

**FISH MONITORING STUDIES IN
BUCK, FOXY AND CROW CREEKS
AND GOOSLY LAKE 2017**

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for

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EXECUTIVE SUMMARY

Fisheries studies were conducted near the Equity Mine site during late August 2017 as part of a provincial Environmental Effects Monitoring (EEM) program conducted for Goldcorp Canada Ltd (Equity Division). The design of the program is to evaluate the effects of treated water releases from Equity Mine into the Foxy and upper Buck Creek drainages. This report presents the fish component of the monitoring program.

The program includes monitoring fish abundance in upper Buck Creek above and below Bessemer Creek confluence. It also monitors metal levels in rainbow trout tissue in samples from Goosly Lake, upper Buck, Foxy and Crow creeks. Over 20 years of background metals information is available at the Goosly Lake and Foxy Creek locations, while eight and nine years of metals data is available for the upper Buck and Crow creek sites respectively.

Three upper Buck Creek fish index sites were sampled for abundance in 2017, including two reference sites upstream from Bessemer Creek and one exposure site located immediately downstream from Bessemer Creek inflows into Buck Creek.

Rainbow trout fry densities at the exposure site below Bessemer Creek were approximately one-half the mean densities compared to all past sampling at this location. Fry densities at the upper long-term reference site were well above those measured at the lower exposure site but were below the long-term average at this uppermost location. Fry densities at the new reference site exceeded those at the exposure site and the long-term reference location for the first time since all sites were established at their present location in 2003.

The 2017 rainbow parr densities at the exposure site were close to the mean since 2003. These densities were comparable to those measured at the two reference sites in 2017 and well below the long-term average at the upper reference site.

Long-term monitoring suggests that typically upper Buck Creek is adequately seeded with fry, and that rainbow trout parr densities in the range of 20 to 40 parr/100 m² reflects the habitat capabilities of the relatively stable stream environment in this section of Buck Creek. The parr densities at the exposure and reference sites were within this range in 2017.

Rainbow trout fry fork lengths were close to the long-term mean for all past years at all sample locations. Fry at the uppermost reference location were significantly larger than their counterparts at the other two sites. There were no significant fork length differences of rainbow age 1+ parr between the long-term reference site and the exposure site. Age 1+ parr were on average 5 mm larger compared to historical sampling at all locations. The larger parr lengths in 2017 at both the long-term reference site and exposure site suggest that common factors throughout the system were affecting parr size.

Overall condition factor of rainbow parr at the Buck, Foxy and Crow creek sites suggest healthy fish at all stream locations in 2017. Goosly Lake rainbow condition factors were near average and within the range of past measurements since 2002.

External fish health assessments conducted in 2017 suggest a low incidence of external abnormalities in rainbow trout from upper Buck, Foxy, and Crow creeks and Goosly Lake.

The analyses of fish tissue metal concentrations for the eight years that both the Buck Creek exposure site (BB1) and the reference site (BB2 old) were sampled indicate cadmium concentrations in the downstream exposure site (BB1) were significantly higher than the reference (BB2 old) location. This pattern persisted in 2017.

The analyses for the eight years up to 2017 that both upper Buck Creek sites were sampled indicate that copper and zinc concentrations in fish muscle tissue were not significantly different between the downstream exposure site and the reference location. However, both copper and zinc levels were significantly lower at the exposure site compared to the reference location in 2017.

All three metals had significant year and site-year interaction effects at the Buck Creek exposure and reference locations. The temporal cadmium and zinc effects were largely the result of high concentrations at the exposure site in 2002.

The results of metal analyses of 20 rainbow trout muscle tissue samples from Goosly Lake indicate that levels of cadmium and zinc were above the mean levels measured since 1982, while copper levels were near the long-term mean. Similar to the mean for all past years, Goosly Lake 2017 rainbow trout had lower cadmium and copper but higher zinc concentrations compared to a sample of other BC lakes.

The data continue to demonstrate a long-term trend of increasing zinc levels in Goosly Lake fish ($p=0.01$). There was an increasing trend in cadmium ($p=0.05$), but no significant trend for copper.

Trend analyses of metal levels in Foxy Creek rainbow trout since 1994 continue to suggest a weak upward trend for zinc over time ($p=0.2$). There were no significant trends over time in copper and cadmium concentrations in Foxy Creek up to 2017.

The analyses for the nine years that both Foxy and Crow creek rainbow trout have been sampled indicate that cadmium levels were significantly greater in the Crow Creek reference site compared to Foxy Creek exposure site. This pattern continued in 2017.

The analyses for the nine years that both Foxy and Crow creek rainbow trout have been sampled up to 2017 indicated that rainbow trout in these two systems did not differ significantly in copper or zinc concentrations between sites, but that there were overall significant differences amongst years.

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1.0 INTRODUCTION

1.1 BACKGROUND

Fisheries studies were conducted around the Equity Mine site during August 2017 as part of an Environmental Effects Monitoring (EEM) program conducted by Goldcorp Canada Ltd. (Equity Division). The 2017 fisheries program included monitoring fish abundance in upper Buck Creek and fish tissue metal levels in Foxy, Crow and upper Buck creeks, and Goosly Lake.

The upper Buck Creek fish sampling compares fish abundance and external fish health characteristics at a reference location upstream from Bessemer Creek (BB2 old) and at a potential exposure site (BB1) located downstream (Figure 1). This sampling has been conducted during 22 previous years since 1987. In 2003 a second reference location (BB2 new) was added closer to Bessemer Creek to allow for a better assessment of potential exposure to treated water releases from the Equity Mine site entering upper Buck Creek through the Bessemer Creek inflows.

The 2017 fish sample program also included collecting fish samples from Goosly Lake and Foxy, Crow and upper Buck creeks to measure levels of selected metals (cadmium, copper and zinc) in fish muscle tissue. Over 20 years of background metals information is available at the Goosly Lake and Foxy Creek locations.

Additional metals sampling has been added to the annual monitoring program during recent years. Crow Creek tissue collection for metal analyses was added since 2012 to serve as a reference location for Foxy Creek. Tissue collection for metals in rainbow trout at the upper Buck Creek sites above and below Bessemer Creek was added to the annual program starting in 2013. Prior to these dates the sites in Crow and upper Buck creeks had been typically monitored only during years of an expanded monitoring program undertaken every four years starting in 2002, with the last extended program conducted in 2014 (Bustard 2015).

The expanded aquatic program last conducted in 2014 (Perrin and Bennett 2015) included summaries of water quality, stream sediments, benthic invertebrate and periphyton. More detailed study area descriptions as well as water quality, temperature and discharge information are summarized in their report.

Perrin and Bennett (2015) indicated that in 2014 mine drainage continued to modify chemical characteristics of Buck and Foxy creeks. They noted that higher metal concentrations, particularly copper and sulphate were prevalent in the Buck Creek exposure section downstream from Bessemer Creek. Metals levels for the reference and exposure sections were less than probable effects levels for toxicity to aquatic life in sediments.

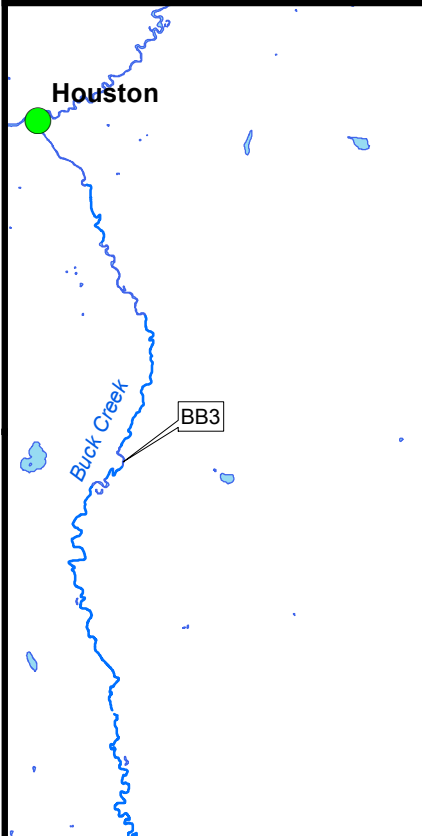
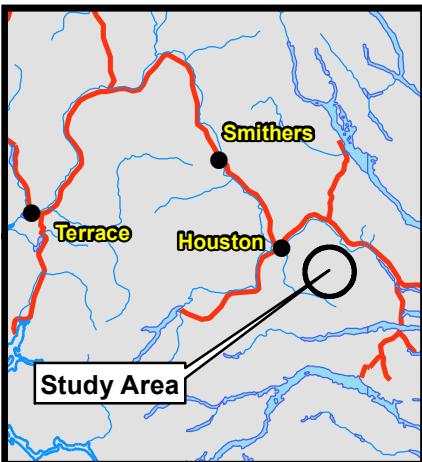
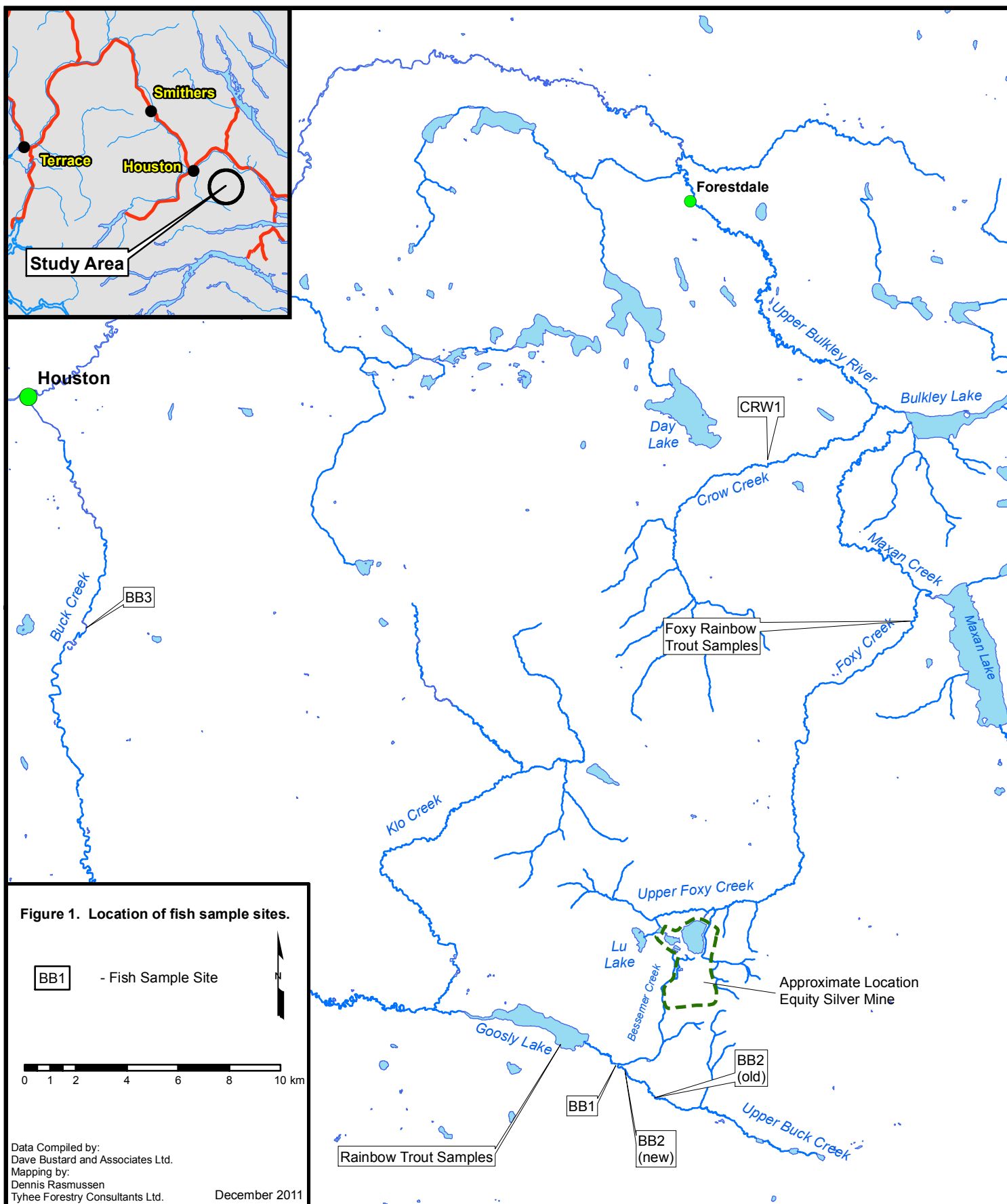
1.2 OBJECTIVES

The 2017 objectives were as follows:

- To compare fish density, size, and external fish health information at the upper Buck Creek index sites located above and below Bessemer Creek.
- To collect rainbow trout muscle tissue for metal analyses and compare results to historical results from sites in Goosly Lake and Foxy, Crow and upper Buck creeks.
- To examine external fish health characteristics of rainbow trout from Goosly Lake and Foxy, Crow and upper Buck creeks.

This work was authorized under fish collection permit #SM17-275911 (Fish, Wildlife & Habitat Management Branch, Ministry of Forest, Lands and Natural Resource Operations).

The author appreciates the assistance of Mike Aziz and Cody Meints of Equity Silver Mine Goldcorp Canada Ltd. for their help during all aspect of this study. Ciara Sharpe assisted with the field studies and Alana Clason undertook most statistical analyses to assist with results interpretation.



2.0 METHODS

2.1 LAKE SAMPLING

Fish sampling was undertaken at Goosly Lake on July 27, 2017 targeting rainbow trout using three floating gillnets (1.5" mesh) at the southwest end of the lake (Figure 1). Nets were monitored continuously and rainbow trout were carefully removed from the nets, placed in holding buckets and processed at the boat launch on the south side of Goosly Lake.

The three nets were not effective in collecting the target of 20 fish by mid-afternoon, so the sampling effort was supplemented with a 90 m long variable mesh floating net to ensure that an adequate sample size for the metal analyses was collected.

All fish were weighed, fork lengths measured, and scales removed for ageing. Only fish collected using the three original gillnets were included in the annual comparison of biological parameters. External fish health assessments were conducted on the lake sample of fish using the same field keys and characteristics as those used since 2002 (Hatfield Consultants Ltd. 2003). Body cavities were opened to confirm the sex of fish samples. Scales from all rainbow trout were aged by Birkenhead Scale Analyses (Lone Butte).

The fish samples were bagged separately and placed on ice in the field, frozen within the day and sent to ALS Labs for dissection of muscle tissue (no skin attached) and subsequent lab analysis for metals.

2.2 STREAM SAMPLING

2.2.1 Buck Creek

The three main fish index sites in upper Buck Creek were sampled in 2017. Sampling was not conducted at a fourth location in lower Bessemer Creek since it was dewatered during late August¹. The fish population studies in upper Buck Creek were conducted between August 29th and 31st, corresponding closely to the timing of past surveys undertaken in Buck Creek since 1987.

Prior to 2002 the potential exposure index site was located approximately 300 m upstream from Goosly Lake. This site was moved in 2002 to a location approximately 1.5 km upstream from the lake, with the top of the site approximately 25 m downstream from the Bessemer Creek confluence (Figure 1). The original reference site (BB2 old) is located a further 2 kms upstream from Bessemer Creek or 3.5 kms from Goosly Lake. The second reference site (BB2 new) was established in 2003 and the bottom of the site is located approximately 50 m upstream from the Bessemer Creek confluence with Buck Creek.

¹ Two age classes of rainbow parr were noted in lower Bessemer Creek at the road crossing on July 27th, but the channel was dry during the August 29-31st period of juvenile sampling in upper Buck Creek.

The juvenile sampling methods have remained similar for all years of sampling in Buck Creek. The sites were blocked with stopnets at their upstream and downstream ends and sampled using a Smith-Root backpack electrofisher. Small adjustments were made to site length to accommodate debris shifting within the site. One thorough sweep up and back down through the sites including a net check constituted a single pass. Two passes were conducted at the three reference sites, typical of most sampling conducted during past years. No third pass sampling was conducted in 2017 due to good declining catches between passes at all sites. Effort was recorded as number of seconds of electrofishing per pass.

Rainbow parr and any other species captured at the sites were measured and weighed. At each site a sample of up to 50 rainbow trout fry was measured to the nearest mm fork length and weighed, with all other rainbow fry simply counted.

Population estimates were derived using the two-pass removal method outlined in Seber and LeCren (1967). Standard error estimates have been derived from methods outlined in Chapman (1951) and used to calculate confidence intervals for the population estimates.

A sample of 30 rainbow trout parr per site was examined for external fish health characteristics using the same field keys and characteristics as in 2002 (Hatfield Consultants Ltd. 2003). These fish were weighed, and scales were removed from representative length classes for ageing (three scales for each 5-mm length class per site between 85 mm and larger). The age separation for fish smaller than this size was clear from length-frequency distributions.

Ten of the larger parr from samples collected at sites BB2 old and BB1 were retained for metal analyses, with each sample comprised of a single fish. Each fish was bagged separately, placed on ice in the field and frozen within the day. The samples were then submitted to ALS Labs as whole fish with the muscle dissections undertaken in the lab to minimize field contamination.

Condition factor (K) was calculated from the length and weight measurements as follows:

$$\text{Condition Factor (K)} = 100(\text{body weight}/\text{length}^3)$$

Sample site areas were calculated by measuring the site length and a series of width measurements at 5 m intervals along the site. Habitat characteristics including a description of bed material, cover, habitat type, pool and riffle depths, and slope were recorded making them comparable to past observations at these sites. Discharge was measured at a single cross section at two of the main sample locations using a Swiffer velocity meter.

