FISH POPULATION MONITORING

IN FOXY AND BUCK CREEKS

SEPTEMBER 2002

Prepared by

DAVID BUSTARD AND ASSOCIATES LTD.

for

EQUITY DIVISION OF PLACER DOME NORTH AMERICA

Houston, B.C.

December 2002

TABLE OF CONTENTS

Page

1.0 INTRODUCTION……. 1
1.1 BACKGROUND..... 1
1.2 STUDY AREA..... 1
1.2.1 Foxy and Crow Creeks..... 1
1.2.2 Buck Creek..... 2
1.2.3 Goosly and Maxan Lakes..... 5

2.0 METHODS…….. 6
2.1 LAKE SAMPLING..... 6
2.2 STREAM SAMPLING 6

3.0 RESULTS .....…….. 8
3.1 FOXY CREEK……. 8
3.2 BUCK CREEK……. 15
3.2.1 Sites BB1 and BB2.....……..... 15
3.2.2 Bessemer Creek.....……..... 22
3.2.3 Site BB3 - Lower Buck Creek……..... 22

4.0 CONCLUSIONS..... 26
4.1 FOXY CREEK..... 26
4.2 BUCK CREEK..... 26

5.0 LITERATURE CITED..... 28

APPENDICES 1-4

LIST OF TABLES

		Page
Table 1.	**Summary of some physical characteristics of Goosly and Maxan Lakes…….....**	**5**
Table 2.	**Catch composition of Foxy Creek fish index sites combined from 1984 to 2002.....**	**10**
Table 3.	**Summary of rainbow trout density estimates by site in Foxy Creek from 1984 to 2002.....**	**12**
Table 4.	**Rainbow trout biomass estimates in Foxy and Crow creeks for all years combined.....**	**13**
Table 5.	**Summary of rainbow trout Age 0+ and Age 1+ fork lengths combined for two Foxy Creek sites for all years and Crow Creek for 2002.....**	**14**
Table 6.	**Catch composition of upper Buck Creek fish index sites combined from 1984 to 2002.....**	**17**
Table 7.	**Summary of rainbow trout density estimates in Buck Creek from 1987 to 2002.....**	**19**
Table 8.	**Rainbow trout biomass estimates for the Buck Creek sample sites from 1987 to 2002.....**	**20**
Table 9.	**Summary of upper Buck Creek rainbow trout Age 0+ (BB2 only) and Age 1+ fork lengths for 1987 to 2002...**	**21**
Table 10.	**Catch composition of the lower Buck Creek (BB3) fish index site combined for period 1987 to 2002.....**	**23**
Table 11.	**Summary of steelhead trout Age 0+ and Age 1+ fork lengths for lower Buck Creek from 1984 to 2002.....**	**25**
Table 12.	**Rainbow trout density and biomass estimates in Foxy, Crow, and Buck creeks compared to some of the best regional rainbow trout rearing streams.....**	**27**

LIST OF FIGURES

		Page
Figure 1.	**Location of fish sample sites 2002……..**	**3**
Figure 2.	**Rainbow trout fry and parr densities combined for the two sites in lower Foxy Creek from 1984 to 2002.....**	**11**
Figure 3.	**Comparison of rainbow trout densities in Foxy and Crow creeks in 2002.....**	**11**
Figure 4.	**Mean fork lengths of Foxy Creek rainbow trout Age 0+ fry and Age 1+ parr from 1984 to 2002.....**	**14**
Figure 5.	**Summary of total number of longnose dace captured at two Foxy Creek sample sites (combined) and in lower Buck Creek (BB3) for all sample periods.....**	**15**
Figure 6.	**Buck Creek rainbow trout fry densities above and below Bessemer Creek from 1987 to 2002.....**	**16**
Figure 7.	**Buck Creek rainbow trout parr densities above and below Bessemer Creek from 1987 to 2002.....**	**18**
Figure 8.	**Mean fork lengths of upper Buck Creek rainbow trout Age 0+ (BB2 only) and Age 1+ parr from 1987 to 2002..**	**21**
Figure 9.	**Steelhead fry and parr densities in lower Buck Creek (BB3) for period 1987 to 2002.....**	**24**
Figure 10.	**Mean fork lengths of lower Buck (BB3) steelhead Age 0+ and Age 1+ parr from 1987 to 2002.....**	**25**

1.0 INTRODUCTION

1.1 BACKGROUND

Fisheries studies were conducted in the vicinity of the Equity Mine site during August and September 2002. These studies were part of an overall program requirement to undertake Environmental Effects Monitoring (EEM) as outlined in a directive from the Ministry of Water Land and Air Protection to Placer Dome Canada[1]. The EEM program was advanced one year in response to flood discharges of untreated water from the mine, particularly during May and June 2002. The results of these fisheries studies will be used in combination with benthic, periphyton, and water quality and sediment studies to contribute to a "weight of evidence approach" to assessing the magnitude and geographic extent of the effect of the mine-related discharges to aquatic resources.

The fisheries component of the EEM is comprised of a fish population assessment in conjunction with a fish health assessment. Fish population studies have been conducted in Foxy and Buck creeks (Figure 1) since the mid-1980's and the work in 2002 builds upon these earlier studies. The fish health assessments are relatively new to the metal mining industry and build upon protocols described in recent guidelines established by Environment Canada[2]. Fish histology studies were added as an additional assessment tool based on discussions with local representatives of WLAP in Smithers.

The fisheries component of the EEM studies comprise a collaborative effort amongst David Bustard and Associates Ltd. (fish population studies and field collections for other components), Hatfield Consultants Ltd. (lake and stream fish health indices) and Dawna Brand from the University of Victoria (histology studies). This report presents the results of the fish population studies and summarizes the sample locations and methods for sample collection for the other study components.

1.2 STUDY AREA

1.2.1 Foxy and Crow Creeks

Foxy Creek originates from high elevation wetlands situated northwest of the Equity Mine at an elevation of approximately 1300 m. It receives drainage from the north slope of the mine property including slopes adjacent to the main pit and tailings pond. Foxy Creek enters an impressive canyon section below the mine and then onto a fan area approximately 3 km upstream from its confluence with Maxan Creek.

The main fisheries values in Foxy Creek are associated with rainbow trout (thought to be mainly of Maxan Lake orgin) spawning on this fan. Juvenile rainbow trout up to three years old rear in Foxy Creek prior to moving into Maxan Lake (Bustard 1993). Longnose

[1] Memo dated July 2, 2002 from Terry Roberts, Regional Waste Manager to Mike Aziz, Placer Dome Canada.
[2] http://www.ec.gc.ca/eem/English/MetalMining/default.cfm

dace and small numbers of chinook juveniles, mountain whitefish, prickly sculpins, longnose suckers and Dolly Varden are present in Foxy Creek during some years.

Rainbow trout were found up to 11 km upstream in Foxy Creek during 1984 surveys. Since that time rainbow and brook trout were stocked in Lu Lake near the mine and progeny of these fish (rainbow) have established in upper Foxy Creek.

The two fish index sites located on the fan section of Foxy Creek (Photos 1 and 2) have a riffle-pool morphology (partially aggrading) and are characterized by a 1-2% slope, bed material comprised of a mix of cobbles and gravels, and a wetted width of 4-5 m typical of late summer streamflows. The stream section is strongly influenced by large debris and channel shifting between sample years is not uncommon.

A new index site was established on Crow Creek in 2002 to serve as a control for Foxy Creek fish health assessments (Photo 3). Similar to the Foxy Creek fish index sites, the Crow Creek site is located in a laterally unstable reach approximately 4 km upstream from its confluence with the upper Bulkley River. Crow Creek originates on the northeast facing slopes adjacent to Foxy Creek, but the overall watershed is smaller with fewer high elevation wetlands compared to Foxy Creek. The slope, bed material, and influence of large debris on channel stability are similar to Foxy Creek.

1.2.2 Buck Creek

Buck Creek upstream from Goosly Lake drains a series of wetlands and moderate slope areas to 1300 m elevation. Beaver dams have a strong influence on the low gradient 3 km reach upstream from Goosly Lake.

