-100	7	249	0.0281
LCSN06	*		*	665.11	*

RBT = rainbow trout
* = no electrofishing due to weather constraints

Physical measurements were recorded at all seven sites. Average depths at the seven sites varied from 0.06m at site LCSN04 to 0.42m at site LCSN06. Higher numbers of fish were observed in 2009 than in 2008 or 2007. The population estimates in the 2009 survey ranged from 318 at site LCSN01.5 to 0 at site LCSN04. Site LCSN02, LCSN05, LCSN05.5, had population estimates of 31, 246, and 24. Refer to Section 2.3.2 for the description of the population estimate.

Table 5. Summary of rainbow trout collected using 3 pass electrofishing at Cranberry Creek, 2009.

Site	Rainbow (#)	Pop'n Estimate	Total Biomass [1] (g)	Area (m^2)
LCSN01.5	21	318	3084.0	902.5
LCSN02	9	31	822.3	797.0
LCSN05	11	246	135.4	1074.0
LCSN05.5	7	24	72.0	249.0
LCSN04	0	0	0	825.3

1 Total biomass is average weight of fish x population estimate.

The data were analyzed for condition factor (K). For salmonids, the K values usually fall in the range of 1.20 to 1.60 for fair to excellent condition fish (Barnham and Baxter 1998). The condition factor of the four sites in 2009 was fair with an average of 1.21, standard deviation of 0.42. Site LCEF05 had the lowest condition factor of 1.03 (N=11) and standard deviation 0.19. All rainbow trout observed at LCEF05 in 2009 were fry with an average fork length of 37 mm and average weight of 0.55g. Site LCEF05.5 had the highest average condition factor of 1.31 (N=8), standard deviation 0.52. The highest number of rainbow trout were observed at site LCSN01.5 (N=21) standard deviation 0.52. Site LCSN01.5 had 43% of the captured rainbow trout in 2009 and a K value of 1.23. Overall, the 2009 fork length and weight observations provide some indications that the population is in fair condition

3.3.1 Rainbow trout

Table 6. Fork length, weight, and condition factor of rainbow trout collected using three pass electroshocking at Cranberry Creek, 2009.

Site	Pass 1			Pass 2			Pass 3		
	FL (mm)	Wet weight (g)	K	FL (mm)	Wet weight (g)	K	FL (mm)	Wet weight (g)	K
LCEF01.5	130	26.9	1.22	96	9.97	1.13	43	0.84	1.06
	129	24.36	1.13	45	1.41	1.55	44	0.82	0.96
	68	10.42	3.31	116	21.34	1.37	48	1.2	1.09
	54	1.64	1.04	126	25.13	1.26	42	0.75	1.01
	57	1.4	0.76				78	8.82	1.86
	49	1.4	1.19				149	42.66	1.29
	46	0.93	0.96						
	45	1.01	1.11						
	53	1.71	1.15						
	51	1.71	1.29						
	118	19.2	1.17						
LCSN02	92	8.35	1.07	51	1.54	1.16	208	122.8	1.36
	164	63.47	1.44	48	1.02	0.92	136	36.64	1.46
				46	0.99	1.02	157	42.84	1.11
				43	0.94	1.18			
LCSN05	40	0.64	1.00	36	0.49	1.05	43	0.85	1.07
	36	0.51	1.09	38	0.52	0.95	34	0.3	0.76
	38	0.82	1.49	38	0.5	0.91	34	0.41	1.04
	36	0.53	1.14	39	0.51	0.86			
LCSN05.5	23	0.31	2.55	44	9	1.06	40	0.86	1.34
	37	0.54	1.07						
	44	0.75	0.88						
	38	0.73	1.33						
	91	8.81	1.17						

Both the habitat assessment and the fish population surveys contribute data that ultimately will result in meeting project objectives. The length weight relationships, population estimates and condition factor provide important information on the status of the rainbow trout population in Lower Cranberry Creek that should provide a good rationale for the current minimum flow release from the diversion weir. The data also provide baseline rainbow trout abundance data against which future monitoring studies can measure a response. The box plots below display the

median, quartiles, maximum and minimum fork lengths, wetted weight and condition factor by site, total for 2009 (Figures 2-4).

