F-C-16

COAL CREEK FISHERIES MONITORING STUDY NO. X

AND

FOREST-WIDE FISHERIES MONITORING - 1991

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October 1992

Sponsored by:

USDA - Forest Service
Flathead National Forest
Under Contract No. P.O. 43-0385-1-0452

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ACKNOWLEDGEMENTS

I wish to thank the following people and agencies participating in the 1991 effort. Flathead National Forest (FNF) funded the project. Hank Dawson, Flathead National Forest Fisheries Biologist served as the contracting agency's representative. Brian Marotz, Fisheries Program Officer for MDFWP's Special Projects Bureau, managed the project. Both Hank and Brian critically reviewed this report, along with Mike Enk and Pat VanEimeren, District Fisheries Biologists for FNF. Jeff Hutten assisted in compiling and analyzing data. Hank Dawson, Chris Donaldson, Mike Enk, Mark Holsten, Jeff Hutten, Scott Ohm, Linda McDevitt, Sharon Sarver and Vicki Willis assisted in field data collection. Lowell Nelson sieve analyzed the streambed gravel samples at the National Forest's Soils Lab. Sharon Sarver typed this manuscript.

ABSTRACT

This is the tenth year of data documenting trends in fish populations and aquatic habitat characteristics in the Coal Creek Drainage and forest-wide. Westslope cutthroat and juvenile bull trout population estimates fluctuated more during 1991 than in past years at the Coal Creek sites. Cutthroat trout were present in both the Big and Goat creek electrofishing sections. A substantial brook trout population exists in Goat Creek. We have observed large annual fluctuations in estimated juvenile bull trout numbers in both Coal Creek sections. Westslope cutthroat trout populations have not shown fluctuations as great. Electrophoretic analysis during 1989 detected two bull trout/eastern brook trout hybrids in a sample of 26 fish from Goat and Lion creeks in the Swan River Drainage. Bull trout spawning escapement during 1991 appeared lower than previous years in most contract reaches. Overall, the 1991 run was well below average in the North and Middle forks and well above average in the Swan River Drainage. We detected significant changes in the median percentage of streambed gravel smaller than 6.35 mm at one contract site. This size class decreased significantly ($\hat{p} < 0.05$) between the 1990 and 1991 sampling at the Big Creek site. All other changes were not significant. Habitat enhancement efforts in the South Fork of Coal Creek resulted in some redistribution of streambed gravels. We observed bull trout spawning in an area of newly deposited gravel beside one of our enhancement structures. Juvenile bull trout populations decreased in this treatment section while increasing in both our control and other treatment sections. Westslope cutthroat trout population estimates remained similar in our control section. We observed similar patterns in both treatment sections. It appears that current enhancement efforts are ineffective, but it is difficult to say conclusively with only a short period of information for one stream. We documented extensive areas of high embeddedness and channel instability in the Big Creek Drainage. Most of the problems stem from older road systems on privately owned lands. Similar degraded conditions are evident downstream on FNF lands. We also noted several BMP departures during our surveys.

INTRODUCTION

This report contains information on the continued assessment and monitoring of fish populations and instream habitat in the upper Flathead River Drainage. The study's primary purpose is to document annual trends in fish population and habitat parameters. In a separate study, we recently compared fisheries variables with information on development in the watershed showing relationships between forest management activities and fisheries (Weaver and Fraley 1991).

The Department of Fish, Wildlife and Parks (DFWP) initiated the original study in 1981, funded by Flathead National Forest (FNF) (Shepard and Graham 1982). Work continued through 1982 (Shepard and Graham 1983a), resulting in an ongoing data collection program (Shepard and Graham 1983b) for examining fluctuations in fisheries variables resulting from both natural and management related causes.

During 1983 and 1984, the study focused mainly on the Coal Creek drainage. FNF contracted with the Cooperative Fisheries Research Unit at Montana State University (MCFRU) to complete this work. The original monitoring program continued along with preliminary examination of the relationship between substrate composition and bull trout embryo survival to emergence (Weaver and White 1985). The 1985 study, conducted by DFWP, involved only a portion of the program including estimation of late summer fish abundance, evaluation of substrate composition in important spawning areas and assessment of the 1985 bull trout spawning run (Weaver and Fraley 1985). The Montana Department of Fish, Wildlife and Parks completed these activities annually from 1985 through 1990. We used existing methods and sampling sites providing comparable results (Weaver and Fraley 1986, 1988; Weaver 1989, 1990, 1991).

Under the current contract (Table 1), DFWP estimated late summer fish abundance for two sections in the Coal Creek Drainage, one section in Big Creek and one Swan River tributary section. We counted bull trout spawning sites in Big, Coal, Whale and Trail creek drainages in the North Fork, three Middle Fork tributaries (Morrison, Granite and Lodgepole creeks) and four Swan River tributaries (Elk, Goat, Squeezer and Lion creeks). Biologists evaluated streambed substrate composition in six important bull trout spawning areas, one adfluvial westslope cutthroat trout spawning area and one adfluvial rainbow trout spawning area. Field crews identified all major stream features (MDFWP 1983) in Big Creek Drainage above Hallowat Creek. The 1991 contract also included an evaluation of the habitat enhancement project in the South Fork of Coal Creek. Researchers conducted fieldwork from July 1991, through March 1992, as a cooperative effort by DFWP and FNF personnel. As in past years, we used existing sampling locations and methods ensuring comparable results.

Table 1. Description of study sties and activities specified under the 1991 contract.

Drainage	Creek	Sampling Area Name	Location	Activity: Fish Abundance	Bull Trout Redd Count	Substrate Monitoring	Habitat Enhancement	Feature ID
North Fork Flathead								
	Big	Skookoleel Bridge	NE 1/4 Sec 33 T32N R21W	X	-	X	-	-
		Monitoring Section	NW 1/4 Sec 8 T32N R21W downstream to NE 1/4 Sec 35 T32N R22W	-	X	-	-	-
		Sediment source survey	SW 1/4 Sec 20 T32N R21W downstream to NE 1/4 Sec 33 T32N R21W	-	-	-	-	X
	North Coal	South Fork Bridge	SW 1/4 Sec 24 T34N R22W	X	-	-	-	-
		N. Coal Coring site	NW 1/4 Sec 23 T34N R22W	-	-	X	-	-
		Monitoring Section	NE 1/4 Sec 30 T34N R22W downstream to NE 1/4 Sec 34 T34N R22W	-	X	-	-	-
	South Fork Coal							
		South Fork	NE 1/4 Sec 26 T34N R22W	X	-	X	-	-
		Lower rehab.	SW 1/4 Sec 26 T34N R22W	X	-	-	X	-
		Upper rehab.	SW 1/4 Sec 26 T34N R22W	X	-	-	X	-
		Monitoring Section	NW 1/4 Sec 34 T34N R22W downstream to NW 1/4 Sec 30 T34N R22W	-	X	-	-	-
	Whale	Monitoring Section	SE 1/4 Sec 29 T36N R23W downstream to SE 1/4 Sec 20 T36N R22W	-	X	-	-	-
	Trail	Monitoring Section	SE 1/4 Sec 25 T36N R23W downstream to SW 1/4 Sec 28 T36N R22W	-	X	-	-	-
Middle Fork Flathead								
	Granite	Monitoring Section	SW 1/4 Sec 32 T29N R14 downstream to S 1/2 Sec 18 T29N R14	-	-	X	-	-
	Morrison	Monitoring section	NW 1/4 Sec 9 T28N R13W downstream to NE 1/4 Sec 9 T27N R13W	-	X	-	-	-
	Lodgepole	Monitoring Section	SW 1/4 Sec 1 T27N R13W downstream to NW 1/4 Sec 10 T27N R14W	-	X	-	-	-

Drainage	Creek	Sampling Area Name	Location	Activity: Fish Abundance	Activity: Bull Trout Redd Count	Activity: Substrate Monitoring	Activity: Habitat Enhancement	Activity: Feature ID
South Fork Flathead								
	Hungry Horse	Lower Coring Site	NW 1/4 Sec 22 T30N R18W	-	-	X	-	-
Swan River								
	Goat	Coring Site	SE 1/4 Sec 10 T23N R17W	X	-	X	-	-
		Monitoring Section	NW 1/4 Sec 12 T23N R17W downstream to SE 1/4 Sec 18 T23N R18W	-	X	-	-	-
	Jim	888 Bridge	NW 1/4 Sec 32 T22N R17W	-	-	X	-	-
	Elk	9591 Bridge	NE 1/4 Sec 16 T20N R17W	-	-	X	-	-
		Monitoring Section	NW 1/4 Sec 23 T19N R18W downstream to NE 1/4 Sec 16 T20N R17W	-	X	-	-	-
	Squeezer	Monitoring Section	SE 1/4 Sec 27 T23N R17W downstream to SW 1/4 Sec 17 T23N R17W	-	X	-	-	-
	Lion	Monitoring Section	NW 1/4 Sec 13 T22N R17W downstream to W 1/2 Sec 8 T22N R17W	-	X	-	-	-
Tally Lake R.D.								
	Fish	Ashley Bridge	NW 1/4 Sec 15 T28N R24W	-	-	X	-	-

In addition to the activities reported, DFWP completed electrofishing estimates in 9 tributary sections, bull trout redd counts in 26 major spawning streams and westslope cutthroat trout redd counts in six important spawning streams. We completed substrate sampling in 10 other spawning areas during the 1991 season. Results of these additional 1991 monitoring efforts in the Flathead Drainage will be presented in other reports (Hanzel and Weaver In Prep.; FBC Master Monitoring Plan Biennial Report In Prep).

