Walter Hardman Project Water Use Plan

Lower Cranberry Creek: Rainbow Trout Biology/Abundance Monitoring (2012 Year 5)

Reference: WHNMON#5

Walter Hardman Water Use Plan Monitoring Program:

Lower Cranberry Creek: Rainbow Trout Biology/Abundance Monitoring

Study Period: 2007-2012

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Lower Cranberry Creek: Rainbow Trout Abundance/Biology Monitoring

WHNMON-5

Year 5 (2012) of 5

TRITON

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DISCLAIMER

This report is written solely for the use of BC Hydro in connection with the Walter Hardman Project Water Use Plan Monitoring Program (WHNMON-5: Lower Cranberry Creek Rainbow Trout Abundance/Biology Monitoring Program), and no person may rely on it for any other purpose without BC Hydro's (BCH) prior written approval. Should a third party use this report without BCH's approval, they may not rely upon it. Triton and BCH accept no responsibility for loss or damages suffered by any third party as a result of decisions made or actions taken based on this report.

- The objective of this report is to address the following scope requirements (BC Hydro, 2006a): To determine how increases in minimum flow affect rainbow trout populations in Lower Cranberry Creek. This will be accomplished by quantitatively determining the age composition, individual size, density and biomass of rainbow trout at various sites, and by qualitatively assessing fish habitat use within the creek.
- This report is based on facts and opinions contained within the referenced documents and facts. We have attempted to identify and consider relevant facts and documents pertaining to the scope of work, as of the time period during which we conducted this analysis. However, our opinions may change if new information is available or if information we have relied on is altered.
- We applied accepted professional practices and standards in developing and interpreting data obtained by our field measurement, sampling and observation. While we used accepted professional practices in interpreting data provided by BC Hydro or third party sources we did not verify the accuracy of data provided by BC Hydro or third party sources.
- This report should be considered as a whole and selecting only portions of the report for reliance may create a misleading view of our opinions.

EXECUTIVE SUMMARY

Lower Cranberry Creek is a small tributary of the Arrow Lakes Reservoir - the lower reaches being valuable habitat to resident Rainbow Trout. The Walter Hardman Hydroelectric facility (25 kms south of Revelstoke, BC) is a run-of-river generating station located on Cranberry Creek, approximately 11.5 kms upstream of the confluence of lower Cranberry Creek with Upper Arrow Lake. The facility diverts water from Cranberry Creek to generate electricity (maximum 8 MW). The output of the facility can theoretically supply electricity to the equivalent of 3700 homes (BC Hydro 2006b). Under the Walter Hardman Project Water Use Plan (BC Hydro 2006b), the Walter Hardman Water Use Planning Consultative Committee developed several programs designed to monitor outcomes of the recommended operational changes and changes to physical works at the generating facility - specifically the provision of a minimum flow of 0.1 m^3s^{-1} past the diversion dam into lower Cranberry Creek by installing a minimum flow facility the upstream end of the diversion channel (Figure 1-2).

This particular program was developed to determine the effect of changes in minimum flow in Lower Cranberry Creek, from Walter Hardman facility, on the resident Rainbow Trout (RB) (*Oncorhynchus mykiss*) population. This report summarizes the findings of Year 5 (of 5) of WHNMON-5 Lower Cranberry Creek Rainbow Trout Abundance/Biology monitoring program.

As in Year 4 (2011) for Year 5 (2012) Triton selected the same eight sites along a 5.47 km section of the creek between the impassable falls 2.30 km upstream of the mouth of the creek to an unnamed tributary 7.73 km upstream from the mouth. These sites were sampled by electrofishing using standards and procedures outlined in Resources Information Standards Committee (RIC) Fish Collection Methods and Standards (RIC 1999) and assessed for fish habitat values using the standards and procedures outlined in the RIC Fish and Fish Habitat Inventory (RIC 1999).

In total 73 Rainbow Trout were captured by electrofishing in 2012 representing four age classes (0+: fry to 3+: adults). The majority of the fish captured were within normal size ranges of healthy fish. Estimated abundance in 2012 was higher than in 2008 (Davis 2009) but lower than in 2011 (Triton 2012a). Similar to previous years of the program (Davis 2009 and Triton 2012a), the habitat quality in Lower Cranberry Creek in 2012 was found to be suitable for Rainbow Trout. However, maintaining a constant minimum flow during low flow times of the year would benefit the Rainbow Trout population by increasing the availability of spawning, rearing and overwintering habitats by maximizing the connectivity between them.

WHNMON-5 STATUS of OBJECTIVES, MANAGEMENT QUESTIONS and HYPOTHESES after year 5 (2012)

Objectives	Management Questions	Management Hypothesis	Year 5 (2012) Status
To determine the effect of changes in minimal flow on the resident Rainbow Trout (RB) population in lower Cranberry Creek by: Providing auxiliary information on the status of the Rainbow Trout population in lower Cranberry Creek in order to support habitat assessments of the fisheries benefits of minimum flow release from the diversion weir. Providing baseline Rainbow Trout abundance data against which future monitoring studies can measure a response	What is the status of the current RB population in lower Cranberry Creek? How do increases in minimum flows affect the RB population and what are the potential benefits of establishing a minimum flow? What is the qualitative capacity of the population to respond to potential habitat improvements resulting from minimum flow releases?	There is no direct management hypothesis associated with this particular study. Rather, this study is intended to better inform existing fish population status and biology, the response of fish to operational changes, and, in conjunction with Rainbow Trout habitat monitoring (Monitoring Program No. WHNMON-2 Rainbow Trout Rearing Habitat in Lower Cranberry Creek) to qualitatively judge the degree to which flow limits populations.	The Rainbow Trout population in lower Cranberry Creek likely is made up of four age classes: 0+ to 3+. Condition factors are at a relatively "normal" level of health. The capacity of the population to respond to habitat improvements through minimum flow releases is likely high. Data suggests healthy individuals with good density and represented by multiple age classes. Minimum flow releases (e.g. 0.1 m^3/s) would likely improve RB habitat in lower Cranberry Creek over base flow conditions. However at higher flows (e.g. 1.5 m^3/s) the influence of the minimum flows would be negated and habitat suitability would begin to decline as velocities become less favorable.

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1. INTRODUCTION

Triton Environmental Consultants Ltd. (Triton) was retained in 2011 by BC Hydro to complete Years 4 and 5 – hereto referred to as “2011” and 2012” - of a five year Rainbow Trout monitoring program on lower Cranberry Creek (2011/2012 and 2012/2013). The program is one of several included in the Walter Hardman Project Water Use Plan (WHN WUP) which is designed to monitor the outcomes of operational changes and changes to physical works on Lower Cranberry Creek, and provide information on which to base future operating decisions (BC Hydro 2006a).

The Walter Hardman Hydroelectric Project is located on Cranberry Creek, within the Columbia-Shuswap Regional District. Cranberry Creek is a 4th order, magnitude 45 stream approximately 25.3 km long (Habitat Wizard 2013). The section of the creek downstream of the diversion dam is lower Cranberry Creek. The sections upstream of the diversion dam are Cranberry Creek and South Cranberry Creek, respectively (Figure 1-1).