The beaver dam typically active at the bridge site (BB2 new) remained open during the July and August period, and this allowed for effective fish sampling without adjusting water levels in 2017.

2.2.2 Foxy and Crow Creeks

Length and weight measurements and an external fish health assessment were conducted on 30 rainbow parr collected by electrofishing in both Foxy and Crow creeks on August 28th 2017². Scales were removed from representative length classes for ageing. The muscle tissue metal analyses were conducted on 10 samples each consisting of a single fish from this same group of fish. The handling procedures were as outlined for the upper Buck Creek samples

2.3 DATA ANALYSES

Data was initially reviewed in Excel format and screened for potential outliers through visual examination. Some of the simpler comparisons between sites including means, standard deviation and t-tests were conducted using Excel data analyses tools. Statistical results in this survey were considered significant at a level of $p=0.10$ following guidance from the Federal Metal Mining Environmental Effects Monitoring (EEM) program (Environment Canada 2012).

Two-way analysis of variance was used to compare the concentration of metals between years and locations (exposed and reference sites) in upper Buck Creek and between Foxy and Crow creeks.

Trend analysis was used to determine the significance of apparent trends over time for metal analyses in fish tissues, and to estimate the magnitude of such trends. The Mann-Kendall test for temporal trend (Hollander and Wolfe 1973) and Sen's slope estimate (Gilbert 1987) were used to evaluate the correlation of tissue metal concentrations with time.

When cadmium levels were below the minimum detection limits, trend analyses and ANOVA were conducted using the minimum detection limit for that year.

² All Foxy Creek fish were sampled in the riprap at the bridge crossing. Rainbow fry were common at this site. Two chinook fry were captured at this site and carcasses from two suspected chinook were present at the bridge site. Crow Creek fish were captured near the Crow Creek bridge crossing on the main access road. Rainbow trout fry were common. No other fish species were present in Crow Creek during sampling.

3.0 RESULTS

Streamflows in late August 2017 were low following a dry summer period. The discharge estimates of 20-30 l/sec at upper Buck Creek fish index sites were in the low range for the past 14 years during the late summer sample period (Appendix 1 Table 1). A summary of maximum daily discharge in lower Buck Creek indicates the flood peak occurred at the middle of May 2017 and was moderately high compared to the average since 1973 (Appendix 1 Figure 1).

As part of the water management program, Equity Mines released treated water into upper Buck Creek from April 11 through July 7, and from upper Foxy Creek from May 10 to July 21, 2017. Releases from the Diversion Pond occurred during periods from July through November on either side of the fish sampling period. In total 79.5% of the approximately 2.7 million m³ of treated water was released into the upper Buck Creek watershed via Bessemer Creek.

3.1 UPPER BUCK CREEK

3.1.1 Buck Creek Fish Composition

The upper Buck Creek catch for all sample sites continues to be dominated by rainbow trout (Table 1). Age 1+ rainbow comprised 92% of the total parr catch at the three sites combined, while the remaining 8% were all age 2+ except for one age 3+ parr at the uppermost site (BB1 old). One of the 422 fish captured in the three sites in 2017 was a longnose sucker (Table 1), while a total of three prickly sculpins were present in the two lowermost Buck Creek index sites in 2017 (Appendix 3 Table 2).

The species composition of the catch at the lower Buck Creek index site (BB1) prior to re-locating it upstream in 2002 indicates that longnose suckers, mountain whitefish, and prickly sculpins were more common in the slow-flowing lowermost section of Buck Creek just upstream from Goosly Lake that was sampled prior to 2002 (Appendix 3 Table 1). Beaver dams in Buck Creek downstream from the present sample sites may restrict these other fish species to the lowermost creek section below the index sites during most years.

Table 1. Summary of fish composition by species combined for all sites in upper Buck Creek 2003 to 2017³.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean
Rainbow fry	283	413	385	107	153	103	298	215	316	320	426	456	557	202	232	298
Rainbow parr	281	194	365	295	181	109	493	217	176	376	222	393	259	219	186	264
LN suckers	0	0	2	1	8	4	4	1	4	18	14	27	7	14	1	7
Prickly sculpins	0	0	0	0	4	0	0	0	0	4	4	0	0	0	3	1
LN dace	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Redside shiner	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Total	564	607	752	403	346	216	795	436	496	718	666	877	823	435	422	570

³ Note - totals are based on estimated catch from the multiple passes.

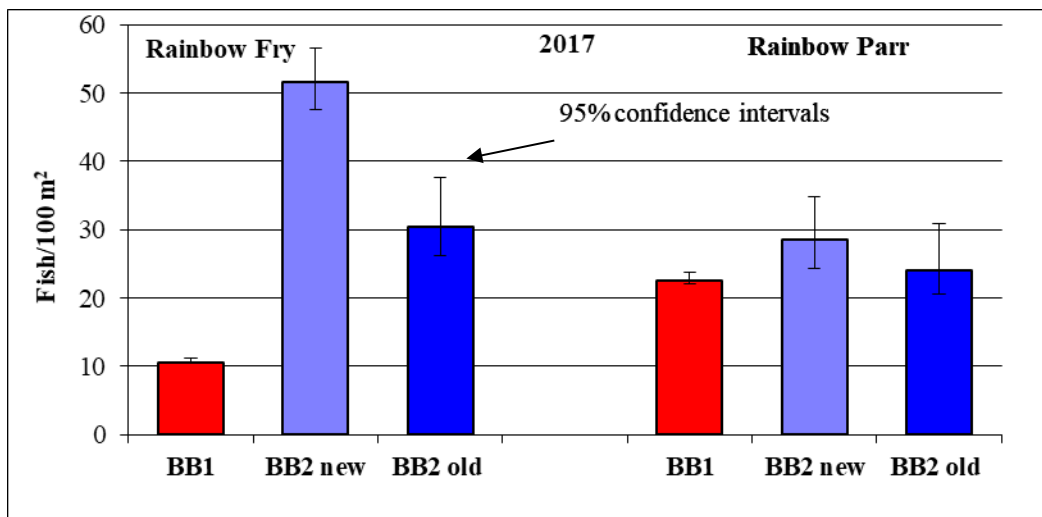
3.1.2 Buck Creek Fish Abundance

Fry densities of 11 fry/100 m² at the exposure site below Bessemer Creek (BB1) were comparable to 2016 and were approximately one-half of the mean densities of past sampling results (23 fry/100 m²) since 2003 (Table 2)⁴.

Rainbow fry densities at the reference site BB2 old were 31 fry/100 m² in 2017. These results are lower than the mean of 53 fry/100 m² since 2003 and were well above the densities measured at the exposure site (BB1) in 2017 (Figure 2). Fry densities at the newer reference site (BB2 new) were high compared to the results at the exposure site (BB1) and exceeded mean fry densities at the long-term reference site (BB2 old) for the first time since 2003 (Table 2).

Rainbow fry densities at the uppermost reference site have been higher than the exposure site (BB1) for all 23 years of record except 2006 (Appendix 2 Table 4 and Appendix 2 Figure 1). The higher densities probably reflect more suitable habitat for fry rearing at the upper location including more riffle habitat, a coarser bed material and a location close to good potential spawning sites as outlined in Bustard (2003).

Figure 2. Rainbow trout fry and parr densities (fish/100 m²) at the Buck Creek index sites in 2017⁵.



⁴ Note – These comparisons focus on the period from 2003 onward, corresponding to the period that both reference sites have been sampled. Sampling results for the period of record are presented in Appendix 2 Table 4.

⁵ Parr age 1+ and greater.

Table 2. Rainbow trout fry and parr densities (fish/100 m²) at the Buck Creek index sites from 2003 to 2017⁶.

Sample Site	Year	Density (fish/100 m ²)	
		0+	Parr
BB1 Downstream from Bessemer Creek	2003	25	32
	2004	12	13
	2005	29	37
	2006	31	34
	2007	9	16
	2008	2	4
	2009	31	77
	2010	16	12
	2011	29	11
	2012	32	41
	2013	48	24
	2014	39	35
	2015	24	21
	2016	11	14
2017	11	23	
	Mean (2003-17)	23.3	26.1
BB2 old Reference site 1.3 km upstream	2003	42	40
	2004	80	41
	2005	51	45
	2006	19	41
	2007	18	23
	2008	18	13
	2009	45	43
	2010	48	43
	2011	61	25
	2012	39	41
	2013	59	33
	2014	140	97
	2015	101	38
	2016	42	46
2017	31	24	
	Mean (2003-17)	52.9	40.7
BB2 new Reference site just upstream from Bessemer Creek	2003	23	20
	2004	61	20
	2005	32	24
	2006	2	21
	2007	15	12
	2008	10	14
	2009	24	37
	2010	6	14
	2011	12	20
	2012	33	39
	2013	35	18
	2014	82	27
	2015	68	29
	2016	16	15
2017	52	29	
	Mean (2003-17)	31.5	22.1

⁶ Combined age 1+ and older parr.

The 2017 rainbow parr densities (23 parr/100 m²) at the exposure site (BB1) were close to the mean since 2003 (Table 2 and Figure 2). The parr densities were comparable to those measured at the two reference sites in 2017 and were well below the long-term average for rainbow parr densities at the upper reference site (BB2 old) based on the average for all years of sampling since 1987 (36 parr/100 m²) (Appendix 2 Table 4).

Combined parr densities at the exposure site (BB1) have been higher than at the new reference site just upstream (BB2 new) in eight of the past 15 years (Table 2). Parr densities have been higher at the long-term reference site than the lower Buck exposure site for nearly all years of measurement.

3.1.3 Buck Creek Fish Size, Condition and Fish Health

Rainbow trout fry mean fork lengths ranged from 38 to 41 mm in 2017 (Table 3). Fry at the uppermost reference site (BB2 old) were significantly larger than their counterparts at the other two sites (Appendix 4 Table 1). Rainbow fry at the second reference site (BB2 new) were not significantly larger compared to the exposure site downstream from Bessemer (BB1) (t-test; p=0.1).

Fry lengths in 2017 were within 2 mm of the long-term mean for all past years at all sample locations (Appendix 4 Table 1).

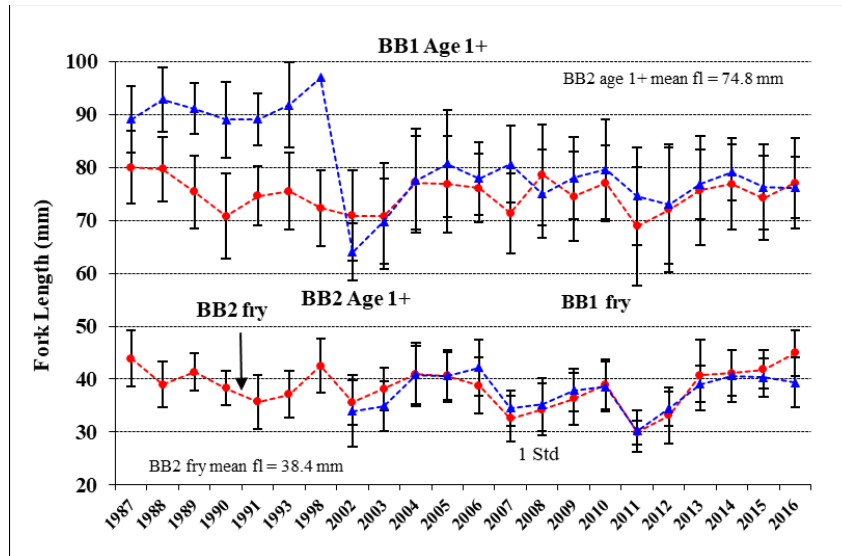
Table 3. Fork length and condition factors for age 0+ and age 1+ rainbow trout at three locations in upper Buck Creek in 2017.

	AGE 0+			AGE 1+		
	Mean fl (mm ± std)	Condition (k ± std)	Sample Size	Mean fl (mm ± std)	Condition (k ± std)	Sample Size
BB2 (old)	40.8 ± 3.2	1.16 ± 0.16	50	80.1 ± 8.0	1.16 ± 0.17	38
BB2 (new)	39.0 ± 4.4	1.10 ± 0.21	50	82.4 ± 7.5	1.03 ± 0.11	61
BB1	37.8 ± 3.8	1.11 ± 0.19	30	81.2 ± 7.2	1.04 ± 0.10	58

There were no significant fork length differences of rainbow age 1+ parr between the reference site and the exposure location below Bessemer Creek (Figure 3) (t-test; p=0.1). Age 1+ parr at the exposure site (BB1) and parr at both reference sites were 5 mm larger compared to the long-term mean at this location (Appendix 4 Table 1).

The condition factors for juvenile rainbow parr provide a relative measure of well-being, with higher condition factors reflecting a heavier or plumper fish. Condition factors of age 1+ rainbow trout are probably a more meaningful measurement than fry condition, as these fish have been rearing for a full year in Buck Creek.

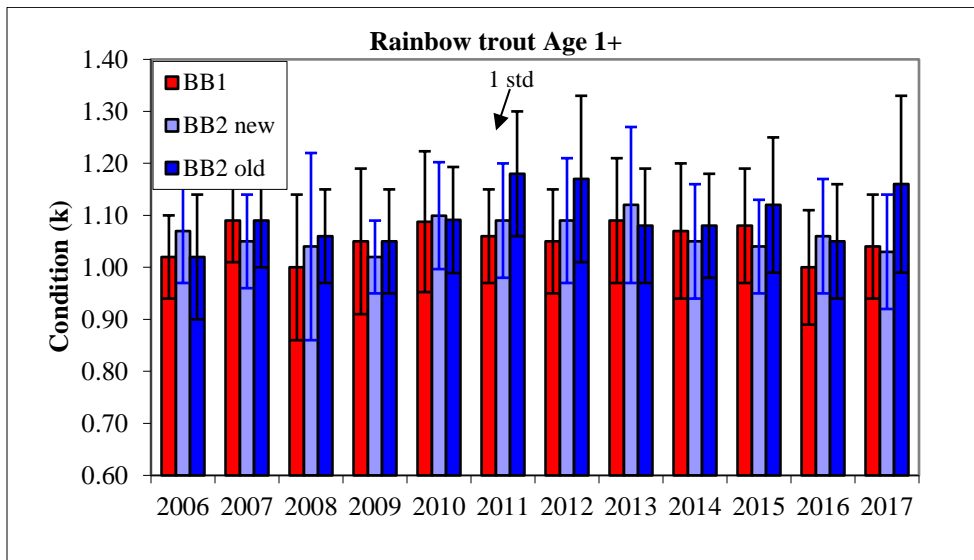
Figure 3. Mean fork lengths of upper Buck Creek age 0+ and age 1+ rainbow trout from 1987 to 2017 at the long-term reference site (BB2 old) compared to the exposure site just downstream from Bessemer Creek (BB1).



The summaries for the three Buck Creek sites (Table 3 and Figure 4) indicate that age 1+ par condition factors in 2017 at the exposure site were not significantly lower than the new reference site (t-test; $p=0.1$) located immediately upstream from Bessemer Creek. However, these sites had significantly lower condition factors than at the long-term upstream reference location. The 2017 results for the long-term reference site were at the upper end of the range compared to past years. Condition factors at these sites have demonstrated considerable variability between sites and years since 2006. Overall condition factors suggested healthy fish at all three locations.

External examination of 30 juvenile rainbow trout at the index sites located above and below Bessemer Creek in 2017 indicated few abnormalities (Appendix 6 Tables 2-4). The incidence of abnormalities has remained at less than 10% at the exposure and reference sites since 2005 (Appendix 6 Table 8).

Figure 4. Condition factors for rainbow trout age 1+ parr for the past 12 years at upper Buck Creek fish index sites.



3.1.4 Upper Buck Creek Fish Tissue Metals

Metal concentrations in juvenile rainbow trout collected in the Buck Creek exposure site downstream from Bessemer Creek (BB1) were compared to the results for fish from a reference site (BB2 old) located upstream (Figure 5). Eight years of data is now available for these site comparisons.

As background, untreated water was released into the exposure area from the mine site in 2002 due to excessively high discharge during a period of rapid snowmelt. Following this period few fish were sampled in the exposure section (n=2) compared to all other years and locations (n=10). Fish tissue cadmium, copper and zinc levels were higher in 2002 after the untreated water releases than in subsequent years (Table 4).

The ANOVA analyses of tissue metal concentrations for all years at both the exposure site (BB1) and the reference site (BB2 old) indicate rainbow trout muscle tissue cadmium concentrations in the downstream exposure site (BB1) were significantly higher than the reference (BB2 old) location (Appendix 5 Table 4). The 2017 results continue to indicate this difference (Figure 5 and t-test; $p=0.1$).

The ANOVA analyses ($p=0.10$) for all years indicated that copper ($p=0.45$) and zinc ($p=0.16$) tissue concentrations were not significantly different between the downstream exposure and reference locations (Appendix 5 Table 4). The results do indicate that both copper and zinc levels in fish muscle tissue were significantly lower at the exposure site compared to the reference location in 2017 (Figure 5 and t-test; $p=0.1$).

Figure 5. Summary of rainbow trout muscle tissue total metal concentration (mean \pm std) sampled at Buck Creek locations above and below Bessemer Creek during eight sample periods from 2002 to 2017.