METHODS

Fish Abundance Estimates

We made juvenile fish abundance estimates by electrofishing 150 m sections in selected tributaries to the North Fork of the Flathead and the Swan rivers. We used the same sections sampled during past years and equipment and procedures described by Shepard and Graham (1983b).

We calculated juvenile bull trout (Age I+) population estimates for important rearing ares in the North and South forks of Coal Creek, Big Creek and Goat Creek. We estimated cutthroat trout populations (Age I+) in both Coal Creek sections. We compared these estimates with records from electrofishing during previous years, assessing trends in fish abundance. We applied the technique of showing population fluctuation described by Platts and Nelson (1988). These authors defined the maximum relative fluctuation (M_s) as the percentage difference between the highest and lowest value of each population statistic relative to the lowest value:

$$M_s = \frac{X_{max} - X_{min}}{X_{min}} \times 100;$$

X_{max} = largest annual value and X_{min} = smallest annual value.

This statistic related the largest observed change to the smallest observed value during the study period, and gives an indication of the magnitude of potential for change of each population statistic evaluated.

They used average relative fluctuation (A_s) to describe the magnitude of change in each population statistic with respect to the mean value of that statistic over the course of the study:

$$A_s = \frac{X_{max} - X_{min}}{X_{avg}} \times 100;$$

X_{max} and X_{min} are as above and X_{avg} = average value over the entire study period.

Total biomass (B_t), the estimated total trout weight, and aerial biomass (B_a), the estimated trout weight per unit surface area, were computed as:

$$B_t = \hat{N}W \text{ and } B_a = \frac{B_t}{lw} ;$$

$\hat{N}$ = estimated trout population size. W = mean trout weight, l = length of the stream section, and w = mean width of the study stream.

Bull Trout Spawning Site Inventories

We conducted bull trout spawning site inventories in sections of twelve tributaries recommended for annual monitoring by Shepard and Graham (1983b). North and Middle fork monitoring sections surveyed included Big, North Coal, South Coal, Whale, Trail, Granite, Morrison and Lodgepole creeks. We surveyed Elk, Goat, Squeezer and Lion creeks in the Swan Drainage. Preliminary bull trout spawning surveys indicated final redd counts could begin during the third week of September. Final surveys were conducted by crews of two walking down the channel. We enumerated, classified, and located all observed redds as described by Shepard and Graham (1983b). A set of maps showing all surveyed sections is available from MDFWP. We compared counts to past surveys of the same tributary section and by the major drainages as a whole, to evaluate trends in spawner escapement.

Spawning Area Substrate Composition

We collected substrate samples from known spawning areas in the upper Flathead Drainage documenting trends and to evaluate potential fry production. Important bull trout spawning areas sampled included those in North Coal, South Fork Coal, Big, Elk, Jim and Goat creeks. Westslope cutthroat spawning areas sampled included Hungry Horse Creek. The rainbow/cutthroat spawning area in Fish Creek was also sampled.

We used standard 15.24 cm hollow core sampler following procedures described by Shepard and Graham (1982). We placed samples in labeled bags and transported then to the Flathead National Forest Soils Lab in Kalispell for analysis. After drying, each core sample was passed through the following sieve series:

76.1 mm (3.00 inch)
50.8 mm (2.00 inch)

25.4 mm	(1.00 inch)
19.0 mm	(0.75 inch)
12.7 mm	(0.50 inch)
9.52 mm	(0.38 inch)
6.35 mm	(0.25 inch)
4.76 mm	(0.19 inch)
2.00 mm	(0.08 inch)
0.85 mm	(0.03 inch)
0.42 mm	(0.016 inch)
0.063 mm	(0.002 inch)
Pan	(<0.002 inch)

Material retained on each sieve was weighed and the percent dry weight in each size class calculated and summed cumulatively. We tested for annual changes in the median percentage smaller than 6.35 mm in each spawning area using Mann-Whitney tests. We estimated average survival to emergence in each of the spawning areas sampled using field developed predictive equations for westslope cutthroat and bull trout (Weaver and Fraley 1991). The equation used for cutthroat trout was:

$$\text{percent survival} = -1.3096244\ (S_{6.35}) + 71.35$$

The equation used for bull trout was:

$$\text{percent survival} = -1.3962821\ (S_{6.35}) + 78.095$$

$(S_{6.35})$ = percent smaller than 6.35 mm;

Habitat Enhancement

The field crew evaluated ongoing habitat enhancement efforts in the South Fork of Coal Creek as part of the 1991 work. We completed the initial surveys on these sections in August, 1988; actual treatment occurred during early September, 1988. This year we electrofished both sections as previously reported and compared these estimates with pretreatment estimates. We obtained substrate scores (Crouse et al. 1981) annually in each section in conjunction with electrofishing efforts.

We selected these sections for several reasons: (1) both fish species were present throughout this area and a 150 m section has been electrofished annually since 1985, providing a period of record for assessing natural population fluctuations; (2) streamside timber in this area has been harvested, limiting potential for natural recruitment of large woody debris; (3) the proximity of an undeveloped timber stand north of road 1686 provided quick access to raw materials; and (4) topography of the area allowed selection, transport and placement of raw materials with minimal impact to the timber stand, riparian zone, and stream channel itself.

We used a replicated treatment-control study design and assumed natural population fluctuations will be similar in both treatment and control sites. Treatment involved placement of whole trees with root wads attached at five locations in each section. Trees were secured in position as recommended by Seehorn (1985).

Stream Feature Identification

All major stream features (MDFWP 1983) in the Big Creek Drainage above the crossing of 316E were located, classified and photographed during surveys of the total channel area in each of the major forks. We surveyed main Big, Nicola, Lakalaho, Kinnimiki and Skookoleel creeks. Side drainages were included in an effort to examine all areas in the sediment contributing zone. We pace located major features during field surveys and later marked these on a map. We prepared a narrative listing of major stream features beginning in the headwaters in section 29 and proceeding downstream to the crossing of Road 316E. We included a list of major problem areas where there is some potential for corrective or stabilizing activities in the management recommendations section.

RESULTS AND DISCUSSION

Fish Abundance Estimates

The 1991 juvenile bull trout population estimate for the North Coal section was the lowest on record; we began sampling in 1982 (Table 2). We observed only one age class (III+) during this years electrofishing in North Coal Creek. These three-year-old bull trout were progeny from adult fish spawning during 1987; one and two-year-old fish should have resulted from adults spawning in 1989 and 1988, respectively. The lack of younger fish in this section does not indicate that both year classes are totally absent in North Coal Creek, but that they are not present at the level previously observed. We have seen gaps in the juvenile bull trout age structure in several other sections resulting from temporary migration barriers (Weaver 1989).

This year's low juvenile bull trout population estimate may have been due to several factors. First, our electrofishing gear may not have been as efficient at capturing smaller bull trout, however we did capture smaller cutthroat trout (32-94 mm) while sampling this section. Our equipment functioned well prior to and after this effort, so gear-related problems are probably not valid explanations. This was the only section where we saw a large decline in juvenile bull trout abundance this year.

Weaver (1989) reported extremely low streamflows during late summer, 1988. A portion of main Coal Creek downstream in Section 29 actually dewatered during late August, however rain during early

Table 2. Summary of annual population estimates ($\hat{N}$), 95 percent confidence intervals and probability of first pass capture ($\hat{P}$) for Age I and older bull trout calculated from electrofishing in the 150 m sections specified for monitoring during 1991.

Drainage	Creek	Section	Date	$\hat{N}$	95% CI	$\hat{p}$
North Fork Flathead						
	North Coal	317 Bridge	8/04/82	17	±9	.60
			8/25/83	18	±3	.78
			8/29/84	48	±12	.63
			8/27/85	41	±5	.77
			9/03/86	29	±12	.59
			8/05/87	47	±17	.56
			8/16/88	39	±5	.69
			9/08/89	44	±18	.54
			8/27/90	33	±3	.65
			8/21/91	9	±4	.67
	South Coal	Section 26	8/28/85	62	±8	.74
			8/06/87	12	±2	.48
			8/08/88	24	±2	.85
			9/29/89	14	±2	.83
			8/24/90	49	±17	.57
			8/16/91	58	±7	.59
	Big	Skookoleel Bridge	9/15/86	47	±5	.78
			8/19/87	48	±6	.75
			8/18/88	67	±6	.56
			9/22/89	83	±11	.54
			9/17/90	65	±17	.48
			8/27/91	47	±9	.52
Swan River						
	Goat	Section 10	8/11/87	66	±6	.79
			8/22/88	32	±4	.80
			8/30/89	34	±2	.86
			9/10/90	10	±0	1.00
			8/20/91	29	±3	.83

September allowed adult bull trout to reach upstream spawning areas. We found ten bull trout redds in the North Coal spawning area during October redd counts in 1988. However, low flow conditions prevailed throughout the winter of 1988-89. It is possible that redd dewatering and freezing may have resulted in high incubation mortality. Similar conditions occurred during winter 1984-85 (Weaver and White 1985a). We have monitored all spawning redds in the Coal Creek Drainage since 1980, with the exception of 1985 and 1987.

McNeil core sampling showed the percentage of material smaller than 6.35 mm in the North Coal spawning area increased significantly ($\hat{p} < 0.05$) between 1987 and 1988 samplings, from 30.2 percent to 39.8 percent. The resulting reduction in embryo survival to emergence (from > 35 percent to < 25 percent) may have contributed to a weak two-year-old age class this year.