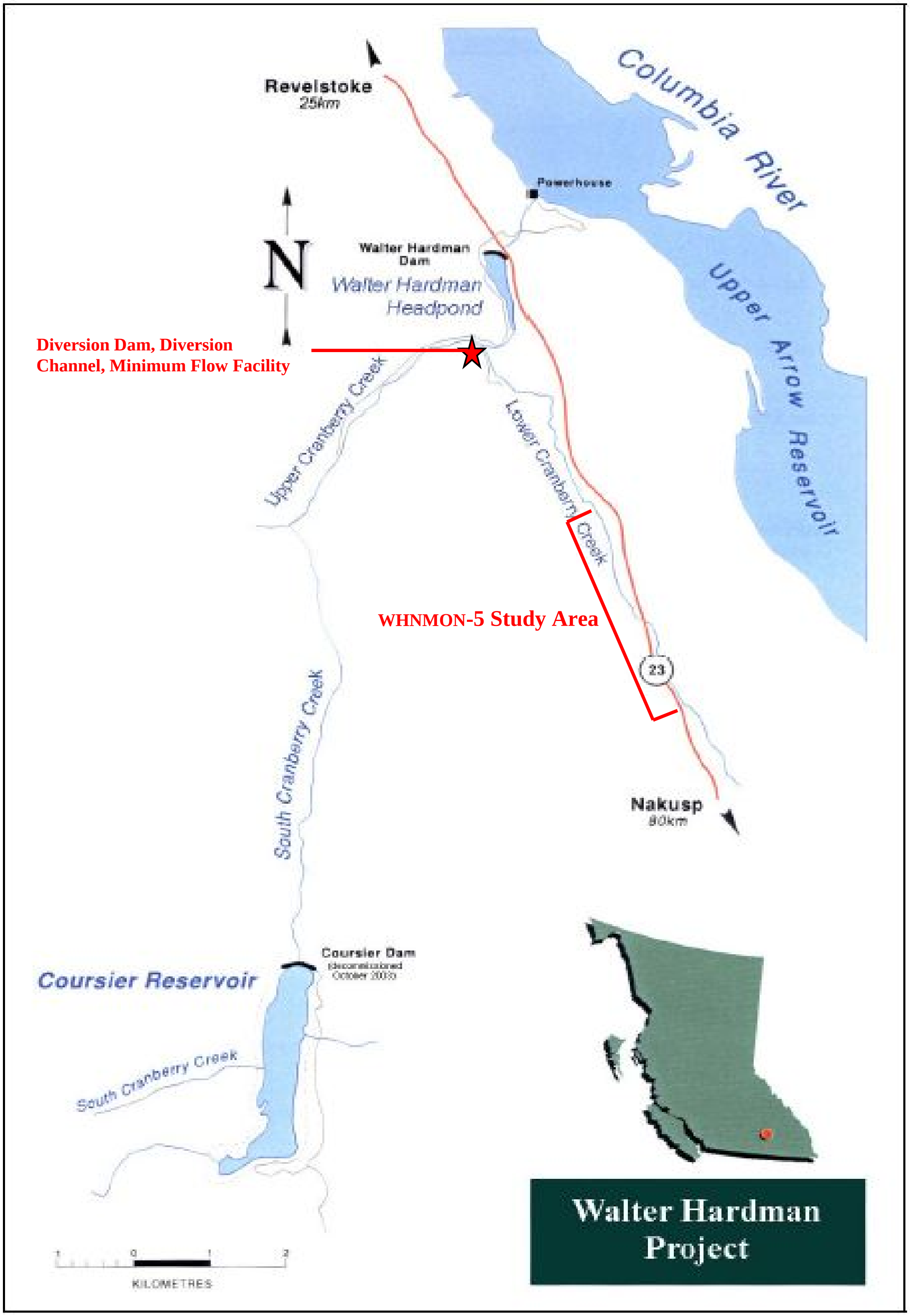

Figure 1-1. Overview map of Walter Hardman Facility and WHNMON-5 study area

The generating station is approximately 25 km south of Revelstoke, B.C. on Highway 23 and diverts water from Cranberry Creek to generate power. When creek flows are greater than plant capacity of ~4.3 m^3s^{-1}, the excess water is diverted into lower Cranberry Creek; however when flows are less than plant capacity no water is diverted into lower Cranberry Creek.

In 2008 and 2009, BC Hydro installed a water diversion pipe at the upstream end of the diversion channel under the works *Walter Hardman Water Use Plan: Walter Hardman Diversion Dam Minimum Flow Release Facility* (WHNWORKS-1). Several subsequent modifications to the system (October and December 2008 and November 2009) were needed to help maintain a minimum flow of 0.1 m^3s^{-1} during times of the year when discharge when water was no longer spilling over the diversion dam wall (BC Hydro 2009). Since the completion of the project in November 2009, the ability to maintain a minimum flow has been reasonably successful (BC Hydro 2010) although the status of the minimum flow facility through 2011 and 2012 has not been reported (BC Hydro 2011).

Figure 1-2. Overview of the minimum flow release facility at Walter Hardman, looking east (Sept 18 2008). (A) Upper Cranberry Creek, (B) Diversion channel, (C) Headworks Operating Gate, (D) Drywells (intakes), (E) Diversion Dam, (F) Upstream end of lower Cranberry Creek. (BC Hydro 2009)

Rainbow Trout are resident in lower Cranberry Creek and it was hypothesized by the Water Use Planning Consultative Committee that a lack of minimum flow would limit the available habitat and reduce productivity of the system (BC Hydro 2006a).

Rainbow Trout life history patterns in British Columbia can generally be described by one of the following strategies (Washington Department of Natural Resources 2005):

- Anadromous (Steelhead): Spawning and juvenile rearing in freshwater; migration to salt water for adult rearing
- Adfluvial: Spawning and juvenile rearing in freshwater streams; migration to lakes or reservoirs for adult rearing
- Fluvial: Spawning and juvenile rearing in small streams; migration to large rivers for adult rearing
- Resident: Entire life history occurs in small streams

In lower Cranberry Creek, and within the limits of this study area, it is likely that the Rainbow Trout population fits into the *resident* and possibly the *adfluvial* patterns, as it is possible for individuals to be "washed" downstream from Coursier Lake (approximately 9.5 kms upstream of the diversion dam) during freshet or flood events and end up in lower Cranberry Creek. However, in this case, individuals would not be able to migrate back upstream to Coursier Lake as adults given that the diversion dam is a barrier.

The Lower Cranberry Creek Rainbow Trout Abundance/Biology Monitoring program (WHNMON-5) has two objectives: It is intended to provide auxiliary information on the status of the resident Rainbow Trout population to support habitat assessments of fisheries benefits of minimum flow release from the diversion dam; it will also provide baseline Rainbow Trout abundance data against which future monitoring studies can measure a response. The overall goal of the program is to determine the effect of changes in minimal flows on the resident Rainbow Trout population in lower Cranberry Creek by addressing the following management questions:

- What is the status of the current Rainbow Trout population in lower Cranberry Creek?
- How do increases in minimum flows affect the Rainbow Trout population and what are the potential benefits of establishing a minimum flow?
- What is the qualitative capacity of the population to respond to potential habitat improvements resulting from minimum flow releases?

This report provides a qualitative analysis of fish habitat use as well as a population estimate for the resident Rainbow Trout population within the study area. It includes a description of age and size class, instantaneous growth rate, health and habitat use at low flows. Data collected was compared with previous studies where possible and applicable. These studies include: Summit Environmental Inc. (Summit) (2000), Davis et al. (2009) which was Year 2 of WHNMON-5 and Triton (2012a) which was Year 4 of WHNMON-5.

2. METHODS

The methodology for Year 5 of WHNMON-5 was consistent with that of Year 4 (2011/2012) of the program (Triton 2012a). It was consistent with the BC Hydro Terms of Reference (BC Hydro 2006a) and the Year 2 final report (Davis 2009). Methods adhered to the Resources Inventory Committee (RIC) Fish and Fish Habitat Inventory (RIC 2000), and the Fish Collection Methods and Standards (RIC 1999).

Similar to WHNMON-5, Summit (2000), in part, investigated fish habitat quality under different flows (high, medium and low) using a similar methodology. Rainbow Trout were captured, enumerated, weighed and measured and categorized into length-age categories. Where comparisons were made the following studies were used: Data from Summit's *Site 5* was used as its fish sampling location was in the WHNMON-5 study area. The Davis (2009) study was Year 2 of WHNMON-5 with the same reach of lower Cranberry Creek being utilized for the study.

2.1 FIELD STUDY

The study area is located along a 5.47 km section of Cranberry Creek between the impassable falls 2.30 km upstream of Upper Arrow Lake, and an unnamed tributary located 7.73 km upstream of the lake (Figure 2-1). Site locations in 2012 were similar to 2011. Sites were selected such that they were representative of the overall creek morphology, could be closed off with stop nets for effective fish sampling and, in order to capture of enough fish to be able to comment on the population, contained habitat characteristics (e.g., presence of instream cover) preferred by resident Rainbow Trout. Sites were flagged using surveyors flagging and labeled with company name, site number and Universal Trans Mercator (UTM) coordinates (NAD83).

As in 2011, eight sites were sampled within the study area with one site (Site 4) corresponding to Davis 2009 site LCSN06 (Figure 2-1). It should be noted that while Summit's "*Site 5*" was within the study area (Table 3-1), they did not report specific UTMs and therefore the degree of overlap with Triton sites 7 and 8, if any, cannot be determined. Rough scaling from Figure 1.1 of Section 1.3 of Summit (2000) suggests that *Site 5* occurs between Triton sites 7 and 8.

In 2012, four of the 2011 sites had to be slightly relocated due to the sampling being completed at a slightly higher flow level which made closing the sites difficult. Site 3 in 2012 was moved 39 m downstream of the 2011 location, Site 4 was moved approximately 50 m upstream of the 2011 location (and overlapped with Site 3 of 2011), Site 5 was moved approximately 65 m upstream of the 2011 location and Site 7 was moved approximately 130 m upstream of the 2011 location.

Closed-site, multi-pass electrofishing was completed at all eight sites using a Smith-Root Model 12B backpack electrofisher with pulse frequency of 60 Hz and pulse width of 6 ms. Voltage settings during sampling varied from 300 to 400 volts depending on water conductivity at each site. Sampling was conducted using the multiple pass depletion method (consecutive passes resulting in decreasing numbers of captures) as developed by Zippin (1958) and described in Lockwood and Schneider (2000). Stop-nets with 5 mm mesh size were set up at each site approximately 50 m apart to isolate a section of the stream prior to electrofishing. Specific placement of the stop-nets was determined on site to select for high habitat values to maximize fish capture potential. One crew member with the electrofisher and one or two crew members, each with a dip net, would then sample the length of the enclosure, in an upstream direction, placing all captured fishes in 5 gal. buckets. Fishes were weighed to the nearest 0.01 g and measured to the nearest 1 mm (fork length: FL) following each pass. All fishes captured were anaesthetized using a solution of clove oil and creek water (0.03g clove oil per L water) as recommended by Anderson et al. (1997) to reduce handling stress before being weighed and measured. Fishes were then placed in a recovery bucket with fresh creek water and an aerator. Sampling passes were carried out until either no target fish are captured or a decline in numbers of target fish occurs over three consecutive passes. Fishes were monitored for signs of stress throughout the handling process, and once fully recovered, were released back into the creek within the vicinity of their capture.

Scale samples were taken from a sub sample of captured Rainbow Trout individuals across all sites to represent the different size classes. Samples were sent to North/South Consultants Inc. to be aged.

Fish habitat assessment at each site followed the standards and procedures established by the Resources Inventory Committee (RIC) (RIC 1999). Data collected included residual pool depth, substrate composition and description of available cover for fish. Water quality data including water temperature, pH, and conductivity was collected at each site as well as site length, stream gradient and UTM location. Representative site photographs were taken to document site conditions during the study period.