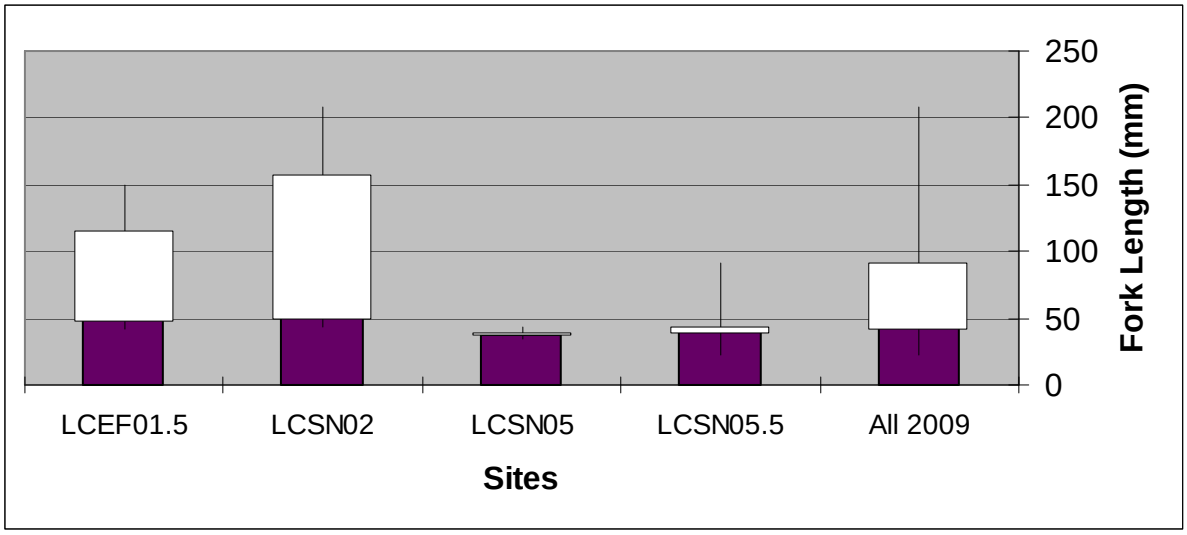

Figure 2. Box plot of rainbow trout fork length (mm) captured at Cranberry Creek, 2009.

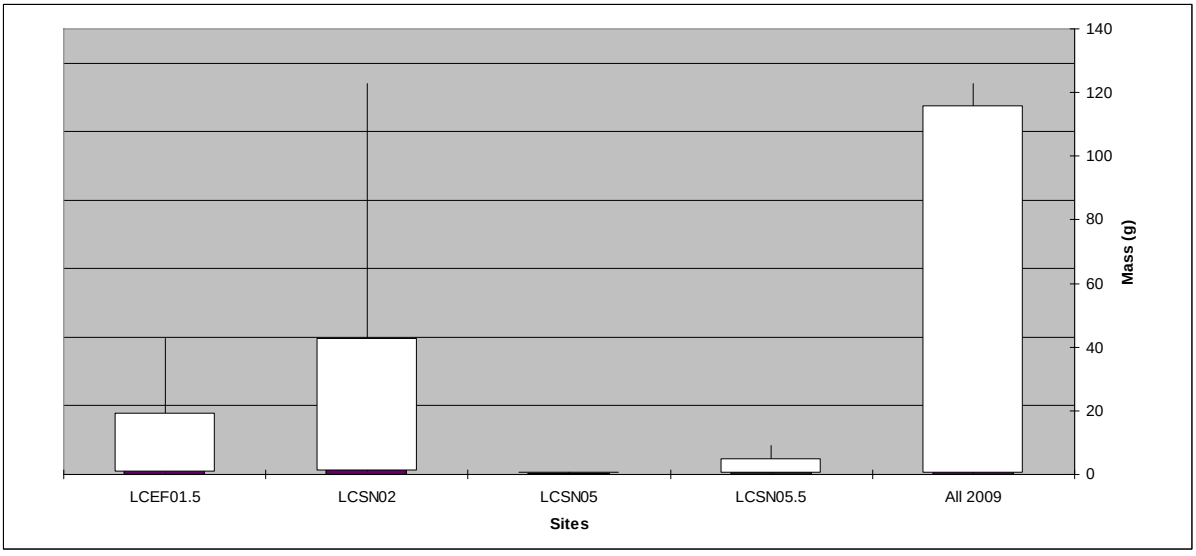

Figure 3. Box plot of rainbow trout wet weights (g) captured at Cranberry Creek, 2009.