Redd counts during 1989 showed more spawning occurred in North Coal Creek than in 1988; we observed 29 bull trout redds. This suggests a stronger one-year-old age class should have been present this year. The Flathead Drainage experienced a rain-on-snow event during early November, 1989. We documented extensive bedload movement in monitored tributaries throughout the upper basin (Weaver and Fraley 1991). This type of bedload movement, especially prior to embryo "eye up," could have been highly destructive to bull trout eggs in the gravel.

Sediment levels in the North Coal spawning area remained relatively high through 1989 (37.8 percent < 6.35 mm). Predicted embryo survival to emergence remained less than 25 percent, which could contribute to a weak one-year-old age class this year.

Substrate score for the North Coal section has declined from a high of 14.2 in 1986, to 13.7 in 1987, 13.0 in 1988 and 12.3 in 1989. We obtained a substrate score of 13.2 in 1990, showing the flushing effects of the high flows during November, 1989. The declining trend continued this year; we obtained a substrate score of 12.7 for this section. Weaver (1989) discussed findings of a basin-wide sediment source survey in the Coal Creek Drainage and recommended stabilizing activities at several documented problem sites. Glacier View Ranger District personnel are treating these sites.

We estimated juvenile bull trout carryover from Age I to Age II in the Dead Horse Bridge section of Coal Creek averaged 42 percent and ranged from 25 to 60 percent during six years of sampling (Weaver 1989). Age II to Age III carryover estimates averaged 35 percent over five years, ranging from 14 to 63 percent. We were unable to satisfactorily factor in emigration of Age I and older fish, so these estimates cannot be viewed as actual age class survival. Juvenile emigration of Age I and older fish has been documented by downstream trapping, so any survival estimates should include coefficients for emigration of each age class. Eighteen percent of the bull trout smolts trapped during past studies were Age I, 49 percent were Age II and 32 percent were Age III (Fraley and Shepard 1989). We feel that emigration is probably variable annually and may largely depend on stream flows. Poor efficiency of block nets and electrofishing gear in containing and capturing Age 0 fish prevented accurate estimation of young-of-the-year bull trout, so we could not calculate Age 0 to Age I carryover.

As previously mentioned, all other 1991 juvenile bull trout population estimates remained within the range observed during past years (Table 2). We saw complete age structures (Age 0 - Age III+) in all 1991 sections with the exception of North Coal Creek. Due to the low probability of first pass capture ($\hat{p}$) associated with several estimates, we completed removal-type estimates (Zippin 1958) for South Coal and Big creeks this year. Shepard and Graham (1983b) recommended 0.60 as the minimum value of $\hat{p}$ for reliable two-pass estimates. When we handle a substantial number of fish during an effort and this minimum level of p is not obtained after two passes, we generally complete a third electrofishing pass and use the removal type estimator.

The 1991 westslope cutthroat trout population estimate for the South Fork of Coal Creek was the lowest recorded since we began sampling in 1985 (Table 3). The field crew completed a third electrofishing pass through this section due to a low p after two passes. We observed at least three age classes during this years sampling (Age I - III+), despite the low number of westslope cutthroat trout captured. We believe both resident and migratory cutthroat trout use this portion of the South Fork of Coal Creek. This section has shown very little variability in cutthroat trout abundance until this year. Possible reasons for the observed decline range from natural population fluctuations to drought-related effects or habitat degradation.

Westslope cutthroat trout abundance in the North Coal section remained within the range observed during past sampling (Table 3). The crew observed a complete age structure including young-of-the-year fish. This suggests cutthroat trout spawning must occur nearby. Weaver (1989, 1990) also reported Age 0 cutthroat trout in this section. We obtained a low p for cutthroat trout during this year's estimate in North Coal Creek; however, since we had an adequate p for juvenile bull trout in this section after two passes and a considerable period of record exists for comparison, the information to be gained by a third pass did not justify increasing the level of the 1991 effort.

Westslope cutthroat trout are present in both Big and Goat creeks, but not in sufficient numbers to calculate population estimates. Both these stream sections probably support migratory cutthroat trout. We observed young-of-the-year cutthroat trout in Big Creek's population monitoring section, suggesting cutthroat spawning must occur somewhere near this site. We also handled several one-year-old cutthroat trout in Big Creek. We have never

Table 3. Summary of annual population estimates ($\hat{N}$), 95 percent confidence intervals and probability of first pass capture ($\hat{P}$) for Age I and older cutthroat trout calculated from electrofishing in the 150 m sections specified for monitoring during 1991.

Drainage	Creek	Section	Date	$\hat{N}$	95% CI	$\hat{p}$
North Fork Flathead						
	North Coal	317 Bridge	8/04/82	40	±7	.72
			8/25/83	27	±4	.82
			8/29/84	48	±12	.50
			8/27/85	51	±36	.45
			9/03/86	40	±11	.64
			8/05/87	63	±2	.91
			8/16/88	51	±9	.69
			9/08/89	51	±9	.69
			8/27/90	39	±8	.53
			8/21/91	36	±27	.33
	South Coal	Section 26	8/28/85	63	±35	.33
			8/06/87	43	±4	.47
			8/08/88	43	±3	.83
			9/29/89	59	±10	.67
			8/27/90	41	±4	.82
			8/16/91	17	±6	.52

found this section of Big Creek to contain large numbers of cutthroat trout. The crew captured only three cutthroat trout in the Goat Creek section, representing two age classes (Age I - II). We have obtained estimatable numbers of cutthroat trout here in past years. Goat Creek supports a thriving eastern brook trout population. The 1991 estimate was 29±12 Age I and older brook trout. We handled five age classes (Age 0 - IV).

Hybridization between eastern brook trout and bull trout has been documented in Goat Creek (Weaver 1990). We recommended genetic samples be collected during future electrofishing efforts in streams where both bull trout and brook trout occur. However, we recommend these collections be made outside the sections used for annual population monitoring.

The electrofishing crew observed sculpins (Cottus spp) in all contract electrofishing sections sampled this year. We recorded what appeared to be three age classes in North Coal, South Fork Coal and Big creeks; Goat Creek appeared to have four age classes. We also found what appear to be tailed frog tadpoles (Ascaphus sp) in the North Coal, Big and Goat creek electrofishing sections.

Time-trend information collected during our ten-year study period shows considerable fluctuations in fish population statistics (Table 4). We observed a maximum annual change of over 400 percent in bull trout numbers in both the North and South forks of Coal Creek electrofishing sections; the mean annual fluctuation was approximately 130 percent.
The fact that westslope cutthroat trout populations in the same sections have not responded similarly is possibly due to differences in habitat preferences between the two species. Juvenile bull trout are extremely substrate oriented; westslope cutthroat trout typically occupy positions higher up in the water column. Changes in streambed materials would affect the substrate oriented species more strongly.

We recommend that FNF select a stream section supporting both westslope cutthroat and bull trout above which no development has occurred or is planned. This site should be annually monitored on a long-term basis to obtain a data set comparable to what is presented in Table 4. This information from an unmanaged watershed will provide better information on natural population fluctuations.

Bull Trout Spawning Site Inventories

We completed the 1991 bull trout redd counts between September 20 and October 25, under optimal conditions. Based on the number of redds observed, the 1991 spawning run appeared well below average in both the North Fork and Middle Fork drainages (Table 5 and Figure 1).

Table 4. Observed maximum and mean annual fluctuations in estimated juvenile bull and westslope cutthroat trout population sizes, total and area biomass and mean weights and lengths for electrofishing sections in the Coal Creek drainage during the period 1982 through 1990. Fluctuations are expressed as percentages of the minimum or average yearly values (maximum and mean fluctuations, respectively).

		% Fluctuation									
				Biomass							
		Number		Total (g/section)		Aereal (g/m^2)		Mean Weight (g)		Mean Length (mm)	
Creek - Section	Years of Data	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean
					Bull Trout						
North Coal	10	433	119	181	104	200	105	245	144	63	51
South Fork Coal	6	417	137	354	145	313	137	265	122	61	49
					Cutthroat Trout						
North Coal	10	133	82	114	82	204	124	156	95	42	33
South Coal	6	271	104	774	161	1050	157	249	140	34	29

Table 5. **Summary of Flathead Basin bull trout spawning site inventories from 1979-1991 in the stream sections monitored annually.**

Drainage: Stream	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	19
							Redd Numbers						
North Fork:													
Big	10	20	18	41	22	9	9	12	22	19	24	25	24
Coal	38	34	23	60	61	53	40	13	48	52	50	29	34
Whale	35	45	98	211	141	133	94	90	143	136	119	109	61
Trail	34[a]	31[a]	78	94	56	32	25	69	64	62	51	65	27
Total	117	130	217	406	280	227	168[b]	184	277	269	224	228	146
Middle Fork:													
Morrison	25[a]	75	32[a]	86	67	38	99	52	49	50	63	24	45
Granite	14	34	14[a]	34	31	47	24	37	34	32	31	21	20
Lodgepole	32	14	18	23	23	23	20	42	21	19	43	12	9
Ole	--[a]	19	19	51	35	26	30	36	45	59	21	20	23
Total	71	142	83	194	156	134	173[b]	167	149	160	158	77	97
Flathead Drainage Monitoring Count	188[a]	272[a]	300[a]	600	436	361	341[b]	351	426	429	402	305	243

[a] Counts may be low due to incomplete survey.

[b] High flows may have obliterated some redds.