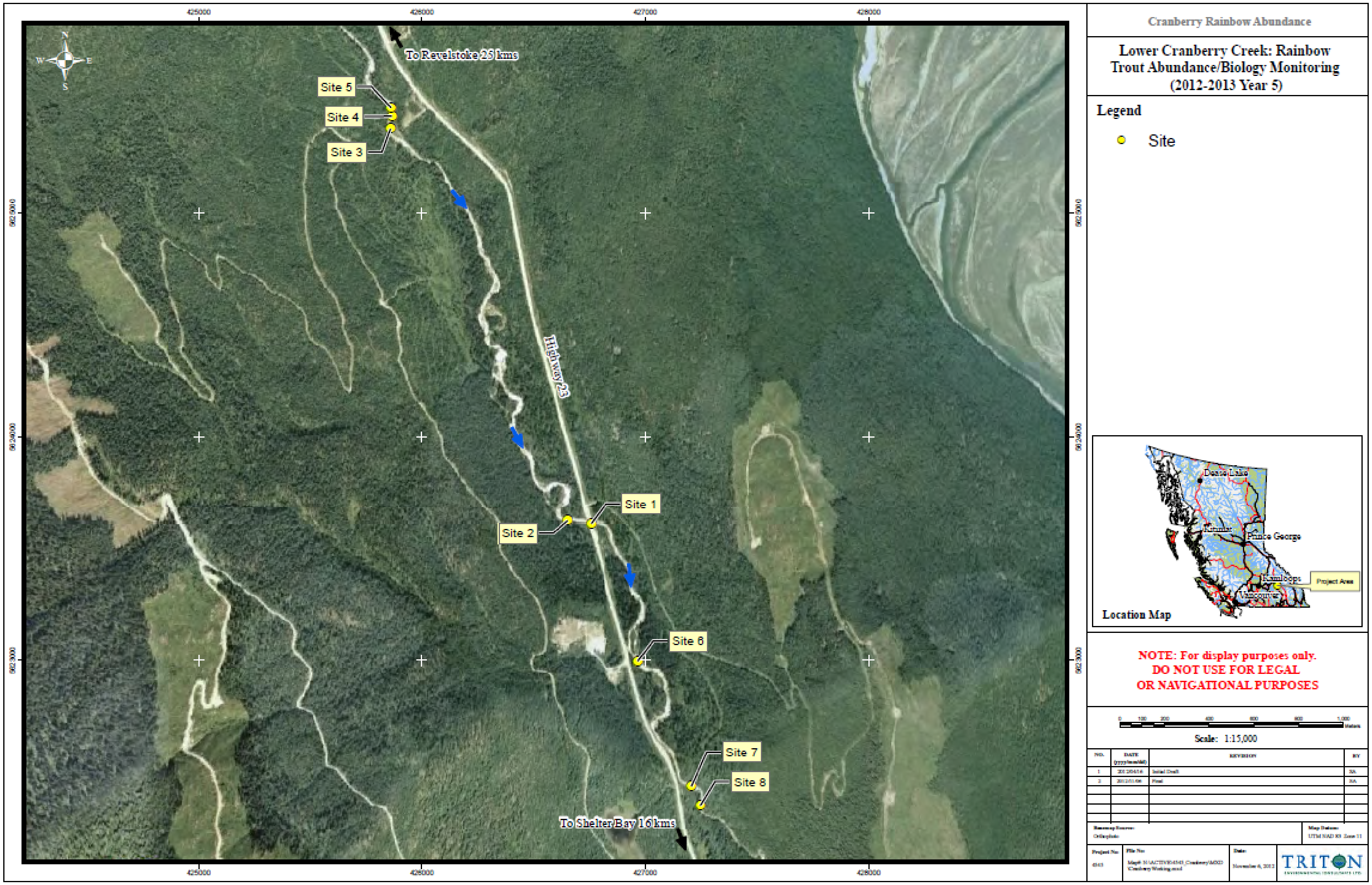

Figure 2-1. WHNMON-5 Study Area, Triton 2012

2.2 DATA ANALYSIS

All data collected was entered into a spreadsheet using MS Excel for analysis and comparison of the following parameters:

- Population estimate and density (using software MicroFish 3.0; Van Deventer, 1989)
- Fish size and age composition
- Biomass per site
- Comparison of results with Davis (2009), Summit (2000) and Triton (2012a)
- Habitat use and availability at various flows

2.2.1 Population Estimate and Density

Electrofishing results were used to calculate population and density of Rainbow Trout. Site density was calculated under the Maximum-likelihood Estimation method (MLE; Zippin, 1956, Seber, 1982)) using the software MicroFish 3.0 (Van Deventer, 1989). MLE is a commonly used method of estimating unknown parametric values under a particular assumption (*i.e.,* normal distribution). MLE was used in conjunction with the depletion method to estimate the size of the local population (Zippin 1958). Observed fish density (fish/100 m^2) was also calculated from collected field data:

$$\text{Observed density (fish per } 100\text{m}^2) = \frac{\text{number of fish captured*}(100)}{\text{measured site area } (\text{m}^2)} \qquad \textbf{(Eq.1)}$$

Where only two passes were performed (Sites 1 and 3) equations 2, 3 and 4 were used (Lockwood and Schneider 2000). Two-pass depletions are unbiased when $p \geq 0.80$ and unreliable when $p \leq 0.20$ (i.e., when less than 20% of the population is caught per pass) (Lockwood and Schneider 2000).

Population Estimate:

$$N = \frac{n^2_1}{(n_1 - n_2)} \qquad \textbf{(Eq.2)}$$

Variance:

$$V = \frac{n_1^2 n_1^2 (n_1 + n_2)}{(n_1 - n_2)^4} \qquad \textbf{(Eq.3)}$$

Probability of capture

$$p = \frac{n_1 - n_2}{n_1} \qquad \textbf{(Eq.4)}$$

Where, N = Population Estimate (number of individuals)
n_1 = number of fish caught on first pass
n_2 = number of fish caught on second pass
V = Variance
p = probability of capture

2.2.2 Age Composition - Length-Weight Relationship – Biomass

Twenty-five scale samples were collected during sampling and aged by North South Consultants Inc. Samples from fish were carefully taken from the widest possible size range of fish to allow to comment on age in each size class. These data were used in conjunction with length-weight field data to delineate a likely age structure. Biomass at each site was calculated as:

$$\text{Biomass (g/m}^2\text{)} = \frac{\text{sum of all recorded weights of captured RB (grams)}}{\text{measured area of the site (m}^2\text{)}} \qquad \textbf{(Eq.5)}$$

2.2.3 Growth Rate and Fish Condition

Instantaneous growth rate (see section 3.3.3 for further explanation) was calculated by using the mean FL in each age class plotted against age. The slope of the best-fit line corresponds to growth rate. Fish condition was quantified as there might be a wide variation in the length-weight relationship depending on the health of individual fish. As cited in Davis (2009), condition indices can provide a relevant measurement of individual fish health based on their length and weight (Anderson and Neumann 1996). Fulton's condition factor (K; Ricker 1975) was used to quantify the relative condition or well-being of captured fish:

$$K = \frac{10^5 W}{L^3} \qquad \textbf{(Eq.6)}$$

Where W is equal to mass in grams (g) and L is equal to fork length in millimeters (mm) and 10^5 is a scaling factor. Typical condition factor range for salmonids is 0.8 to 2.0. Barnham and Baxter (1998) proposed a grading scale for fish condition (salmonids) factor in which a value of 1.2 suggests "a fair fish, acceptable to many anglers", whereas a value of 1.4 suggests "a good, well-proportioned fish". Values less than 1.0 are considered "poor" and reflect long, thin bodies.

3. RESULTS AND DISCUSSION

3.1 RECONNAISSANCE SURVEY

Site locations in 2012 were approximately the same as in 2011. Sites were selected such that they were representative of the overall creek morphology, were able to be closed off with stop nets for effective fish sampling and, in order to help ensure capture of enough fish to be able to comment on the population, contained habitat characteristics (ex; presence of instream cover) preferred by fluvial Rainbow Trout. Sites were flagged using surveyors flagging and labeled with company name, site number and Universal Trans Mercator (UTM) coordinates (NAD83).

A total of eight sites were sampled within the study area with one site (Site 4) in close proximity to Davis 2009 site LCSN06. Summit's "*Site 5*", was assumed to occur between Triton sites 7 and 8. (Table 3-1). Sections 3.1.1 and 3.1.2 provide habitat descriptions and representative site photographs.