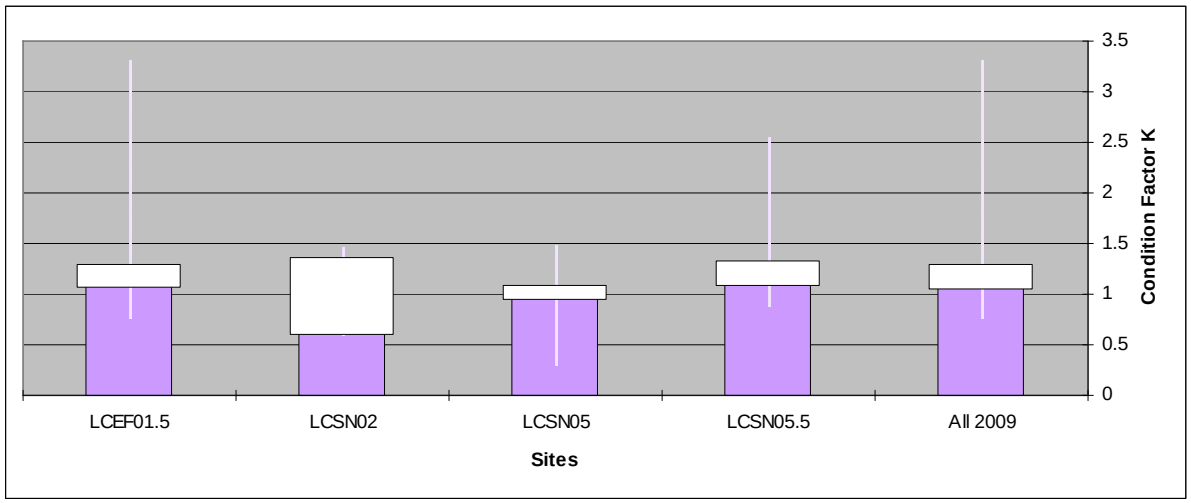

Figure 4. Box plot of rainbow trout condition indices (K) captured at Cranberry Creek, 2009.

3.3.2 Physical parameters

Juvenile rainbow trout prefer runs with depths of < 0.25 m and velocities of 0.2-0.4 m/s (McPhail 2007). Water depths were suitable (< 0.25 m) at the majority of the sites (Table 2; Appendix B). Water velocities varied among sites from an average 0.03 m/s (Site LCSN05.5) to average 0.8 m/s (Site LCSN05) with some values falling within the suitable range for juvenile rainbow trout (Sites LCSN02 and LCSN06).

The change in monitoring methods and the reduction in flows in 2009 from 2008 limits direct data comparisons between rainbow trout population observations. The lower flows may have caused most rainbow trout to move to areas with large woody debris. In small streams, overhead cover such as that provided by riparian vegetation and large woody debris is considered an essential component of good trout habitat (McPhail 2007). Annual flow rates and population observations will be conducted in 2010.

3.4 Future survey work

Clearly the study design has been compromised due to required changes to sample sites as well as sampling methods. Good data exists for all three years but some data cannot be compared from year-to-year. A more rigorous juvenile trout sampling regime is required to provide reliable estimates of abundance. Two independent methods need to be used to determine fish densities required for estimating abundance. The three pass depletion electrofishing methodology used in this study and described by Hayes et al. (2007) needs to be validated for efficiency by marking and recapturing trout using block nets at upstream and downstream locations within the sampling site(s). The Chapman version of the Peterson estimator (Ricker 1975) can be used in analysis of the mark-recapture data. Length of stream sampled needs to be consistent amongst the sites (ideally 100 m^2 each) and all sites need to be sampled. A minimum sample of 30 fish per site is required to complete a mark recapture.

Assumptions inherent to mark-recapture methodology include:

1) Emigration and immigration by fish during the sampling period must be negligible;
2) All fish within a specified sample group must be equally vulnerable to capture during a pass;
3) Vulnerability to capture of fish in a specified sample group must remain constant for each pass;
4) Collection effort and conditions which affect collection efficiency, such as water flow and clarity, must remain constant.

The purpose of this study is to provide reliable information on the status of the rainbow trout population in lower Cranberry Creek to support habitat assessments of the benefits to fish of minimum flow rates from the diversion weir. The site visit and observations recorded in 2009 does provide some information on the resident rainbow trout population in lower Cranberry Creek. The population estimates in the 2009 survey ranged from 318 at site LCSN01.5 to 0 at site LCSN04. The rainbow trout observed in the study area had an average condition factor of 1.21 giving some indication the population is in fair condition. Different flow conditions and methods limit yearly comparisons at this stage. Data collected thus far will assist in determining how the different suggested flow conditions affect rainbow trout abundance and habitat.

Bias is the difference between the true values and the estimated values. Some aspects that present bias include; more undercut banks and available refuge for fish, amount of cobble substrate, and water transparency. The field site visits occurred once a year during times with the lowest annual flows. These low flows present the worst case scenario for the population. This creates some bias in the overall status of the rainbow trout population within the study area for 2009. More frequent visits during a variety of flow conditions would provide a better indication of the true population values in the study area. Although the sites were selected to reflect the whole study area, they also ensure the minimum flow impacts are reviewed and assessed. Additional sites in areas less affected by minimum flows throughout the watershed, and surrounding water bodies would reduce bias and provide a bigger picture of the status of the rainbow trout population in the area.