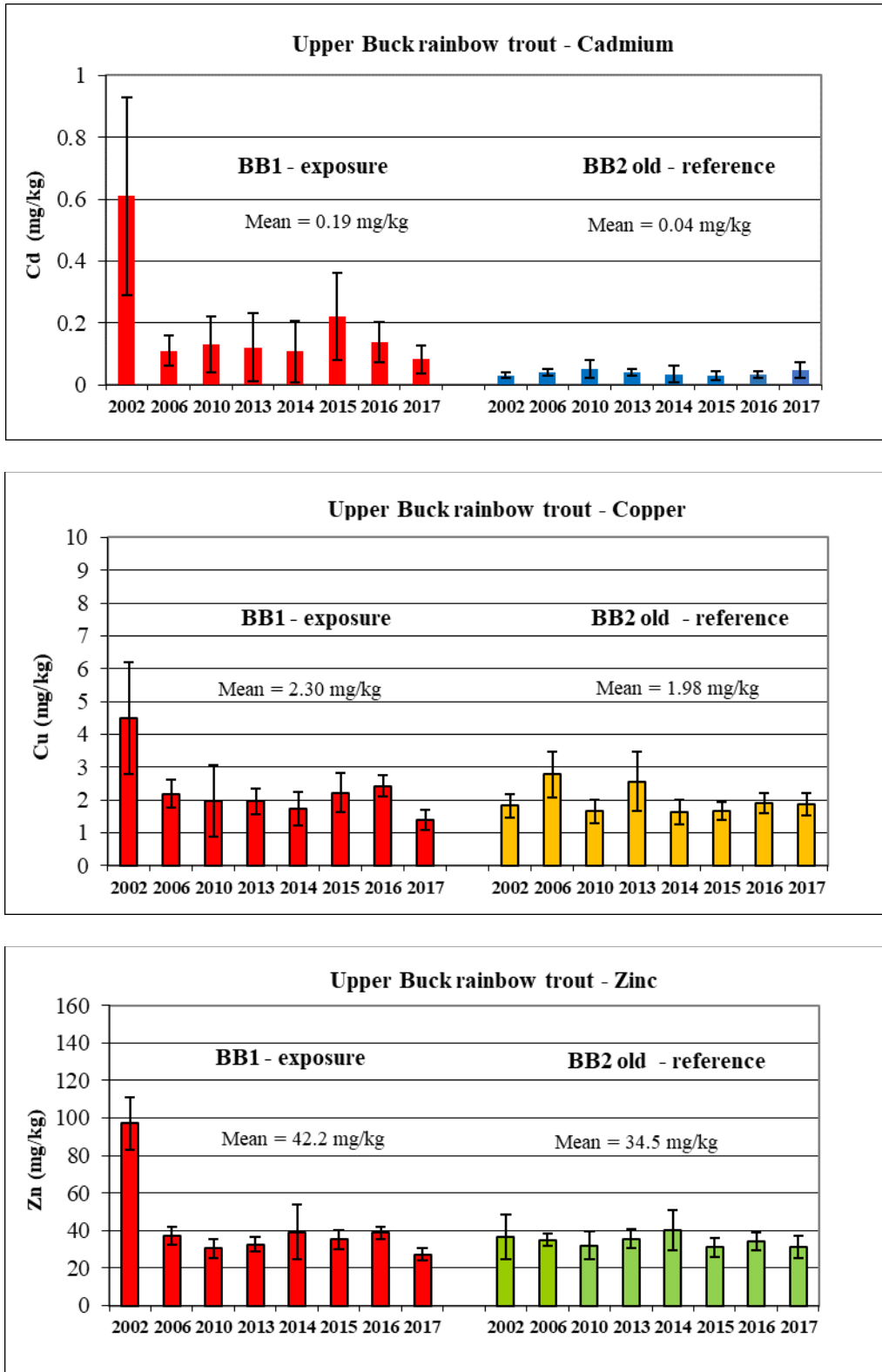


Table 4. Summary of 2017 metal concentrations (mean \pm std) in rainbow trout in the Buck Creek exposure site (BB1) compared to the Buck Creek reference site (BB2 old).

Location	Year	Muscle Tissue Metal Concentration (mg/kg dry weight)			
		N	Cd	Cu	Zn
Buck Creek Exposure (BB1)	2002	2	0.61 \pm 0.32	4.50 \pm 1.70	97.3 \pm 14.0
	2006	10	0.11 \pm 0.05	2.19 \pm 0.44	37.1 \pm 4.7
	2010	10	0.13 \pm 0.09	1.97 \pm 1.08	30.4 \pm 5.0
	2013	10	0.12 \pm 0.11	1.96 \pm 0.39	32.7 \pm 4.0
	2014	10	0.11 \pm 0.10	1.72 \pm 0.51	39.2 \pm 14.7
	2015	10	0.22 \pm 0.14	2.22 \pm 0.60	35.2 \pm 4.86
	2016	10	0.14 \pm 0.06	2.43 \pm 0.34	38.7 \pm 3.5
	2017	10	0.08 \pm 0.04	1.40 \pm 0.30	27.3 \pm 3.1
	Mean		0.19 \pm 0.12	2.30 \pm 0.67	42.2 \pm 6.7
Upper Buck Reference (BB2 old)	2002	10	0.03 \pm 0.01	1.82 \pm 0.36	36.5 \pm 12
	2006	10	0.04 \pm 0.01	2.78 \pm 0.70	35.1 \pm 3.3
	2010	10	0.05 \pm 0.03	1.65 \pm 0.35	32.0 \pm 7.5
	2013	10	0.04 \pm 0.01	2.56 \pm 0.90	35.6 \pm 4.9
	2014	10	0.03 \pm 0.03	1.63 \pm 0.38	40.1 \pm 10.8
	2015	10	0.03 \pm 0.02	1.66 \pm 0.26	31.2 \pm 5.02
	2016	10	0.03 \pm 0.01	1.91 \pm 0.31	34.2 \pm 4.97
	2017	10	0.05 \pm 0.03	1.86 \pm 0.34	31.1 \pm 6.03
	Mean		0.04 \pm 0.02	1.98 \pm 0.45	34.5 \pm 6.81

All three metals had significant year effects and significant site-year interactions (Appendix 5 Table 4). The temporal cadmium effects were largely a result of elevated levels in 2002 in the exposure site BB1 compared to most other years. These high cadmium tissue concentrations were not found in the reference site (BB2 old), resulting in significant site-year interactions. It should be noted that only two fish were collected in the exposure site for metal samples in 2002 compared to 10 samples during all other sampling events at both locations.

Significant temporal effects in copper muscle tissue concentrations were largely driven by increased concentrations in 2006 and 2013, most pronounced in the reference site (BB2 old) compared to the downstream exposure site (Figure 5). Copper concentrations were also unusually high in the exposure site (BB1) in 2002, but the exposure site sample was only comprised of two samples.

Significant temporal effects and interaction between year and site of zinc levels in fish muscle tissue were almost exclusively a result of high concentrations in the exposure site (BB1) in 2002 (Figure 5).

3.2 GOOSLY LAKE

3.2.1 Goosly Lake Rainbow Trout Life History Characteristics and Fish Health

The Goosly Lake rainbow trout that were captured in the standard mesh size nets and used in the 2017 metal analyses and for external fish health assessment were all age 3+ to 4+ with a mean fork length of 17.7 cm (Table 5 and Appendix 6 Table 1). This is within the range of past samples at the lake using the same net mesh size. The mean condition factor of 1.0 was comparable to condition since 2002 (Table 5).

Studies conducted in 2014 (Perrin and Bennett 2015) suggest that although sediment quality is improving in Goosly Lake (lower metals content), benthic invertebrate abundance and diversity is not.

Table 5. Summary of biological parameters of rainbow trout sampled in Goosly Lake 2002 to 2017⁷.

Location	Year	N	Length (cm ± SD)	Weight (g ± SD)	Condition (K ± SD)	Age (mean ± SD)
Goosly Lake	2002	53	18.3 ± 2.1	57.0 ± 16.9	0.92 ± 0.09	4.4 ± 1.06
	2003	16	20.4 ± 3.7	95.9 ± 45.9	1.04 ± 0.15	3.5 ± 0.63
	2004	20	18.8 ± 2.7	67.6 ± 26.8	1.00 ± 0.09	3.8 ± 0.85
	2005	20	16.3 ± 2.5	45.1 ± 17.8	0.99 ± 0.05	2.8 ± 1.02
	2006	30	17.4 ± 1.0	50.9 ± 7.0	0.96 ± 0.07	2.7 ± 0.60
	2007	20	18.5 ± 1.3	64.3 ± 15.1	1.00 ± 0.06	3.1 ± 0.31
	2008	20	17.8 ± 1.3	55.9 ± 10.9	0.98 ± 0.08	3.3 ± 0.44
	2009	20	18.3 ± 1.1	57.3 ± 9.0	0.94 ± 0.07	3.2 ± 0.41
	2010	20	17.2 ± 1.3	53.2 ± 11.2	1.03 ± 0.06	3.3 ± 0.55
	2011	17	18.1 ± 1.4	54.4 ± 10.1	0.92 ± 0.10	3.2 ± 0.56
	2012	20	18.2 ± 9.0	59.3 ± 9.1	0.97 ± 0.07	2.8 ± 0.64
	2013	20	17.7 ± 1.4	57.8 ± 12.5	1.03 ± 0.07	3.4 ± 0.59
	2014	20	17.3 ± 0.7	51.6 ± 4.7	1.00 ± 0.06	3.4 ± 0.51
	2015	20	18.3 ± 1.25	58.3 ± 13.5	0.94 ± 0.07	3.7 ± 0.59
	2016	6	16.6 ± 2.0	46.7 ± 13.2	1.00 ± 0.10	3.2 ± 0.75
2017	7	17.7 ± 1.08	56.8 ± 12.3	1.01 ± 0.08	3.7 ± 0.49	
Mean			18.1 ± 0.9	59.3 ± 11.5	0.98 ± 0.04	3.3 ± 0.43

External fish health parameters collected for Goosly Lake rainbow trout since 2002 are summarized by year (Appendix 6 Table 7). Most external parasites were black spot cysts that are not included as abnormalities.

⁷ 2002 data from Hatfield Consultants (2003). A subsample of 2002 rainbow trout was used in the Goosly Lake metal analyses, while all fish from 2003 to 2015 have been used. Only 6 of the fish sampled in 2016 and 7 fish in 2017 were from standard mesh size nets and included in the biological parameter comparison. Fish captured in the variable mesh nets tended to be on average smaller, so only those fish captured in the standard mesh size nets were considered comparable for biological parameters such as fish length and weight (See Appendix 6 Table 1), while all fish were considered suitable for metal analyses.

Some of the abnormalities noted in earlier years such as marginate and frayed gills (Appendix 6 Table 7) may have been linked to stress while fish were held in holding pens (Brand 2002).

3.2.2 Goosly Lake Fish Tissue Metals

The results of metal analyses of the 20 rainbow trout muscle tissue samples from Goosly Lake indicate that levels of cadmium and zinc were above the mean levels measured since 1982, while copper levels were near the mean (Table 6). Detailed results of the analyses for each fish are presented in Appendix 5 Table 1.

Zinc levels in the Goosly Lake rainbow muscle tissue were higher than a sample of BC lakes summarized in Rieberger (1992) and past results for the reference Maxan Lake (Table 6). Cadmium levels were considerably lower than the summary of provincial lakes (Table 6). The minimum detection levels for Cd have improved from 0.03 mg/kg for the period prior to 2014 to 0.01 mg/kg since 2014 (Figure 6). Cadmium levels in most fish (95%) were above these detection limits (Appendix 5 Table 1).

Copper levels in Goosly Lake fish of 1.53 mg/kg dry weight (Figure 6 and Table 6) were nearly identical to mean levels recorded in Goosly Lake fish to date. These levels are slightly higher than copper levels in Maxan Lake fish tissues (Table 6) and lower than the mean of 1.95 mg/kg from a sample of BC lakes (Table 6).

The trend analysis on metal concentration in Goosly Lake fish tissue over time indicates no trend in copper at alpha levels of 0.10 and lower (Table 7). Cadmium concentrations show an upward trend over time, at an alpha value of 0.05. Zinc concentrations show an increasing trend over time at an alpha of 0.01 and higher.

Table 6. Summary of 2017 metal concentrations (mean \pm std) of rainbow trout in Goosly Lake compared to historical means⁸.

Location	Year	Muscle Tissue Metal Concentration (mg/kg dry weight)		
		Cd ⁹	Cu	Zn
Goosly	2017	0.08 \pm 0.05	1.53 \pm 0.43	50.4 \pm 17.4
Goosly mean all years	1982 to 2017	0.04 \pm 0.02	1.58 \pm 0.38	38.7 \pm 10.0
Maxan mean (reference)	2002, 2010, 2014	0.02 \pm 0.0	1.37 \pm 0.33	24.6 \pm 6.2
BC lakes - Rieberger (1992) ¹⁰		1.15 \pm 0.15	1.95 \pm 1.45	21.4 \pm 6.5

⁸ The 2004 metal results are not included in summaries due to different sample treatment in the lab that yielded results that are not comparable to other years.

⁹ From 1998 to 2013 when cadmium levels in individual fish were below detection levels (0.03 mg/kg), we have assumed levels of 0.03 mg/kg to calculate mean cadmium levels. Since 2014 minimum detection levels for Cd improved to 0.01 mg/kg.

¹⁰ Muscle tissue information. We have assumed 80% moisture content to convert the wet weight information reported in Rieberger (1992) to dry weights presented in this report.

Figure 6. Summary of rainbow trout muscle tissue total metal concentration (mean ± std) sampled in Goosly Lake 1982 to 2017.

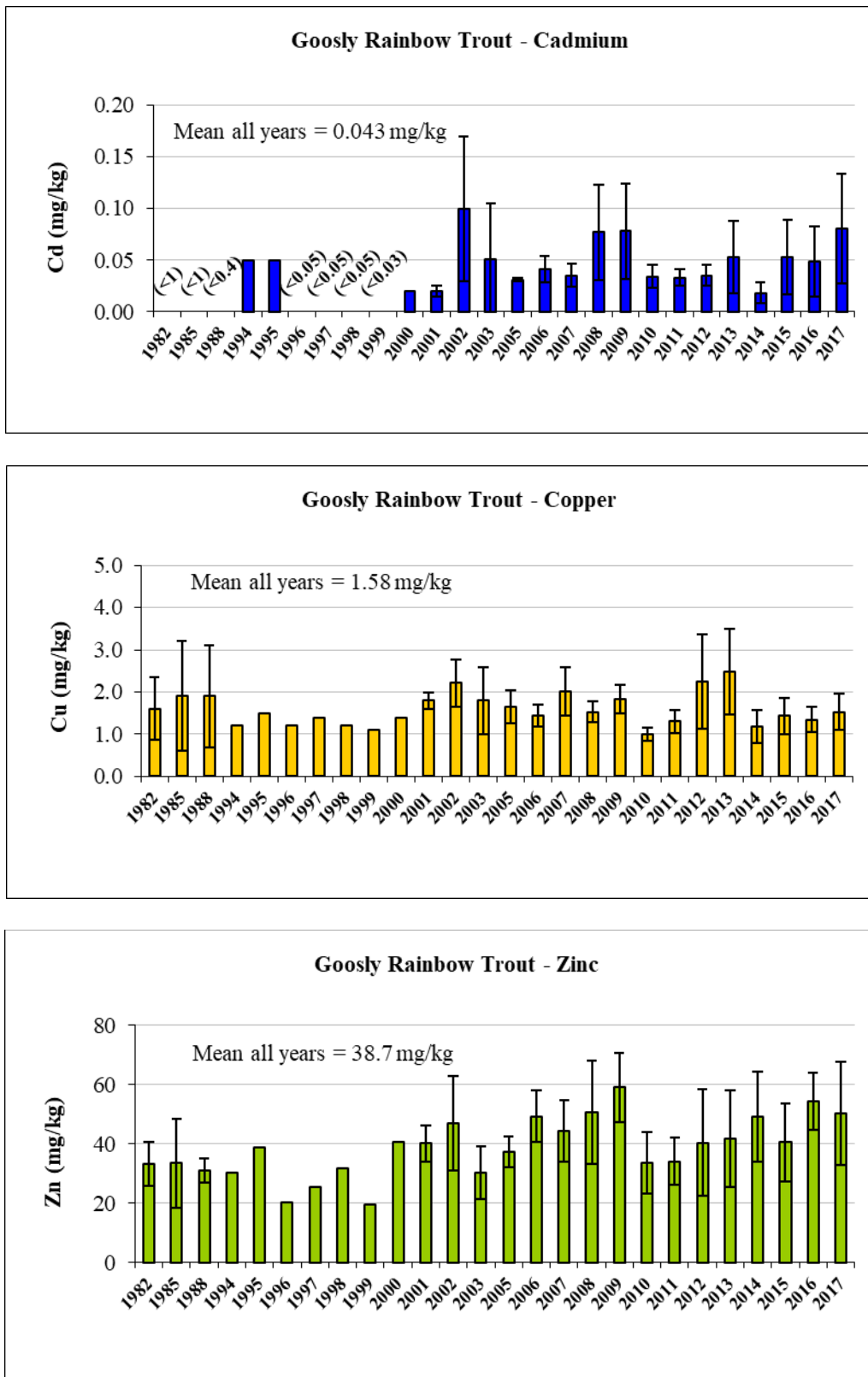


Table 7. Results of trend analyses of Goosly Lake cadmium, copper, and zinc in rainbow trout muscle tissue, 1982 to 2017.