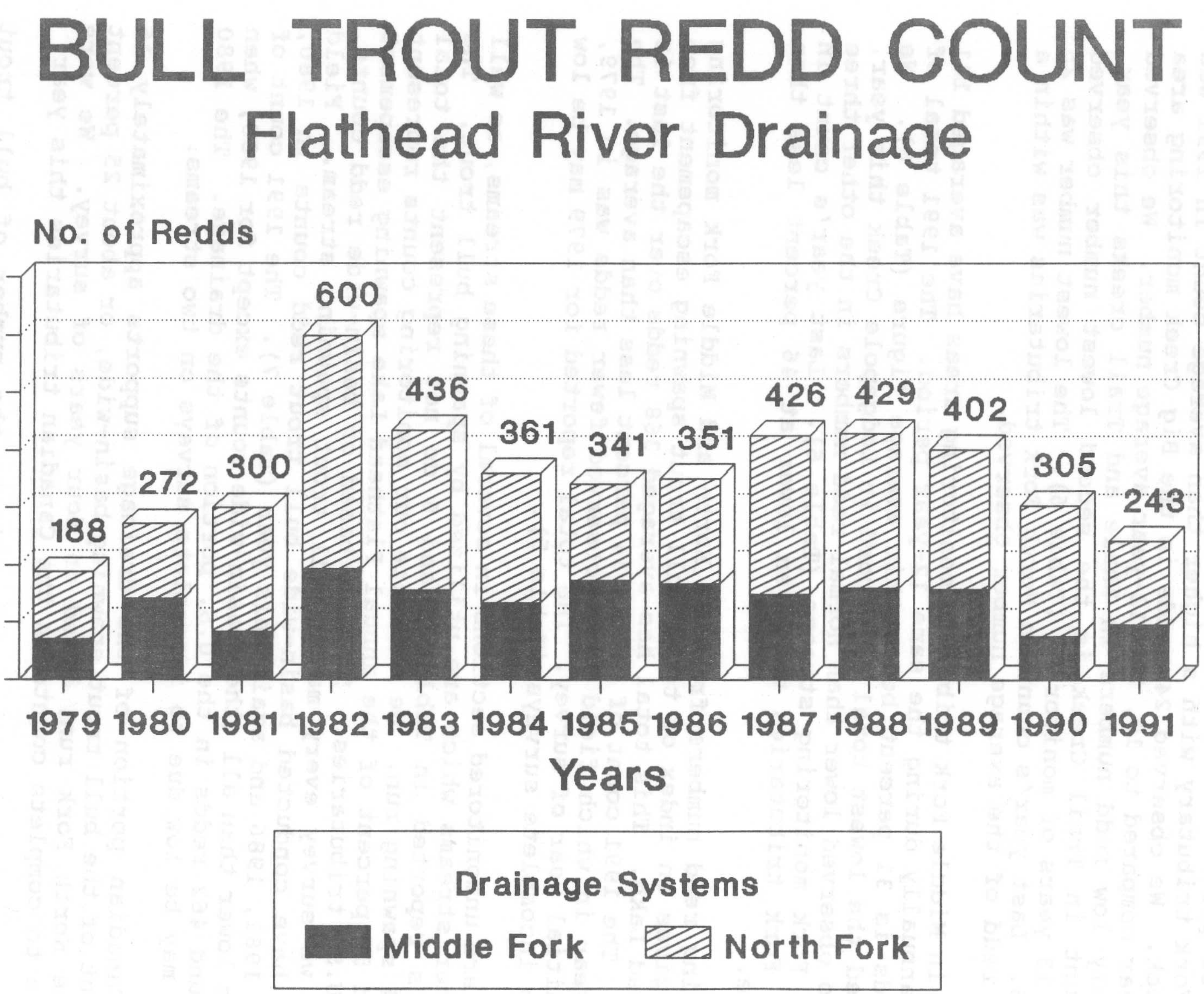

Figure 1. Results of bull trout redd counts in the annual monitoring sections in the Flathead River Drainage from 1979-1991.

North Fork tributary monitoring areas have averaged 229 redds during 12 years of annual counts (1979-1990). This year's total of 146 is 36 percent below this average figure (Table 6). The only North Fork tributary with a higher than average count in 1991 was Big Creek. We observed 24 redds in the Big Creek monitoring area this year compared to 19, the 12-year average number. We observed extremely low redd numbers in Whale and Trail creeks this year. The count in Trail Creek is the second lowest number observed during 13 years of monitoring (Table 6). The lowest number was 25 in 1985. Last year's count in North Fork tributaries was within a single redd of the average number observed.

Counts in Middle Fork tributary monitoring areas have averaged 141 redds annually during the same 12-year period. The 1991 total of 97 redds is 31 percent below this average figure (Table 6). We recorded the lowest total on record in Lodgepole Creek this year. We also observed lower than normal redd numbers in the other three Middle Fork monitoring streams (Table 6). Last year's count in Middle Fork tributaries was even lower at 46 percent less than average.

Combining redd numbers from the North and Middle Fork monitoring areas gives an index of total bull trout spawning escapement from Flathead Lake. This total has averaged 368 redds over the last 12 years. The 1991 count of 243 is 34 percent less than average. The only year in which field crews observed fewer redds was in 1979, the initial year of survey. The total reported for 1979 may be low due to incomplete surveys (Table 5).

There are unmonitored sections in several of these streams, as well as other streams which are utilized by spawning bull trout. The numbers reported in Tables 5 and 6 do not represent the total annual spawning run. We estimate our monitoring counts represent around 50 percent of the annual Flathead Lake spawning escapement into U.S. tributaries. This is based on basin-wide redd counts, where we survey every major bull trout spawning stream. Field crews have conducted basin-wide bull trout redd counts in 1980, 1981, 1982, 1986 and again this year (Table 7). The 1991 count of 516 is lower than all other basin-wide counts except for 1980, when we found 462 redds in the U.S. portion of the drainage. The 1980 count may be low due to incomplete surveys on two streams.

The Canadian portion of the drainage supports approximately 15 percent of the bull trout spawning basin-wide, or about 25 percent of the North Fork run, based on four years of survey. We were unable to complete counts on the Canadian tributaries this year.

We use basin-wide counts to estimate the number of bull trout successfully spawning in the Flathead River Drainage. We convert redd counts to approximate fish numbers by making the following assumptions: (1) the Canadian portion of the drainage supports 15 percent of the bull trout spawning; (2) we located 75 percent of

Table 6. Summary of the mean number of bull trout redds observed and the percent difference between the 1991 count and the long-term means for the stream sections monitored annually in the Flathead Drainage.

North Fork Monitoring Areas:

Creek	12 Year $\bar{x}$	Range	1991	% Difference
Big	19.2	9-41	24	↑ 25.0
Coal	41.8	13-61	34	↓ 18.7
Whale	112.8	35-211	61	↓ 45.9
Trail	55.1	25-94	27	↓ 51.0

12 year mean annual count = 229

(range = 117-406)

1991 count = 146; 36.2% lower than average

Middle Fork Monitoring Areas:

Creek	12 Year $\bar{x}$	Range	1991	% Difference
Morrison	55.0	24-99	45	↓ 18.2
Granite	29.4	14-47	20	↓ 32.0
Lodgepole	24.2	12-42	9	↓ 62.8
Ole	32.8	19-59	23	↓ 29.9

12 year mean annual count = 141

(range = 71-194)

1991 count = 97; 31.2% lower than average

Combined Flathead Lake Spawning Run:

12 year mean annual count = 368

(range = 188-600)

1991 count = 243; 34.0% lower than average

Table 7. **Summary of the number of bull trout redds observed in the U.S. portion of the Flathead Drainage during basin-wide survey years.**

	1980	1981	1982	1986	1991
North Fork:					
Big	15	24	45	12	32
Hallowat	8	14	31	3	27
Coal	48	30	95	35	42
South Coal	2	24	9	4	8
Mathias	10	10	17	10	8
Red Meadow	6	19	10	8	15
Whale	47	101	236	90	61
Shorty	4	17	56	35	6
Trail	31	82	101	69	27
Total	171	321	600	266	226
Middle Fork:					
Nyack	14	14	23	27	22
Park	--	13	0	87	19
Ole	19	23	51	36	23
Bear	9	12	23	21	23
Long	8	--	--	--	12
Granite	34	14	34	37	20
Morrison	75	32	86	52	45
Lodgepole	14	18	23	42	9
Schafer	10	12	17	30	12
Dolly Varden	21	31	36	42	23
Clack	10	7	7	16	11
Bowl	29	10	19	36	14
Strawberry	17	21	39	41	20
Trail	31	26	30	53	37
Total	291	233	388	520	290
Basin-wide Total	462	554	988	786	516

all redds; and (3) an average of 3.2 spawners construct each completed redd. We estimate that about 2,375 bull trout spawned successfully this year in the Flathead Drainage. The average estimated run during past years when we completed basin-wide counts was about 3,450 bull trout. The 1991 estimate is 31 percent below this figure.

Possible causes for the low number of redds this year range from natural fluctuations to overharvest and habitat degradation; from effects of the drought conditions during 1984-85, 1987 and 1988, to predation on young bull trout in the lake and lower river system, or a changing trophic structure in Flathead Lake. Most likely a combination of factors resulted in the decreased spawning run this year.

In general, the annual monitoring area counts reflect basin-wide trends. We observed the highest number of redds basin-wide during 1982, followed by 1986 and 1981 respectively. Field crews found fewer redds in 1980 and 1991 (Table 7). This same pattern is evident when monitoring area counts during these years are pulled out and ranked. This suggests that the information gained during the abbreviated annual monitoring counts adequately indexes basin-wide trends in spawner escapement in the Flathead Drainage.

We conducted bull trout redd counts in Swan River tributaries between September 20 and October 10, 1992. Since 1982, Elk, Goat, Squeezer and Lion creeks have been inventoried annually (Table 8 and Figure 2). The 1991 counts were the second highest on record totaling 366. This count is 44.1 percent above the 9-year average (Table 9). Only Goat Creek was below the 9-year average (Table 9).