4.0 Summary

4.1 Habitat quality

The habitat metrics measured over the three years will help infer whether or not there is stability within the stream and also if there is good habitat for all stages of rainbow trout. The work by Andrusak and Slaney (2004) provides a good assessment of habitat conditions in lower Cranberry Creek and suggestions are made to improve habitat quality. The 2007-2009 study results suggest this stream has high biological potential and a network of complex habitat is present to support all life stages of rainbow trout. Rocks and cobbles were present at most sites – such habitat has the highest habitat potential for rainbow trout (Michigan Department of Environmental Quality 1997). The low levels of fines seen at the sites promote good habitat for macroinvertebrates which serve as a food source for rainbow trout. Overhanging and mature riparian vegetation along the stream course fuels the food chain by adding nutrients to the stream and providing insects as a food source. Well-vegetated banks are usually stable regardless of bank undercutting; undercutting actually provides excellent cover for fish (Platts et al. 1983). There is substantial room for improvement, especially pool formations that can be accomplished through construction of LWD structures (Andrusak and Slaney 2004).

4.2 Rainbow trout population

The total number of rainbow trout captured in 2009 increased from 2008. The density of rainbow trout was 0.0158 fish/m^2 in 2009, compared to 0.0053 fish/m^2 in 2008, and 0.0255 fish/m^2 in 2007. The lower numbers in 2008 may be the result of fish moving to the side channels and areas with cover during a high water event, where they would be unobservable. The change in sampling methods may have also affected the number of fish observed. Likewise, the alteration of five sites electrofished in 2009 from seven sites in 2008 also limits the ability to compare years. The reduction in sites visited in 2009 continues to meet the project objectives. The overall condition indices were calculated from the length and weight of 49 rainbow trout captured within the study area in 2009. During each of the three sample years the water flows have been highly variable thus comparisons between years should be viewed with caution. Observed depths in 2009 were lower than in 2008. The flow discharge data will be reviewed and included in the five year study review. A more in-depth analysis of the annual variations will also be conducted at the end of the five year study period.

To date, this study has not obtained sufficient biological data in a standardized manner; hence, there is need for much more sampling from herein. Ultimately, environmental and habitat data can be used in existing habitat suitability models to compare the density of rainbow trout in Cranberry Creek to potential carrying capacity and density in other similar streams. Note that it is assumed that the trout in lower Cranberry Creek are resident fish but the possibility that adfluvial rainbow trout utilize this system cannot be ruled out, as discussed in Andrusak and Slaney (2004). More rigorous sampling is proposed in 2010 and a greater effort will be made to communicate directly with those from BC Hydro who are involved in this project.

5.0 Recommendations

- Fish collection methodologies require improvement including mark-recapture to determine efficiency of electroshocking.
- Discard snorkel surveys in favor of electroshocking.
- Determine age structure of rainbow trout.
- Improve communications with BC Hydro.

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Appendix A

Scientific Collection Permit (4 pages)

BRITISH COLUMBIA The Best Place on Earth | Ministry of Environment

FISH COLLECTION PERMIT
Inventory

File: 34770-20

Permit No.: CB09-56386

Permit Holder: Okanagan Nation Alliance – Shayla E. Lawrence
3255 C Shannon Lake Road, Westbank BC V4T 1V4

Client No.: 11832

Authorized Persons: Heidi McGregor, Jim Clarricoates, Keith Louis, Cash Tonasket, Carla Davis, Natasha Andy.

Pursuant to section 19 of the *Wildlife Act*, RSBC 1996, Chap. 488, and section 18 of the Angling and Scientific Regulations, BC Reg. 125/90, the above named persons are hereby authorized to collect fish for scientific purposes from non-tidal waters subject to the conditions set forth in this Permit:

Permitted Sampling Period: August 26, 2009 to September 14, 2009
Permitted Waterbodies: Kootenay Region – Lower Cranberry Creek (300-735400)
Permitted Sampling Techniques: EF, snorkeling (subject to permit terms and conditions)
Target Species: RB (subject to permit terms and conditions)

Provincial Conditions: (Permit holders must be aware of all terms and conditions):
See Appendix A.
Region Specific Conditions:
See Appendix A.

Authorized by:
Wayne Stetski
Regional Manager, Environmental Stewardship Division
Kootenay Region

Wayne Stetski

Date: August 26, 2009 Permit Fee $25

Any contravention or failure to comply with the terms and conditions of this permit is an offense under the *Wildlife Act*, RSBC 1996, Chap. 488 and B.C. Reg. 125/90.

Ministry of Environment
Environmental Stewardship Division
Permit & Authorization Service Bureau
PO Box 9372 Stn Prov Gov
Victoria BC V8W 9M3
Telephone: 1.866.433.7272
Facsimile: (250) 952-4344

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Permit No.: CB09-56386

Appendix A: Fish Collection Permit Conditions

Any Variation of the following terms and conditions will require explicit authorization by the appropriate regional Fish & Wildlife Section Head.