	Variable Measured	Number of Observations	Slope (units/year)	Mann Kendall Statistic	Tau	Alpha	Critical	Significant?
Sen's Slope Estimator	Cd	26	0.0003	94	0.301	0.01	0.360	No
						0.05	0.280	Up
						0.1	0.237	Up
						0.2	0.188	Up
	Cu	26	0.001	7	0.022	0.01	0.360	No
						0.05	0.280	No
						0.1	0.237	No
						0.2	0.188	No
	Zn	26	0.63	154	0.475	0.01	0.360	Up
						0.05	0.280	Up
						0.1	0.237	Up
						0.2	0.188	Up

3.3 FOXY AND CROW CREEKS

3.3.1 Foxy and Crow Creeks Rainbow Trout Life History Characteristics and Fish Health

Foxy and Crow creek rainbow trout used for the metal and fish health assessments were a mix of age 1+ to age 3+ fish (Appendix 6 Tables 5 and 6). The 2017 Foxy Creek sample averaged 10.3 cm fork length, larger than the average of samples from the past 16 years of sampling (Table 8). The Crow Creek fish averaged 9.0 cm fork length (Table 8 and Appendix 6 Table 6) near the average for past fish samples from this system. Overall, Crow Creek rainbow trout collected for metals and fish health assessments were of comparable age but smaller and poorer condition than the Foxy Creek fish samples in 2017 (Table 8).

Two external abnormalities were noted in the juvenile fish sample from Foxy Creek in 2017 while Crow Creek fish had no abnormalities (Appendix 6 Tables 5 and 6). The incidence of external abnormalities on juvenile rainbow trout from these two systems has remained at 10% or less since 2009 (Appendix 6 Table 9).

3.3.2 Foxy and Crow Creek Fish Tissue Metals

Metal concentrations in rainbow trout in 2017 indicate that levels of cadmium and zinc in Foxy Creek fish tissue were below the average measured since 1994 while copper levels were close to the mean of past sampling (Figure 7). The mean concentration of copper measured in 2017 fall within the range of historical levels measured in both Foxy and Crow creeks for those years when both creeks have been sampled since 2002 (Table 9). Zinc concentrations in Foxy Creek were at the low end of the range. Cadmium levels in Foxy Creek were lower than the historical range

while levels in Crow Creek fish were historically high¹¹. Detailed results for each fish sampled from Foxy and Crow creeks for 2017 are presented in Appendix 5 Table 3.

The trend analyses of metal concentrations in Foxy Creek rainbow from 1994 to 2017 indicate a weak increasing trend in zinc concentration over time at alpha value of 0.2 (Table 10). At all alpha values, there were no trends over time in copper and cadmium concentrations in Foxy Creek up to 2017 (Table 10). Both copper and zinc trends have declined over the past five years.

Table 8. Summary of biological parameters of rainbow trout sampled in Foxy and Crow creeks 2002 to 2017¹².

Location	Year	N	Length (cm ± SD)	Weight (g ± SD)	Condition (k ± SD)	Age (mean ± SD)
Foxy Creek	2002	194	5.70 ± 2.2	2.9 ± 2.7	1.0 ± 0.14	na
	2003	38	8.95 ± 2.1	10.1 ± 7.5	1.21 ± 0.07	1.5 ± 0.63
	2004	58	7.89 ± 1.6	6.0 ± 4.2	1.08 ± 0.09	1.1 ± 0.29
	2005	30	10.5 ± 1.8	14.0 ± 7.7	1.11 ± 0.10	1.6 ± 0.56
	2006	30	10.4 ± 2.8	16.5 ± 19.0	1.12 ± 0.13	1.3 ± 0.60
	2007	30	9.19 ± 1.7	9.3 ± 6.5	1.05 ± 0.12	1.4 ± 0.61
	2008	30	8.75 ± 1.8	9.0 ± 5.9	1.17 ± 0.09	1.4 ± 0.50
	2009	30	10.2 ± 1.6	12.4 ± 6.9	1.05 ± 0.08	1.3 ± 0.61
	2010	30	9.30 ± 1.4	8.8 ± 5.2	1.01 ± 0.08	1.1 ± 0.39
	2011	25	8.39 ± 1.2	7.3 ± 3.2	1.17 ± 0.10	1.1 ± 0.28
	2012	30	9.87 ± 11.1	11.4 ± 4.0	1.14 ± 0.14	1.3 ± 0.50
	2013	30	9.46 ± 1.3	10.0 ± 4.1	1.14 ± 0.09	1.2 ± 0.38
	2014	26	10.3 ± 2.4	14.3 ± 1.81	1.10 ± 0.10	1.2 ± 0.63
	2015	30	9.61 ± 1.8	10.4 ± 7.6	1.03 ± 0.09	1.1 ± 0.31
	2016	29	9.85 ± 1.7	11.1 ± 6.2	1.04 ± 0.08	1.2 ± 0.44
2017	30	10.3 ± 1.7	15.1 ± 9.2	1.23 ± 0.14	1.3 ± 0.55	
	Mean		9.29 ± 1.2	10.5 ± 3.5	1.10 ± 0.07	1.3 ± 0.15
Crow Creek	2002	30	8.67 ± 1.28	7.75 ± 4.0	1.10 ± 0.16	1.3 ± 0.45
	2006	30	9.83 ± 2.02	11.0 ± 7.0	1.03 ± 0.08	1.3 ± 0.60
	2010	30	9.07 ± 1.86	9.50 ± 7.8	1.09 ± 0.09	1.5 ± 0.59
	2012	30	10.1 ± 1.41	11.8 ± 4.9	1.06 ± 0.07	1.8 ± 0.43
	2013	30	9.15 ± 1.58	9.63 ± 6.0	1.14 ± 0.10	1.3 ± 0.53
	2014	30	9.59 ± 2.25	11.1 ± 9.7	1.09 ± 0.09	1.5 ± 0.76
	2015	30	8.98 ± 1.81	9.04 ± 7.2	1.09 ± 0.09	1.4 ± 0.56
	2016	30	10.3 ± 1.97	13.2 ± 9.4	1.06 ± 0.10	1.5 ± 0.63
	2017	30	8.95 ± 1.36	8.45 ± 4.45	1.10 ± 0.10	1.2 ± 0.43
	Mean		9.40 ± 0.57	10.16 ± 1.7	1.08 ± 0.03	1.42 ± 0.17

¹¹ This result was strongly influenced by a single fish that was subject to a second analysis with similar results.

¹² A subsample of the Foxy and Crow creek fish has been used in the metal analyses. Typically, the 10 largest fish found in the sample are used each year.

Figure 7. Summary of rainbow trout muscle tissue total metal concentration (mean \pm std) sampled in Foxy Creek 1994 to 2017.

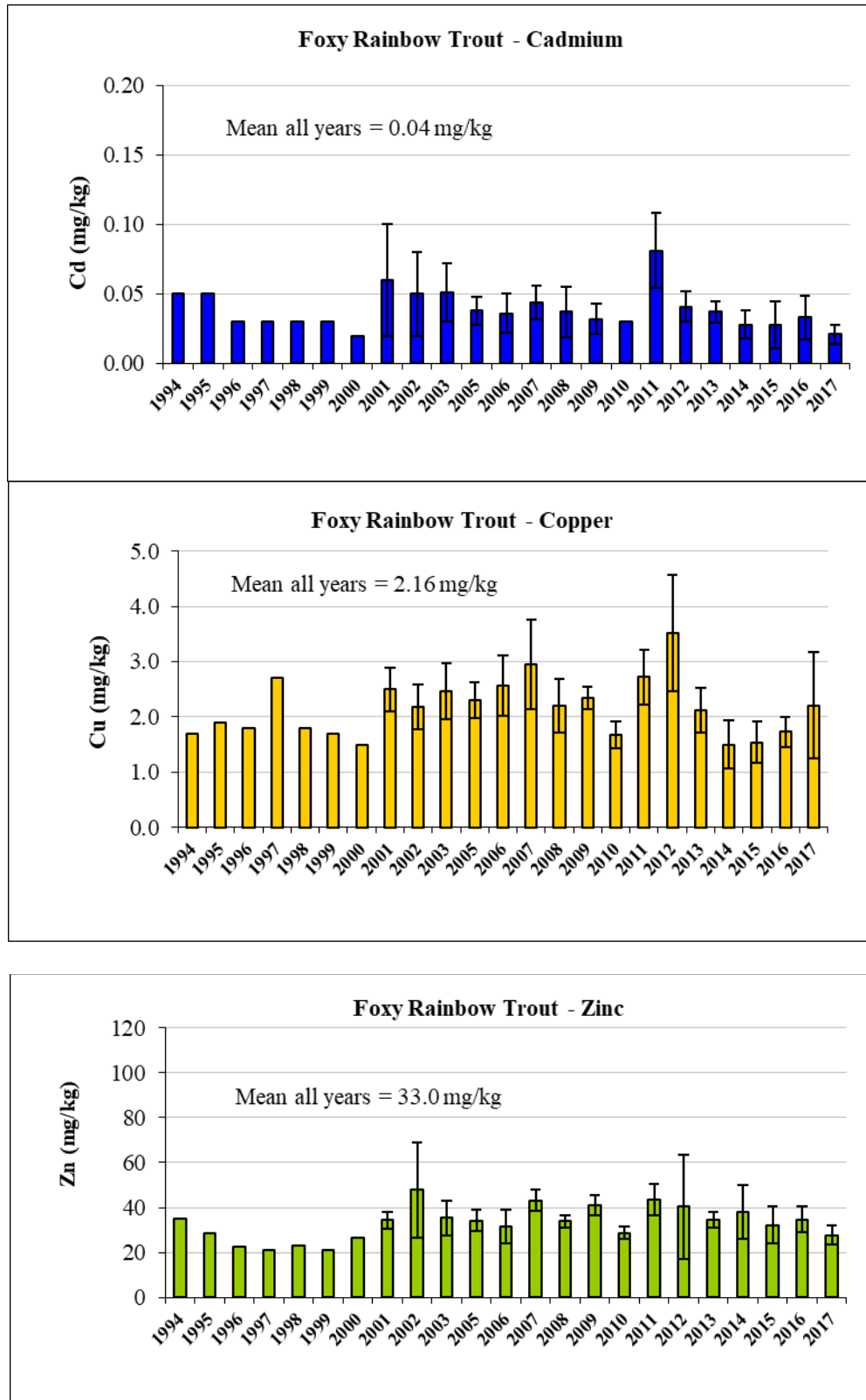


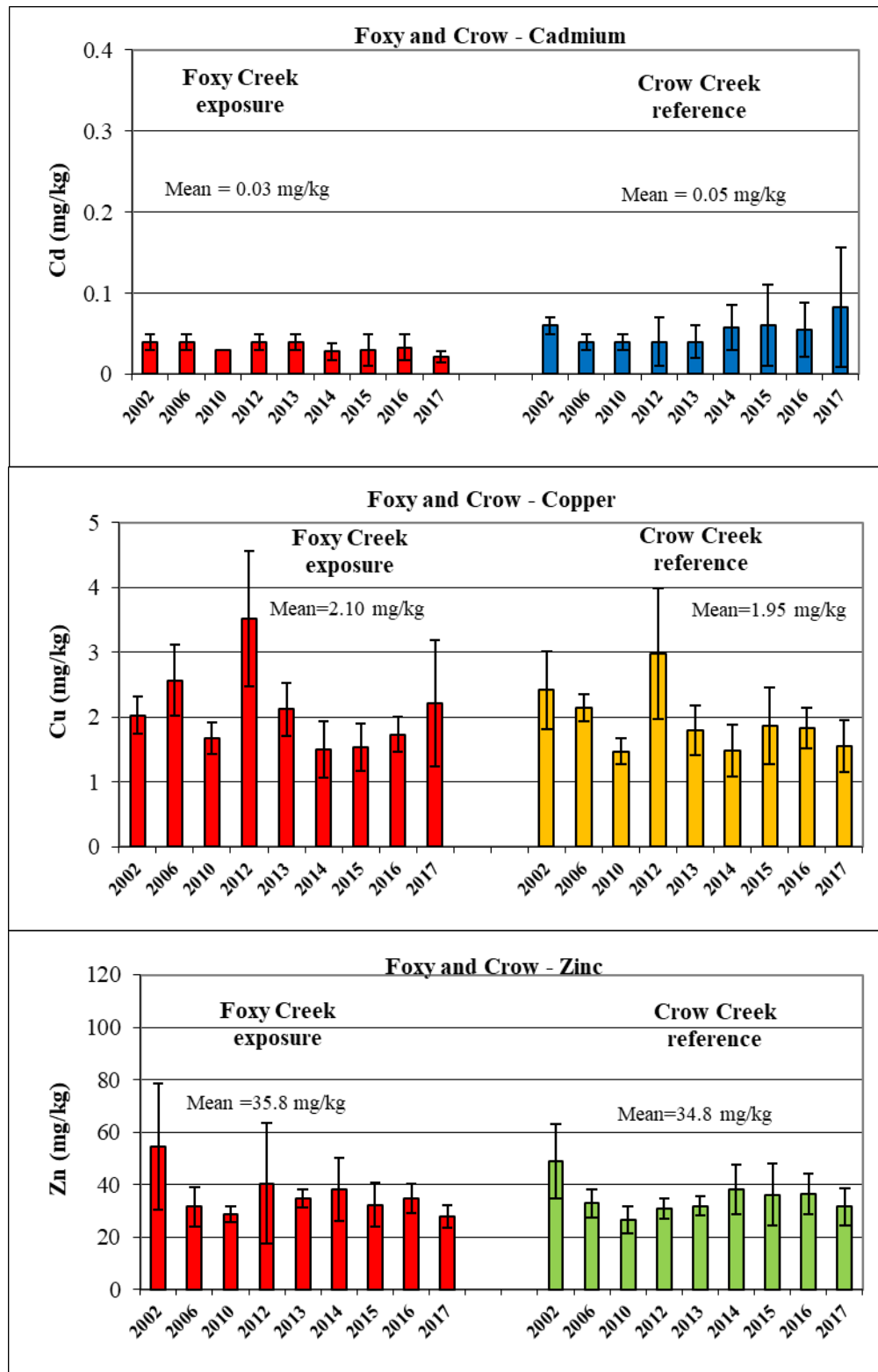
Table 9. Summary of 2017 metal concentrations (mean \pm std) in rainbow trout in Foxy Creek compared to historical means and to the Crow Creek reference site.

Location	Year	Muscle Tissue Metal Concentration (mg/kg dry weight)			
		N	Cd	Cu	Zn
Foxy Creek	2002	10	0.04 \pm 0.01	2.03 \pm 0.29	54.5 \pm 24
	2006	10	0.04 \pm 0.01	2.57 \pm 0.55	31.5 \pm 7.7
	2010	10	<0.03	1.68 \pm 0.24	28.8 \pm 3.0
	2012	10	0.04 \pm 0.01	3.52 \pm 1.05	40.4 \pm 23
	2013	10	0.04 \pm 0.01	1.94 \pm 0.64	32.2 \pm 9.4
	2014	10	0.03 \pm 0.01	1.50 \pm 0.44	38.0 \pm 12.0
	2015	10	0.03 \pm 0.02	1.54 \pm 0.37	32.2 \pm 8.32
	2016	10	0.03 \pm 0.02	1.73 \pm 0.27	34.7 \pm 5.79
	2017	10	0.02 \pm 0.01	2.21 \pm 0.97	27.8 \pm 4.40
Foxy mean	2002 to 2017		0.03 \pm 0.01	2.08 \pm 0.54	35.6 \pm 10.8
Crow Creek	2002	10	0.06 \pm 0.01	2.42 \pm 0.60	48.9 \pm 14.0
	2006	10	0.04 \pm 0.01	2.15 \pm 0.21	32.8 \pm 5.4
	2010	10	0.04 \pm 0.01	1.47 \pm 0.20	26.6 \pm 5.0
	2012	10	0.04 \pm 0.03	2.98 \pm 1.01	30.9 \pm 4.0
	2013	10	0.04 \pm 0.02	1.80 \pm 0.38	31.8 \pm 3.7
	2014	10	0.06 \pm 0.03	1.48 \pm 0.40	38.2 \pm 9.4
	2015	10	0.06 \pm 0.05	1.86 \pm 0.59	36.2 \pm 11.7
	2016	10	0.06 \pm 0.03	1.83 \pm 0.31	36.4 \pm 7.6
	2017	10	0.08 \pm 0.07	1.56 \pm 0.40	31.6 \pm 7.05
Crow mean	2002 to 2017		0.05 \pm 0.03	1.95 \pm 0.46	34.8 \pm 7.55

Table 10. Results of trend analyses of Foxy Creek cadmium, copper, and zinc in rainbow trout muscle tissue, 1994 to 2017.

	Variable Measured (mg/kg)	Number of Observations	Slope (units/year)	Mann Kendall Statistic	Tau	Alpha	Critical	Significant?
	Sen's Slope Estimator	Cd	23	0	-50	-0.204	0.01	0.391
0.05							0.296	No
0.1							0.257	No
0.2							0.202	No
Cu		23	0.002	12	0.048	0.01	0.391	No
						0.05	0.296	No
						0.1	0.257	No
						0.2	0.202	No
Zn		23	0.393	53	0.210	0.01	0.391	No
						0.05	0.296	No
						0.1	0.257	No
						0.2	0.202	Up

Figure 8. Summary of rainbow trout muscle tissue total metal concentration (mean \pm std) sampled at Foxy and Crow creeks during nine time periods from 2002 to 2017.



The ANOVA analyses for all years that both Foxy and Crow creeks have been sampled (Appendix 5 Table 5) indicate that cadmium levels were significantly greater in the Crow Creek reference site compared to the Foxy Creek exposure site. In 2017 there was a significant interaction between year and site driven by elevated concentrations in Crow Creek compared to Foxy Creek (Appendix 5 Table 5). The results of the 2017 sampling continued to indicate that Crow Creek cadmium concentrations in fish muscle tissue were significantly higher than in Foxy Creek (Figure 8 and t-test; $p=0.1$).