The upper index site (BB2) is located at the top of the low gradient reach (Figure 1), has a slope of 1%, a good mix of pool and riffles with excellent potential spawning gravels for rainbow trout in some sections (Photo 6). Despite extensive beaver activity downstream, rainbow trout from Goosly Lake are always able to access this stream section during the spring spawning period. In 2002, BB2 was moved approximately 300 m upstream from the location that was sampled from 1987 to 1998 due to beaver activity at the old site.

The lower index site (BB1) is located in the low gradient section between Bessemer Creek and Goosly Lake. Site BB1 (Buck below Bessemer) was moved upstream to a location within approximately 50 m of the confluence of Bessemer Creek (Photo 4), directly downstream from the periphyton and benthic sample locations. Earlier samples in this section of Buck Creek have been located closer to Goosly Lake than the 2002

Figure 1 – pdf separate file

site[3]. This section of stream is low gradient (<0.5%), predominantly pool habitat, with fine bed material not suitable for spawning. The new location close to Bessemer Creek has a higher component of free-flowing stream compared to the lower site that has been sampled up to 1998.

1.2.3 Goosly and Maxan Lakes

Goosly Lake has been exposed to mine related discharge via Buck Creek since 1980 and detailed background and historical information is available elsewhere (e.g., Godin 1992; Wilkes and Maclean 1987). The lake has populations of rainbow trout, mountain whitefish, kokanee, largescale and longnose suckers, redside shiners and peamouth chub.

The fish health surveys required a reference site to compare responses of fish populations collected at Goosly Lake. Maxan Lake was selected as a reference lake to compare fish health indices based on similarities of some basic physical characteristics (Table 1)[4]. Maxan Lake has similar fish species as outlined in Goosly Lake, but also has northern pike minnows present.

Table 1. Summary of some physical characteristics of Goosly and Maxan Lakes.

	Goosly Lake[5]	**Maxan Lake[6]**
Lake elevation (m)	~880	~780
Surface Area (ha)	241	638
Maximum depth (m)	20	25
Mean depth (m)	10.3	14.5

[3] When Site BB1 was initially established, the confluence of Bessemer and Buck Creek was not obvious. Bessemer entered a wetland complex and the direct point of entry into Buck was not obvious. The channel in lower Bessemer Creek is now very distinct and its confluence is clearly defined.
[4] Observations during the field collections suggested that Maxan Lake is a higher productivity lake (based on high plankton abundance) compared to Goosly Lake.
[5] Goosly Lake survey data from Whately (1968). Data on file WLAP, Smithers.
[6] Maxan Lake survey data from Burns and Klein (1973). Data on file WLAP, Smithers.

2.0 METHODS

2.1 LAKE SAMPLING

Fish Collections

Fish sampling was undertaken in Goosly Lake on August 6 and 7th, 2002, and targeted rainbow trout (20 males and 20 females of the sentinel species for fish health surveys). Floating small mesh (<2" mesh size) gillnets were used for the surveys. The rainbow trout netting was undertaken close to a "processing" site at the southwest end of Goosly Lake (Figure 1). The nets were monitored continuously since the histology sampling required that fish remain alive until the time of sampling. Fish were carefully removed from the gillnets and transferred to a net holding pen established at the processing site.

Ten rainbow trout and nine largescale suckers were collected in Goosly Lake for metal analyses. The rainbow trout were captured near the south end of the lake while the suckers were gillnetted at the shallow north end of Goosly Lake in the evening. Muscle tissue samples (20 grams) were placed on ice in the field, frozen within the day and shipped to ALS Labs for analysis. All fish were weighed, fork lengths measured and scales and otoliths removed for aging (only otoliths for sucker specimens).

Maxan Lake was sampled on August 8 and 9th, 2002. Sampling was based out of the campsite at the north end of the lake. Floating gillnets were used in Maxan targeting rainbow trout. All of the rainbow trout were sampled in the northwest end of Maxan Lake within one km of the campsite and holding and processing procedures were similar to those used at Goosly Lake.

The largescale sucker sample was difficult to obtain in Maxan Lake. Ten samples were obtained at night at the north end outlet area of the lake using a mix of floating and sinking gillnets.

2.2 STREAM SAMPLING

Stream fish sampling was undertaken during the period September 3 to 10, 2002. This time frame corresponds closely to the timing of past surveys undertaken in Foxy and Buck creeks since 1984. Only juvenile fish are present in the streams during this period. Fish from the population studies in lower Foxy and Crow creeks as well as in Buck Creek above and below Bessemer were used in the fish health indices and histology sampling.

Fish Population Sampling and Estimates

The juvenile sampling methods have remained similar for all years of sampling in Foxy and Buck creeks. The sites were blocked with stopnets at their upstream and downstream ends and sampled using a Smith-Roote backpack electrofisher. One thorough sweep up and back down through the sites including a net check constituted a single pass. At least

Photo 1. Lower Foxy Creek fish index site (FF1).

Photo 2. Lower Foxy Creek fish index (FF2).

Photo 3. Lower Crow Creek fish index site (CRW1).

Photo 4. Buck Creek index site downstream from Bessemer Creek (BB1)

Photo 5. Stream habitat between BB1 and Bessemer Creek confluence.

Photo 6. Fish index site in Buck Creek.

two passes were conducted at each site. Effort was recorded as number of seconds of electrofishing per pass.

Population estimates have been derived using the two-pass removal method outlined in Seber and LeCren (1967). A mark-recapture estimate was used in Foxy Creek in 1984 (Ricker 1975). Standard error estimates have been derived from methods outlined in Chapman (1951) and used to calculate confidence intervals for the population estimates. Rainbow parr and all other species captured at the sites were measured and weighed. A sample of 50 rainbow trout fry was measured to the nearest mm fork length and weighed, with all other rainbow fry simply counted. Scales were removed from a sample of up to 30 rainbow trout parr in each system for aging[7].

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 similar to past methods at these sites. Two photos (upstream and downstream) were taken at each site.

Several modifications were made to site locations in upper Buck Creek in 2002 and these are shown on Figure 1 and referred to as "new" locations (i.e., sampled in 2002) versus "old" (sampled prior to 2002). Sample sites in lower Buck and Foxy creeks remained at the same locations.

Two additional sites were established in 2002 (Figure 1) compared to the past program. A site in lower Bessemer Creek was sampled to update fish distribution in the lower reach that drains the waste rock and pit area. As well, a new fish sample site was established in Crow Creek to serve as a control stream for fish health and population studies in lower Foxy Creek.

3.0 RESULTS

3.1 FOXY CREEK

In 2002 just under 98% of all fish estimated in the two sites were rainbow trout comprising a mix of fry and predominantly yearling parr (Table 2). Longnose dace were the only other fish species captured in lower Foxy Creek in 2002, comprising the remaining 2% of the catch.

Rainbow trout have dominated the catches during all years of sampling since 1984 (Table 2). Longnose dace have been the only other species consistently present in the samples and have typically comprised less than 5% of the overall sample (6 of the 9 years of sampling).

[7] All aging of stream resident fish was undertaken by Dave Bustard.

Chinook fry have not been sampled in Foxy Creek since 1990, while coho were only sampled in the lower creek for two years following hatchery outplantings in 1990. Prickly sculpins and longnose suckers have also not been sampled in the Foxy Creek sites since 1991. Similarly, only a single whitefish has been captured at these sites since that time.

Sample data indicated that fry densities (159 fry/100 m^2) were in the upper range of past estimates, exceeded only in 1990 and 1991. Streamflows were low during the 2002 program, and the total area sampled (443 m^2) was the lowest for all years of data collection (Table 2). The actual number of fry estimated in the study sites (705) is very close to the long-term mean (708) for these sites combined (Table 2). Detailed population estimates for each of the Foxy sites summarized in Appendix 1.

Rainbow fry densities continue to show high year-to-year variability at the Foxy Creek sites, presumably reflecting variability in spawner abundance, incubation conditions, and probably the beginning of density-dependent interactions following emergence in early August.