Provincial Conditions

1. This collecting permit is not valid
   - in national parks,
   - in provincial parks unless a Park Use Permit is also obtained,
   - in tidal waters,
   - for eulachon or for salmon* other than kokanee, or
   - for collecting fish by angling unless the permit holder and crew members possess a valid angling licence.

   This collecting permit is **only** valid for species listed as threatened, endangered or extirpated under the Species at Risk Act (SARA) **in conjunction with a permit issued under Section 73 of SARA from Fisheries and Oceans Canada.**

   *Contact the Department of Fisheries and Oceans for fish collecting permits for salmon, eulachon or SARA listed species (see Appendix B).

2. The permit holder (or the project supervisor) named on the application for a scientific collection permit will carry a copy of this permit while engaged in fish collecting and produce it upon request of a conservation officer, fisheries officer or constable.

3. Any specimens surplus to scientific requirements and any species not authorized for collection in this permit shall be immediately and carefully released at the point of capture.

4. Fish collected under authority of this permit shall not be used for food or any purpose other than the objectives set out in the approved application for a scientific collection permit. The permit holder shall not sell, barter, trade, or give away, or offer to sell, barter, trade or give away fish collected under authority of this permit. Dead fish shall be disposed of in a manner that will not constitute a health hazard, nuisance or a threat to wildlife.

5. No fish collected under authority of this permit shall be
   - transported alive unless authorized by this permit, or
   - transplanted unless separately authorized by the Federal/Provincial Fish Transplant Committee.

6. The permit holder shall, within 90 days of the expiry of this permit, submit a report of fish collection activities. Interim reports may also be required and shall be submitted as required by the permit issuer. All submissions must be filed electronically to: http://www.env.gov.bc.ca/fish_data_sub/index.html

   Reporting specifications, information and templates are available from this website and outline the mandatory information requirements. Prior notification of submission or questions regarding data report standards can be made to: fishdatasub@gov.bc.ca

7. This collecting permit is subject to cancellation at any time and shall be surrendered to a conservation officer on demand or to the issuer upon written notice of its cancellation.

8. This permit is valid only for the activities approved on the application form and in accordance with any restrictions set out therein.

9. This permit is valid only for trained, qualified staff named in the Application. The permit holder will comply with all Worker's Compensation Board requirements and other regulatory requirements. Permit holders are responsible for ensuring staff members listed on the permit are properly certified for specific sampling methods or activities (e.g. electroshocking).

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Permit No.: CB09-56386

Appendix A: Fish Collection Permit Conditions Continued

10. All sampling equipment that has been previously used outside of B.C. must be cleaned of mud and dirt and disinfected with 100mg/L chlorine bleach before using in any water course to prevent the spread of fish pathogens (e.g. Whirling disease) and / or invasive plant species. Any washed off dirt or mud must be disposed of in a manner such that it cannot enter a watercourse untreated.

11. No electrofishing is to take place in waters below five degrees C.

12. Electrofishing may not be conducted in the vicinity of spawning gravel, redds, or spawning fish, or around gravels which are capable of supporting eggs or developing embryos of any species of salmonid at a time of year when such eggs or embryos may be present.

13. Angling must only occur in accordance with the regulations specified in the current BC Freshwater Fishing Regulations Synopsis.

Region Specific Conditions

Region 4 (Kootenays)

- No electrofishing will be permitted between September 15 and June 15 in streams containing bull trout.
- The permit holder must contact the local zone Conservation Officer Service prior to initiating the field collections.

Permit No.: CB09-56386

Appendix B: Table 1 - Species at Risk

The following are species at risk that have been listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as either endangered, threatened or a species of special concern. Species also listed under the Species at Risk Act (SARA) are identified with an asterisk, and are subject to additional permitting requirements through the Federal Department of Fisheries and Oceans (DFO).

Common Name	Scientific Name
Benthic Paxton Lake Stickleback	**Gasterosteus sp.*
Benthic Vananda Creek Stickleback	**Gasterosteus sp.*
Limnetic Paxton Lake Stickleback	**Gasterosteus sp.*
Limnetic Vananda Creek Stickleback	**Gasterosteus sp.*
Nooksack Dace	**Rhinichthys sp.*
Morrison Creek Lamprey	**Lampetra richardsoni*
Vancouver Lamprey (Cowichan Lake Lamprey)	**Lampetra macrostoma*
Cultus Pygmy Sculpin	**Cottus sp.*
Shorthead Sculpin	**Cottus confusus*
Hotwater Physa	**Physella wrighti*
Limnetic Enos Lake Stickleback	*Gasterosteus sp.*
Benthic Enos Lake Stickleback	*Gasterosteus sp.*
Salish Sucker	*Catostomus sp.*
Speckled Dace	*Rhinichthys osculus*
Charlotte Unarmoured Stickleback	*Gasterosteus aculeatus*
Columbia Mottled Sculpin	*Cottus bairdi hubbsi*
Giant Stickleback	*Gasterosteus sp.*
Green Sturgeon	*Acipenser medirostris*
Umatilla Dace	*Rhinichthys umatilla*
White Sturgeon	*Acipenser transmontanus*