Table 3-1. Rainbow Trout Abundance Sample Sites, 2012

Site ID	UTM 11U Coordinates (NAD83)		Elevation (m)	Site Length (m)	Comment
	Easting	Northing			
Site 1	426777	5623617	597	50	Hwy. 23 crossing; Triton site 2011(Year 4)
Site 2	426648	5623632	598	51	Triton site 2011(Year 4)
Site 3	425879	5625344	629	49	Moved 39 m downstream from 2011 location
Site 4	425855	5625387	629	45	Moved 50 m upstream from 2011 location
Site 5	425819	5625514	630	53	Moved 65 m upstream from 2011 location
Site 6	426944	5623025	591	47	Triton site. Near LCSN04 (Davis Year 2). Moved 37 m upstream from 2011 location
Site 7	427142	5622536	586	45	Moved 135 m upstream from 2011 location
Site 8	427256	5622371	583	48	Triton site 2011(Year 4)

3.1.1 Habitat Quality Descriptions

Table 3-2. Rainbow Trout Habitat Descriptions, September 5th to 7th, 2012

Site	Stream Temp (^{0}C)	Stream Stage[A]	Total Cover[B]	Habitat Category			Comments[C]
				Rearing	Overwintering	Spawning	
Site 1	9.9	L	T	Low	Low	Low-Mod	Low rearing due to limited cover; Low O/W due to lack of deep (>0.5m) pools; Low-Mod spawning due to some suitable-sized gravels
Site 2	10.3	L	M	Mod - High	Mod - High	Low	Mod-High rearing due to boulder and OV cover; Mod-High O/W due to some deep (0.9m) pool habitat; Low spawning due to limited amount of suitable sized spawning gravel
Site 3	8.4	L	M	Low - Mod	None	Low	Low-Mod rearing due to lack of abundant cover; No O/W due to lack of deep pools; Low spawning due to limited abundance of suitable gravel
Site 4	9.6	L	M	Mod	Low	Low	Mod rearing due to adequate cover and habitat complexity; Low O/W due to limited pools >0.5m deep; Low spawning due to limited suitably sized gravels
Site 5	12.5	L	M	Mod	None	None	Mod rearing due to adequate cover and habitat complexity; No O/W due to lack of suitably deep pools; No spawning due to too large substrate
Site 6	11.3	L	M	Mod	None	None	Mod rearing due to adequate cover; No O/W due to lack of suitably deep pools; No spawning due to too large substrate
Site 7	8.6	L	M	Mod	Low	Low	Mod rearing due to adequate cover and habitat complexity; Low O/W due to one small pool >0.5m deep; Spawning limited due to small amounts of suitable sized gravels. RB fry caught here suggests possibility of spawning area
Site 8	12.4	L	M	High	None	None	High rearing due to abundant boulder cover and good habitat complexity; No O/W due to lack of suitably deep pools; No spawning due to too large substrate

[A] Stream Stage refers to discharge during the study period; L – Low: corresponds to flow ≤ 30% of Bankfull Depth (RIC 1999)

[B] Total Cover refers to all structure in the wetted channel and to 1 m above water surface that provide hiding, feeding, and resting places for fish. It is expressed as a percentage of the area of the site; T – Trace; <5% cover exits at the site. M – Moderate: 5-20% cover exists at the site (RIC 1999).

[C] O/W – Overwintering; OV – Overhanging stream vegetation

3.1.2 Site Descriptions

Every effort was made during 2012 to place sites such that there was 100% overlap with 2011 sites. For four of the eight sites (Sites 1, 2, 4 and 8) we were able to mirror the site locations. However, due to difference in creek morphology from 2011 to 2012, 100% overlap was not possible at Sites 3, 5, 6 and 7 such that the site could be effectively closed and sampled as described in the sampling methods. Every effort was made, in this case, to position sites 3, 5, 6 and 7 as close as possible to the 2011 locations.

Site 1

This 50 meter long site, at the Highway 23 bridge crossing, consisted of a riffle at the upstream end, glide/run under the bridge and shallow riffle at the downstream end. The morphology at the upstream end was different in 2012 compared to 2011 with bed load mobilization changing the left margin from glide/run to riffle. See Plate 1 below for comparison (2012 on left; 2011 on right).

Plate 1. Overview photos of Site 1 on lower Cranberry Creek comparing 2012 (left) and 2011 (right). View is downstream from mid-channel at the upstream end of the site.

Site 2

This 51 meter long site was located approximately 80 m upstream of Site 1 and consisted of a glide with cobble/gravel/boulder substrates. The right margin was dominated by rip rap and boulder providing the majority of quality rearing habitat while the left bank was shallow-sloped and cobble-dominated with no instream or overhead cover. Comparative site photographs from 2012 (left) and 2011 (right) show higher discharge in 2012 than in 2011 with similar morphology.

Plate 2. Overview photos of Site 2 on lower Cranberry Creek comparing 2012 (left) and 2011 (right). View is downstream from left wetted edge at the upstream end of the site.

Site 3

This 49 meter long site was located approximately 1.9 km upstream of the Highway 23 bridge crossing and 39 meters downstream of Site 3 in 2011. As in 2011, the site was uniform riffle-pool with boulder/cobble substrates. The majority of the flow was against the right bank with boulders the dominant source of instream cover. Overhead vegetation cover was limited to a few meters at the upstream end of the site along the right bank.

Plate 3. Overview photos of Site 3 on lower Cranberry Creek comparing 2012 (left) and 2011 (right). View is downstream from mid channel at the upstream end of the site.

Site 4

This 45 meter long site was located approximately 2 km upstream of the Highway 23 bridge crossing and 50 m upstream of 2011 Site 4. This year's Site 4 matched 2011 Site 3. The site consisted of riffle-pool morphology with boulder/cobble substrates and a bedrock controlled pool at the upstream end headed by a steep riffle. Cover at this site was provided mainly instream boulders and secondarily by overhead vegetation at the downstream end of the site along the right margin. The bedrock pool at the upstream end of the site was deeper and narrower in 2012 compared to 2011. Plate 4 below shows this location in 2012 (left picture) and 2011(right picture).

Plate 4. Overview photos of Site 4 on lower Cranberry Creek comparing 2012 (left) and 2011 (right). View is downstream from mid channel at the upstream end of the site.

Site 5

This 53 meter long site was located approximately 2.1 km upstream of the Highway 23 bridge crossing, 65 m upstream of 2011 Site 5, and consisted mainly of riffle-pool morphology and boulder/cobble substrate, similar to 2011. Cover was limited to a few instream boulders and moderate amount of overhanging vegetation cover and limited small woody debris cover along the left margin.

Plate 5. Overview photos of Site 5 on lower Cranberry Creek comparing 2012 (left) and 2011 (right). View is upstream from mid channel at the downstream end of the site.

Site 6

This 47 meter long site was located approximately 630 m downstream of the Highway 23 bridge crossing (35 m upstream of 2011 Site 6), was riffle/pool morphology and consisted of cobble/boulder substrates, similar to 2011. Cover for this site was primarily overhead vegetation along the left margin at the downstream half of the site. Instream cover was limited to a trace amount of small woody debris along the left margin at the upstream end of the site.

Plate 6. Overview photos of Site 6 on lower Cranberry Creek comparing 2012 (left) and 2011 (right). View is downstream for both from right bank (2012) and mid channel (2011).

Site 7

This 45 meter long site was located approximately 1.2 km downstream of the Highway 23 bridge crossing, 130 m upstream of 2011 Site 7, and was glide morphology with riffle-pool at the upstream end of the site, similar to 2011 morphology. Substrate composition was cobble/gravel with cover consisting of primarily large woody debris along the left margin throughout the site.

Plate 7. Overview photos of Site 7 on lower Cranberry Creek comparing 2012 (left) and 2011 (right). View is upstream from mid channel at the downstream end (2012) and midway (2011) location of the site.

Site 8

This 48 meter long site was located approximately 1.42 km downstream of the Highway 23 bridge crossing and was riffle/pool morphology with a cobble/gravel riffle at the downstream end, a bedrock pool mid-site and a boulder/cobble riffle at the upstream end of the site. The 2012 location directly overlapped the 2011 location. Cover at the site was mainly provided by instream boulders with overhead vegetation along the left margin providing cover as well. Comparative site photographs from 2012 (left) and 2011 (right) show higher discharge in 2012 compared to 2011.


Plate 8. Overview photos of Site 8 on lower Cranberry Creek comparing 2012 (left) and 2011 (right). View is upstream for both from mid channel for both. Note the lower water level in 2011 (right photo) compared to 2012 (left photo).

3.2 FISH HABITAT CONDITIONS

3.2.1 Water Temperature and Water Depth

Water temperatures during sampling ranged from 8.4 °C at Site 3 (09:40 hrs) to 12.5 °C at Site 5 (14:16 hrs). The mean temperature across all sites was 10.4 °C (SD = 1.6), compared to 12.8 °C (SD = 2.4) in 2011. This is well within normal preferred range of 7 °C to 18 °C for Rainbow Trout (Raleigh et al. 1984 as cited in McPhail 2007). Water temperatures were lower in 2011 and 2012 than in 2008 (Davis 2009) where water temperatures ranged from 11.5 °C to 17.5 °C with a mean of 13.4 °C (SD = 2.0). Site sampling in 2008 was carried out approximately one month earlier than in 2011 and 2012 which could account for the warmer water temperatures.

Discharge of lower Cranberry Creek at time of 2012 sampling was characterized as *Low* and morphology as riffle-pool. However, discharge in 2012 was greater than at the same time in 2011 with a greater degree of connectivity between pools. Similar to 2011 residual pool depths in 2012 varied within and between sites from 0.20 m to 0.95 m. Mean residual pool depth across all sites in 2012 was 0.47 m which was marginally less than the 2011 average of 0.57 m. As stated previously, creek discharge was greater in 2012 than in 2011. This is evident from comparing site photos (particularly sites 4 and 8). The shallower average is likely due to most site locations not overlapping completely from 2011 to 2012 – measuring locations differed year to year.

3.2.2 Spawning – Rearing – Overwintering Habitat Quality

Three of the eight sites in 2012 were characterized as having no suitable gravels for spawning RB (Sites 5, 6 and 8). The remaining sites contained low to moderate (Site 1) or limited (Sites 2, 3, 4 and 7) spawning habitat. This result was not unexpected as sites were selected to maximize the chance of RB captures where good cobble/boulder cover was essential for rearing cover. These areas did not contain high value spawning substrates.