Rainbow parr densities (37 parr/100 m^2) continue to range in a tight band between approximately 30 and 50 parr/100 m^2 observed during most years (Figure 2). The total number of parr captured in 2002 was the second lowest for the nine years of sampling (Table 2), possibly reflecting the low water conditions leading to reduced overall rearing haibtat present at the lower Foxy sample sites in 2002 (Table 2). Rainbow parr are predominantly age 1+ fish (~85% of the combined estimates summarized in Table 3).

Estimates of rainbow fry and parr have consistently been higher at index site FF2 compared to FF1 in lower Foxy Creek (Table 3). We suspect this reflects the better habitat complexity (LOD and larger bed material) present at the upper site.

Crow Creek was sampled as a control site to compare to Foxy Creek rainbow trout populations for the first time in 2002. Rainbow trout were the only species present at the sample site (Appendix 1). Both rainbow trout fry and parr densities are significantly lower in Crow Creek compared to the Foxy Creek sites (Figure 3 and Table 3).

Table 2. Catch composition of Foxy Creek fish index sites combined from 1984 to 2002.

SPECIES	1984	1987	1988	1989	1990	1991	1993	1998	MEAN (84-98)	2002
Rainbow Fry	799	660	768	546	929	1194	305	461	708	705
(%)	*57.2*	*72.7*	*66.3*	*62.8*	*55.8*	*67.5*	*59.1*	*61.5*	*62.9*	*79.5*
Rainbow Parr	593	202	319	315	246	349	143	255	303	161
(%)	*42.4*	*22.2*	*27.5*	*36.2*	*14.8*	*19.7*	*27.7*	*34.0*	*28.1*	*18.2*
Chinook	4	0	0	2	29	0	0	0	4	0
(%)	*0.3*	*0*	*0*	*0.2*	*1.7*	*0*	*0*	*0*	*0.3*	*0.0*
Coho	0	0	0	0	249	4	0	0	32	0
(%)	*0*	*0*	*0*	*0*	*15.0*	*0.2*	*0*	*0*	*1.9*	*0.0*
Longnose Dace	2	36	49	6	205	198	68	32	75	21
(%)	*0.1*	*4.0*	*4.2*	*0.7*	*12.3*	*11.2*	*13.2*	*4.3*	*6.2*	*2.4*
Mountain Whitefish	0	6	16	1	2	22	0	1	6	0
(%)		*0.7*	*1.4*	*0.1*	*0.1*	*1.2*	*0*	*0.1*	*0.5*	*0.0*
Prickly Sculpins	0	4	3	0	2	0	0	0	1	0
(%)		*0.4*	*0.3*	*0*	*0.1*	*0*	*0*	*0*	*0.1*	*0.0*
Longnose Suckers	0	0	4	0	3	1	0	0	1	0
(%)			*0.3*		*0.2*	*0.1*	*0*	*0*	*0.1*	*0.0*
Total	**1398**	**908**	**1159**	**870**	**1665**	**1768**	**516**	**749**	**1129**	**887**
Area (m^2)	624	531	659	678	523	530	642	540	591	443
Length (m)	104	104	103	103	104	104	104	102	104	102

Figure 2. Rainbow trout fry and parr densities combined for the two sites in lower Foxy Creek from 1984 to 2002.

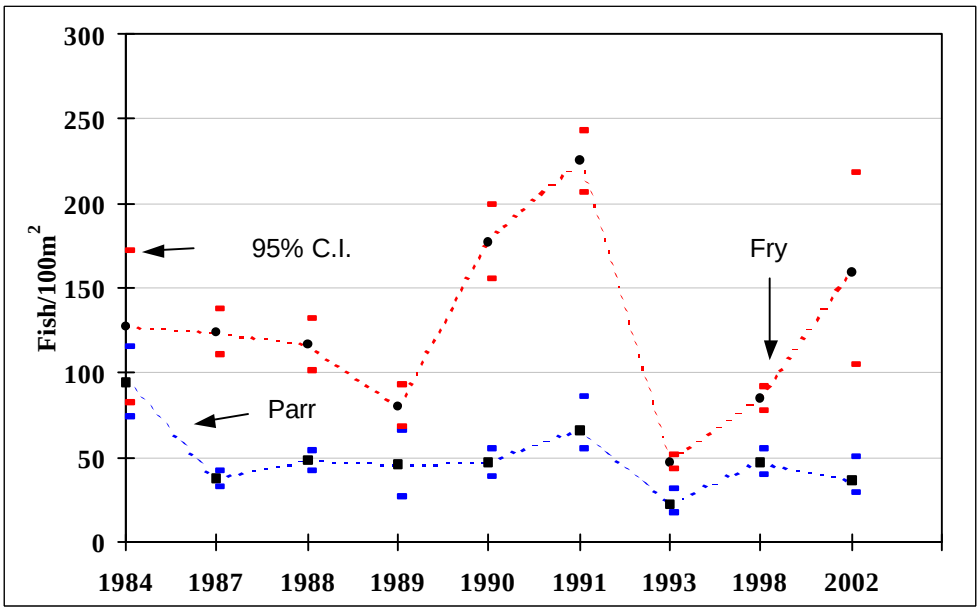
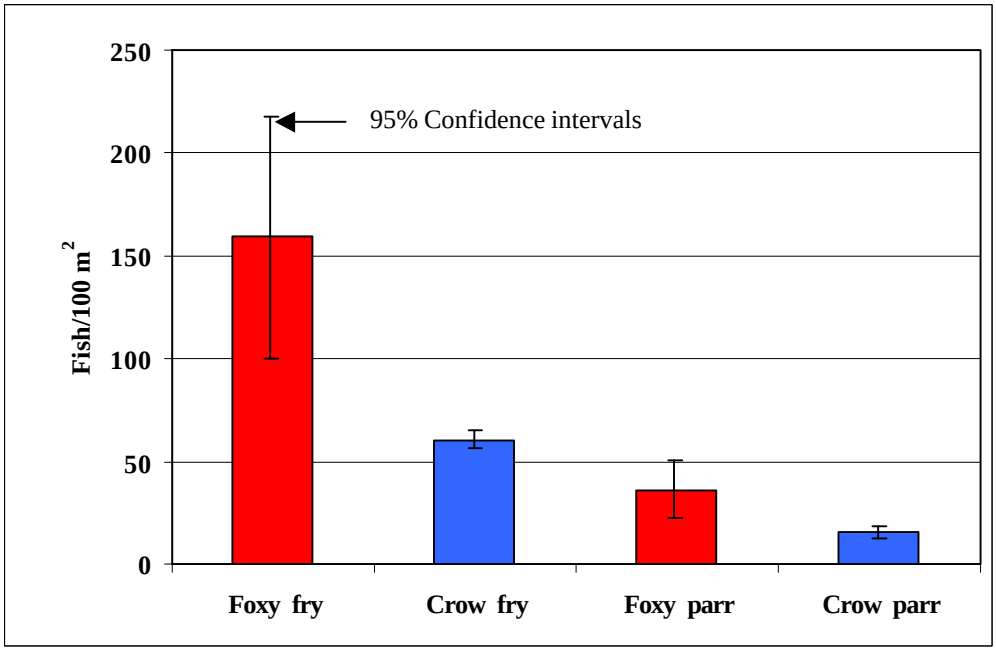


Figure 3. Comparison of rainbow trout densities in Foxy and Crow creeks in 2002.



.

Table 3. Summary of rainbow trout density estimates by site in Foxy Creek from 1984 to 2002.

SAMPLE SITE	YEAR	DENSITY (fish/100 m^2)		
		0+	1+	>=2+
FF1	1984	88	63	21
	1987	66	30	9
	1988	32	26	5
	1989	34	55	4
	1990	181	18	1
	1991	187	37	1
	1993	38	16	1
	1998	77	32	6
	Mean (84-98)	87.9	34.6	6.0
	2002	148	18	2
FF2	1984	166	86	20
	1987	203	30	6
	1988	182	55	7
	1989	110	34	4
	1990	175	63	3
	1991	251	62	22
	1993	61	25	3
	1998	98	55	7
	Mean (84-98)	155.7	51.3	8.9
	2002	172	45	10
COMBINED	1984	127	75	21
	1987	135	30	8
	1988	107	41	6
	1989	72	45	4
	1990	178	41	2
	1991	219	50	12
	1993	50	21	2
	1998	87	44	6
	Mean (84-98)	121.8	42.9	7.5
	2002	160	31	6
CROW1	2002	61	13	2

The rainbow trout biomass estimate for the two Foxy Creek sites combined was 3.4 grams/m^2 in 2002 (Table 4). This was lower than the nine-year average of 4.4 grams/m^2. Estimates have ranged from 1.6 to 9.6 grams/m^2 since 1984[8]. Crow Creek biomass estimates are less than one-half of those obtained in Foxy Creek.