ANOVA analyses for all years of sampling indicate fish from Foxy and Crow creeks did not differ significantly in copper concentrations between sites, but there were overall significant differences in years and with year-site interactions (Appendix 5 Table 5). These effects were driven by a copper spike in both systems in 2012 (Figure 8). Copper concentrations in fish muscle tissue were significantly higher in Foxy than in Crow Creek in 2017 (t-test; $p=0.1$).

ANOVA analyses also indicated zinc metal concentrations were not significantly different between Foxy and Crow creek sites, but they were different between years (Appendix 5 Table 5). The year effect in this case was likely driven by high concentrations of zinc at both the reference and exposure sites in 2002 compared to all other years (Figure 8). Zinc concentrations in fish muscle tissue were not significantly different between the two sites in 2017 (t-test; $p=0.1$).

Copper and zinc concentrations tend to track each other in the two systems (Figure 8) and the Crow Creek reference measurements provide a measure of natural annual variability in metal concentrations in fish muscle tissue in these systems.

4.0 CONCLUSIONS

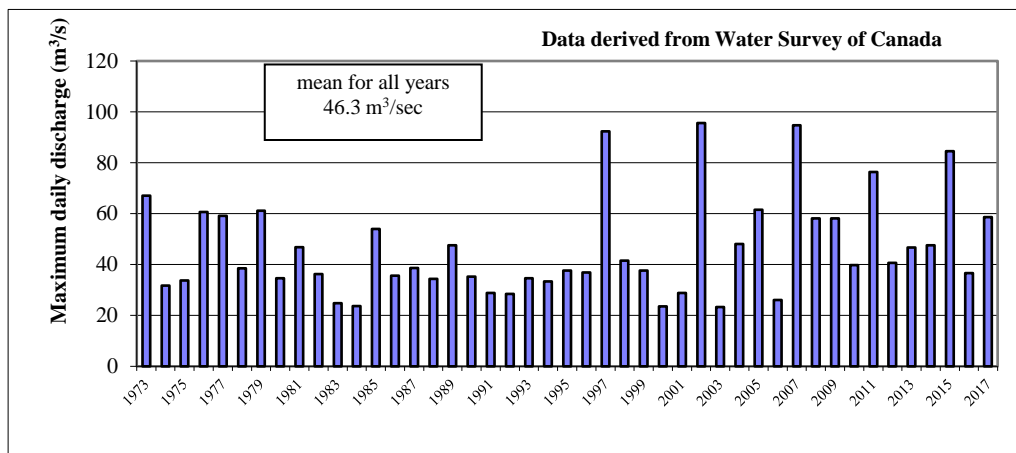
- Three upper Buck Creek fish index sites were sampled in 2017, including two reference sites upstream from Bessemer Creek and one exposure site located immediately downstream.
- The stream fish sampling was conducted during late August in a period of low stream flows. Treated water releases into Foxy Creek ended in late July and into Buck Creek by early August, prior to the fish sample period. Some Diversion Pond releases continued intermittently into November.
- Rainbow trout fry densities at the exposure site downstream from Bessemer Creek were approximately one-half of the levels compared to past sampling. Fry densities at the upper long-term reference site were well above those measured at the lower exposure site but were below the long-term average at this uppermost location. Fry densities at the new reference site exceeded those at the exposure site and the long-term reference location for the first time since these sites were established at their present location in 2003. The higher densities at this site may reflect less impoundment by beavers in 2017.
- The 2017 rainbow parr densities at the exposure site were close to the mean since 2003. These densities were comparable to those measured at the two reference sites in 2017 and well below the long-term average at the upper reference site.
- Long-term monitoring suggests that typically upper Buck Creek is adequately seeded with fry, and that rainbow trout parr densities in the range of 20 to 40 parr/100 m² reflects the habitat capabilities of the relatively stable stream environment in this section of Buck Creek. The parr densities at the exposure and reference sites were within this range in 2017.
- Rainbow trout fry fork lengths in Buck Creek were within 2 mm of the long-term mean for all past years at all sample locations. Fry at the uppermost reference location were significantly larger than their counterparts at the other two sites. There were no significant fork length differences of rainbow age 1+ parr between the long-term reference site and the exposure site. Age 1+ parr were on average 5 mm larger compared to historical sampling at all locations.
- The larger parr lengths in 2017 in Buck Creek at both the long-term reference site and exposure site suggest that environmental factors common throughout the system were affecting parr size. This larger size may also reflect the large fry present in the system in 2016 (Appendix 4 Table 1).
- Age 1+ rainbow parr condition factors in 2017 at the exposure site in Buck Creek were not significantly different than the lower reference site. Condition factors were highest at the long-term reference site.

- The overall condition factors of rainbow parr at the Buck, Foxy and Crow creek sites suggest healthy fish at all stream locations in 2017. Goosly Lake rainbow condition factors were near average and within the range of past measurements since 2002.
- External fish health assessments conducted in 2017 suggest a low incidence of external abnormalities in rainbow trout from upper Buck, Foxy, and Crow creeks and Goosly Lake.
- The analyses of fish tissue metal concentrations for the eight years that both the Buck Creek exposure site (BB1) and the reference site (BB2 old) were sampled indicate cadmium concentrations in the downstream exposure site (BB1) were significantly higher than the reference (BB2 old) location. This pattern persisted in 2017.
- The analyses for the eight years up to 2017 that both upper Buck Creek sites were sampled indicated that copper and zinc concentrations in fish muscle tissue were not significantly different between the downstream exposure site and the reference location. However, both copper and zinc levels were significantly lower at the exposure site compared to the reference location in 2017.
- All three metals had significant year and site-year interaction effects at the Buck Creek exposure and reference locations. The temporal cadmium and zinc effects were largely the result of high concentrations at the exposure site in 2002.
- The results of metal analyses of 20 rainbow trout muscle tissue samples from Goosly Lake indicate that levels of cadmium and zinc were above the mean levels measured since 1982, while copper levels were near the long-term mean. Similar to the mean for all past years, Goosly Lake 2017 rainbow trout had lower cadmium and copper, but higher zinc concentrations compared to a sample of other BC lakes.
- The data continue to demonstrate a long-term trend of increasing zinc levels in Goosly Lake fish ($p=0.01$). There was also an increasing trend in cadmium ($p=0.05$), but no significant trend for copper.
- Trend analyses of metal levels in Foxy Creek rainbow trout since 1994 continue to suggest a weak upward trend for zinc over time ($p=0.2$). There were no significant trends over time in copper and cadmium concentrations in Foxy Creek up to 2017.
- The analyses for the nine years that both Foxy and Crow creek rainbow trout have been sampled indicate that cadmium levels were significantly greater in the Crow Creek reference site compared to the Foxy Creek exposure site. This pattern continued in 2017.
- The analyses for the nine years that both Foxy and Crow creek rainbow trout have been sampled up to 2017 indicated that rainbow trout in these two systems did not differ significantly in copper or zinc concentrations between sites, but that there were overall significant differences amongst years.

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Appendix 1 Figure 1. Maximum daily discharge during the snowmelt freshet (Apr-June) in lower Buck Creek from 1973 to 2017.



Year	Date	Max daily flow (m ³ /s)	Year	Date	Max daily flow (m ³ /s)
1973	16-May	67.1	1996	25-May	36.9
1974	27-May	31.7	1997	15-May	92.4
1975	12-May	33.7	1998	04-May	41.6
1976	06-May	60.6	1999	25-May	37.7
1977	27-Apr	59.2	2000	11-Jun	23.5
1978	15-Jun	38.5	2001	29-May	28.8
1979	03-May	61.2	2002	22-May	95.6
1980	12-May	34.6	2003	27-Apr	23.3
1981	15-May	46.8	2004	05-May	48.1
1982	05-Jun	36.3	2005	27-Apr	61.5
1983	30-Apr	24.8	2006	04-Jun	26.1
1984	20-May	23.7	2007	07-Jun	94.8
1985	21-May	54	2008	19-May	58.2
1986	31-May	35.6	2009	21-Apr	58.2
1987	09-May	38.6	2010	21-May	39.8
1988	14-May	34.4	2011	30-May	76.4
1989	05-May	47.6	2012	28-May	40.7
1990	30-May	35.3	2013	13-May	46.7
1991	10-May	28.8	2014	15-May	47.6
1992	20-Apr	28.5	2015	15-May	84.5
1993	22-May	34.6	2016	26-Apr	36.7
1994	01-May	33.4	2017	13-May	58.6

Appendix 1 Table 1. Summary of discharge estimates at juvenile fish sample sites during the juvenile sample period since 2004.

Discharge estimate (l/s)							
Year	BB1	BB2 old	BB2 new	Bessemer	FF1	FF2	CRW1
2017	20	30	nm	dry			
2016**	120	54	nm	dry			
2015	53	31.7	nm	1-2***			
2014	24.7	22.2	nm	dry	nm	45.9	5.4
2013	55	43	50	trickle			
2012	48.8	55	43	1-2***			
2011*	264	112	138	72			
2010	nm	60.5	70.1	dry	nm	45	6
2009	nm	nm	26.9	dry			
2008	474	485	294	86.7			
2007	181	188	256	13			
2006	28.3	22.9	21.2	dry	54	83	11
2005	nm	108	108				
2004**	390	59	76				

*Bessemer discharge provided by Equity Mines Ltd.

**Heavy rain between sampling dates

***Visual estimate

Appendix 2 Table 1. Electrofishing site BB2(old) 2017.

SITE:	BB2 OLD	PHOTOS:	DATE:	Aug 29/17
SITE LOCATION:	2 km upstream from bridge - same location as past years.			
ACCESS:	Veh	EFFORT:	PASS 1	1596 secs
			PASS 2	1275 secs
SLOPE (%):	1	TEMP (C):	11.0	TIME 14:00 COND. pH:
SAMPLING COMMENTS:	Good sample. Low flows			

POPULATION ESTIMATES:

SPECIES	AGE	FL		PASS			NUMBER	S.E.	N/M*M	N/100M	MEAN BIOMASS	
		RANGE	MEAN	1	2	U1+U2					WT	g/m*m
Rbt	0+	40-47	40.8	40	15	55	64.0	7.1	0.305	106.7	0.82	0.250
Rbt	1+	63-95	80.1	27	11	38	45.6	7.2	0.217	75.9	6.03	1.308
Rbt	2+	101-128	112.0	3	1	4	4.5	1.5	0.021	7.5	17.3	0.371
Rbt	3+	179	179.0	1	0	1	1.0	0.0	0.005	1.7	64.4	0.307
Rbt	4+					0	0.0	0.0	0.000	0.0		0.000
LN Dace	0+					0	0.0	0.0	0.000	0.0		0.000
LN Dace	>1+					0	0.0	0.0	0.000	0.0		0.000
Ln Sucker	0+					0	0.0	0.0	0.000	0.0		0.000
LN Sucker	>1+					0	0.0	0.0	0.000	0.0		0.000
Prickly Sculpin	>1+					0	0.0	0.0	0.000	0.0		0.000
M. Whitefish	>1+					0	0.0	0.0	0.000	0.0		0.000
Lamprey	all					0	0.0	0.0	0.000	0.0		0.000
TOTAL							115.1		0.548	191.8		2.236

LOCATION	WIDTH (m)		SITE COVER (%)	SITE WATER TYPE (%)	MEAN DEPTH (cm)
0	2.6	LOD	20	POOL	80
3	3.3	COBBLE	20	RIFFLE	20
6	5.2	IN VEG		RUN	
9	3.4	OVER VEG	30	OTHER	
12	3.9	CUTBANK	30		
15	4.0	DEEP POOL			
18	4.7			D90/50:	15/4
20	3.1	TOTAL	70	(cm)	
24	2.8				
	2.0				
	3.5				
AREA (M*M)	210.0	MARGIN (M)	60		

HABITAT COMMENTS:
No changes to site in past year. Lots of aquatic moss and algae.
Discharge = 20.0 l/s.

Appendix 2 Table 2. Electrofishing site BB1 2017.

SITE:	BB1	PHOTOS:	DATE:	Aug 30/17
SITE LOCATION:	Top of site approximately 25 m below Bessemer Creek confluence.			
ACCESS:	Veh	EFFORT:	PASS 1	1702 secs
			PASS 2	1548 secs
SLOPE (%):	<0.5	TEMP (C):	13.0	TIME 12:00 COND. pH:
SAMPLING COMMENTS:	Low flows			

POPULATION ESTIMATES:

SPECIES	AGE	FL RANGE	FL MEAN	PASS			NUMBER	S.E.	N/M*M	N/100M	MEAN WT	BIOMASS g/m*m
				1	2	U1+U2						
Rbt	0+	32-46	37.8	27	3	30	30.4	0.8	0.106	44.7	0.61	0.065
Rbt	1+	62-97	81.2	50	8	58	59.5	1.7	0.208	87.5	5.65	1.178
Rbt	2+	99-132	115.0	5	0	5	5.0	0.0	0.018	7.4	16.2	0.284
Rbt	3+			0	0	0	0.0	0.0	0.000	0.0		0.000
Rbt	4+			0	0	0	0.0	0.0	0.000	0.0		0.000
LN Dace	0+			0	0	0	0.0	0.0	0.000	0.0		0.000
LN Dace	>1+			0	0	0	0.0	0.0	0.000	0.0		0.000
Ln Sucker	0+			0	0	0	0.0	0.0	0.000	0.0		0.000
LN Sucker	>1+			0	0	0	0.0	0.0	0.000	0.0		0.000
Prickly Sculpin	>1+	95	95.0	1	0	1	1.0	0.0	0.004	1.5	10.7	0.038
M. Whitefish	>1+			0	0	0	0.0	0.0	0.000	0.0		0.000
Lamprey	all			0	0	0	0.0	0.0	0.000	0.0		0.000
TOTAL							95.9		0.336	141.0		1.564

LOCATION	WIDTH (m)		SITE COVER (%)		SITE WATER TYPE (%)	MEAN DEPTH (cm)
0	4.9	LOD	60		POOL	54
3	5.2	COBBLE			RIFFLE	8
6	5.0	IN VEG			RUN	
9	6.6	OVER VEG	20		OTHER	
12	1.5	CUTBANK	20			
15	2.2	DEEP POOL				
18	3.8				D90/50:	12/3
20	4.6	TOTAL	80		(cm)	
24	4.0					
	4.2					
AREA (M*M)	285.6	MARGIN (M)	68			

HABITAT COMMENTS:
More debris in upper section of site from adjacent forest.
Discharge = 29.8 l/s

Appendix 2 Table 3. Electrofishing site BB2(new) 2017.

SITE:	BB2 NEW	PHOTOS:	DATE:	Aug 31, 2017
SITE LOCATION:	Downstream net just below bridge as in past years.			
ACCESS:	Veh	EFFORT:	PASS 1	2690 secs
			PASS 2	1829 secs
SLOPE (%):	<0.5	TEMP (C	12	TIME: COND. pH:
SAMPLING COMMENTS:	Beaver dam opened to lower flows this year by 40 cm. Heavy rain for three days.			