There were 471 redds enumerated in the Swan Drainage basin-wide counts during 1991. The 366 redd total from the annually monitored streams indicates they represent 78 percent of the system total. Assuming we located 75 percent of the redds present and that 3.2 adults construct each completed redd, we estimate that 1,885 adult bull trout from Swan Lake successfully spawned in Swan River tributaries during 1991.

Spawning Area Substrate Composition

Field crews have annually sampled spawning gravel composition in both forks of Coal Creek since 1985 (Table 10). Spawning area gravel sampling in North Coal Creek shows considerable fluctuations occur here regularly. We observed a significant decrease ($p < 0.10$) in the median percentage of material smaller than 6.35 mm between 1985 and 1986. Sampling results showed no significant change between 1986 and 1987 and a significant increase ($p < 0.05$) in fine material between 1987 and 1988. We observed no significant change between 1988 and 1989 and a significant decrease ($p < 0.10$) between 1989 and 1990. The current sampling showed no significant change since 1990.

Table 8. Summary of Swan Drainage bull trout spawning site inventories from 1982-1991 in the stream sections monitored annually.

Stream	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Elk	56	91	93	19	53	162	201	186	136	140
Goat	33	39	31	40	56	31	46	34	27	31
Squeezer	41	57	83	24	55	64	9[a]	67	42	101
Lion	63	49	88	26	46	33	65	84	58	94
Total	193	236	295	109[a]	210	290	321[a]	371	263	366

[a]High flows may be obliterated some redds.

Table 9. Summary of the mean number of bull trout redds observed and the percent difference between the 1991 count and the long-term means for the stream sections monitored annually in the Swan Drainage.

Creek	9 Year $\overline{x}$	Range	1991	% Difference
Elk	110.8	19-201	140	↑ 26.4
Goat	37.4	27-56	31	↓ 17.1
Squeezer	49.1	9-83	101	↑ 105.7
Lion	56.9	26-88	94	↑ 65.2

9 year mean annual count = 254

(range = 109-371)

1991 count = 366; 44.1% above average

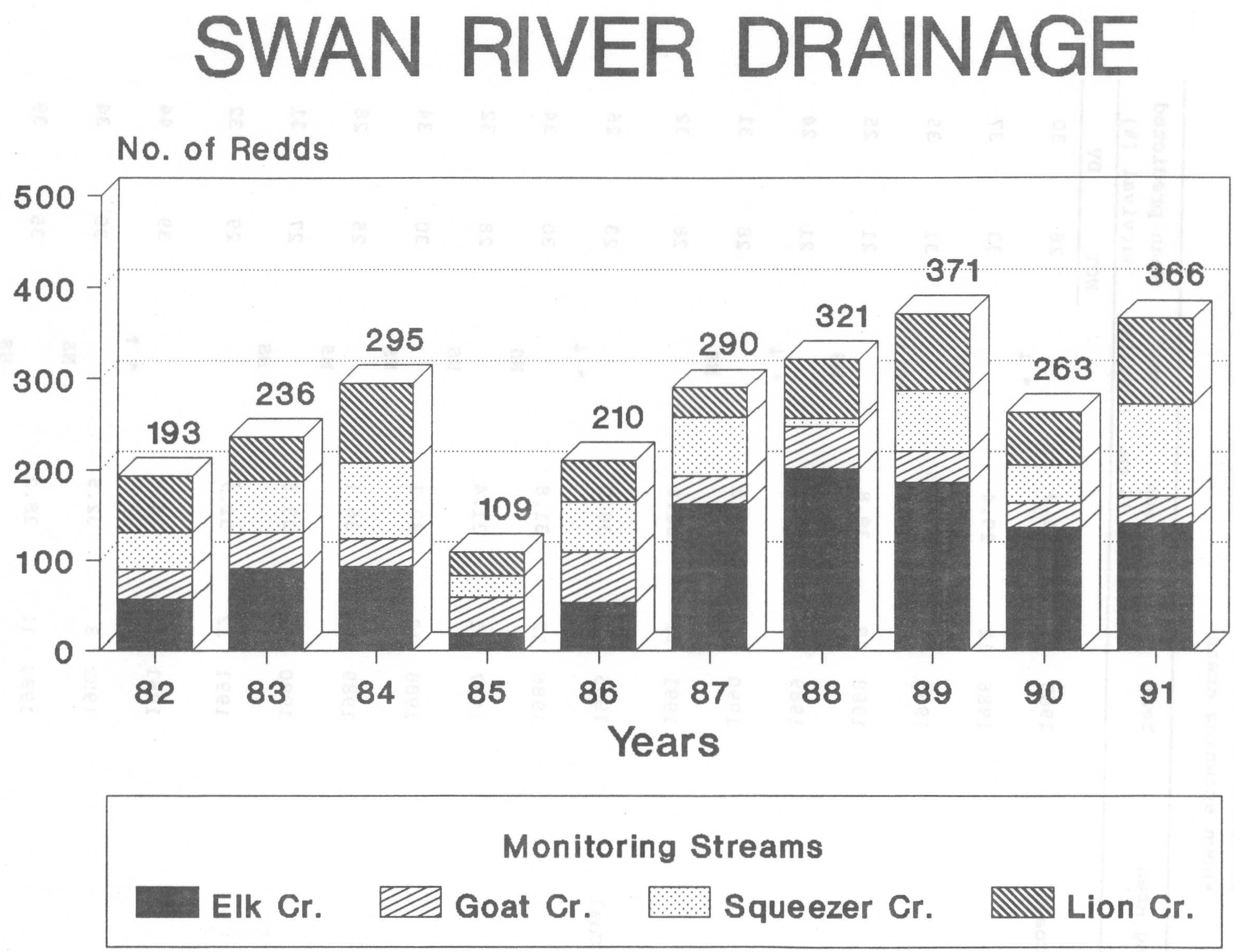

Figure 2. Results of bull trout redd counts in the annual monitoring sections in the Swan River Drainage from 1979-1991.

Table 10. Summary of annual median percentages of streambed material smaller than 6.35 mm in diameter, Mann-Whitney test results and mean predicted embryo survival to emergence, based on core sampling in known spawning areas.

Spawning Area	Year	n	Median % < 6.35 mm	Test[1/] results	Mean predicted survival (%) WCT	Mean predicted survival (%) DV
North Coal	1985	12	34.9		26	30
				* ↓		
	1986	12	29.4		33	37
				NS		
	1987	12	30.2		31	35
				** ↑		
	1988	12	39.8		21	25
				NS		
	1989	12	37.8		21	24
				* ↓		
	1990	12	32.8		28	31
				NS		
	1991	11	32.6		28	32
South Coal	1985	12	36.0		23	26
				* ↓		
	1986	12	31.8		30	34
				NS		
	1987	12	31.4		28	32
				NS		
	1988	12	32.1		30	34
				NS		
	1989	12	36.1		25	28
				NS		
	1990	12	33.6		27	31
				NS		
	1991	12	32.7		29	32
Big	1981	12	23.8		39	44
				* ↑		
	1982	8	32.5		30	34
				NS		
	1983	12	28.2		35	39
				NS		
	1984	12	27.8		34	39
				NS		

(Cont. on next page)

Spawning Area	Year	n	Median % < 6.35 mm	Test[1/] Results	Mean Predicted Survival (%)	
					WCT	DV
Big (continued)	1985	12	28.7		33	38
				* ↓		
	1986	12	21.6		43	48
				* ↑		
	1987	12	29.1		30	34
				** ↑		
	1988	12	40.3		19	22
				** ↑		
	1989	12	48.5		12	15
				NS		
	1990	12	51.8		7	8
				** ↓		
	1991	12	32.9		27	30
Jim	1988	12	41.1		17	20
				** ↑		
	1989	12	50.3		7	9
				** ↓		
	1990	12	42.4		14	17
				NS		
	1991	12	39.0		19	22
Elk	1989	12	37.6		23	27
				NS		
	1990	12	39.8		18	21
				NS		
	1991	12	35.0		26	29
					37	40
Goat	1987	12	26.7		40	44
				NS		
	1988	12	24.3		29	34
				** ↑		
	1989	8	35.0		37	42
				* ↓		
	1990	12	27.9		27	31
				NS		
	1991	12	34.1			
Fish	1986	12	20.5		--	--
				** ↑		

(Cont. on next page)

Spawning Area	Year	n	Median % < 6.35 mm	Test[1/] Results	Mean Predicted Survival (%)	
					WCT	DV
Fish (continued)	1987	12	32.8		--	--
				*↓		
	1988	12	26.3		--	--
				** ↑		
	1989	12	34.2		--	--
				NS		
	1990	12	36.8		--	--
				NS		
	1991	13	34.2			
Hungry Horse	1986	12	27.8		34	--
				** ↑		
	1987	12	35.0		27	--
				NS		
	1988	12	34.8		25	--
				** ↓		
	1989	12	29.2		32	--
				** ↑		
	1990	12	36.0		25	--
				NS		
	1991	12	36.1		26	--

[1/] * significant at the 10% level
** significant at the 5% level
↑ increase
↓ decrease
NS not significant

Timber harvest activities are occurring above our sampling station in North Coal Creek, including new road construction and major reconstruction during the early 1980s. Surveyors noted considerable natural erosion and slumping in the headwaters area as well as several management-related sediment sources (Weaver 1989). The Sequoia index for the northern fork of Coal Creek above our sampling station was 6.70 (Potts and McInerny 1990). This figure represents the percentage of the watershed disturbed by management activities during the last ten years. Predicted embryo survival has ranged from 21 to 33 percent for westslope cutthroat and from 24 to 37 percent for bull trout during the period of record (Table 10).