Foxy Creek rainbow trout fry averaged 36.1 mm fork length in 2002, comparable to the long-term mean of 37.8 mm in Foxy Creek and similar to Crow Creek fry (Figure 4 and Table 5). Age 1+ rainbow parr averaged near 78 mm, very similar to the longterm mean at these sites (Table 5).

Table 4. Rainbow trout biomass estimates in Foxy and Crow creeks for all years combined.

YEAR	BIOMASS (g/m^2)
	FOXY CREEK COMBINED
1984	9.6
1987	3.3
1988	3.3
1989	2.5
1990	4.4
1991	5.5
1993	1.6
1998	5.3
Mean (84-98)	**4.4**
2002	3.4
Std. Mean	*2.5*
	CROW CREEK
2002	1.3

[8] It should be noted that population and biomass estimates obtained in 1984 were derived from mark-recapture estimates, and that since that date estimates are based on the removal method. Studies elsewhere have shown that although removal methods such as those used in this study (with at least one hour between passes) provide reasonable population estimates, they tend to underestimate the total population and are less reliable than mark-recapture estimates, especially in sites with complex debris cover and deeper pools (Peterson and Cederholm 1984).

Figure 4. Mean fork lengths of Foxy Creek rainbow trout Age 0+ fry and Age 1+ parr from 1984 to 2002.

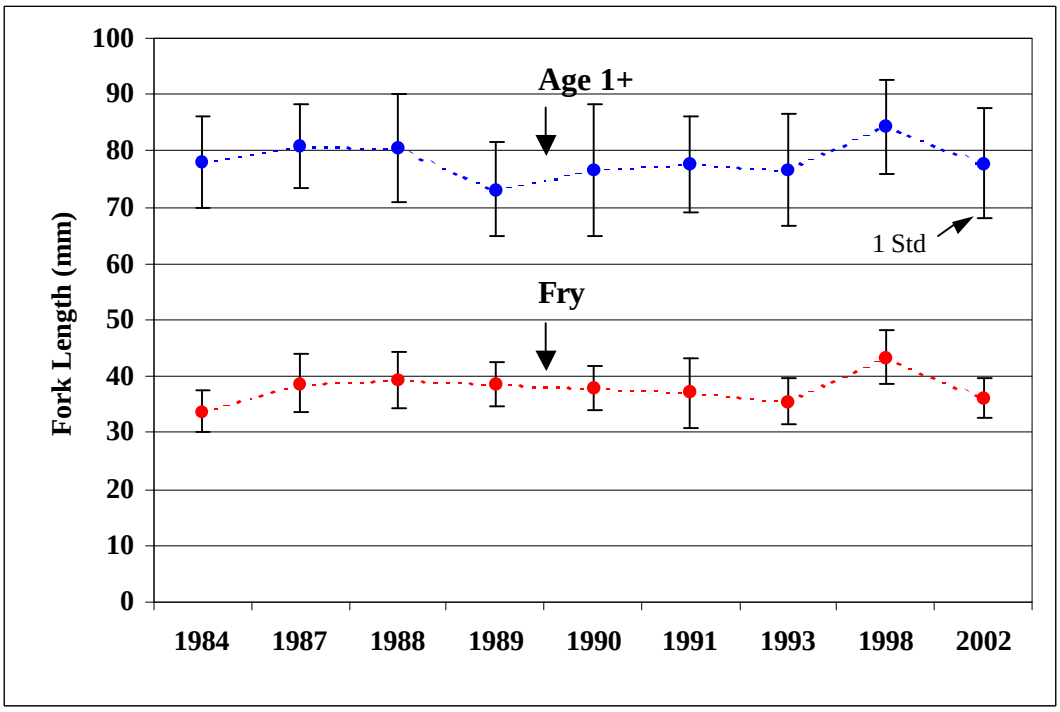
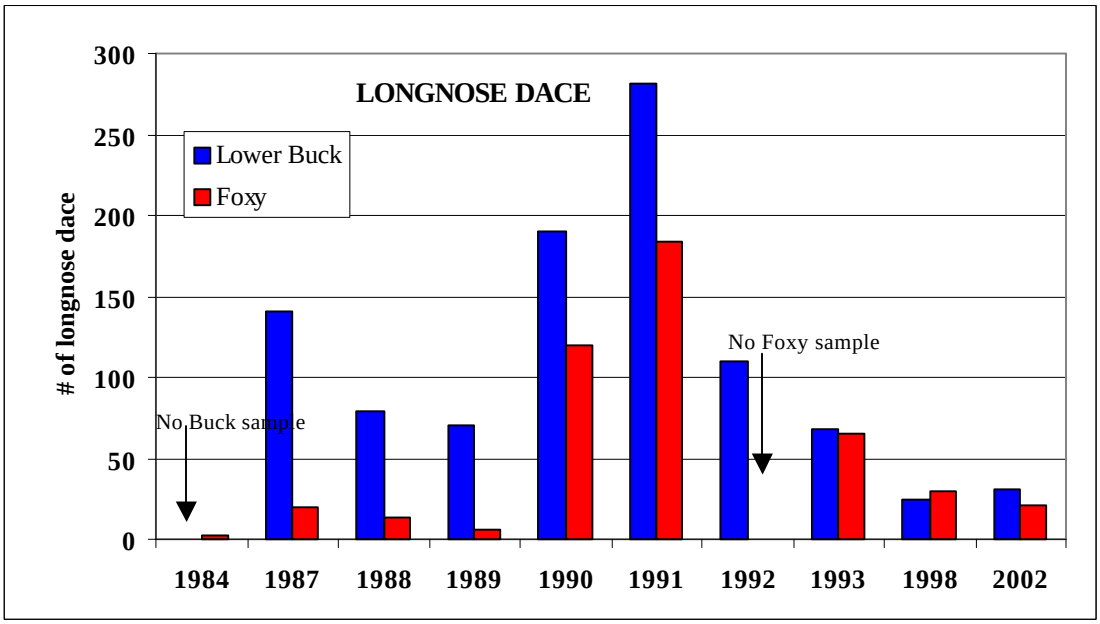


Table 5. Summary of rainbow trout Age 0+ and Age 1+ fork lengths combined for two Foxy Creek sites for all years and in Crow Creek for 2002.

	Age 0+			Age 1+		
	Mean fl	Std.	Sample	Mean fl	Std.	Sample
Foxy	(mm)		Size	(mm)		Size
1984	33.8	3.68	245	78.1	8.08	235
1987	38.8	5.04	73	80.8	7.40	148
1988	39.3	4.90	60	80.4	9.51	246
1989	38.5	3.90	60	73.2	8.20	204
1990	38.0	3.90	60	76.6	11.60	196
1991	37.1	6.10	100	77.7	8.59	253
1993	35.6	4.08	123	76.6	10.00	116
1998	43.4	4.71	84	84.3	8.30	194
Mean (84-98)	38.1	2.83	8	78.5	3.35	8
2002	36.1	3.47	98	77.8	9.80	106
Crow	38.6	4.10	55	74.5	6.80	43

Catches of longnose dace in Foxy Creek have been declining since the early 1990's but are still above levels measured during the period 1987 to 1989 (Figure 5). A similar decline in estimates has occurred in lower Buck Creek, the other index site with significant longnose dace numbers. See Appendix 3 for more details.

Figure 5. Summary of total number[9] of longnose dace captured at two Foxy Creek sample sites (combined) and in lower Buck Creek (BB3) for all sample periods.