Rearing habitat for fry and juveniles is characterized by mainly cobble-boulder substrates with an abundance of both in-stream and overhanging vegetation cover (McPhail 2007). Abundant escape and resting cover is essential to high value Rainbow Trout rearing habitat for stream populations and is characterized by cobble/boulder substrates, undercut banks and large woody debris. These areas provide refuge from predators, staging for forage locations and resting areas (Raleigh et al. 1984). Rearing habitat quality was diverse between all the sites. Site 1 contained low quality rearing habitat whereas Sites 3 and 8 contained moderate to high and high quality habitat (Table 3-2). Fish capture data reflected these habitat values with Site 1 having the lowest abundance (n = 3) and Sites 3 and 8 having the highest abundance (n = 18 each).

Ideal overwintering habitat is characterized by an abundance of cover, pool depths > 0.5 m, a dissolved oxygen > 9 mg/L, either by seasonal flow or groundwater influence, and water temperatures greater than 0 °C (Raleigh et al 1984). Although this study's scope did not include overwintering temperature monitoring or dissolved oxygen, residual pool depths and cover quantity were measured. Overwintering habitat values ranged from *None* at Sites 3, 5, 6 and 8 (lack of deep pools) to *Low* at Sites 1 and 4 (few deep pools) to *Moderate* at Site 2 (several sufficiently deep pools) (Table 3-2).

3.3 POPULATION DYNAMICS

As in 2011, electrofishing sampling yielded Rainbow Trout captures at all eight sites in 2012. In total, 73 individuals were captured in 2012 compared to 146 in 2011. Age classes were delineated by producing a length-frequency histogram as well as analyzing the scale aging results. Similar to 2011, though less defined this year, the population likely was represented by four age classes: 0+ to 3+ fish. Similar to 2011 as well, adult fish were likely those fish in the 3+ age category or greater than 150 mm FL. As stream residents are typically smaller-bodied than fluvial and adfluvial individuals, maturity may be reached at 150 mm FL (Northcote and Hartman 1988 as cited in McPhail 2007). The majority of fish captured in 2012 were juveniles (n=70) with 1 adult captured and 2 fry. Sites 2 and 8 had the most fish captured (n=18 each) while Site 1 had the fewest (n=3).

The ability to compare population dynamics data between the 2012 and 2008 results (Davis 2009) and draw meaningful conclusions is limited as only 3 RB were captured by electrofishing in 2008 at one site versus 73 Rainbow Trout captured in 2012 at eight sites. As well, 2012 sampling took place one month later than in 2008. Comments and photos from Davis (2009) suggest that creek discharge was higher in 2008 during the time of sampling than in 2012. However, no gauging station exists on the creek and as a result there is no data available. As such, comparison of results was focused on 2011 and 2012.

3.3.1 Population Estimate and Density

The software *MicroFish version 3.0* (Van Deventer 2012) was used to obtain the Maximum Likelihood Population Estimate (MLE), corresponding confidence range (95% confidence interval – CI_{95}) and capture probability at sites where three consecutive passes were performed. Where two passes were performed (Sites 1 and 3), the methodology followed Lockwood and Schneider (2000) (equations 2, 3 and 4 in section 2.2.1 of this report). Table 3-3 summarizes Rainbow Trout capture data by site and the resulting MLE. The only species captured other than Rainbow Trout were Sculpins, most likely Torrent Sculpin as they are historically documented in the study area (Summit 2000). The incidental capture of Sculpins was noted and those that were captured were removed from the sampling area to limit their stress during subsequent electrofishing passes. Rainbow Trout density was calculated for each site and is summarized in Table 3-4.

Table 3-3. Rainbow Trout Population Estimate, 2012

Site ID	Pass	Effort (EF sec)	Number Fish Captured	Pop'n Est. (n) MLE	Confidence Range$_{(95\%\ CI)}$ (+/- n fish)	Capture Probability (p)
1	1	463	3	3[A]	3	1
1	2	481	0			
2	1	474	11	18	2	0.69
2	2	478	6			
2	3	507	1			
3	1	576	4	4	4	1
3	2	622	0			
4	1	660	5	11	5	0.50
4	2	716	2			
4	3	487	1			
4	4	503	2[B]			
5	1	485	5	7	1	0.78
5	2	515	2			
5	3	502	0			
6	1	757	3	5	1	0.71
6	2	578	2			
6	3	553	0			
7	1	723	6	8	1	0.80
7	2	657	1[C]			
7	3	698	1			
7	4	543	0			
8	1	567	14	18	1	0.78
8	2	515	3			
8	3	387	1			

[A] Where 2 passes were performed; refer to equations 2, 3 and 4 (section 2.2.1).
[B] Passes 3 and 4 were combined to obtain MLE. The entries into *MicroFish 3.0* were *5, 3, 2*.
[C] Passes 2 and 3 were combined to obtain MLE. The entries into *MicroFish 3.0* were *6, 2, 0*.

Table 3-4 Rainbow Trout Density Results 2011 and 2012

2012						2011	
Site ID	Pop'n Est. (n fish)	Estimated 95% Confidence Interval (+/- n fish)	Measured Area (m^2)	Fish Density (fish/100m^2)	Estimated 95% Confidence Interval[B] (+/- n fish)	Fish Density (fish/100m^2)	Estimated 95% Confidence Interval (+/- n fish)
1	3[A]	3	455.0	0.66	0.66	6.84	0.51
2	18	2	382.5	4.70	0.52	6.42	1.28
3	4[A]	4	534.1	0.75	0.75	13.68	0.42
4	8	5	346.5	2.31	1.44	8.24	2.15
5	7	1	514.1	1.36	0.19	5.31	0.38
6	5	1	380.7	1.31	0.26	4.94	0.41
7	8	1	432.0	1.85	1.85	1.46	1.46
8	18	1	384.0	4.67	0.26	3.85	0.55

[A] Sites 1 and 3 values were calculated using Eq 2 and 3 (section 2.2.1) to obtain population estimate and corresponding variance.
[B] Confidence Interval here is calculated from first converting MLE CI into a percent then multiplying that value by fish density.

Of the seven sites sampled by Davis in 2008, only one site (site LCEF05.5) yielded Rainbow Trout through electrofishing (n = 3). Fish size and abundance data for the remaining six sites were gathered through snorkel surveys with Rainbow Trout observed at sites LCSN01.5, 03 and 04. Davis (2009) reported a population estimate and density calculation for site LCEF05.5 but only density calculations for sites LCSN01.5, 03 and 04 (Table 3-4).

Table 3-5 Summary of Davis 2008 sampling results (see Tables 3 and 4, Davis 2009)

Site ID	Sampling Method	# Obs	Length (cm)	Weight (grams)	Pop'n Estimate	Density[B] (fish/100m^2)	Biomass (g/m^2)	Condition Factor - K
LCSN01.5	Snorkel	3	0-15	nr	nr	1.09	nr	nr
LCSN03	Snorkel	3	0-30	nr	nr	3.57	nr	nr
LCSN04	Snorkel	1	0-10	nr	nr	0.23	nr	nr
LCEF05.5	EF	3	16.37[A]	34.40[A]	4	4.00	1.23	0.82

[A] These were the calculated means (mass assumed to be grams): (14.6cm, 30.4g, K=0.98), (14.5cm 28.3g, K=0.93) and (20.0cm, 44.5, K=0.56).
[B] Density was converted from fish/m^2 as reported in Davis 2009 to fish/100m^2
nr – "not reported"

The 2011 Rainbow Trout densities were higher than in 2008, while the 2012 densities were lower than in 2008. It should be noted once again that the ability to compare densities between 2012 and 2008 is limited due to low catch numbers in 2008. The mean density in 2008 was 2.22 fish/100 m^2 (N=4; SD = 1.85; Table 3-5) while it was 6.34 fish/100 m^2 in 2011(N=8; SD = 3.60) and 2.20 fish/100 m^2 (N=8; SD = 1.62) in 2012 (Table 3-4).

Summit *Site 5* (Summit 2000), which was likely between Triton Sites 7 and 8, yielded a population estimate of 30 Rainbow Trout. This was higher than Sites 7 and 8 in 2011(6 and 14 Rainbow Trout, respectively) and 2012 (8 and 18 Rainbow Trout, respectively). As well, Rainbow Trout density was greater at *Site 5* in 2000 (4.97 fish/100m^2) than in 2011 (Site 7 1.46 fish/100m^2, Site 8 3.85 fish/100m^2) and 2012 (Site 7 1.85 fish/100m^2, Site 8 4.67 fish/100m^2). Additionally, *Site 5* was reported to have the largest measured population of all sites sampled in 1997 and 1998 (Summit 2000). It should be noted that for their study Summit used additional sampling methods such as minnow-trapping and snorkel surveys whereas WHNMON-5 used only electrofishing. These additional sampling methods likely account for the greater numbers of RB captured and observed in 1997 and 1998 at *Site 5*.

3.3.2 Age Composition - Length-Weight Relationship – Biomass

Of the 73 Rainbow trout captured, scale samples from 25 individuals were collected and sent for age analysis to *North/South Consultants Inc*. In an effort to represent each age class, multiple scale samples were taken from the widest variety of lengths possible.