Applications for permits to specifically collect and retain listed species must be reviewed by the appropriate Recovery Team, who will screen permits to ensure that any impacts on listed species are acceptable. For white sturgeon the contact is Steve McAdam (steve.mcadam@gov.bc.ca). For listed non-game freshwater fish the contact is Jordan Rosenfeld (jordan.rosenfeld@gov.bc.ca), co-chair of the Non-Game Freshwater Fish Recovery Team.

Appendix B

Raw Data for Habitat Survey

Site	LCSN01.5			**Date**	August 5/2007		
Crew	Jim Clarricoates, Keith Louis, Carla Davis						
Site length	25 m		**Location**	11U 4300205E 5618141N			
Water temp	13 °C (hand)						
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Mean**	**SD**
Wet Width (m)	10.4	11.1	11.3	10.5	11.6	**10.98**	**1.00**
Bank full width (m)	13.3	13.2	12.9	13	12.7	**13.02**	**4.05**
Velocities	0.22	0.29	0.37	0.38	0.24	**0.3**	**0.07**
Depth (m)	0.5	0.8	0.8	0.6	0.5	**0.64**	**0.15**
Substrate	0 % fines, 0 % sands, 0% gravel, 10% cobble, 40% boulders, 50 % bedrock						
Total Cover	no LWD, no SWD,						
Cover	Boulders						
Instream Vegetation	none	**Riparian**	Sx, Willow, Alder –Mature				
Gradient	1-5 %						

Site	LCSN02			**Date**	August 5/2007		
Crew	Jim Clarricoates, Keith Louis, Carla Davis						
Site length	70 m		**Location**	11U 0427157E, 5622453N			
Water temp	17.5 °C		**Air Temp**	28 °C @ 4:02			
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Average**	**SD**
Wet Width (m)	9.55	10.5	10.6	10.9	12.1	**10.73**	**0.92**
Bank full width (m)	15.45	15.1	18.7	18	20.4	**17.53**	**2.24**
Velocities	0.12	0.19	0.3	0.21	0.01	**0.17**	**0.11**
Depth (m)	0.2	0.52	0.8	0.73	0.2	**0.49**	**0.28**
Substrate	5% sand, 10% gravel, 60% cobble, 25% boulder						
Total Cover	trace < 5%, LWD trace <1% clumped, SWD <2% trace, no submerged cover or undercut banks present						
Site gradient	1-5%						

Instream vegetation	none

Site	LCEF03			**Date**	August 6/2008		
Crew	Jim Clarricoates, Carla Davis, Keith Louis						
Site length			**Location**	11U 0427091E, 5622784N			
Water temp	13.5 °C		**Air Temp**	31°C			
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Average**	**SD**
Wet Width (m) main channel	16.5	15.8	15.1	13.8		**15.3**	**0.92**
side channel	6.4	6.35	4.2	3.4	2.9	**4.65**	**0.66**
Bank full width (m)	31.7	29.8	30.4	30.1	30.8	**30.56**	**0.35**
Velocities Main channel	0.05	0.58	0.47	0.38	0.19	**0.334**	**0.14**
Side Channel	0.14	0.18	0.32	0.15	0.04	**0.166**	**0.14**
Depth (m) main channel	0.33	0.38	0.11	0.05	0.1	**0.194**	**0.03**
side channel	0.11	0.18	0.23	0.40	0.50	**0.284**	**0.14**
Substrate	15% fines, 10% sand, 45% gravel, 30% cobble						
LWD present	70% of site (dominant), trace SWD						
Total Cover	abundant (LWD), submerged debris, undercut banks						
Site gradient	1-5%						

Site	LCSN04			**Date**	August 7/2008		
Crew	Jim Clarricoates, Carla Davis, Keith Louis						
Site length	38 m		**Location**	11U 426931E 5623050N			
Water temp	12.5 °C		**Air Temp**	17.5 °C @ 9:30 am Sunny			
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Average**	**SD**
Wet Width (m)	10.7	12.3	10.9	10.3	12.3	**11.3**	**0.94**
Bank full width (m)	14.7	13.3	13.1	13.9	23.7	**15.74**	**4.49**
Velocities	0.08	0.18	0.61	0.44	0.37	**0.34**	**0.21**
Depth (m)	0.4	0.47	0.38	0.25	0.08	**0.32**	**0.15**

Substrate	2% fines, 1 % sand, 10% gravel, 86% cobble, 1% boulder		
Total Cover	trace (3% of site) clumped LWD, trace (2%) SWD, undercut banks present		
Instream vegetation	none	**Riparian**	Sx, Alder, Willow – Mature
Site gradient	1-5%		