3.2 BUCK CREEK

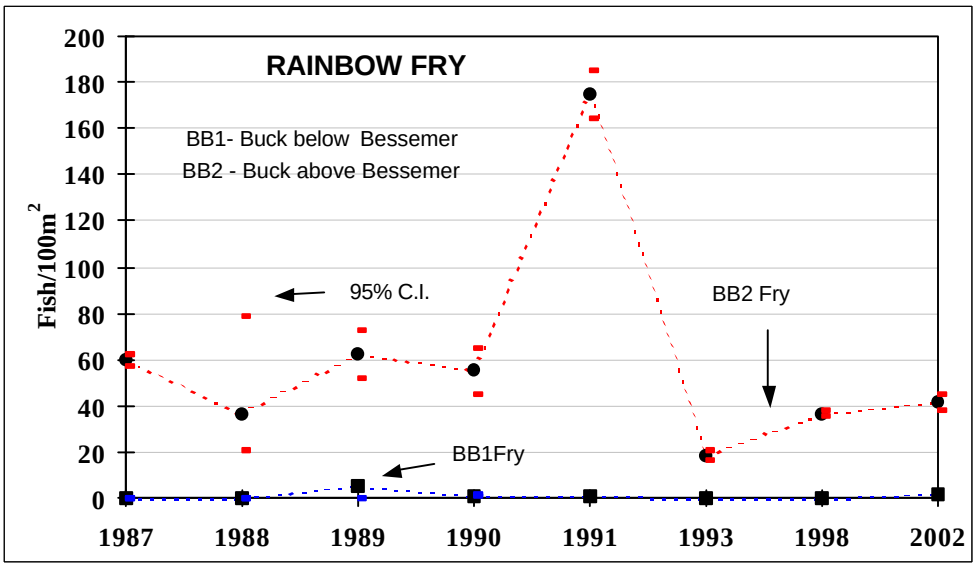
3.2.1 Sites BB1 and BB2 – Upper Buck Creek

Rainbow trout were the only fish species captured at BB1 located approximately 50 m downstream from the Bessemer Creek inflows (Table 6). Habitat conditions in the new site location were less affected by beaver activity and more of the site was free-flowing offering habitat better suited for rainbow trout (Photo 4).

Other fish species such as prickly sculpins, longnose suckers or mountain whitefish have usually been present in catches in lower Buck Creek (Table 6). None were present in the 2002 sample despite suitable habitat within the site.

[9] There has been difficulty obtaining good declining catches of longnose dace during electrofishing surveys in most years. We suspect this is a result of the reduced size of their swim bladder causing them to sink into the bed material upon electroshocking. The poor recovery rate has led to large error values in the two-pass estimates – so we have presented data in this chart as total catch for the two passes combined.

Figure 6. Buck Creek rainbow trout fry densities above and below Bessemer Creek from 1987 to 2002.



All fish sampled at BB2 located upstream from Bessemer Creek were rainbow trout except for a single longnose sucker. This is consistent with past sampling in the vicinity of this upper site. This site was at a new location approximately 300 m upstream from the old site, and had similar habitat characteristics to the old location (Figure 1), including potential spawning areas within the site.

Rainbow trout fry densities for the sites below (BB1) and above (BB2) Bessemer Creek are shown in Figure 6 and Table 7. Fry densities above Bessemer Creek were 41 fry/100m^2, comparable to past densities for most years excluding the very high densities in 1991.

Rainbow fry densities below Bessemer remained low at 2 fry/100m^2. This is consistent with past surveys below Bessemer Creek. However, more of the habitat in the new sample site was suitable for rainbow fry rearing. These densities should be considered low relative to the potential of this stream section.

Rainbow parr estimates at the upper Buck Creek sites are summarized in Figure 7 and Table 7. Only 5 parr were captured at site BB1 (2 parr/100m^2) despite considerable effort in a large sample area (354 m^2) and sections of good potential parr habitat. Rainbow parr estimates in Buck Creek below Bessemer Creek have declined since earlier surveys conducted in this stream section during the years 1987 to 1991.

Table 6. Catch composition of upper Buck Creek fish index sites combined from 1984 to 2002.

SPECIES	1987	1988	1989	1990	1991	1993	1998	Mean (87-98)	2002
	SITE BB1								
Rainbow Fry	1	0	21	5	2	0	0	4	16
(%)	*1.3*	*0.0*	*26.6*	*4.2*	*2.4*	*0.0*	*0.0*	*4.9*	*53.3*
Rainbow Parr	37	29	24	86	57	15	1	36	5
(%)	*48.7*	*56.9*	*30.4*	*72.3*	*67.9*	*50.0*	*5.9*	*47.4*	*23.8*
Mountain Whitefish	13	0	8	8	0	1	0	4	0
(%)	*17.1*	*0.0*	*10.1*	*6.7*	*0.0*	*3.3*	*0.0*	*5.3*	*0.0*
Prickly Sculpins	25	22	25	20	24	12	2	19	0
(%)	*32.9*	*43.1*	*31.6*	*16.8*	*28.6*	*40.0*	*11.8*	*29.3*	*0.0*
Longnose Suckers	0	0	1	0	1	1	14	2	0
(%)	*0.0*	*0.0*	*1.3*	*0.0*	*1.2*	*3.3*	*82.4*	*12.6*	*0.0*
Brassy Minnow	0	0	0	0	0	1	0	0	0
(%)	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*3.3*	*0.0*	*0.5*	*0.0*
TOTAL	**76**	**51**	**79**	**119**	**84**	**30**	**17**	**65**	**21**
Area Sampled (m^2)	409	394	406	476	445	502	402	433	354
Length (m)	66	63	65	71	65	70	56	65	50
	SITE BB2								
Rainbow Fry	190	130	213	188	599	77	130	218	106
(%)	*66.2*	*61.0*	*69.2*	*61.4*	*84.5*	*57.9*	*47.1*	*63.9*	*58.8*
Rainbow Parr	97	83	95	118	110	55	146	101	73
(%)	*33.8*	*39.0*	*30.8*	*38.6*	*15.5*	*41.4*	*52.9*	*36.0*	*40.7*
Longnose Suckers	0	0	0	0	0	1	0	0	1
(%)	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*3.3*	*0.0*	*0.5*	*3.3*
TOTAL	**287**	**213**	**308**	**306**	**709**	**133**	**276**	**319**	**180**
Area (m^2)	319	359	343	340	342	426	355	355	257
Length (m)	66	63	65	71	65	70	70	67	60

Parr densities at the site above Bessemer Creek (BB2) were 28 parr/100m^2, close to the long-term mean for the upper creek (Table 7). These densities fall between levels measured in Foxy and Crow creeks (Table 3) and indicate that the upper site in Buck Creek provides productive habitat for rainbow trout rearing. Most rainbow juveniles move out of the stream at some time prior to the end of their third summer in the stream. Approximately 6% of the parr sampled at this site are age 2+ or older (Table 7).

The site biomass estimates further illustrate the decline in fish productivity in Buck Creek below Bessemer Creek (Table 8). The total biomass production at BB1 (<0.1 grams/m^2) has been significantly lower since 1998 compared to previous sampling. Total biomass at the upper site BB2 (1.7 grams/m^2) has remained well within the range of past measurements at these sites.

Additional sampling was conducted in Buck Creek in the vicinity of Bessemer Creek in an attempt to increase the sample size of rainbow parr for the fish health studies. A single pass upstream through the 50 m section immediately upstream from the fish index site to the Bessemer confluence (950 seconds of electrofishing) resulted in one additional rainbow parr collected in an area that we rated as excellent parr habitat (Photo 5). Immediately upstream from Bessemer Creek, in comparable habitat, 250 seconds of electrofishing effort yielded a catch of 10 rainbow parr.

Figure 7. Buck Creek rainbow trout parr densities above and below Bessemer Creek from 1987 to 2002.