Streambed sampling data from the South Fork of Coal Creek suggests considerably less variability. We observed a significant decrease ($p < 0.10$) in fine material between 1985 and 1986 (Table 10). Sampling has shown no significant change in the annual median percentage of material smaller than 6.35 mm since this time.

Surveyors observed major sediment contributing areas in the South Fork of Coal drainage above a series of relatively stable beaver dams. A large amount of sediment is currently stored in the channel behind these dams. This partially explains why we observed little variability. Also, no major land disturbing activities have occurred above our sampling station since we began monitoring. The Sequoia index value for the South Fork watershed above this point is 3.90 (Potts and McInerny 1990).

A large portion of the material stored behind the beaver dams originated in a 1956 harvest unit. This fine material will likely impact spawning gravel downstream and show up in our sampling at some point after the dams fail. Consequently, we believe the ten-year recovery rate used in the Sequoia index may be inadequate and the index value for the watershed above the South Coal coring site is probably not valid. Predicted embryo survival ranged from 23 to 30 percent for westslope cutthroat and from 26 to 34 percent for bull trout during the period of record (Table 10).

The Big Creek spawning area has a continuous period of record of gravel composition dating back to 1981 (Table 10). We relocated our sampling transects on two separate occasions during this period due to changes in channel morphology, however, we always sampled areas where bull trout spawning occurred. During the first seven years of sampling, gravel composition in Big Creek's spawning area fluctuated between 21.6 percent and 32.5 percent < 6.35 mm. Samples collected in 1988 showed a significant increase ($p < 0.05$) in fine materials had occurred. We observed another significant increase ($p < 0.05$) between 1988 and 1989. The percentage of fine material increased again between 1989 and 1990, reaching the highest level observed in any Flathead spawning area. This smaller change was not significant. At this point, predicted embryo survival to emergence was 7.0 and 8.0 percent for westslope cutthroat and bull trout, respectively.

High spring flows during 1991 apparently flushed large amounts of fine material from the major spawning area near Skookoleel Road Bridge. The median value for the 1991 samples was 32.9 percent (Table 10). During bull trout redd counts in fall, 1991 we noted the stream channel from the Nicola Creek junction downstream through this spawning area showed obvious flood signs. It appeared that most of the high flow stemmed from the Nicola Creek Drainage. The crossing of Nicola Creek by Road 316 washed out during the 1991 spring runoff period.

We sampled two bull trout redds in Big Creek this year. Results indicate one contained approximately 28.5 percent < 6.35 mm, while the other contained around 40 percent < 6.35 mm. The field crew observed sac-fry in the first redd sampled indicating we hit the actual incubation/emergence environment. Predicted embryo survival to emergence from this redd was about 40 percent. Lower survival was predicted from the other redd sampled (approximately 22 percent).

This is the fourth year of annual sampling in Jim Creek at the crossing of Forest Road 888. A portion of the upper Jim Creek basin was recently developed. Timber harvest and associated road construction took place on private timberlands in the West Fork of Jim Creek during fall and winter, 1988.

The median percentage of material smaller than 6.35 mm during our initial sampling was 41.1 percent (Table 10). We collected these samples after the planned development, but prior to any runoff. A water quality monitoring program showed elevated turbidity levels below the disturbed area during spring runoff, 1989 (Water Quality Bureau 1990). A subsequent audit of best management practices identified several major departures associated with the West Jim sale (Ehinger and Potts 1990).

Our 1989 core sampling suggested a significant increase ($\hat{p} < 0.05$) in fine material had occurred several miles downstream at the 888 bridge (Table 6). Crews also collected McNeil core samples immediately above and below the timber sale area in West Jim Creek as part of the Flathead Basin Commission's cooperative study (Weaver and Fraley 1991). Samples collected above the sale area showed no significant change. We observed no change in Lion Creek, the neighboring drainage paired for comparison. However, samples from just below the sale area indicated a significant increase ($p < 0.05$) had occurred. This observed increase was the second largest annual change documented for a sampling area in ten years of sampling. We concluded that the observed change resulted from the development activity in West Jim Creek (Weaver and Fraley 1991).

It is not possible to determine whether the change we noted downstream at the 888 bridge resulted from the sale in West Jim Creek, but the timing and the magnitude of change appeared quite similar. Last year's sampling suggests a significant decrease ($p < 0.05$) since the 1989 sampling. Levels of fine material are now quite similar to what we observed prior to the West Jim Sale (Table 10). Predicted embryo survival dropped to less than 10 percent for both westslope cutthroat and bull trout during 1989 (Table 10). We saw no significant change at the Jim Creek coring site between 1990 and 1991.

This is the third year of annual sampling in Elk Creek. We saw no significant change in the percentage of material smaller than 6.35 mm since we began sampling (Table 10). Predicted embryo survival remained quite similar for both westslope cutthroat and bull trout (Table 10). The Sequoia index for Elk Creek above our sampling station is 0.00, indicating no disturbance in the watershed (Potts and McInerny 199). However, we know of major natural sediment sources and high levels of channel storage in Elk Creek below its upper fork. The Sequoia index does not consider natural sediment sources or other natural phenomena which may alter streambed conditions. Therefore, we feel that Elk Creek is not typical of spawning area streambed conditions in undeveloped watersheds in the Flathead Basin and would be extremely difficult to develop without increased sediment loading. Average gravel composition in spawning areas of undeveloped watersheds where we feel the Sequoia index is accurate was 29.8 percent smaller than 6.35 mm (range 24.8 to 33.6; $n = 7$).

The field crew has annually sampled Goat Creek since 1987 (Table 10). Our sampling site was relocated in 1989 to an area where bull trout spawning occurs annually. The significant increase observed between 1988 and 1989 may partially result from this change. We saw a significant decrease ($p < 0.10$) in fine material between 1989 and 1990 and no change between 1990 and 1991 (Table 10).

This is the fifth year of annual sampling in Fish Creek. This stream also shows considerable annual fluctuations in spawning gravel composition (Table 10). The 1990 sampling resulted in the highest median percentage of material smaller than 6.35 mm observed to date (Table 10). However, the 1990 median level was not significantly greater than what we observed in 1989. This year's results show no significant change although some minor flushing appears to have occurred.

Both the Sequoia index and H_2OY model output for Fish Creek were extremely high compared to other Flathead Basin tributaries. Over 22 percent of the watershed has been disturbed during the last ten years and current water yield is approximately 17 percent over natural (Potts and McInerny 1990). I would expect spawning gravel composition to be in much worse condition given these data. The fish species utilizing Fish Creek for spawning and rearing are generally rainbow-cutthroat hybrids; no predictive survival to emergence model is presently available.

Field crews have sampled spawning gravel in Hungry Horse Creek annually since 1986. We have observed considerable fluctuations (Table 10). Researchers had to relocate the sampling site in 1989 due to a channel change which resulted after Hungry Horse Ranger District personnel placed fill material across a side channel along Forest Road 38. Predicted westslope cutthroat trout embryo survival has ranged from 25 to 34 percent during our period of record (Table 10). No bull trout spawning occurs in Hungry Horse Creek. I observed several treatable sediment sources during westslope cutthroat trout redd counts in recent years.

Habitat Enhancement

All ten trees remained as placed in 1988 throughout the test period. Field crews annually checked the area during high flows in late May and early June. At the flows observed to date, it appears that we could have placed several of the trees further out in the channel and still kept them in place. This would have provided more cover during extremely low flow periods. Much of the cover available earlier in the test is no longer present due to loss of limbs and deposition around the trees.

We continued to observe redistribution of streambed material resulting from our activities. The upper treatment section now contains noticeably more gravel and less larger material than prior to the test. Substrate score for this section declined from 13.2 in 1988 to 12.8 in 1989, to 12.5 in 1990 and to 12.1 this year. During the 1989 redd counts we observed a spawning site associated with one of our trees. Streambed material here was too large for spawning prior to placement of the tree.

The lower treatment section has remained more stable than the upper section. Substrate scores in the lower treatment section have varied from 11.2 in 1988 to 11.1 in 1989, 11.3 in 1990 and 10.6 in 1991. We also observed a decreasing trend in substrate score for the control section (12.0, 11.8, 11.5 and 11.4 in 1988-91 respectively).

Estimated juvenile bull trout numbers and densities declined almost equally in both treatment sections as well as the control section during the first year post-treatment (Table 11). Estimates completed after the second year showed juvenile bull trout numbers and densities in the control and lower treatment sections increased similarly, while the upper treatment section continued to show reduced numbers. Densities were slightly higher in the upper treatment section than during the previous year. The 1991 estimates of juvenile bull trout numbers and densities showed a large increase over the pre-treatment estimate in the control section. We saw no change from pre-treatment estimates in the lower section. The upper treatment section continued to show declining juvenile bull trout numbers and densities (Table 11).