POPULATION ESTIMATES:

SPECIES	AGE	FL		PASS		U1+U2	NUMBER	S.E.	N/M*M	N/100M	MEAN BIOMASS	
		RANGE	MEAN	1	2						WT	g/m*m
Rbt	0+	30-51	39.0	99	28	127	138.0	6.2	0.517	281.7	0.69	0.357
Rbt	1+	62-96	82.4	43	18	61	74.0	9.7	0.277	150.9	5.81	1.611
Rbt	2+	103-125	112.5	4	0	4	4.0	0.0	0.015	8.2	15.4	0.231
Rbt	3+					0	0.0	0.0	0.000	0.0		0.000
Rbt	4+					0	0.0	0.0	0.000	0.0		0.000
LN Dace	0+					0	0.0	0.0	0.000	0.0		0.000
LN Dace	>1+					0	0.0	0.0	0.000	0.0		0.000
Ln Sucker	0+	24.0	24	0	1	1	1.0	0.0	0.004	2.0	0.12	0.000
Ln Sucker	>1+					0	0.0	0.0	0.000	0.0		0.000
Prickly Sculpin	>1+	105-110	107.5	1	1	2	2.0	na	0.007	4.1	18.4	0.138
M. Whitefish	>1+					0	0.0	0.0	0.000	0.0		0.000
TOTAL							219.0		0.821	446.9		2.337

LOCATION	WIDTH (m)	SITE COVER (%)	SITE WATER TYPE (%)	MEAN DEPTH (cm)
0	5.3	LOD	50	POOL 95 79
3	3.8	COBBLE	30	RIFFLE 5 26
6	3.3	IN VEG	10	RUN
9	3.7	OVER VEG	10	OTHER
12	7.6	CUTBANK	0	
15	6.8	DEEP POOL		
18	9.4			D90/50: 10/2
20	5.0	TOTAL	50	(cm)
	<u>4.1</u>			
	5.4			
AREA (M*M)	266.8	MARGIN (M)	49	

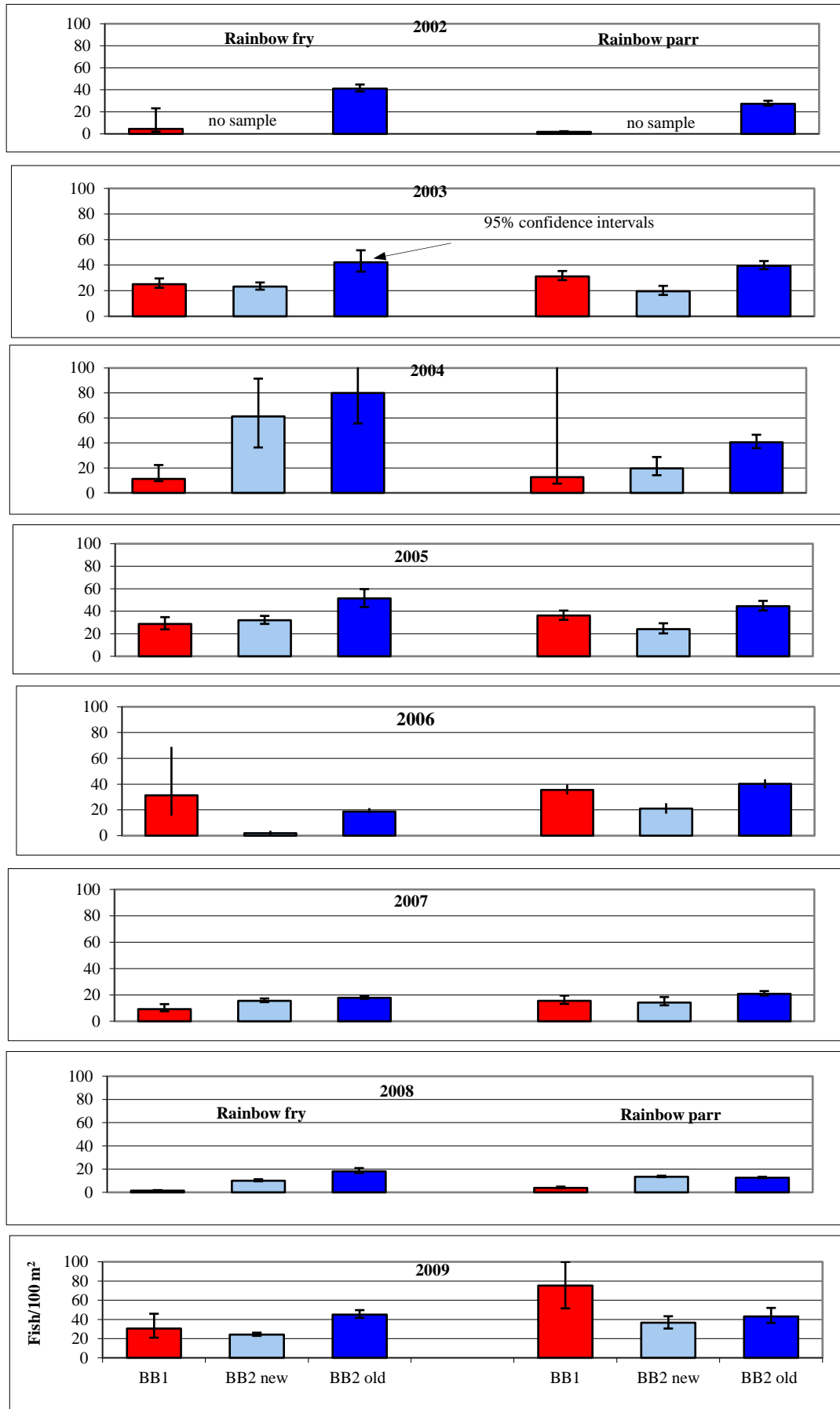
HABITAT COMMENTS:	
Staff gauge = 0.28; Discharge = measured downstream	Two 30' nets
Bessemer Creek was dry in late July so not sampled in 2017.	
Beaver dam open this year. Pools are lower since July.	Lots of aquatic moss and algae.

Appendix 2 Table 4. Summary of rainbow trout densities in upper Buck Creek sites for all years by age classes to 2017.

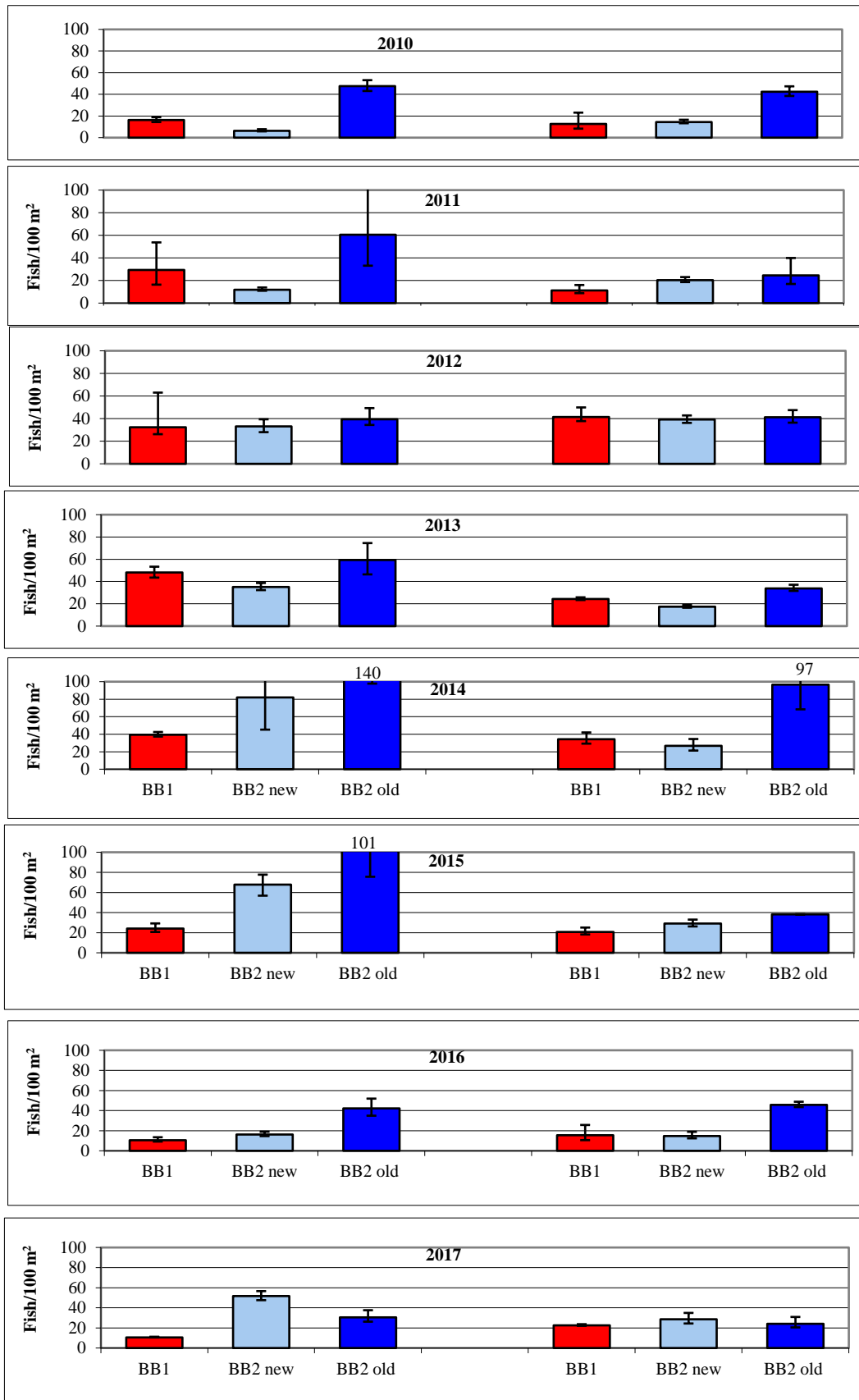
Sample Site	Year	Density (fish/100 m ²)		
		0+	1+	>=2+
BB1	1987	0.0	7.0	2.0
Downstream from	1988	0.0	6.0	1.0
Bessemer Creek	1989	5.0	4.0	2.0
	1990	1.0	16.0	2.0
	1991	0.4	9.0	4.0
	1993	0.0	2.0	1.0
	1998	0.0	0.0	0.2
	2002	4.5	1.5	0.3
	2003	25.1	28.9	3.1
	2004	12.4	12.4	0.2
	2005	28.7	36.2	0.3
	2006	31.3	29.7	4.1
	2007	9.2	9.9	5.6
	2008	1.5	3.3	0.4
	2009	30.6	63.6	13.3
	2010	16.1	11.6	0.5
	2011	29.3	9.6	1.0
	2012	32.4	39.6	1.5
	2013	48.2	24.0	0.3
	2014	39.3	34.1	0.9
	2015	24.1	20.5	0.3
	2016	10.6	14.1	0.3
	2017	10.6	20.8	1.8
	Mean (87-17)	15.7	17.6	2.0
BB2 - old	1987	59.0	27.0	3.0
Reference site	1988	36.0	23.0	0.0
2 km upstream	1989	62.0	27.0	1.0
	1990	55.0	34.0	1.0
	1991	175.0	32.0	1.0
	1993	18.0	12.0	0.2
	1998	37.0	39.0	2.0
	2002	41.1	24.2	4.3
	2003	42.2	36.8	2.8
	2004	80.0	39.8	0.7
	2005	51.3	43.1	1.4
	2006	18.7	34.6	6.7
	2007	17.8	19.3	3.8
	2008	18.1	12.3	0.3
	2009	45.0	38.1	5.1
	2010	47.6	39.1	4.3
	2011	60.5	21.3	4.0
	2012	39.4	40.9	0.4
	2013	59.3	33.0	0.4
	2014	139.7	89.6	7.7
	2015	101.3	35.4	2.8
	2016	42.2	43.0	2.9
	2017	30.5	21.7	2.6
	Mean (87-17)	55.5	33.3	2.5
BB2 - new	2003	23.3	18.7	0.9
Reference site	2004	61.2	19.6	0.0
just upstream from	2005	32.0	23.6	0.5
Bessemer Creek	2006	1.9	19.9	1.2
	2007	15.4	8.9	3.4
	2008	10.0	13.2	0.3
	2009	24.2	33.8	3.3
	2010	6.3	13.5	0.8
	2011	11.8	17.9	2.1
	2012	33.1	38.5	0.9
	2013	35.1	15.5	2.0
	2014	82.0	26.6	0.6
	2015	67.9	28.8	0.3
	2016	16.2	13.5	1.0
	2017	51.7	27.7	1.5
	Mean (03-17)	31.5	21.3	1.3
BESI*	2002	0.9	0.0	2.8
Bessemer Creek	2005	11.5	0.0	2.3
at lower road	2007	0.0	9.3	5.6
	2008	0.0	0.0	0.0
	2011	1.0	0.0	0.0
	2012	0.0	0.0	0.0

* Sampled in years when creek not dewatered.

Appendix 2 Figure 1. Rainbow trout fry and parr densities (fish/100m²) at the Buck Creek index sites from 2002 to 2017.



Appendix 2 Figure 1 (Cont'd). Rainbow trout fry and parr densities (fish/100m²) at the Buck Creek index sites from 2002 to 2017.



Appendix 3 Table 1. Catch composition at Upper Buck Creek fish sample sites 1987 to 2017.

SPECIES	1987	1988	1989	1990	1991	1993	1998	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean	
SITE BB1																									
Rainbow Fry	1	0	21	5	2	0	0	16	72	45	112	107	27	6	97	68	126	109	158	87	77	39	30	52.4	
(%)	1.3	0.0	26.6	4.2	2.4	0.0	0.0	76.2	43.9	60.8	43.9	48.0	35.1	27.3	28.3	57.1	72.0	42.7	66.4	48.8	53.5	41.9	31.7	35	
Rainbow Parr	37	29	24	86	57	15	1	5	92	29	142	115	47	15	245	51	45	138	80	81	66	53	65	66.0	
(%)	48.7	56.9	30.4	72.3	67.9	50.0	5.9	23.8	56.1	39.2	55.7	51.6	61.0	68.2	71.4	42.9	25.7	54.1	33.6	45.6	45.8	57.0	67.3	48	
Mountain Whitefis	13	0	8	8	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	
(%)	17.1	0.0	10.1	6.7	0.0	3.3	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	
Prickly Sculpins	25	22	25	20	24	12	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	5.7
(%)	32.9	43.1	31.6	16.8	28.6	40.0	11.8	0.0	0.0	0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	9.3
Longnose Suckers	0	0	1	0	1	1	14	0	0	0	0	1	3	1	1	0	4	8	0	10	1	1	0	2.0	
(%)	0.0	0.0	1.3	0.0	1.2	3.3	82.4	0.0	0.0	0	0.0	0.4	3.9	4.5	0.3	0.0	2.3	3.1	0.0	5.6	0.7	1.1	0.0	5.0	
Peamouth Chub*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	
(%)	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	
TOTAL	76	51	79	119	84	30	17	21	164	74	255	223	77	22	343	119	175	255	238	178	144	93	96	129	
Area Sampled (m²)	409	394	406	476	445	502	402	354	287	403	389	341	356	427	319	423	430	336	329	233	319	369	285	375	
SITE BB2 (OLD)																									
Rainbow Fry	190	130	213	188	599	77	130	106	111	214	148	47	58	53	105	123	150	94	141	212	252	103	64	152	
(%)	66.2	61.0	69.2	61.4	84.5	57.9	47.1	58.8	51.6	66.5	53.6	31.6	46.0	57.6	51.0	52.3	70.4	48.8	61.4	49.2	72.6	46.2	55.6	58.0	
Rainbow Parr	97	83	95	118	110	55	146	73	104	108	128	102	67	39	101	112	63	99	88	219	95	112	51	98	
(%)	33.8	39.0	30.8	38.6	15.5	41.4	52.9	40.7	48.4	33.5	46.4	68.4	53.2	42.4	49.0	47.7	29.6	51.2	38.6	50.8	27.4	50.2	44.4	42	
Longnose Suckers	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	8	0	0.5	
(%)	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.6	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.1		
TOTAL	287	213	308	306	709	133	276	180	215	322	276	149	126	92	206	234	213	193	229	431	347	223	115	259	
Area (m²)	319	359	343	340	342	426	355	257	257	268	288	252	341	320	233	257	248	239	237	225	249	244	210	287	

Appendix 3 Table 1. Catch composition at Upper Buck Creek fish sample sites 1987 to 2017.

SPECIES	1987	1988	1989	1990	1991	1993	1998	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean
	SITE BB2 (NEW)																							
Rainbow Fry									100	149	125	7	59	37	96	24	40	117	127	157	228	60	138	97.6
(%)									54.1	72.0	56.8	8.2	53.6	40.7	39.0	29.1	38.8	43.3	61.1	63.1	68.7	50.4	116	48.3
Rainbow Parr									85	58	94	78	47	51	147	55	68	139	63	74	98	54	78	79.3
(%)									45.9	28.0	42.7	91.8	42.7	56.0	59.7	66.0	61.2	51.5	30.3	29.7	29.5	45.4	65.5	48.9
Prickly Sculpins									0	0	1	0	4	0	0	0	0	4	5	0	0	0	2	1.0
(%)									0.0	0.0	0.5	0.0	3.6	0.0	0.0	0.0	0.0	1.5	2.2	0.0	0.0	0.0	1.7	0.6
Longnose Suckers									0	0	0.0	0.0	4	3	3	1	0	10	14	17	6	5	1	4.2
(%)									0.0	0.0	0.0	0.0	3.6	3.3	1.2	1.2	0.0	3.7	6.5	6.8	1.8	4.2	0.8	2.2
Longnose Dace									0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0.2
%									0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Redside shiner									0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0.1
%									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
TOTAL									185	207	220	85	110	91	246	83	108	270	209	249	332	119	219	184
Area (m²)									432	408	389	370	380	390	397	382	338	354	363	348	336	370	267	368

NOTES:

Site BB1 was moved upstream to ~50 m below Bessemer Ck mouth in 2002.

Site BB2 old was moved ~300 m upstream in 2002 due to beaver impounding at the old site.

* 1993 specimen was re-examined in 2007 - former identification as brassy minnow was incorrect.

Appendix 3 Table 2. Prickly sculpin summary for sites in upper Buck Creek to 2017.

Site BB1						
Date	Area (m²)	Number	Mean Fork Length (mm)	Range (mm)		Mean Wt (g)
				Min	Max	
1987	409	20	74.0	54	103	4.9
1988	394	19	77.4	55	103	6.3
1989	406	25	65.6	40	101	3.1
1990	476	15	85.5	71	108	7.8
1991	445	17	90.5	59	111	10.5
1993	502	12	85.6	62	102	8.8
1998	402	2	80.0	69	82	7.2
Site moved to upstream location in 2002						
2002	354	0				
2003	287	0				
2004	403	0				
2005	389	1	93	93	93	10.6
2006-2016	223-430	0				
2017	286	1	95	95	95	10.7
Site BB2(new)						
2003-2004	389-432	0				
2005	389	1	105	105	105	16.3
2006	370	0				
2007	380	4	95.5	78	130	7.5
2008-2011	338-397	0				
2012	354	4	75.8	67	83	5.7
2013	363	4	104.7	90	123	15.5
2014-16	336-370	0				
2017	266.8	2	107.5	105	110	18.4
Site BB2(old)						
No sculpins have r been sampled at this location since 1987						

Appendix 4 Table 1. Mean fork length of upper Buck Creek rainbow trout for all years.