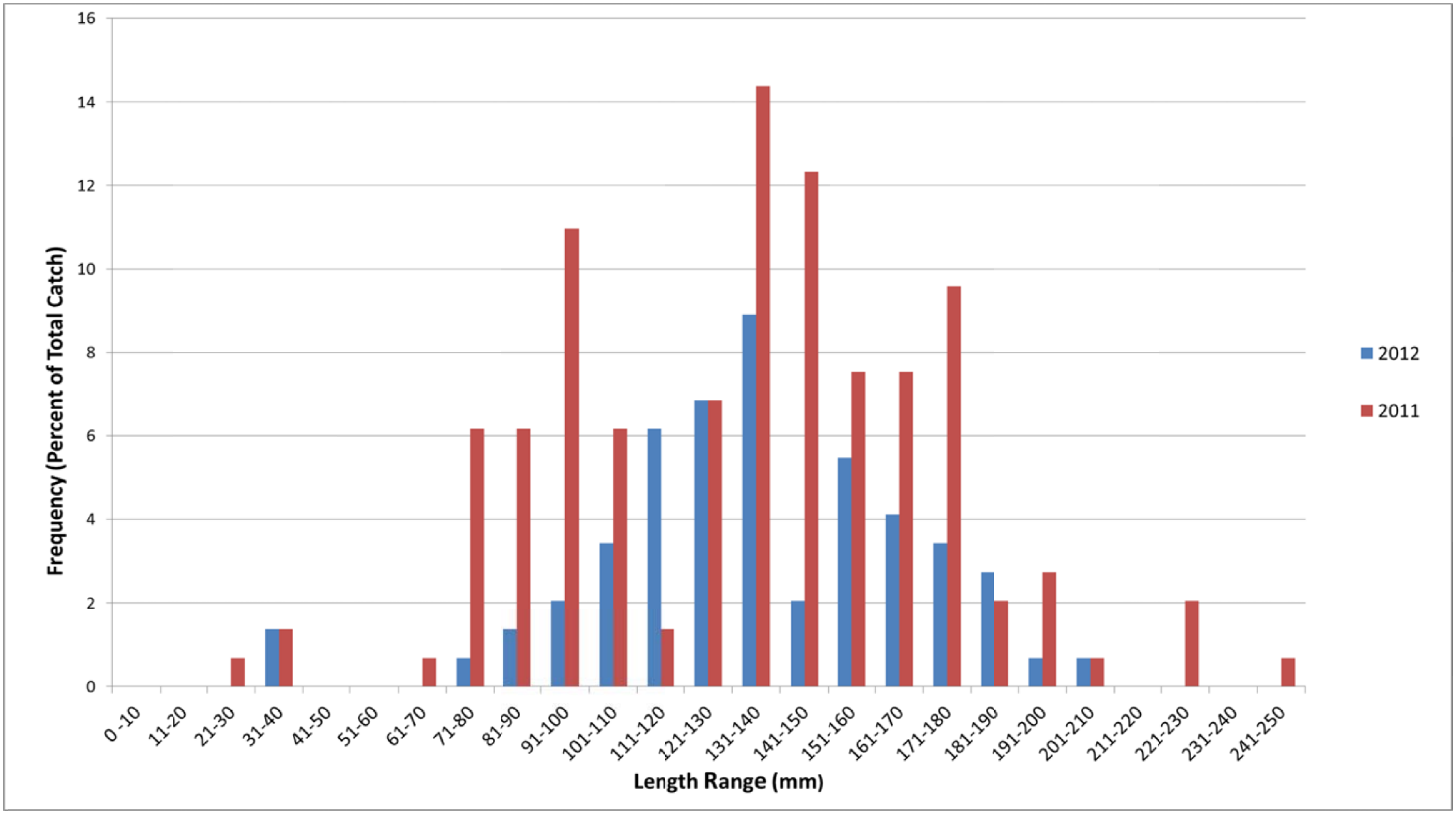

Figure 3-1. Length Frequency for Rainbow Trout captured during the 2011 (N=146) and 2012 (N=73) WHNMON-5 field programs.

For 2012 data (Figure 3-1) it was estimated that 0+ (fry) fish ranged in length from 0 to 60 mm FL, 1+ fish from 61 to 90 mm, 2+ fish from 91 to 140 mm and 3+ from 141 to 210 mm. Except for fry, the 2012 ranges were narrower than the estimated ranges in 2011 where 1+ fish ranged from 60 to 120 mm, 2+ from 120 to 200 mm and 3+ from 200 to 230 mm (Table 3-5).

Table 3-6. Length range for represented age classes for 2011 and 2012.

	Fork Length at age (mm)			
Study Year	**0+ to 1+**	**1+ to 2+**	**2+ to 3+**	**3+[A]**
2012	0 -60	61- 90	91 – 140	> 140
2011	0 -60	61 - 120	121 – 200	> 200

[A] The upper limit fork length for the 3+ age group was likely not represented by any individuals captured in 2012 or 2011.

There was a strong relationship between weight and length for all years ($R^2 > 0.97$).

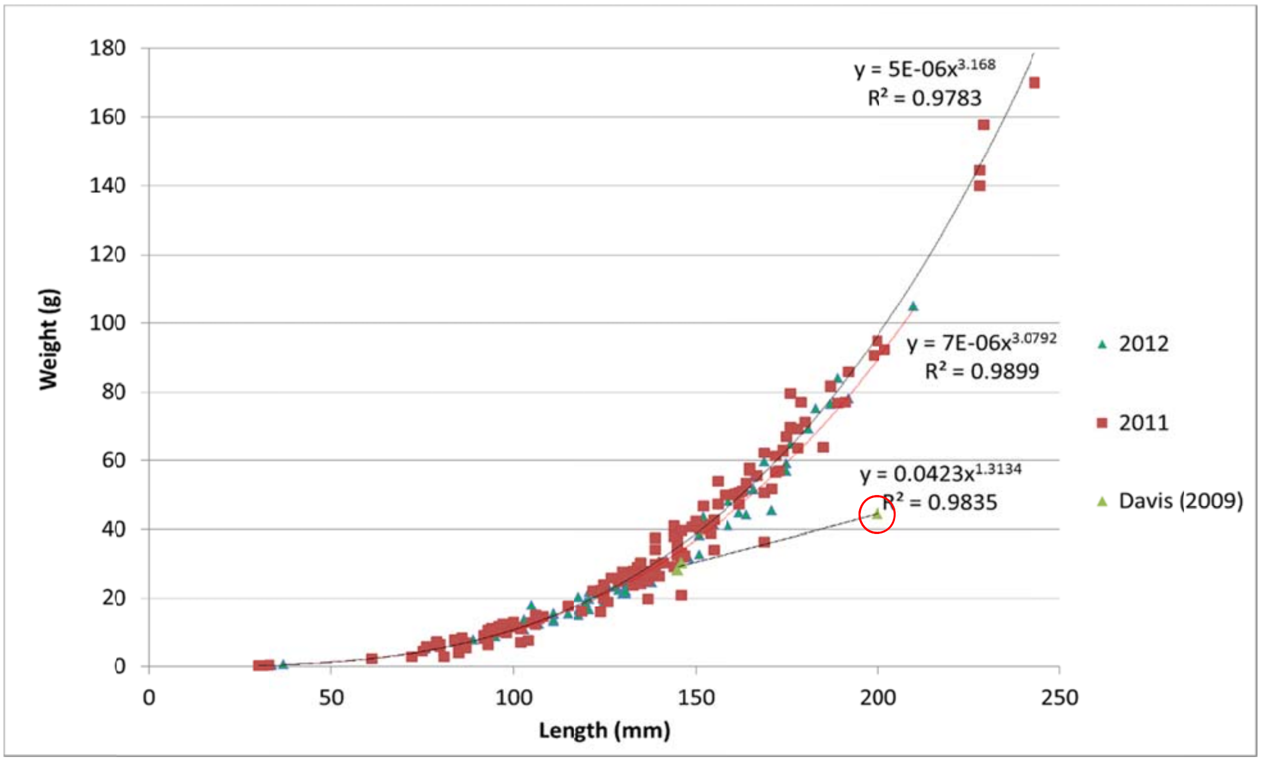

Figure 3-2. Weight Length regression for Rainbow Trout captured during the 2008 (Davis 2009), 2011 and 2012 (Triton 2012; Triton 2013) field programs.

Data from 2011 and 2012 show similar characteristics: Two of the three data points from 2008 are also similar but the third (200e mm, 44.5g; red circle) is an outlier. It is possible that there was a field measurement or data transcription error with respect to the 44.5 g weight measurement.

Figure 3-3 compares WHNMON-5 (2011 and 2012 field programs) and CLBMON-17, Middle Columbia Juvenile fish habitat Use, tributary sampling data. The Middle Columbia program began in 2008 with 2013 scheduled as the final field season. Sampling sites for this project include main stem (Columbia River and Upper Arrow Lake) sites as well as five (5) tributary sites (Jordan River, Illecillewaet River, Tonkawatla Creek, Drimmie Creek and Begbie Creek). The weight length relationships between Cranberry Creek and other five (5) additional Columbia River tributaries are similar. This suggests that Rainbow Trout in Cranberry Creek are similar in terms of length and weight to Rainbow Trout in other Middle Columbia River tributaries.