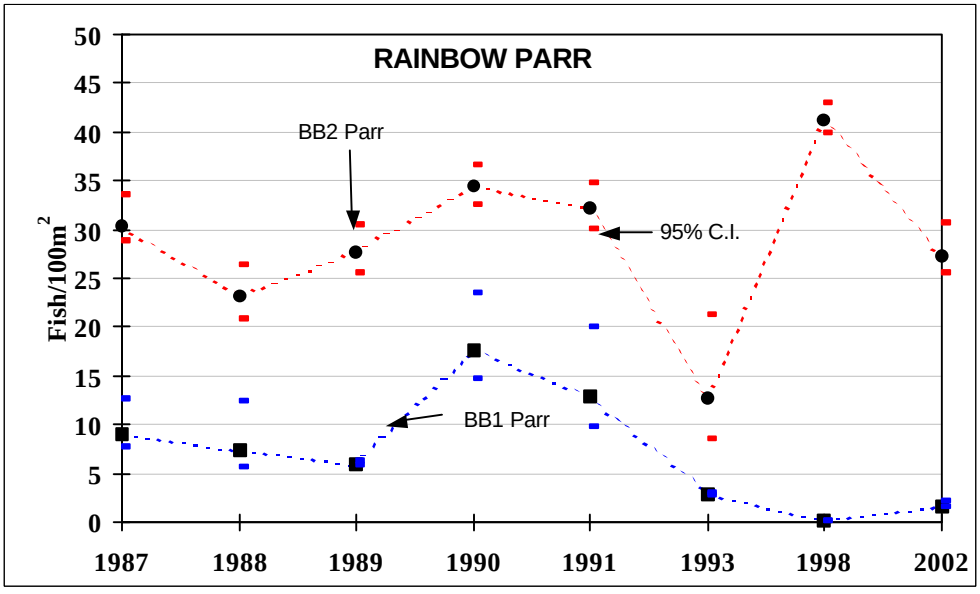


Table 7. Summary of rainbow trout density estimates in Buck Creek from 1987 to 2002.

SAMPLE SITE	YEAR	DENSITY (fish/100m^2)		
		Age 0+	Age 1+	Age >=2+
BB1	1987	0	7	2
	1988	0	6	1
	1989	5	4	2
	1990	1	16	2
	1991	<1	9	4
	1993	0	2	1
	1998	0	0	<1
	Mean (87-98)	**1.0**	**6.3**	**2.0**
	2002	2	2	<1
BB2	1987	59	27	3
	1988	36	23	0
	1989	62	27	1
	1990	55	34	1
	1991	175	32	1
	1993	18	12	<1
	1998	37	39	2
	Mean (87-98)	**63.1**	**27.7**	**1.3**
	2002	41	24	4
BES1	**2002**	**0.9**	**0.0**	**2.8**
BB3	1987	53	8	4
	1988	16	7	2
	1989	24	12	3
	1990	14	5	4
	1991	45	5	4
	1992	2	9	2
	1993	7	1	2
	1998	1	19	12
	Mean (87-98)	**20.3**	**8.3**	**4.1**
	2002	53	15	1

In summary, over 5400 seconds[10] of electrofishing effort immediately below Bessemer Creek yielded 6 rainbow parr. A few meters above Bessemer Creek, 200 seconds of effort yielded 10 rainbow parr.

Table 8. Rainbow[11] trout biomass estimates for the Buck Creek sample sites from 1987 to 2002.

	BIOMASS (g/m^2)		
	BB1	**BB2**	**BB3**
1987	0.77	2.35	2.01
1988	0.70	1.32	1.06
1989	0.51	1.58	1.51
1990	1.49	2.61	1.74
1991	1.22	2.42	1.81
1992[12]			0.97
1993	0.46	1.04	0.55
1998	0.03	2.22	3.80
Mean	**0.74**	**1.93**	**1.68**
2002	0.09	1.68	1.91
Std of mean	*0.49*	*0.61*	*0.99*

Rainbow trout fry in upper Buck Creek averaged 35.6 mm fork length above Bessemer (BB2 – Table 9) and 34.0 mm at BB1 (Appendix 1). The long-term mean fry size at BB2 is 39.7 mm (Table 9). There is insufficient fry data for similar comparisons at BB1.

Age 1+ parr at the upper control site (BB2) were approximately 4 mm smaller in fork length than the long-term average at the upper site. A small sample size of rainbow yearlings (5) at BB1 averaged 64.0 mm compared to 91.4 mm based on the long-term average (Figure 8).

[10] This includes combined effort in the index site (BB1 new – 4488 seconds of effort) and the sampling outside the index site (950 seconds of effort).
[11] All juvenile rainbow trout captured at BB3 are assumed to be the progeny of steelhead trout based on the predominance of steelhead spawners present in this section of lower Buck Creek.
[12] 1992 data from Bustard (1993) as part of a steelhead index sampling program in Morice.

Figure 8. Mean fork lengths of upper Buck Creek rainbow trout Age 0+ (BB2 only) and Age 1+ parr from 1987 to 2002.

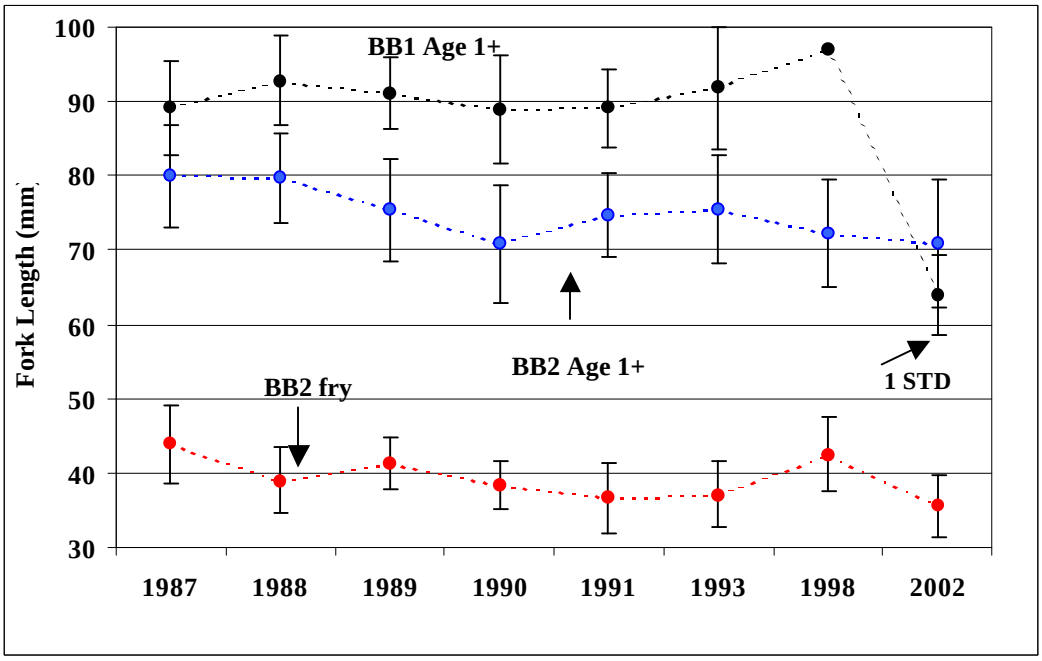


Table 9. Summary of upper Buck Creek rainbow trout Age 0+ (BB2 only) and Age 1+ fork lengths for 1987 to 2002.

	BB2 AGE 0+			BB2 AGE 1+			BB1 AGE 1+		
	Mean fl (mm)	Std.	Sample Size	Mean fl (mm)	Std.	Sample Size	Mean fl (mm)	Std.	Sample Size
1987	43.9	5.26	30	80.0	6.81	82	89.1	6.33	23
1988	39.0	4.35	30	79.7	6.05	36	92.8	6.00	18
1989	41.3	3.56	32	75.4	6.86	87	91.1	4.85	16
1990	38.3	3.22	30	70.8	8.06	107	89.0	7.19	63
1991	35.7	5.05	49	74.6	5.65	101	89.1	4.90	38
1993	37.1	4.44	50	75.5	7.29	36	91.8	8.10	8
1998	42.5	5.08	45	72.3	7.19	134	97.0	na	1
Mean (87-98)	**39.7**	**2.98**	**7**	**75.5**	**3.44**	**7**	**91.4**	**2.88**	**7**
2002	35.6	4.18	50	70.9	8.53	58	64.0	5.40	5

3.2.2 Bessemer Creek

A new index site (BES1) was established in Bessemer Creek in 2002 immediately downstream from the lower road crossing (Figure 1). The channel in this section was mainly a long fast riffle with little complexity and no instream large debris. A 42 m long section was sampled comprising over 100 m^2 of habitat (Appendix 1).