Table 11. **Population estimates ($\hat{N}$), densities (#/100m^2), and percent change in estimated numbers for Age I+ westslope cutthroat and bull trout in sections of the South Fork of Coal Creek selected for habitat enhancement testing.**

	Pre-treatment		First Year			Second Year			Third Year		
	(8/88)		Post-treatment (8/89)			Post-treatment (8/90)			Post-treatment (8/91)		
Section	$\hat{N}$	Density	$\hat{N}$	Density	(%)	$\hat{N}$	Density	(%)	$\hat{N}$	Density	(%)
					Bull Trout						
Control	24±2	2.5	14±2	1.4	(↓ 42)	49±17	4.4	(↑ 104)	58±7	4.4	(↑ 142)
Upper	160±6	15.2	101±16	9.9	(↓ 37)	108±22	12.8	(↓ 32)	69±22	6.6	(↓ 57)
Lower	65±4	10.3	40±4	5.7	(↓ 38)	1286	14.2	(↑ 97)	64±7	5.5	(↓ 2)
					Westslope Cutthroat Trout						
Control	43±3	4.4	59±10	5.8	(↑ 37)	41±4	3.6	(↓ 5)	17±6	1.3	(↓ 60)
Upper	20±6	2.5	13±33	1.3	(↓ 35)	10±4	1.0	(↓ 50)	--	--	(↓ --)
Lower	34±1	5.4	41±29	5.7	(↑ 20)	22±8	2.9	(↓ 35)	18±15	0.1	(↓ 47)

[1/]Percent change in numbers.

It appears that we began this test at a low point in the fluctuating juvenile bull trout population. Our estimates for the control section in 1985 was 62±8 (Table 2). The 1987 estimate of 12±2 has been the lowest observed. Although the pre-treatment estimate in 1988 increased to 24±2 (Table 2) it was still about 35 percent below the average of six annual estimates for this section.

As previously mentioned a population decrease occurred during the first year pre-treatment (1989) in all sections, then we saw an increasing trend through 1990 and 1991 in the control section. Platts and Nelson (1988) stated that a divergence in the pattern of fluctuation generally indicates treatment induced effects. Since the lower treatment section has responded similarly to the control section, treatment induced effects are not suggested here.

The results to date in the upper treatment section provide valuable information on what not to do in future efforts. This section provided optimal bull trout rearing habitat prior to the test, as evidenced by the high substrate score (13.2) and high juvenile bull trout density (15.2). By placing the trees in this area we caused rapid recruitment of gravel and finer substrate throughout the section. The large, unembedded substrate preferred by rearing bull trout which originally predominated has gradually filled in with smaller materials. This area now appears more similar to bull trout spawning habitat than rearing habitat and juvenile densities have declined by approximately 55 percent.

Although increasing spawning habitat may be a tool we can pursue in future enhancement efforts, it was not the goal of this project. At this point, it appears that placing whole trees in the channel has no effect on juvenile bull trout numbers and density in some situations and may actually have a negative influence on rearing if the site selected already provides good rearing potential.

Examination of the westslope cutthroat trout population data shows a similar pattern of fluctuation for all three sections (Table 11). Again, treatment induced effects are not suggested. An increase in estimated cutthroat numbers and densities during the first year may have resulted due to increased overhead cover, but we observed a similar increase in the control section. This probably indicates an overall increase in the cutthroat population in the South Fork of Coal Creek. As noted in the Fish Abundance section, the cutthroat trout population in South Coal Creek is at the lowest level observed to date.

We recommend further testing of rearing habitat enhancement projects. The long-term health of both westslope cutthroat and bull trout populations in the Flathead Drainage largely depends on maintenance of suitable rearing habitat. The potential for further large woody debris introduction in the existing treatment section in South Coal Creek should be explored, as should opportunities in other critical rearing drainages. Tests using boulder clusters may yield better results with bull trout.

Stream Feature Identification

These surveys showed highly unstable channel areas existed in the Big Creek Drainage above the Skookoleel Road Bridge (316E) (Appendix A). The majority of the problems observed resulted from road systems in older cutting units. Problems resulting from actual timber harvest activities are less obvious and not as large. Many of the problem areas are on private lands. Several recent slumps provide major sediment sources. Sediment resulting from old failures is still present in large amounts, causing in channel migration, deposition, and high embeddedness levels. We also identified several management-related problems on FNF lands. Again, most stemmed from the lack of SMZ's and road related problems associated with older activities.

RECOMMENDATIONS

Continuation of this monitoring program will allow a greater understanding of factors which limit fish populations in the upper Flathead Basin and how land management decisions may influence them. Based on findings in this and previous studies, we recommend the following work to be cooperatively completed by MDFWP and FNF:

1. Monitoring

   A. Continue monitoring fish populations in selected stream sections. Bull trout rearing streams with established electrofishing sections include Big, Coal, South Fork Coal, North Coal, Red Meadow, Whale, Trail, Swift, Ole, Morrison, Quintonkin, Elk, Goat, Lion, Squeezer, Piper, and Jim creeks. Established sections for monitoring westslope cutthroat populations include North Coal, South Fork Coal, Cyclone, Langford, Red Meadow, Swift, Akokala, Challenge, Hungry Horse, Margaret, Tiger, Lost Mare, Emery, McInernie, Felix, Harris, Logan, and Quintonkin creeks. Rainbow trout population monitoring sections are located in Fish and Freeland creeks.

   B. Maintain annual measurement of substrate quality in both westslope cutthroat and bull trout spawning areas by core sampling. Monitoring sites in bull trout spawning areas include Big, Coal, North Coal, South Fork Coal, Whale, Trail, Swift, Granite, Elk, Goat, Squeezer, and Lion creeks. Coring sites in westslope cutthroat spawning areas include both upper and lower Hungry Horse, Margaret, Tiger, Emery, Challenge, Cyclone, and Swift creeks. Coring sites in rainbow trout spawning areas include Fish and Freeland creeks.

   C. Continue bull trout spawning site surveys in areas recommended for annual monitoring in Flathead River and Swan River tributaries.

D. Select and monitor fish population statistics in an undeveloped watershed on a long-term basis. This stream should support both westslope cutthroat and bull trout and would provide better information on "natural fluctuations."

E. Cooperatively pursue funding opportunities to assure that sampling continues at the Flathead Basin Commission Master Monitoring Plan sites. The importance of a continuous period of record can not be over emphasized.

2. Future Data Needs

A. Identify sediment sources contributing to high levels of fine material existing in other critical westslope cutthroat and bull trout spawning areas. A detailed sediment source analysis is an excellent method to assess natural and management-related effects.

B. Investigate winter rearing habitat and groundwater influence for both westslope cutthroat and juvenile bull trout. It is possible that these may be the factors which limit fish populations in many Flathead tributaries.

C. Collect samples for genetic analysis from streams where this information is not currently available. We should try to document all pure strain westslope cutthroat trout populations and test juvenile bull trout populations which occur in sympatry with eastern brook trout.

D. Identify major spawning areas used by migratory westslope cutthroat trout. The low flow spring predicted for 1992 should provide a rare opportunity to locate spawning areas.

E. Continue testing habitat enhancement efforts in the South Fork of Coal Creek and in streams where channel stability is greater than in the South Fork of Coal Creek. Boulder clusters should be tested for enhancing bull trout rearing habitat. The original habitat evaluation should be duplicated during the 1992 field season, providing quantitative information on cover still being produced by the trees after four years.

3. Management

A. Survey the following areas in the upper Big Creek Drainage considering potential for corrective or stabilizing measures to reduce sediment input:

Area	Priority
New slump at crossing of Road 316A in the SW 1/4 of Section 14	1
Two partially plugged CMP's crossing Road 1696 in Sections 19 and 20 as well as the rest of road in the sediment contributing zone	2
Road systems in old units in Section 24 where perennial stream channels are now present	2
Cut-slope failure where road 5286 crosses Kinnimiki Creek	3
Road slump along 316 downstream from the Nicola-Big junction (Section 5)	3
Sediment trap with accessible clean out at the upper crossing of Big Creek by Road 1696	3
Water bars on Road 316 in the SW 1/4 Section 10 and NE 1/4 Section 11	3
Slumping draw and wet spot in Road 316 near the concrete bridge over Nicola Creek in NE 1/4 Section 10	3
Potential fish migration barriers in Big Creek in Section 12 and at junction of tributary in Section 14	4
Potential areas for placement of large woody debris or other channel stabilization structures in the head ends of tributaries to upper Big and Nicola Creeks	5

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APPENDIX A

Narrative description of stream features in the Big Creek Drainage upstream from the crossing of Road 316E during 1991

This survey began in the headwaters of Big Creek in Section 20, T32N, R21W. We proceeded down the Big Creek Drainage surveying side drainages as we encountered them. Major tributaries surveyed included Nicola, Lakalaho, Kinnimiki and Skookoleel creeks. We split the surveyed area into three subareas for this narrative:

1. Headwaters downstream to the boundary between sections 14 and 11.

2. Boundary between sections 14 and 11 downstream to the junction with Nicola Creek, including Nicola Creek Drainage.

3. Nicola junction downstream to the Skookoleel Creek road crossing (316E), including Lakalaho, Kinnimiki and Skookoleel creeks.

The narrative for each of these subareas is further partitioned into discussions of overall physical characteristics, road systems and stream channel characteristics.

Subarea 1 - Headwaters to section line between 14 and 11.

Physical Characteristics

Large portions of sections 14, 23 and 24 in T32N, R22W and Sections 19 and 20 in T32N, R21W are privately owned. The U.S. Forest Service manages all other lands surveyed. Areas on the north side and most of the southern side of Big Creek downslope from Road 316 has been logged from the headwaters downstream to the boundary of sections 14 and 11. Stream Management Zones (SMZ's) are generally non-existent throughout these old cutting units. The road system in these old units has generally revegetated, however, in several areas runoff and/or groundwater has concentrated forming "tire track" stream channels, with defined bed and banks. These channels were flowing water when I surveyed the area in early September, 1991. The presence of aquatic invertebrates in these channels suggests that they flow yearlong. These channels increase the drainage density in the headwaters of Big Creek, enhancing efficiency of water delivery to the main Big Creek channel. Although these old units and their road systems have recovered vegetatively, hydrologic recovery is no longer possible.