	BB2 (Old) AGE 0+			BB1 AGE 0+			BB2 (New) AGE 0+		
	Mean fl (mm)	Std.	Sample Size	Mean fl (mm)	Std.	Sample Size	Mean fl (mm)	Std.	Sample Size
1987	43.9	5.26	30						
1988	39.0	4.35	30						
1989	41.3	3.56	32						
1990	38.3	3.22	30						
1991	35.7	5.05	49						
1993	37.1	4.44	50						
1998	42.5	5.08	45						
2002	35.6	4.18	50	34.0	6.68	7			
2003	38.2	4.01	30	34.9	4.74	30	36.6	3.46	30
2004	40.9	6.01	48	40.8	5.51	42	43.4	5.00	51
2005	40.6	4.97	52	40.6	4.51	50	42.0	5.52	50
2006	38.8	5.37	44	42.2	5.31	54	46.7	6.50	7
2007	32.6	4.30	48	34.5	3.30	50	36.0	4.60	50
2008	34.3	4.88	52	35.2	5.0	6	38.4	5.40	37
2009	36.3	4.85	50	37.9	4.0	50	38.9	4.56	50
2010	39.0	4.75	50	38.6	4.7	49	45.3	4.70	21
2011	29.9	2.28	50	30.2	3.89	51	32.4	2.58	37
2012	33.2	5.30	51	34.4	3.20	50	36.9	4.00	50
2013	40.8	6.62	52	39.0	3.43	50	45.5	7.25	55
2014	41.1	4.31	46	40.6	4.97	50	39.1	5.37	51
2015	41.8	3.60	51	40.3	3.70	51	42.1	3.90	50
2016	44.9	4.30	49	39.4	4.70	33	42.2	5.70	50
2017	40.8	3.22	50	37.8	3.77	30	39.0	4.42	50
Mean (87-17)	38.5	4.5	45.2	37.5	4.5	40.8	40.3	4.9	42.6

	BB2 (Old) AGE 1+			BB1 AGE 1+			BB2 (New) AGE 1+		
	Mean fl (mm)	Std.	Sample Size	Mean fl (mm)	Std.	Sample Size	Mean fl (mm)	Std.	Sample Size
1987	80.0	6.81	82	89.1	6.33	23			
1988	79.7	6.05	36	92.8	6.00	18			
1989	75.4	6.86	87	91.1	4.85	16			
1990	70.8	8.06	107	89.0	7.19	63			
1991	74.6	5.65	101	89.1	4.90	38			
1993	75.5	7.29	36	91.8	8.10	8			
1998	72.3	7.19	134	97.0	na	1			
2002	70.9	8.53	58	64.0	5.40	5			
2003	70.8	9.93	90	69.8	7.99	76	65.0	8.47	70
2004	77.1	8.80	97	77.5	9.87	25	76.6	7.90	58
2005	76.8	9.13	113	80.7	10.16	126	79.6	6.93	77
2006	76.1	6.40	81	77.9	6.90	95	77.1	6.90	64
2007	71.3	7.50	62	80.6	7.30	31	80.4	6.90	32
2008	78.6	9.50	37	75.0	8.33	13	72.7	8.40	50
2009	74.5	8.48	76	78.0	7.82	129	78.6	6.71	98
2010	77.0	7.22	88	79.6	9.47	33	80.6	9.02	49
2011	68.9	11.20	37	74.6	9.23	34	80.5	7.70	56
2012	72.0	11.80	85	73.0	11.30	83	73.5	7.30	124
2013	75.7	10.33	73	76.8	6.63	53	81.3	6.95	53
2014	76.8	8.64	143	79.1	5.35	67	80.5	7.08	72
2015	74.2	7.90	118	76.3	8.00	56	75.2	7.10	87
2016	77.0	8.50	99	76.2	5.80	38	74.7	7.10	40
2017	80.1	7.96	38	81.2	7.23	58	82.4	7.48	61
Mean (87-17)	75.0	8.2	81.7	76.9	8.4	63.8	77.2	7.5	66.1

Note: BB1 age 1+ mean lengths are from 2003 onward due to site re-location and small sample size prior to 2003.

Appendix 5 Table 1. Metal concentration in rainbow trout muscle tissue from Goosly Lake, 2017.

Metal concentrations in muscle tissue			
(mg/kg dry weight)			
	Cadmium	Copper	Zinc
RBT1	0.012	1.00	20.6
RBT2	0.014	1.08	27.4
RBT3	0.022	1.22	32.3
RBT4	0.059	2.45	43.1
RBT5	0.055	2.22	49.4
RBT6	0.031	1.11	28.0
RBT7	0.045	1.07	29.4
RBT8*	0.010	1.23	47.5
RBT9	0.086	1.49	55.4
RBT10	0.069	1.77	58.5
RBT11	0.099	1.26	34.3
RBT12	0.158	1.67	61.0
RBT13	0.151	1.59	90.2
RBT14	0.104	1.99	61.3
RBT15	0.071	1.22	58.4
RBT16	0.070	2.29	59.1
RBT17	0.207	1.59	65.8
RBT18	0.089	1.50	63.8
RBT19	0.131	1.52	56.1
RBT20	0.113	1.36	65.5
Mean	0.080	1.53	50.4
Std	0.053	0.43	17.37

* Cadmium levels were below detection of 0.01 mg/kg in 2017.

Detection from 1999 to 2013 was <0.03. Detection was < 0.01 from 2014 onward.

Appendix 5 Table 2. Metal concentration in rainbow trout muscle tissue from Buck Creek BB1 and BB2 (old), 2017.

Site BB1 (exposure)			
Metal concentration (mg/kg dry weight)			
	Cadmium	Copper	Zinc
RBT1	0.094	1.63	29.1
RBT2	0.064	1.06	24.5
RBT3	0.136	1.30	27.0
RBT4	0.162	1.89	23.8
RBT5	0.033	1.06	22.2
RBT6	0.057	1.41	30.0
RBT7	0.057	1.15	30.0
RBT8	0.017	1.15	31.4
RBT9	0.094	1.66	29.4
RBT10	0.106	1.67	25.3
Mean	0.082	1.40	27.3
Std	0.045	0.30	3.15

Site BB2 old (reference)			
Metal concentration (mg/kg dry weight)			
	Cadmium	Copper	Zinc
RBT1	0.043	1.74	26.4
RBT2	0.028	1.32	26.7
RBT3	0.043	1.71	26.6
RBT4	0.022	1.59	26.3
RBT5	0.060	1.80	30.6
RBT6	0.037	1.71	26.0
RBT7	0.049	2.09	30.7
RBT8	0.101	1.86	42.5
RBT9	0.074	2.42	38.8
RBT10	0.012	2.38	36.3
Mean	0.047	1.86	31.1
Std	0.026	0.34	6.03

* Cadmium levels were below detection of 0.01 mg/kg in 2017.

Detection from 1999 to 2013 was <0.03. Detection was < 0.01 from 2014 onward.

Appendix 5 Table 3. Metal concentration in rainbow trout muscle tissue in Foxy and Crow Creeks, 2017.

Foxy Creek			
(mg/kg dry weight)			
	Cadmium	Copper	Zinc
RBT1	0.029	3.27	29.7
RBT2	0.026	1.41	26.1
RBT3	0.018	2.05	23.6
RBT4	0.023	2.28	27.5
RBT5*	0.015	3.68	28.5
RBT6	0.027	3.60	38.7
RBT7	0.031	1.27	27.3
RBT8	0.012	1.46	28.5
RBT9	0.017	1.90	23.0
RBT10	0.013	1.16	25.2
Mean	0.021	2.21	27.8
Std	0.007	0.97	4.40

Crow Creek			
(mg/kg dry weight)			
	Cadmium	Copper	Zinc
RBT1	0.074	1.60	35.6
RBT2	0.113	1.71	45.5
RBT3	0.056	1.75	38.1
RBT4	0.050	1.18	30.0
RBT5	0.045	1.17	28.6
RBT6	0.047	1.34	25.8
RBT7	0.052	1.81	32.1
RBT8	0.052	1.12	21.3
RBT9**	0.285	2.43	25.3
RBT10	0.055	1.50	33.7
Mean	0.083	1.56	31.6
Std	0.074	0.40	7.05

* Cadmium levels were below detection of 0.01 mg/kg in 2017.

Detection from 1999 to 2013 was <0.03.

Detection was < 0.01 from 2014 onward.

**Repeat sampling by lab with similar results.

Appendix 5 Table 4. ANOVA table comparing metal concentrations in rainbow trout fish tissue at the exposure site BB1 to the long-term reference site BB2 old comparing eight time periods from 2002 to 2017.

Effect	DF	SS	MS	F value	P-value
Cadmium					
Site (BB1 vs. BB2 old)	1	0.41	0.41	85.84	<0.001
Year	7	0.11	0.02	3.20	<0.01
Site*Year	7	0.43	0.06	12.65	<0.001
Residuals	136	0.66	0.00		
Copper					
Site (BB1 vs. BB2 old)	1	0.18	0.18	0.57	0.45
Year	7	13.22	1.89	6.18	<0.001
Site*Year	7	19.65	2.81	9.18	<0.001
Residuals	136	41.58	0.31		
Zinc					
Site (BB1 vs. BB2 old)	1	102.00	101.90	1.97	0.16
Year	7	3375.00	482.10	9.34	<0.001
Site*Year	7	6168.00	881.20	17.08	<0.001
Residuals	136	7018.00	51.60		

Appendix 5 Table 5. ANOVA table comparing metal concentrations in rainbow trout fish tissue at the exposure site Foxy Creek to the reference site Crow Creek comparing nine time periods from 2002 to 2017.

Effect	DF	SS	MS	F value	P-value
Cadmium					
Site (Foxy vs. Crow)	1	0.0200	0.0105	22.82	<0.001
Year	8	0.0058	0.0007	1.01	0.43
Site*Year	8	0.0134	0.0017	2.33	0.02
Residuals	162	0.1160	0.0007		
Copper					
Site (Foxy vs. Crow)	1	0.72	0.721	2.29	0.13
Year	8	46.95	5.868	18.66	<0.001
Site*Year	8	5.28	0.66	2.10	0.04
Residuals	162	50.96	0.315		
Zinc					
Site (Foxy vs. Crow)	1	25	25.3	0.21	0.65
Year	8	7762	970.2	8.18	<0.001
Site*Year	8	784	98.0	0.83	0.58
Residuals	162	19206	118.6		

Appendix 6 Table 1. External fish health assessment for Goosly Lake, 2017.

Date: July 27

2017

Fish #	Metal #	Age	Sex	Length (mm)	Weight (g)	K	Fins	Pseudo-branches	Skin	Thymus	Eye	Gills	Opercles	Spinal Anomal	Parasites External	Total # Anomalies	
1	1	4	M	184	69.10	1.1092	N	N	N	N	N	N	N	N	N	0	
2	2	4	Imm	195	76.97	1.0380	N	N	N	N	N	N	N	N	N	0	
3	3	3	F	178	51.77	0.9179	N	N	N	N	N	N	N	N	N	0	
4	4	4	F	170	51.97	1.0578	N	N	N	N	N	N	N	N	black spot	0	
5	5	4	F	164	47.01	1.0658	N	N	N	N	N	N	N	N	black spot	0	
6	6	3	F	167	42.52	0.9129	N	N	N	N	N	N	N	N	black spot	0	
7	7	4	Imm	180	58.40	1.0014	N	N	N	N	N	N	N	N	internal	0	
8	8	6	M	282	188.30	0.8397	N	N	N	N	N	N	N	N	gills	1	
9	9	3	F	170	42.80	0.8712	N	N	N	N	N	N	N	N	gills	1	
10	10	3	F	150	35.47	1.0510	N	N	N	N	N	N	N	N	black spot	0	
11	11	3	Imm	125	22.54	1.1540	N	N	N	N	N	N	N	N	N	0	
12	12	3	Imm	133	25.48	1.0830	N	N	N	N	N	N	N	N	N	0	
13	13	4	F	170	47.57	0.9682	N	N	N	N	N	N	N	N	black spot	0	
14	14	4	M	170	55.60	1.1317	N	N	N	N	N	N	N	N	N	0	
15	15	3	M	165	44.87	0.9989	N	N	N	N	N	N	N	N	N	0	
16	16	2	Imm	130	24.16	1.0997	N	N	N	N	N	N	N	N	N	0	
17	17	3	F	135	29.92	1.2161	N	N	N	N	N	N	N	N	N	0	
18	18	4	F	168	45.09	0.9509	N	N	N	N	N	N	N	N	internal	0	
19	19	3	F	147	32.03	1.0083	N	N	N	N	N	N	N	N	N	0	
20	20	3	Imm	120	20.53	1.1881	N	N	N	N	N	N	N	N	N	0	
Mean		3.50		176.9	56.8	1.0147				Mean length, weight, condition, and age for Fish 1 to 7 - standard mesh size							
Std		0.83		10.81	12.31	0.075											
TOTALS						0	0	0	0	0	0	0	0	0	2	2	

NOTES:

K=condition factor
 N = normal
 P = parasites.

Thymus - Mild hemorrhage = 3 or less red spots
 Moderate = more than 3 spots - both sides
 P- Does not include black spot cysts or internal parasites on stomach.

Variable mesh
 Note mean length of 1.5" mesh fish = 176.9
 Mean length of variable mesh fish = 145.5 mm

Appendix 6 Table 2. External fish health assessment for Buck Creek Site BB2 old, 2017.

Date: Aug 29 2017

Fish #	Metal #	Scale	Age	Length (mm)	Weight (g)	K	Fins	Pseudo-branches	Skin	Thymus	Eye	Gills	Opercles	Spinal Anomal	Total # Anomalies
1	1	1.1		83	7.43	1.2994	N	N	N	N	N	N	N	N	0
2	2	1.2	1	95	8.96	1.0451	N	N	N	N	N	N	N	N	0
3	3	1.3	1	90		0.0000	N	N	N	N	N	N	N	N	0
4	4	2.1	2	115	17.38	1.1428	N	N	N	N	N	N	N	N	0
5	5	2.2	1	83	6.13	1.0721	N	N	N	N	N	N	short	N	1
6	6	2.3	1	82	6.69	1.2133	N	N	N	N	N	N	N	N	0
7	7		1	85	6.05	0.9851	N	N	N	N	N	N	N	N	0
8	8		1	79	5.47	1.1094	N	N	N	N	N	N	N	N	0
9	9		1	76	5.33	1.2142	N	N	N	N	N	N	N	N	0
10	10		1	70	3.83	1.1166	N	N	N	N	N	N	N	N	0
11			1	80	5.13	1.0020	N	N	N	N	N	N	N	N	0
12			1	73	4.89	1.2570	N	N	N	N	N	N	N	N	0
13	7	3.1	1	92	8.43	1.0826	N	N	N	N	N	N	N	N	0
14	8	3.2	1	94	9.54	1.1486	N	N	N	N	N	N	N	N	0
15	9	3.3	1	86	6.69	1.0518	N	N	N	N	N	N	N	N	0
16	10	4.1	2	128	24.26	1.1568	N	N	N	N	N	N	N	N	0
17		4.2	1	77	6.01	1.3164	N	N	N	N	N	N	N	N	0
18			1	81	5.85	1.1008	N	N	N	N	N	N	N	N	0
19			1	73	4.88	1.2544	N	N	N	N	N	N	N	N	0
20			1	84	5.99	1.0106	N	N	N	N	N	N	N	N	0
21			1	77	5.63	1.2332	N	N	N	N	N	N	N	N	0
22			1	80	6.45	1.2598	N	N	N	N	N	N	N	N	0
23			1	63	3.98	1.5917	N	N	N	N	N	N	N	N	0
24		4.3	3	179	64.44	1.1236	N	N	N	N	N	N	N	N	0
25		5.1	1	87	7.84	1.1906	N	N	N	N	N	N	N	N	0
26			1	77	5.69	1.2464	N	N	N	N	N	N	N	N	0
27			1	67	3.80	1.2635	N	N	N	N	N	N	N	N	0
28			1	81	6.19	1.1648	N	N	N	N	N	N	N	N	0
29		5.2	2	104	17.64	1.5682	N	N	N	N	N	N	N	thick	1
30			1	79	4.83	0.9796	N	N	N	N	N	N	N	N	0
31		5.3	2	101	10.01	0.971561	N	N	N	N	N	N	N	N	0
Mean				87.8	9.515	1.1400	N	N	N	N	N	N	N	N	0
Std				21.59	11.31	1.1291	N	N	N	N	N	N	N	N	0
TOTALS							0	0	0	0	0	0	1	1	2

NOTES:

K=condition factor
N = normal
P = parasites

Thymus - Mild hemorrhage = 3 or less red spots
 Moderate = more than 3 spots - both sides
 Parasites do not include black spot cysts or internal parasites on stomach.

Age based on break-out from scale results
 and length-frequency for site
 >95 mm= 2+

Appendix 6 Table 3. External fish health assessment for Buck Creek Site BB1, 2017.