A total of four rainbow trout were captured in this site in Bessemer Creek. Fry densities were 1 fry/100 m^2 while rainbow parr densities were 3 parr/100 m^2 comparable to the low abundance estimates in Buck Creek below the Bessemer Creek confluence (Table 7).

It is interesting to note the presence of a newly-emerged rainbow trout fry (28 mm fork length) at the Bessemer Creek site. This fish must have been the progeny of rainbow trout that had spawned in Bessemer Creek or the bottom end of an inlet to Bessemer Creek, since we suspect stream velocities were too high for this fry to have moved up from Buck Creek into this location on Bessemer Creek.

3.2.3 Site BB3 - Lower Buck Creek

The lower Buck Creek catch was dominated (84%) by juvenile steelhead trout particularly age 0+ fish (Table 10). The remainder of the catch consisted of longnose dace (15.5%) and a single longnose sucker (<1%). Longnose dace comprised a smaller percentage of the overall catch in 2002 compared to most years.

Juvenile steelhead fry and parr densities at BB3 are summarized in Figure 9 and Table 7. Steelhead fry densities were 53 fry/100m^2 at BB3 in 2002. This is more than double the long-term mean at this site.

The nine years of data at this index site suggest that steelhead fry densities demonstrate high variability from year-to-year, and typically the strength of the previous year's adult steelhead spawning escapement plays a significant role in determining fry densities. The 2001 steelhead escapement was relatively strong based on the test fishery index for Skeena steelhead at Tyee in 2001 (Appendix 4).

Table 10. Catch composition of the lower Buck Creek (BB3) fish index site combined for period 1987 to 2002[13].

SPECIES	1987	1988	1989	1990	1991	1992	1993	1998	MEAN (87-98)	2002
Steelhead Fry	217	66	109	58	175	8	32	5	84	133
(%)	*39.7*	*28.6*	*40.1*	*14.7*	*34.7*	*5.1*	*11.8*	*2.2*	22.1	*64.5*
Steelhead Parr	49	39	67	40	34	37	16	101	48	41
(%)	*9.0*	*16.9*	*24.6*	*10.1*	*6.7*	*23.6*	*5.9*	*48.8*	18.2	*19.6*
Longnose Dace	279	108	89	282	282	110	217	86	182	32
(%)	*51.0*	*46.8*	*32.7*	*71.4*	*55.8*	*70.1*	*80.4*	*41.5*	56.2	*15.5*
Mountain Whitefish	2	15	3	7	1	1	4	0	4	0
(%)	*0.4*	*6.5*	*1.1*	*1.8*	*0.2*	*0.6*	*1.5*	*0.0*	1.5	*0.0*
Longnose Suckers	0	3	4	8	13	1	1	15	6	1
(%)	*0.0*	*1.3*	*1.5*	*2.0*	*2.6*	*0.6*	*0.4*	*7.2*	2.0	*0.5*
TOTAL	**547**	**231**	**272**	**395**	**505**	**157**	**270**	**207**	**323**	**207**
Area (m^2)	413	416	458	399	390	352	462	323	402	252
Length (m)	44	43	43	43	43	43	43	43	43	43

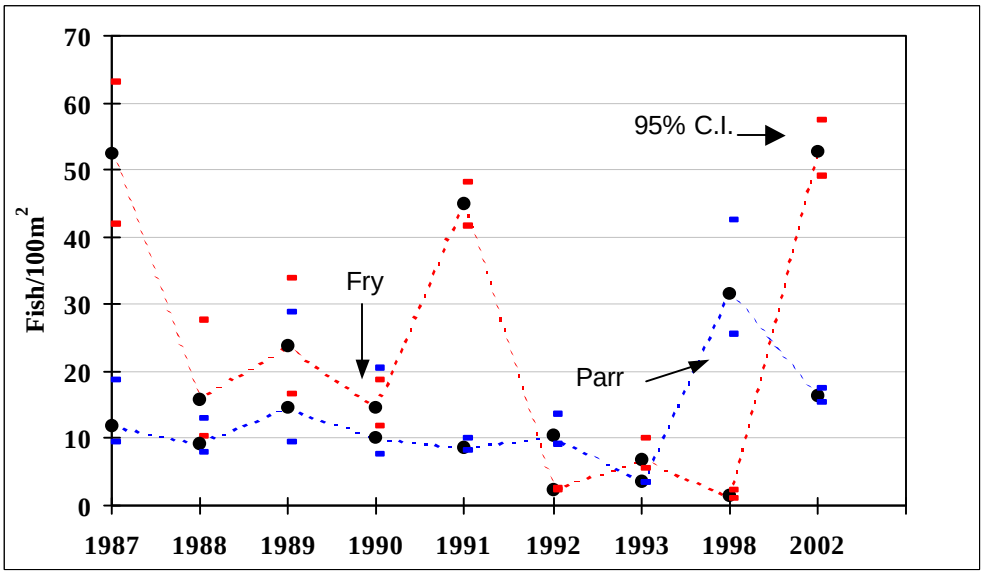
[13] Based on estimates derived from two-pass removal electroshocking. It is difficult to obtain good decline catches for longnose dace, and these estimates have a large error associated with them. See Figure 8 for alternate abundance estimates.

Steelhead trout parr densities of just over 16 parr/100 m^2 at BB3 are close to the long-term average of 12 parr/m^2 at this site (Table 7). Parr densities have been consistent for all years of record except 1998, when parr densities were well above normal, largely reflecting a strong older parr component in the catch. Most parr were age 1+ in 2002.

We continue to suspect that in most years, fry recruitment into Buck Creek is adequate to seed the habitat at the index site. The years 1992, 1993 and 1998 stand out as periods of under-recruitment. Parr densities were low in 1993 following the low fry year in 1992 but there was no measure of parr densities 1994 and 1999 following these other low fry years.

Figure 5 compares longnose dace abundance over time by simply combining the total catches from the two sampling passes in lower Buck Creek for each year. This figure indicates longnose dace abundance has been low for the past two sample periods (1998 and 2002) compared to all previous years. A similar comparison for Foxy Creek sites also suggests declining dace abundance since the early 1990's.

Figure 9. Steelhead fry and parr densities in lower Buck Creek (BB3) for period 1987 to 2002.



The biomass of steelhead (combined fry and parr) in 2002 was 1.9 grams/m^2 (Table 8). This is very close to the long-term average of 1.7 grams for the nine years of data at this site.

Steelhead fry averaged 45 mm fork length at BB3 in 2002 (Figure 10 and Table 11). This compares to a long-term average of 51 mm at this site. Large fry were present at this site in 1992 and 1998, two years of very low densities. Age 1+ steelhead averaged 84 mm in 2002, close to the long-term mean of 86 mm for this site since first sampling in 1987.

Figure 10. Mean fork lengths of lower Buck (BB3) steelhead Age 0+ and Age 1+ parr from 1987 to 2002.