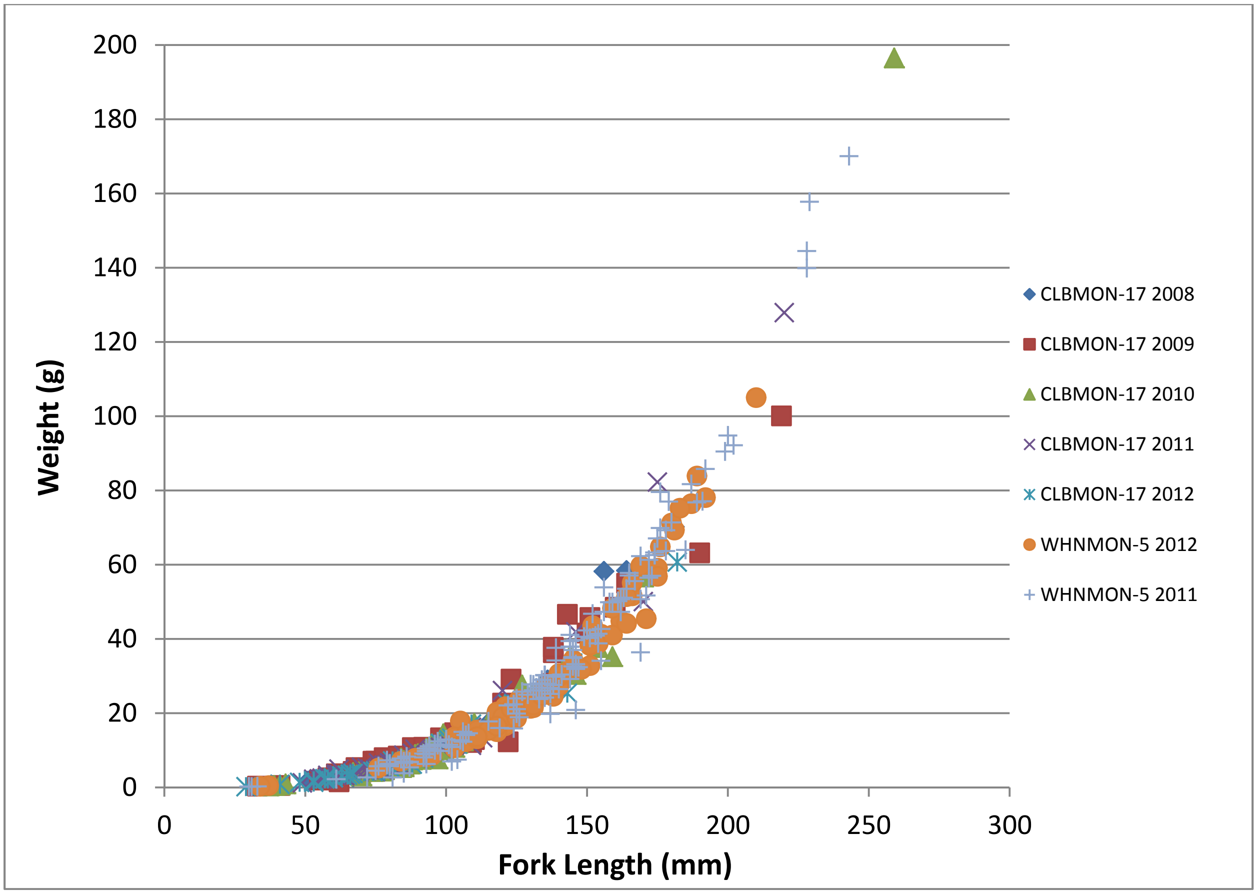

Figure 3-3. Weight Length regression comparison between WHNMON-5 (2011, 2012 field programs) and CLBMON-17 (2008 – 2012 field programs) for captured Rainbow Trout.

Biomass was also calculated for each site as the total weight of all captured Rainbow Trout divided by the measured area of the site to yield grams per square meter (Figure 3-4). The decrease in biomass observed in 2012 compared to 2011 may be a function of the decreased degree of habitat fracturing that was observed because of higher discharge visually observed in 2012. Higher flows in 2012 than in 2011 likely allowed fishes to move more freely throughout the creek.

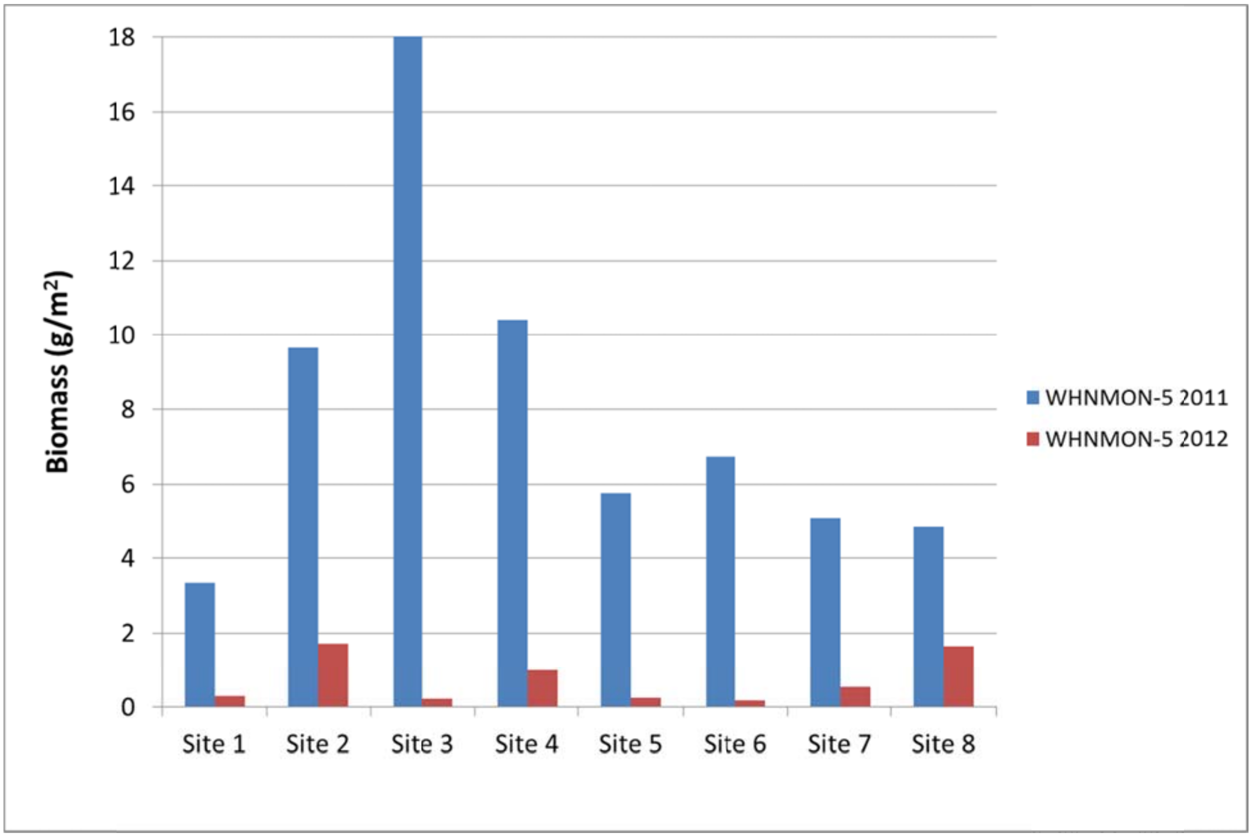

Figure 3-4. Biomass by site for Rainbow Trout captured during the 2011 and 2012 field programs

Over the three years of which data is available, 2011 had the highest mean biomass (8 sites; mean = 8.00 g/m^2, SD = 4.79) followed by 2012 (8 sites; mean = 0.64 g/m^2, SD = 0.73 g/m^2) and 2008[1] (2 sites; mean 0.64 g/m^2, SD = 0.87).

Population estimates, density and biomass rely on the ability to capture fish. Though no discharge monitoring station has been installed to date, lower Cranberry Creek discharge was noted to be higher in 2012 than in 2011 (BC Hydro 2011). Last season's program concluded that the low discharge of Cranberry Creek likely concentrated the Rainbow Trout population by reducing the connectivity between pool habitats (Triton 2012a). Comparing some of the 2012 field program site photos to the same areas last year we observed that discharge was greater

[1] Two sites were electrofished in 2008: LCEF05.5 (2 RB caught) and LCSN03 (0 fish caught)

allowing fishes to access a greater number of habitats which in turn may have decreased the density at any one point in the stream. It should be emphasized that discharge was not measured in 2012 and that comparisons between discharge in 2011 versus 2012 relied on the observation of the water level at sites that overlapped one hundred per cent (e.g., Sites 4 and 8).

3.3.3 Growth Rate and Fish Condition

Growth rate is usually calculated through mark-recapture studies. Individuals are tracked over a period of time – their length and weight measured through the different life stages. This results in an accurate estimation of growth rate through the life span of an individual. Growth rate values for this study are fundamentally different. Instead of a classic change-of-length over time of an individual, we are taking an instantaneous snapshot of a population and comparing between age classes rather than following individuals over time. Through each life stage, growth rate is variable – depending on water temperature and depth (Rainbow Trout adults preferring 7-18 °C), availability of food, predation and habitat suitability (Raleigh et al., 1984 as cited in McPhail, 2007).

To investigate growth rate for this program, the difference in mean fork length between the age classes present was calculated for both 2011 and 2012 (Table 3-6). Differences were greater between each of the classes in 2011, suggesting that growing conditions may have been more favorable that year. Mean temperature at the sites was cooler in 2012 (10.4 °C vs. 12.8°C) which may have had an effect on growth rate. However, it is unknown what conditions were like in the winter and spring of each year.