Site	LCSN05			**Date**	August 7/2008		
Crew	Jim Clarricoates, Carla Davis, Keith Louis						
Site length	25.5 m			**Location**	11U 426647E 5623700N		
Water temp	14 °C			**Air Temp**	32 °C @12:03 pm		
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Average**	**SD**
Wet Width (m)	5.2	5.9	6.4	7.3	7.2	**6.4**	**0.89**
Bank full width (m)	23	24.1	26.8	28	27.1	**25.8**	**2.14**
Velocities	0.000	0.110	0.250	0.360	0.080	**0.160**	**0.14**
Depth (m)	0.09	0.32	0.66	0.85	1.1	**0.604**	**0.40**
Substrate	10 % fines, 20 % sands, 40% gravel, 30% cobble						
Total Cover	6 % of site with even LWD, 6 %with SWD,						
Cover	submerged, instream, overhead and undercut banks						
Instream Vegetation	none	**Riparian**	Sx, Willow, Alder -Mature				
Site gradient	1-5 %						

Site	LCSN05.5		**Date**	August 7/2008			
Crew	Jim Clarricoates, Carla Davis, Keith Louis						
Site length	20.6 m		**Location**	11U 0311505E, 5524782N			
Water temp	11.5 °C		**Air Temp**	18.5 °C @4:11			
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Average**	**SD**
Wet Width (m)	4.3	5.1	5	4.9	4.8	**4.82**	**0.31**
Bank full width (m)	7.8	8.7	8.6	8.3	9.5	**8.58**	**0.62**
Velocities	0.81	0.75	0.83	0.59	0.14	**0.624**	**0.29**
Depth (m)	0.11	0.17	0.2	0.15	0.1	**0.146**	**0.04**
Substrate	5 % sand, 35% gravel, 60% cobble, 1 % boulder						
Cover	10% of site with clumped LWD, 2% with SWD present						
Instream Cover	submerged and undercut banks (20 % of right bank)						

Site gradient	1-5%

Site	LCSN06		**Date**	August 8/2008			
Crew	Jim Clarricoates, Carla Davis, Keith Louis						
Site length	19.6 m		**Location**	11U 425857E 5625419N			
Water temp	12 °C		**Air Temp**	16.5 °C @10;38 am			
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Average**	**SD**
Wet Width (m)	8.2	8.3	7.5	9.8	9.4	**8.64**	**0.94**
Bank full width (m)	11.5	11.7	11	11.2	11.1	**11.3**	**0.29**
Velocities	0.18	0.68	0.51	0.1	0.02	**0.298**	**0.28**
Depth (m)	0.32	0.55	0.7	0.48	0.42	**0.494**	**0.14**

Substrate	1% fines, 1 % sand, 1% gravel, 20% cobble, 62% boulder, 15% bedrock
Total Cover	no LWD, no SWD,
Instream vegetation	None
Site gradient	1-5%

Site	LCSN01.5			Date	Sept1/2009		
Crew	Carla Davis, Jim Clarricoates, Cash Tonasket						
Site length	95.6 m		Location	11U 4300205E 5618141N			
Water temp	13.7 °C Air 20 °C (hand) @ 10:31						
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Average	SD
Wet Width (m)	7.9	8.6	10.0	15.1	5.6	9.4	1.00
Bank full width (m)	12.1	12.0	20.4	20.1	16.6	16.2	4.05
Velocities	0.14	0	0.13	0.04	0	0.062	0.07
Depth (m)	0.32	0.44	0.21	0.12	0.06	0.23	0.15

Substrate	0 % fines, 0 % sands, 0% gravel, 10% cobble, 40% boulders, 50 % bedrock		
Total Cover	10% LWD, 25% SWD,		
Cover	Boulders		
Instream Vegetation	none	**Riparian**	Sx, Willow, Alder –Mature
Gradient	1-5 %		

Site	LCSN02			**Date**	Sept2, 4/2009		
Crew	Carla Davis, Jim Clarricoates, Cash Tonasket						
Site length	66.5 m		**Location**	11U 0427157E, 5622453N			
Water temp	15 °C Air 20 °C (hand)		**Air Temp**	20 °C @ 9:48			
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Average**	**SD**
Wet Width (m)	8.4	9.3	12.7	14.5	15	11.98	3.00
Bank full width (m)	14	20.5	20.4	21.5	19.5	19.18	2.98
Velocities	0	0.13	0.29	0.13	0	0.11	0.12
Depth (m)	0.21	0.35	0.54	0.35	0.12	0.314	0.16
Substrate	5% sand, 10% gravel, 60% cobble, 25% boulder						
Total Cover	trace < 5%, LWD trace <1% clumped, SWD <2% trace, no submerged cover or undercut banks present						
Site gradient	1-5%						
Instream vegetation	none						