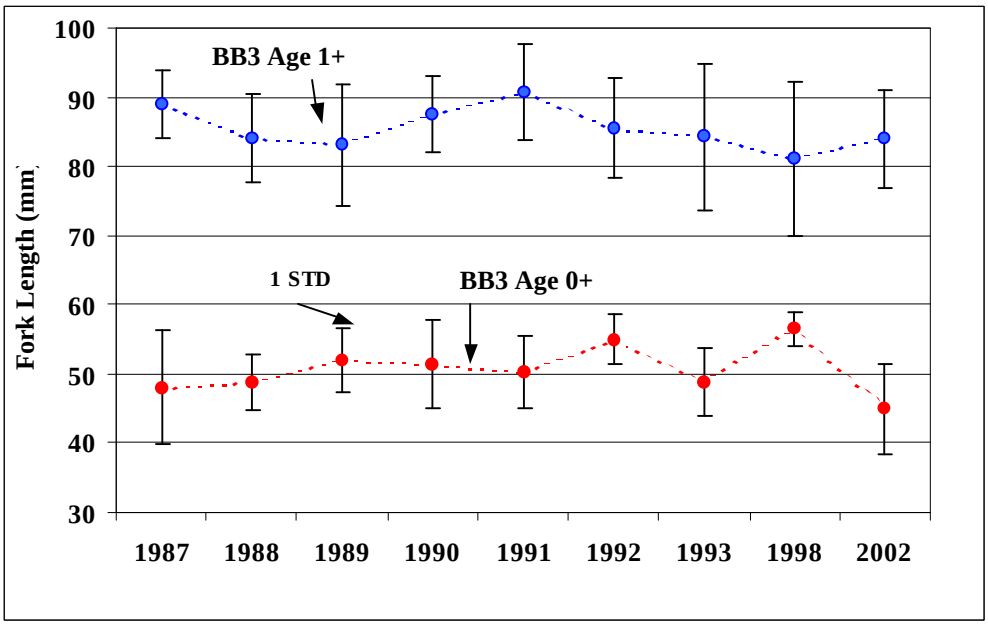


Table 11. Summary of steelhead trout Age 0+ and Age 1+ fork lengths for lower Buck Creek from 1984 to 2002.

	BB3 Age 0+			BB3 Age 1+		
	Mean fl (mm)	Std.	Sample Size	Mean fl (mm)	Std.	Sample Size
1987	48.0	8.18	40	89.0	4.81	32
1988	48.7	4.07	22	84.1	6.44	25
1989	51.9	4.63	27	83.2	8.82	37
1990	51.3	6.39	32	87.5	5.54	21
1991	50.3	5.24	51	90.7	6.93	16
1992	55.0	3.57	8	85.5	7.25	27
1993	48.8	4.85	26	84.3	10.61	9
1998	56.5	2.52	4	81.1	11.06	48
Mean (87-98)	**51.3**	**3.07**	**8**	**85.7**	**3.19**	**8**
2002	45.0	6.49	50	84.0	7.10	36

4. 0 CONCLUSIONS

4.1 FOXY CREEK

- Population estimates conducted at the two index sites in lower Foxy Creek that have been sampled nine times since 1984 suggest that rainbow trout fry continue to be abundant in lower Foxy Creek. Fry densities were 159 fry/100 m^2, the third highest on record.

- Rainbow parr abundance of 37parr/100 m^2 continues to fall within a band ranging from 30 to 50 parr/100 m^2, characteristic of this section of lower Foxy Creek for most years of sampling (Figure 3).

- Fish population estimates were conducted in Crow Creek for the first time in 2002. While the system is dominated by rainbow trout, and the stream habitat characteristics are comparable, the overall densities and biomass estimates for rainbow trout are lower than those measured in Foxy Creek.

- Foxy Creek rainbow trout densities and biomass estimates are high regionally. They compare favorably to historical data collected at some of the best rainbow trout spawning streams in the area shown in Table 12.

- Mean fork lengths of rainbow fry and age 1+ fish in 2002 were similar to past estimates conducted since 1984 (Figure 4).

4.2 BUCK CREEK

- Distinct differences in the abundance of rainbow trout fry and parr in the two upper Buck Creek sites were noted in 2002. Rainbow fry and parr estimates (41 fry and 28 parr/100 m^2 respectively) at the index site above Bessemer Creek were within the range of estimates in past years (Table 7). Parr abundances at the downstream site were low (2 parr/100 m^2) compared to most past estimates, and occurred despite moving the sample site to more suitable habitat. Fry abundance below Bessemer Creek remained low, similar to past years.

- Additional sampling in the immediate vicinity of the Bessemer Creek confluence showed distinct differences in fish use within a short distance above and below the creek. This is perhaps best demonstrated by effort versus catch at the Bessemer Creek confluence area. Over 5400 seconds of electroshocking immediately below Bessemer Creek yielded 6 rainbow parr compared to 10 parr in 250 seconds of effort immediately upstream. The lack of other fish species in the catch at BB1 in 2002 further suggests avoidance or poor fish survival in Buck Creek below Bessemer.

Table 12. Rainbow trout density and biomass estimates in Foxy, Crow and Buck creeks compared to some of the best regional rainbow trout rearing streams[14].

	DENSITIES (fish/100m^2)		BIOMASS (g/m^2)
TRIBUTARY	**FRY**	**PARR**	**RBT COMBINED**
Duncan Creek	196	40	6.0
Morrison Arm Trib.	147	67	5.1
Nithi River	241	37	5.8
Ramsay	134	12	3.1
Uncha	92	3	2.2
Crow (2002)	**61**	**15**	**1.3**
Foxy 2002	**160**	**37**	**3.4**
Foxy (84-98)	**122**	**50**	**4.4**
BB2 Buck (87-98)	**60**	**29**	**1.9**

- Rainbow trout fry and parr densities were also very low in Bessemer Creek. The presence of newly-emerged rainbow fry suggests spawning has occurred somewhere in lower Bessemer Creek in 2002.

- The low biomass estimates and the small mean size of the few age 1+ parr captured downstream from Bessemer Creek are further indications of the limited capability of this stream section to support fish in 2002. The lack of rainbow parr at this site in 1998 suggests that the decline in fish abundance may date back to 1993 given that most of the catch in 1998 was comprised of young-of–the-year longnose suckers.

- Sampling in lower Buck Creek in the steelhead index site suggests 2002 was a year of strong steelhead fry and parr recruitment (53 fry and 16 parr/100 m^2 respectively – Table 7). Mean biomass was above the long-term average (Table 8), and has only been exceeded in two of the nine years of sampling at this site.

- These densities of steelhead fry and parr are high on a regional basis compared to other key steelhead rearing streams.[15]

[14] These estimates are taken from a summary presented in Bustard 1990. We are not aware of any more current information providing comparable rainbow density and biomass information for rainbow trout streams in the vicinity of the Equity project area.

[15] See Bustard (2002) for a review of historical densities for steelhead in the nearby Morice River. This report can be located on the web at www.cfdcnadina.ca

- Steelhead fry were approximately 6 mm smaller than average for this period (Table 11), similar to smaller fry in the upper Buck Creek control site (BB2) in 2002 (Table 9).

5.0 LITERATURE CITED

Bustard, D. 1984. Assessment of benthic invertebrate and juvenile fish populations in Foxy and Buck creeks, September 1984. Man. report prepared for Equity Silver Mines Ltd.

Bustard, D. 1993. Rainbow trout spawning studies in Foxy Creek 1993. Manuscript report prepared for Homestake Canada Ltd.

Bustard, D. 1987-1998. Fish population monitoring in Foxy and Buck Creeks September 1987-98. A series of Man. reports prepared for Equity Silver Mines Ltd.

Bustard D. 2002. Conserving Morice Watershed fish populations and their habitat. Stage II Biophysical Profile. Watershed-based Fish Sustainability Planning prepared for Community Futures Development Corporation of Nadina www.cfdcnadina.ca.

Chapman, D.G. 1951. Some properties of hypergeometric distribution with applications to zoological sample censuses. Univ. of California Publ. in Statistics 1:131-159, Berkeley, Cal., USA.

Godin, B. 1992. Water quality and sediment analysis Equity Silver Mines data from 1988, 1989 and 1990 surveys. Regional Program Report 92-02 Environment Canada Conservation and Protection, North Vancouver, B.C.

Peterson, N. and C.J. Cederholm. 1984. A comparison of the removal and mark-recapture methods of population estimation for juvenile coho salmon in a small stream. North Amer. J. of Fisheries Mmgt. Vol 4, No. 1, 1984.

Seber, G.A.F. and E.D. LeCren. 1967. Estimating population parameters from catches large relative to the population. J. Anim. Ecol. 36: 631-643.

Wilkes, B. and D.B. Maclean. 1987. The effect of Equity Silver Mine on Goosly Lake. Environmental Section Report 87-01. Waste Management Branch, Ministry of Environment and Parks, Northern Region, Smithers.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. 191. Fish. Res. Bd. Can. Ottawa, Ont.