Table 3-7. Change in mean fork length of Rainbow Trout between age classes for Lower Cranberry Creek in 2011 and 2012.

Age	2011 (mm)	2012 (mm)
0+ to 1+	60	51
1+ to 2+	60	34
2+ to 3+	67	43

Fish condition is a measure of general health of a fish based on its length and weight. Fulton's condition factor (K) calculation (Equation 6) was used to calculate the health of each fish captured.

Mean condition factor for Rainbow Trout at all eight sites in 2012 was 1.09 (Table 3-7) which was comparable to 2011 (mean K of 1.13). Compared to Davis 2009, mean K at each of the eight sites in 2012 was higher than at Site LCEF05.5 (the only Davis site believed to be in close proximity to a Triton site). However, difference in sample size (73 RB in 2012 vs. 3 RB in 2008) limits our ability to draw meaningful conclusions in this regard. A condition factor of 1.1 suggests average health for salmonids (Barnham and Baxter 1998).

Condition factors for Rainbow Trout in 2012 (mean K = 1.09, n=73) were significantly lower than in 2011 (mean K = 1.13, n = 146) (two-tailed t-test, $p < 0.05$). Condition factors for Rainbow Trout in lower Cranberry Creek were also compared to that of other Columbia River tributaries near Revelstoke. In CLBMON-17 (Middle Columbia River Juvenile Fish Habitat Use), part of the sampling program included electroshocking five tributaries of the Middle Columbia River: Jordan River, Illecillewaet River, Tonkawatla Creek, Drimmie Creek and Begbie Creek (Triton 2012b). Rainbow Trout capture data from the five tributaries from the fall sampling trip only (September – lower flows) for 2008 to 2012 was compiled and compared to Cranberry Creek data for 2011 and 2012. K values for Cranberry Creek Rainbow Trout in 2011 were not significantly different than K values for RB in the five tributaries ($p > 0.05$) whereas K values for RB in 2012 for Cranberry Creek were significantly lower than K values for RB in the five tributaries ($p < 0.05$). All condition factor values (all years, all sites) fall within the "Poor to Fair" category for salmonids (Barnham and Baxter 1998). However, as the mean K value for lower Cranberry Creek RB in 2011 and 2012 as well as mean K value for other aforementioned Columbia River tributaries all fall with the "Poor to Fair" category, the differences in K are not likely biologically significant. That is to say, lower Cranberry Creek RB are likely as healthy as other RB in different tributaries throughout the middle Columbia River.

Table 3-8. Condition Factor for Rainbow Trout captured during the 2012 field program compared to results of site LCEF05.5 (Davis 2009) and other Middle Columbia River tributaries as part of CLBMON-17 (Triton 2009, 2010a, 2011 and field data from 2012 sampling season).

Site	Fish captured	Min K	Max K	Mean K	SD K
1	3	1	1.17	1.1	0.08
2	18	0.93	1.55	1.11	0.15
3	4	0.92	1.2	1.09	0.12
4	10	0.91	1.25	1.13	0.11
5	7	0.96	1.19	1.09	0.08
6	5	1.01	1.09	1.07	0.07
7	8	0.87	1.24	1.07	0.12
8	18	0.96	1.23	1.05	0.08
LCEF05.5	**3**	**0.56**	**0.98**	**0.82**	**n/r**
CLBMON-17[A]	**40**	**0.65**	**1.67**	**1.19**	**0.22**

[A]Data from this study included RB captures from Jordan River, Illecillewaet River, Tonkawatla Creek, Drimmie Creek and Begbie Creek during the September sampling trips for the years 2008 to 2012.

Condition factor is affected by age of the individual, maturity, the amount and type of food consumed, the amount of fat reserve and the degree of muscular development (Barnham and Baxter 1998). Lower K in 2012 than in 2011 for lower Cranberry Creek could simply be related to seasonal variations in habitat conditions. It is possible that harsh winter conditions negatively affected food production or that rearing habitat quality was negatively affected by high discharge during spring freshet. For example, if freshet mobilized more fines than seasonally average, it's possible that boulder cover was reduced as interstitial spaces became inundated with finer material. As of June 1, 2012 the River Forecast Center reported the Columbia Region as having a delayed snow melt with higher than average runoff from June to August as recorded at the Illecillewaet River hydrometric station at Greeley (station # 08ND013) (MoE 2012).

The overall health status of captured Rainbow Trout in lower Cranberry Creek suggests a moderately healthy (mean K = 1.09) Rainbow Trout population (Barnham and Baxter 1998). However, as the study area is not closed (Coursier Lake is upstream), the type of Rainbow Trout population in the study area cannot be determined with absolute certainty. The influence of adfluvial individuals (typically larger than resident individuals) resident to Coursier Lake could lead an overestimate of the health of the population within the study area.

4.0 CONCLUSIONS

The objective of this monitoring program was to determine the potential benefits of minimum flows for Rainbow Trout in lower Cranberry Creek. In particular, the purpose of this study was to provide additional baseline data on how the resident Rainbow Trout population may respond to future changes in minimum flows (BC Hydro 2006a).

Where possible and applicable, data from the 2011 and 2012 sampling seasons were compared to historical data, both on Cranberry Creek (Davis 2009 and Summit 2000) and other Middle Columbia River tributaries (Triton 2009, 2010b, 2011 and 2012). Different sampling methodologies and higher creek discharge during data collection in 2008 (Davis 2009) compared to 2011 and 2012 limit the strength of comparisons. However, habitat quality and biological potential was inferred in 2008 as being suitable for Rainbow Trout (Davis 2009). Habitat quality assessments in 2011 and 2012 showed generally marginal habitat values across the majority of the sites. In order to capture enough RB to effectively comment on population dynamics, site selection concentrated on higher value rearing locations. These locations did not necessarily contain high value spawning and overwintering sites, which is not to say that these types of location are not abundant within the study area. Rainbow Trout distribution in 2012 was likely more widespread than in previous years as water levels were higher during the time of sampling than that in 2011.

Since the entry in operation of the minimum flow facility in 2009, the ability to successfully maintain a minimum flow downstream of the diversion dam has met with reasonable success (BC Hydro 2010). Minimum flow maintenance information was not available for 2011 (BC Hydro 2011). Maintaining a constant minimum flow, especially throughout the low flow season, would benefit Rainbow Trout in lower Cranberry Creek by providing connectivity between different habitats - maximizing the potential growth and health of the resident Rainbow Trout population by providing quality rearing, overwintering and spawning habitat.

4.1 STATUS OF MANAGEMENT QUESTIONS

Based on Year 5 of the Lower Cranberry Creek Rainbow Trout Abundance/Biology Monitoring Study, the following conclusions can be drawn in relation to each of the three key management questions:

1. *What is the status of the current RB population in lower Cranberry Creek?*

The population dynamics and overall health status of captured Rainbow Trout in lower Cranberry Creek in both 2011 and 2012 suggest a moderately healthy Rainbow Trout population. In both years mean condition factor of captured fish was 1.13 (2011) and 1.09 (2012), suggesting individuals of average health (Barnham and Baxter 1998). Twice as many fish were captured in 2011 than in 2012 but this could be an artifact of lower flows in 2011, fragmenting the habitat and concentrating the fish in isolated pools. Growth rates were higher in 2011 than 2012 which was likely due to water temperatures being greater in 2011 resulting in higher productivity.

2. *How do increases in minimum flows affect the RB population and what are the potential benefits of establishing a minimum flow?*

Analysis of the effects of minimum flows on the Rainbow Trout population in Lower Cranberry Creek was beyond the scope of WHNMON-5. However, results of WHNMON-2 Lower Cranberry Creek Rainbow Trout Rearing Habitat Monitoring (Triton 2013) suggested that incremental increases in flow would have a positive effect on the quality and quantity of effective rearing habitat for Rainbow Trout life stages. This positive relationship would continue until the habitat suitability exceeded preferred thresholds for each of the life history phases, after which time habitat suitability would begin to decline because of the increase in water velocity. In terms of discharge, these thresholds are 1.0 m^3s-1 and 1.5 m^3s-1 for fry and juveniles, respectively. Additionally, initiating a minimum flow in lower Cranberry Creek of 0.1 m^3s-1 would improve the quality and quantity of rearing and spawning habitat for Rainbow Trout when base flows are less than 1.0 m^3s-1 (Triton 2013).

3. *What is the qualitative capacity of the population to respond to potential habitat improvements resulting from minimum flow releases?*

Results from Years 4 and 5 of WHNMON-5 show that the population of Rainbow Trout in Lower Cranberry Creek consists of individuals of average health with densities ranging from 0.66 to 13.68 fish per m^2. Individuals from multiple age classes were represented in each year of sampling suggesting that successful recruitment is occurring and that habitat suitable for different ages is present. Based on these observations it is expected that the population would be able to respond to habitat improvements resulting from minimum flow releases.

5.0 RECOMMENDATIONS

Additional years of this study would be beneficial in not only expanding the understanding of the status of RB in lower Cranberry Creek but in providing important baseline information on which future water use planning decisions can be based. The study was originally designed as a five year program; however only the last two years yielded sufficient numbers of fish to reliably monitor the population. Differences in numbers of fish captured and condition factors between those two years could suggest changes in the population or be the result of natural year-to-year variation, or an artifact of higher flows in 2012. A larger data set from additional years of study would therefore be beneficial to better understand the population dynamics of resident Rainbow Trout in the system.

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