Several ski runs and one chairlift currently exist in the headwaters area of Big Creek. A considerable amount of new development associated with the ski area is now under consideration.

Road System

Roads in the headwaters area include 1696, 316 and 316A. Road 1696 crosses the chairlift at its lower terminal site. A high flow channel is evident looking up the lift line from this crossing. Some erosion has occurred in this channel. A large amount of fill has been placed on an 18" CMP where this channel passes under the lower terminal. A pipe failure here could result in large amounts of this fill going into Big Creek. If the lower terminal site is relocated during the Big Mountain expansion project, I recommend removing this CMP and the fill material present. The channel below the lift landing shows signs of high water yields.

Some cut slope erosion is evident on Road 1696 at the road junction just passed the chairlift. A water bar is needed in Road 1696 above the CMP at the switchback in the center of Section 24. The next channel crossing on 1696 is a 36" CMP. This channel shows only minor high water damage although most of the fine material is gone. The next channel crossing on Road 1696 is main Big Creek. Deposition is evident here above a 36" CMP. This would be a good place for a drop structure or sediment trap with road accessibility for removing the deposited material. Another channel crosses 1969 just beyond here, where considerably more material has recently moved through an 18" CMP. This pipe is partially blocked by vegetation and trapped streambed materials at the inlet. The next crossing on Road 1969, the existing CMP is not in what appears to be the present channel. The next crossing of 1969 has deposited material partially blocking the inlet to a 18" CMP. This channel transports considerable amounts of water during high flows. I observed water flowing in this channel immediately below the pipe. Road 1696 confines the Big Creek channel in several spots in sections 24 and 14. There was a cut slope failure and material side cast along the channel near the junction of Big Creek and the small drainage in Section 14.

Road 316A joins 1696 in the SW concern of Section 13. The Big Creek crossing of 316A near this junction washed out some time ago. Big Creek now passes through a 60" CMP. Fish could easily pass through this pipe. Increased water yield in the drainage above here could result in channel instability and another washout at this crossing. The next stream crossing 316A looks stable now, but probably contributed sediment in past years. We located a major new slump at the second tributary crossing on 316A in the SW 1/4 of Section 14. This area was potentially the worst spot we documented this year. Road 316A crossed one more tributary in SE 1/4 Section 15. We observed excessive old logging debris in the channel near this crossing and an old log deck. Perhaps these logs could be used to disperse sediment storage throughout the channel in this area.

We noted a wet spot in Road 316 0.3 miles west of the chairlift crossing. The survey crew saw no other problems with the drainage and stream crossings on Road 316 in the upper Big Creek Drainage.

APPENDIX B

Log of photos taken during sediment source surveys in the Big Creek Drainage during late summer and fall, 1992

BIG CREEK SEDIMENT SOURCE SURVEY

Summer-Fall 1991

Roll #1

1	Big Creek Drainage - Skookoleel Creek in the distance
2	Headwaters of Big Creek
3	Headwaters of Big from the foot of chairlift
4	Lift line up back side of Big Mountain
5	Channel below the CMP under the base of the lift
6	Eroding road junction just past the chairlift (1696)
8	2nd crossing below lift on 1969 - lots of deposition ↑ CMP
9	Channel junction - ski hill #1 and main Big
10	Channel junction - ski hill #2 and Big
12	Equipment in channel during old logging operation
13	Channel junction - ski hill #3 and Big
14	Same shot from above
16	Equipment in channel - old - unstable banks
17	Channelization during old logging
18	Washout due to road system in old unit
19	Old roads in unit above #18
20	Deposition on windthrow - mostly due to roads
21	Old roads in unit
22	Old roads in unit
23	Old roads in unit
24	WCT
26	Crossing of 316A 5′ CMP ≈ 80′ long - no barrier
27	Crossing of 316A
29	Just below the 316A crossing - lots of dep. and braid

Roll #2

2	Washout of 316A crossing - old
3	Existing fill - 316A crossing - high flow may pass
4	Slump in 2nd wetted draw crossing - 316A
5	Slump in 2nd wetted draw crossing - 316A
6	Slump in 2nd wetted draw crossing - 316A
8	Big Creek Drainage above Nicola
9	Units in Big Creek above Nicola - no SMZ
10	Units in Big above Nicola - no SMZ
11	Headwaters of Big Creek - upper basin shot
13	Old logging debris in unnamed trib. to Big
14	Unit in unnamed trib. to Big; Note: Debris and slumps

15 Unit in unnamed trib. to Big
17 Channel junction - unnamed trib. to Big Cr.

18 Channel below this junction; Note: absence of recruitable LOD
19 Channel in other fork - debris will go soon and no new available
20 Slump in 316A - 2nd channel
22 Slump - 316A
23 Slump - 316A
24 Slump - 316A
25 Slump - 316A
26 Slump - 316A
27 Slump - 316A
28 Channel below slump in 316A
29 Channel below slump in 316A
30 Channel below slump in 316A
31 Channel below slump in 316A

Roll #3

1 Bedrock chute in slump channel - 500 paces ↓ slump
2 Deposit on windthrow in slump channel
3 Another smaller slump in same channel
4 Same channel; note: no potential for LOD recruitment
5 1,000 paces below the 316A crossing - slump channel
6 Possible barrier in this channel - management related!
7 2.0 m high falls - possible barrier - management related!
8 logging debris in channel - slump channel
9 Inflow from cutting unit just above Big Cr. jct. - roads!
10 Inflow into slump channel and Big Cr. - roads!
11 Big Creek near the jct. of slump channel - road 1696
12 Barrier at mouth of slump channel
13 Big Creek below this junction and above Nicola Creek
14 Big Creek above Nicola - massive depositional area

Roll #4

1 Deposition - Big Creek above Nicola
2 Old crossing on Big Creek above Nicola
3 Potential barrier above Nicola Creek
4 Potential barrier above Nicola Creek
5 Same shot - Big ↑ Nicola
6 Same shot - Big ↑ Nicola

8	Nicola junction - blown out, deposition and braiding
9	Nicola junction - new debris accumulation
11	Nicola crossing - 316 ↓ blowout
12	Main Nicola from gate on 1692
13	Nicola above 1692
14	Nicola below 1692
15	Nicola junction with Big Creek s below these units

Roll #5

1	Trib. to upper Nicola - north side and 1692 crossing
2	Trib. to Nicola - crossing of 1655
3	Crossing of 316 over this trib. - pipe needs work!
4	Crossing of 316 over this trib. - needs water bar!
5	Crossing of 5287 over this trib. - looking ↓ 48" CMP
6	Crossing of 5287 looking ↑ 48" CMP
7	Main Nicola crossing of 316 - Section 10
8	Below the 316 crossing of Nicola Creek in Section 10
9	Junction of trib. from Section 16 with Nicola Creek
10	Road 316 ditch just above the concrete bridge over Nicola Creek
11	Spring channel at the Nicola Bridge - 316
12	Crossing of 316 over Nicola Creek - Bridge
13	Crossing of 316 over Nicola Creek
14	Sluice out opposite spring inflow into Nicola Creek

Roll #6

1 & 2	Nicola above lowest crossing of 316 - ↑ H_2OY
3	316 crossing of Nicola - this is the new CMP - 1991
4	Slump along 316 just below Nicola crossing - 1st bull trout redds
5	Big Creek below Nicola - unstable channel area due to runoff
6	Big Creek below Nicola - unstable channel area due to runoff
7	Big Creek below Nicola - unstable channel area due to runoff
9	Big Creek below Nicola - unstable channel area due to runoff
10	Big Creek below Nicola - unstable channel area due to runoff
11	Big Creek below Nicola - unstable channel area due to runoff
12	Big Creek below Nicola - unstable channel area due to runoff
13	Big Creek below Nicola - unstable channel area due to runoff
14	Mouth of Skookoleel Creek

Roll #7

1	Ridgeline between Skookoleel and Kimmerley creeks
2	Canyon Creek Drainage from Smokey Ridge
3	GNP in background - Smokey Ridge
4	Headwaters in Skookoleel Creek
5	Into Skookoleel Creek - Section 14 and 15
6	Across Skookoleel Creek - Section 14 and 15
7	Skookoleel Creek Drainage
8	East side Skookoleel Drainage
9	Skookoleel Creek Drainage
10	Skookoleel Creek Drainage
11	East ridge - Skookoleel Creek
12	Looking down Skookoleel into Elelehun in distance
13	Looking down Skookoleel into Elelehun in distance
14	Headwaters of Skookoleel

Roll #8

1	Lake in Kimmerley Creek - GNP in distance
2	Slurry bomber dumping a load on a small fire in McGinnis
3	Looking down the North Fork from Kimmerley
4	Skookoleel Creek
5	Skookoleel Creek East Bridge
7	NF from Smokey Ridge
8	NF from Smokey Ridge
9	Lake in Kimmerley
10	From road 5286
11	Elelehun from road 5286
12	Road 5286 - Kinnimiki Creek
13	Kinnimiki Creek Drainage
14	Kinnimiki Creek Drainage

Roll #9

1	Elelehun Creek Drainage from road 5286
2	Elelehun Creek Drainage from road 5286
3	Elelehun Creek Drainage from road 5286
4	Elelehun Creek Drainage from road 5286
5	Kinnimiki Drainage from 5286
6	Kinnimiki Drainage from 5286
7 - 10	Crossing of 5286 - Kinnimiki Creek
11 - 12	Skookoleel Creek crossing 5286
13 - 14	Skookoleel Creek Drainage