Date: August 30

2017

Fish #	Metal #	Scale	Age	Length (mm)	Weight (g)	K	Fins	Pseudo-branches	Skin	Thymus	Eye	Gills	Opercles	Spinal Anomal	Total # Anomalies
1	1	1.1	1	82	5.14	0.9322	N	N	N	N	N	N	N	N	0
2	2	1.2	1	99	10.39	1.0708	N	N	N	N	N	N	N	N	0
3	3	1.3	1	92	7.33	0.9413	N	N	N	N	N	N	N	N	0
4	4	2.1	1	97	10.22	1.1198	N	N	N	N	N	N	N	N	0
5	5	2.2	1	93	8.90	1.1065	N	N	N	N	N	N	N	N	0
6	6	2.3	1	85	6.51	1.0600	N	N	N	N	N	N	N	N	0
7	7	3.1	2	110	13.39	1.0060	N	N	N	N	N	N	N	N	0
8	8	3.2	2	130	20.17	0.9181	N	N	N	N	N	N	N	N	0
9	9	3.3	1	88	7.68	1.1270	N	N	N	N	N	N	N	N	0
10	10	4.1	1	86	6.37	1.0015	N	N	N	N	N	N	N	N	0
11		4.2	1	88	6.67	0.9788	N	N	N	N	N	N	N	N	0
12		4.3	2	132	26.75	1.1631	short caud	N	N	N	N	N	N	N	1
13		5.1	1	85	7.14	1.1626	N	N	N	N	N	N	N	N	0
14		5.2	1	84	5.73	0.9668	N	N	N	N	N	N	N	N	0
15			1	82	6.67	1.2097	N	N	N	N	N	N	N	N	0
16			1	76	4.89	1.1140	N	N	N	N	N	N	N	N	0
17			1	77	4.97	1.0886	N	N	N	N	N	N	N	N	0
18			1	73	3.49	0.8971	N	N	N	N	N	N	N	N	0
19			1	93	8.05	1.0008	N	N	N	N	N	N	N	N	0
20			1	77	4.40	0.9638	N	N	N	N	N	N	N	N	0
21			1	83	5.64	0.9864	N	N	N	N	N	N	N	N	0
22			1	72	4.15	1.1119	N	N	N	N	N	N	N	N	0
23			1	73	3.98	1.0231	N	N	N	N	N	N	N	N	0
24			1	81	4.70	0.8844	N	N	N	N	N	N	N	N	0
25			1	92	7.55	0.9696	N	N	N	N	N	N	N	N	0
26			1	93	8.19	1.0182	N	N	N	N	N	N	N	N	0
27			1	79	5.18	1.0506	N	N	N	N	N	N	N	N	0
28			1	81	5.33	1.0029	N	N	N	N	N	N	N	N	0
29			1	73	4.49	1.1542	N	N	N	N	N	N	N	N	0
30			1	77	4.53	0.9923	N	N	N	N	N	N	N	N	0
							N	N	N	N	N	N	N	N	0
Mean			1.10	87.8	7.62	1.0341	N	N	N	N	N	N	N	N	0
Std			0.31	14.67	4.91	0.0863									
TOTALS							1	0	0	0	0	0	0	0	1

NOTES:

K=condition factor

N = normal

P = parasites

Thymus - Mild hemorrhage = 3 or less red spots

Moderate = more than 3 spots - both sides

Parasites do not include black spot cysts or internal parasites on stomach.

Age based on break-out from scale results

and length-frequency for site

>97 mm = 2+

99 mm to 132 mm

Appendix 6 Table 4. External fish health assessment for Buck Creek Site BB2 new, 2017.

Date: August 31

2017

Fish #	Metal #	Scale	Age	Length (mm)	Weight (g)	K	Fins	Pseudo-branches	Skin	Thymus	Eye	Gills	Opercles	Spinal Anomal	Total # Anomalies
1	1	1.1	1	94	8.64	1.0402	N	N	N	N	N	N	N	N	0
2	2	1.2	2	110	14.65		N	N	N	N	N	N	N	N	0
3	3		1	72	3.96	1.0610	N	N	blacl sp	N	N	N	N	N	1
4	4		1	78	3.96	0.8345	N	N	N	N	N	N	N	N	0
5	5		1	72	4.44	1.1896	N	N	N	N	N	N	N	N	0
6	6		1	78	5.79	1.2201	N	N	N	N	N	N	N	N	0
7	7	1.3	1	90	6.75	0.9259	N	N	N	N	N	N	N	N	0
8	8	2.1	1	88	6.3	0.9245	N	N	N	N	N	N	N	N	0
9	9	2.2	1	87	6.03	0.9157	N	N	N	N	N	N	N	N	0
10	10		1	74	4.52	1.1154	N	N	N	N	N	N	N	N	0
11			1	92	8.44	1.0839	N	N	N	N	N	N	N	N	0
12			1	78	6.09	1.2833	N	N	N	N	N	N	N	N	0
13			1	77	4.48	0.9813	N	N	N	N	N	N	N	N	0
14		3.1	1	82	6.38	1.1571	N	N	N	N	N	N	N	N	0
15		3.2	1	82	6.07	1.1009	N	N	N	N	N	N	N	N	0
16		3.3	1	91	7.62	1.0112	N	N	N	N	N	N	N	N	0
17			1	91	7.08	0.9395	N	N	N	N	N	N	N	N	0
18			1	79	4.74	0.9614	N	N	N	N	N	N	N	N	0
19			1	83	5.27	0.9217	N	N	N	N	N	N	N	N	0
20			1	81	5.18	0.9747	N	N	N	N	N	N	N	N	0
21			1	66	3.27	1.1374	N	N	N	N	N	N	N	N	0
22			1	76	4.56	1.0388	N	N	N	N	N	N	N	N	0
23			1	74	4.29	1.0587	N	N	N	N	N	N	N	N	0
24			1	77	4.85	1.0624	N	N	N	N	N	N	N	N	0
25			2	112	14.67	1.0442	N	N	N	N	N	N	N	N	0
26		4.1	2	125	21.30	1.0906	N	N	N	N	N	N	N	N	0
27		4.2	2	103	11.03	1.0094	N	N	N	N	N	N	N	N	0
28			1	88	7.58	1.1123	N	N	N	N	N	N	N	N	0
29			1	71	3.66	1.0226	N	N	N	N	N	N	N	N	0
30			1	91		0.0000	N	N	N	N	N	N	N	N	0
Mean			1.13	85.4	6.95	1.0075									
Std			0.35	13.29	3.97	0.2182									
TOTALS							0	0	0	0	0	0	0	0	0

NOTES:

K=condition factor
N = normal
P = parasites

Thymus - Mild hemorrhage = 3 or less red spots
 Moderate = more than 3 spots - both sides
 Parasites do not include black spot cysts or internal parasites on stomach.

Age based on break-out from scale results
 and length-frequency for site
 >99= 2+

Appendix 6 Table 5. External fish health assessment for Foxy Creek Site FF2, 2017.

Date: August 28

2017

Fish #	Metal #	Scale	Age	Length (mm)	Weight (g)	K	Fins	Pseudo-branches	Skin	Thymus	Eye	Gills	Opercles	Spinal Anomal	Total # Anomalies
1	1	1.1	2	108	19.03	1.5107	N	N	N	N	N	N	N	N	0
2	2	1.2	2	125	23.52	1.2042	N	N	N	N	N	N	N	N	0
3	3	1.3	2	126	30.71	1.5352	N	N	lesion	N	N	N	N	N	1
4	4	2.1	2	127	31.70	1.5476	N	N	N	N	N	N	N	N	0
5	5	2.2	3	148	45.70	1.4097	N	N	N	N	N	N	N	N	0
6	6	2.3	2	130	26.93	1.2258	N	N	N	N	N	N	N	N	0
7	7	3.1	1	103	12.14	1.1110	N	N	black sp	N	N	N	N	N	0
8	8	3.2	2	114	18.49	1.2480	N	N	N	N	N	N	N	N	0
9	9	3.3	2	118	21.04	1.2806	N	N	N	N	N	N	N	N	0
10	10	4.1	1	100	11.14	1.1140	N	N	black sp	N	N	N	N	N	0
11		4.2	1	108	16.08	1.2765	N	N	N	N	N	N	N	N	0
12		4.3	2	118	21.20	1.2903	N	N	N	N	N	N	N	N	0
13		5.1	1	101	10.34	1.0036	N	N	bump	N	N	N	N	N	1
14		5.2	1	98	10.80	1.1475	N	N	N	N	N	N	N	N	0
15		5.3	1	82	7.53	1.3657	N	N	N	N	N	N	N	N	0
16		6.1	1	86	7.69	1.2090	N	N	N	N	N	N	N	N	0
17		6.2	1	105	12.51	1.0807	N	N	N	N	N	N	N	N	0
18		6.3	1	106	14.15	1.1881	N	N	N	N	N	N	N	N	0
19			1	103	11.68	1.0689	N	N	N	N	N	N	N	N	0
20		7.1	1	113	16.55	1.1470	N	N	N	N	N	N	N	N	0
21		7.2	1	93	8.67	1.0779	N	N	N	N	N	N	N	N	0
22			1	88	8.84	1.2972	N	N	N	N	N	N	N	N	0
23			1	86	7.11	1.1178	N	N	N	N	N	N	N	N	0
24		7.3	1	93	9.88	1.2283	N	N	N	N	N	N	N	N	0
25			1	86	6.75	1.0612	N	N	N	N	N	N	N	N	0
26			1	75	4.86	1.1520	N	N	N	N	N	N	N	N	0
27			1	89	8.62	1.2227	N	N	N	N	N	N	N	N	0
28			1	84	7.52	1.2688	N	N	N	N	N	N	N	N	0
29			1	107	15.47	1.2628	N	N	N	N	N	N	N	N	0
30			1	84	7.80	1.3160	N	N	N	N	N	N	N	N	0
Mean			1.3	103.5	15.15	1.2323									
Std			0.55	17.18	9.22	0.1390									
TOTALS							0	0	2	0	0	0	0	0	2

NOTES:

K=condition factor

N = normal

P = parasites

Thymus - Mild hemorrhage = 3 or less red spots

Moderate = more than 3 spots - both sides

Parasites do not include black spot cysts or internal parasites on stomach.

Age based on break-out from scales.

Break-off from age 1 and 2 at fl <114 mm

Heads under bridge from two small chinook spawners?

Note- lots of rbt fry observed during collections with all collected in rip-rap under bridge. Electrofishing time = 388 seconds; 2 chinook fry sampled.

Appendix 6 Table 6. External fish health assessment for Crow Creek Site CRW1, 2017.

Date: August 28

2017

Fish #	Metal #	Scale	Age	Length (mm)	Weight (g)	K	Fins	Pseudo-branches	Skin	Thymus	Eye	Gills	Opercles	Spinal Anomal	Total # Anomalies
1	1	1.1	1	83	5.79	1.0126	N	N	N	N	N	N	N	N	0
2	2	1.2	1	83	6.52	1.1403	N	N	N	N	N	N	N	N	0
3	3	1.3	1	82	5.66	1.0265	N	N	N	N	N	N	N	N	0
4	4	2.1	2	105	13.16	1.1368	N	N	N	N	N	N	N	N	0
5	5	2.2	2	103	12.07	1.1046	N	N	N	N	N	N	N	N	0
6	6	2.3	1	87	8.84	1.3424	N	N	N	N	N	N	N	N	0
7	7	3.1	1	95	9.46	1.1034	N	N	N	N	N	N	N	N	0
8	8	3.2	2	126	22.60	1.1298	N	N	N	N	N	N	N	N	0
9	9	3.3	1	88	7.20	1.0565	N	N	N	N	N	N	N	N	0
10	10	4.1	1	85	7.03	1.1447	N	N	N	N	N	N	N	N	0
11		4.2	1	93	8.48	1.0543	N	N	N	N	N	N	N	N	0
12			1	79	5.53	1.1216	N	N	N	N	N	N	N	N	0
13			1	83	5.68	0.9934	N	N	N	N	N	N	N	N	0
14			2	120	17.67	1.0226	N	N	N	N	N	N	N	N	0
15		5.1	2	109	14.77	1.1405	N	N	N	N	N	N	N	N	0
16			2	109	16.73	1.2919	N	N	N	N	N	N	N	N	0
17		5.2	2	91	7.64	1.0138	N	N	N	N	N	N	N	N	0
18			1	93	8.30	1.0319	N	N	N	N	N	N	N	N	0
19			1	87	6.77	1.0281	N	N	N	N	N	N	N	N	0
20			1	75	4.48	1.0619	N	N	N	N	N	N	N	N	0
21		5.3	1	73	5.18	1.3316	N	N	N	N	N	N	N	N	0
22		6.1	1	73	4.23	1.0874	N	N	N	N	N	N	N	N	0
23		6.2	1	98	9.27	0.9849	N	N	N	N	N	N	N	N	0
24		6.3	1	89	7.42	1.0525	N	N	N	N	N	N	N	N	0
25		7.1	1	88	7.32	1.0741	N	N	N	N	N	N	N	N	0
26		7.2	1	79	5.07	1.0283	N	N	N	N	N	N	N	N	0
27		7.3	1	76	4.47	1.0183	N	N	N	N	N	N	N	N	0
28			1	82	5.86	1.0628	N	N	N	N	N	N	N	N	0
29			1	73	5.11	1.3136	N	N	N	N	N	N	N	N	0
30			1	79	5.30	1.0750	N	N	N	N	N	N	N	N	0
Mean			1.23	89.5	8.45	1.0995									
Std			0.43	13.63	4.45	0.10									
TOTALS							0	0	0	0	0	0	0	0	0

NOTES:

K=condition factor

N = normal

P = parasites

Thymus - Mild hemorrhage = 3 or less red spots

Moderate = more than 3 spots - both sides

Parasites do not include black spot cysts or internal parasites on stomach.

Note: Fry observed during sampling that was conducted in rip-rap under bridge and downstream. 367 electrofishing seconds.

Age based on break-out from scale results

Scales difficult to read first annulus.

Break-off from age 1 and 2 at fl <94 mm

Appendix 6 Table 7. Goosly Lake external fish health summaries from 2002 to 2017.

Feature	Abnormality	Survey year															
		2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002
Eyes	Opaque	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gills	Frayed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1
	Marginate	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	8
Skin	Aberration	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Fins	Erosion	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	2
Opercula	Shortening	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Thymus	Hemorrhage	0	1	0	0	1	0	0	2	1	1	1	1	4	9	0	0
Pseudobranchs	Swollen	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	nr
	Lithic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	nr
Spinal/cranial		0	0	0	0	0	0	0	0	nr	nr	nr	nr	nr	nr	nr	nr
Parasites	Presence	9	4	0	4	0	3	1	0	1	1	2	3	1	2	4	12
Total External		2	6	1	4	3	4	1	3	3	1	3	6	5	13	12	23
Number of Fish Evaluated		20	20	20	20	20	20	20	20	20	20	20	30	20	20	20	55
% Affected		10	30	5	20	15	20	5	15	15	5	15	20	25	65	60	42

nr=not recorded

External parasites are "black spot" cysts not included in total.

Appendix 6 Table 8. Stream fish health summaries Buck Creek, 2002 to 2017.

Feature	Abnormality	BB1 - Below Bessemer															
		2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002
Eyes	Opaque	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gills	Frayed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Marginate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skin	Aberration	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Fins	Erosion	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Opercula	Shortening	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	1
Thymus	Hemorrhage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	nr
Pseudobranchs	Swollen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	nr
	Lithic	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	nr
Spinal/cranial		0	0	0	1	2	0	0	1	nr	nr	nr	nr	nr	nr	nr	nr
Parasites	Presence	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Total		1	0	0	1	2	0	0	1	0	1	0	2	0	4	4	3
Number of Fish		30	30	30	30	30	30	30	30	15	30	30	30	30	28	30	7
% Affected		3.3	0	0	3.3	6.7	0	0	3.3	0	6.7	0.0	6.7	0.0	14.3	13.3	42.9

Feature	Abnormality	BB2 (old) - Reference															
		2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002
Eyes	Opaque	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gills	Frayed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Marginate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skin	Aberration	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Fins	Erosion	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
Opercula	Shortening	1	0	0	0	0	0	0	0	1	0	0	0	0	2	3	
Thymus	Hemorrhage	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudobranchs	Swollen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lithic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spinal/cranial		1	0	0	0	0	1	0	0	nr	nr	nr	nr	nr	nr	nr	nr
Parasites	Presence	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Total		2	0	1	0	0	1	0	2	0	2	0	0	1	0	2	3
Number of Fish		30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
% Affected		6.7	0	3.3	0	0	3.3	0	6.7	0.0	6.7	0.0	0.0	3.3	0.0	6.7	10.0

Appendix 6 Table 9. Stream fish health summaries in Foxy and Crow creeks, 2002 to 2017.

Feature	Abnormality	Foxy															
		2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002
Eyes	Opaque	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gills	Frayed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Marginate	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Skin	Abberation	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Fins	Erosion	0	0	1	0	0	1	0	1	0	0	1	1	1	0	3	2
Opercula	Shortening	0	0	0	0	0	0	0	0	2	0	0	0	3	3	0	0
Thymus	Hemorrhage	0	0	0	0	1	0	0	0	3	10	3	5	4	0	nr	nr
Pseudobranchs	Swollen	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	nr
	Lithic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	nr
Spinal/cranial		0	0	0	0	0	0	0	nr	nr	nr	nr	nr	nr	nr	nr	nr
Parasites	Presence	2	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0
Total		2	0	1	0	1	3	0	3	1	5	12	5	6	8	7	2
Number of Fish		30	29	30	26	30	30	25	30	30	30	30	30	30	58	30	30
% Affected		6.7	0	0	0	3.3	10.0	0	10.0	3.3	16.7	40.0	16.7	20.0	13.8	23.3	6.7

Feature	Abnormality	Crow									
		2017	2016	2015	2014	2013	2012	2010	2006	2002	
Eyes	Opaque	0	0	0	0	0	0	0	0	0	
Gills	Frayed	0	0	0	0	0	0	0	0	0	
	Marginate	0	0	0	0	0	0	0	0	0	
Skin	Abberation	0	0	0	0	2	0	0	0	0	
Fins	Erosion	0	0	0	0	0	0	0	0	0	
Opercula	Shortening	0	0	0	0	0	0	0	0	0	
Thymus	Hemorrhage	0	0	0	0	0	0	0	1	nr	
Pseudobranchs	Swollen	0	0	0	0	0	0	0	0	nr	
	Lithic	0	0	0	0	0	0	0	0	nr	
Spinal/cranial		0	0	0	0	0	0	nr	nr	nr	
Parasites	Presence	0	1	0	1	0	0	0	0	0	
Total		0	1	0	1	2	0	0	1	0	
Number of Fish		30	30	30	30	30	30	30	30	30	
% Affected		0	3.3	0	3.3	6.7	0	0.0	3.3	0	