Site	LCEF03			**Date**	August 31/2009		
Crew	Carla Davis, Jim Clarricoates, Cash Tonasket						
Site length (m)	120		**Location**	11U 0427091E, 5622784N			
Water temp (oC)			**Air Temp**	24.2°C @16:23			
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Average**	**SD**
Wet Width (m) main channel	5.12	5.84	8	3.34	8.53	6.166	2.86
Bank full width (m)	23	39.04	31.56	30.12	20.55	28.854	5.98
Velocities (m/s) Main channel	0.08	0.04	0.24	0.16	0.09	0.13	0.08
Depth (m) main channel	0.09	0.06	0.09	0.14	0.05	0.19	0.04
Substrate	15% fines, 10% sand, 45% gravel, 30% cobble						
LWD	10% of site (dominant), trace SWD						

present	
Total Cover	abundant (LWD), submerged debris, undercut banks
Site gradient	1-5%

Site	LCSN04			**Date**	Sept 1, 4/2009		
Crew	Carla Davis, Jim Clarricoates, Cash Tonasket						
Site length	105 m		**Location**	11U 426931E 5623050N			
Water temp	19 °C		**Air Temp**	30 °C @ 15:53			
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Average**	**SD**
Wet Width (m)	6.1	8.6	7.1	5.4	12.1	7.86	2.85
Bank full width (m)	16.4	14.2	13.2	21	19.4	16.84	3.83
Velocities	0	-	0.43	0.35	-	0.04	0.11
Depth (m)	0	0.05	0.11	0.2	0.01	0.12	0.11
Substrate	2% fines, 1 % sand, 10% gravel, 86% cobble, 1% boulder						
Total Cover	trace (3% of site) clumped LWD, trace (2%) SWD, undercut banks present						
Instream vegetation	none	**Riparian**	Sx, Alder, Willow – Mature				
Site gradient	1-5%						

Site	LCSN05		**Date**	Sept1,2/2009			
Crew	Carla Davis, Jim Clarricoates, Cash Tonasket						
Site length	148m		**Location**	11U 426647E 5623700N			
Water temp	16.8 °C		**Air Temp**	21.9°C @11:49			
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Average**	**SD**
Wet Width (m)	5.2	5.9	6.4	7.3	7.2	7.26	0.89
Bank full width (m)	23	24.1	26.8	28	27.1	25	5.67
Velocities	0.33	0.3	0.17	0.13	0.03	0.08	0.11
Depth (m)	0.11	0.04	0.05	0.03	0.03	0.26	0.03
Substrate	10 % fines, 20 % sands, 40% gravel, 30% cobble						
Total Cover	20 % of site with even LWD, 6 %with SWD,						
Cover	submerged, instream, overhead and undercut banks						
Instream Vegetation	none	**Riparian**	Sx, Willow, Alder -Mature				
Site gradient	1-5 %						

Site	LCSN05.5		**Date**	Sept 2, 4/2009			
Crew	Carla Davis, Jim Clarricoates, Cash Tonasket						
Site length	62.5 m		**Location**	11U 0311505E, 5524782N			
Water temp	14.5 °C		**Air Temp**	18.6 °C @13:30			
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Average**	**SD**
Wet Width (m)	3.9	6	5.7	2.8	1.5	3.98	2.20
Bank full width (m)	9.2	7.9	7.9	8.4	11.8	9.04	1.88
Velocities	0.07	0.22	0.06	0.07	-	0.03	0.06
Depth (m)	0.04	0.07	0.09	0.08	0.01	0.19	0.02
Substrate	5 % sand, 35% gravel, 60% cobble, 1 % boulder						
Cover	20% of site with clumped LWD, 2% with SWD present						
Instream Cover	submerged and undercut banks (40 % of right bank)						
Site gradient	1-5%						

Site	LCSN06		**Date**	Sept 2/2009			
Crew	Carla Davis, Jim Clarricoates, Cash Tonasket						
Site length	74.9 m		**Location**	11U 425857E 5625419N			
Water temp	17.3 °C		**Air Temp**	12.5 °C @15:07			
	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	**Average**	**SD**
Wet Width (m)	6.4	7.6	9.3	8.9	12.2	8.88	1.94
Bank full width (m)	10.6	10.4	13.1	12.7	16.4	12.64	2.47
Velocities	0.18	0.4	0.37	0.23	0	0.15	0.14
Depth (m)	0.22	0.2	0.29	0.26	0.11	0.42	0.06
Substrate	1% fines, 1 % sand, 1% gravel, 20% cobble, 62% boulder, 15% bedrock						
Total Cover	no LWD, no SWD,						
Instream vegetation	None						
Site gradient	1-5%						