Kalispel Resident Fish Project

Habitat

Annual Report
2002

DOE/BP-00004574-1

March 2003

This Document should be cited as follows:

Andersen, Todd, Jason Olson, ''Kalispel Resident Fish Project'', Project No. 1995-00103, 121 electronic pages, (BPA Report DOE/BP-00004574-1)

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This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

KALISPEL RESIDENT FISH PROJECT

ANNUAL REPORT

2002

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BONNEVILLE POWER ADMINISTRATION,
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PROJECT NUMBER 1995-00-100

CONTRACT NUMBER 95-BI-37227

Executive Summary

In 2002 the Kalispel Natural Resource Department (KNRD) continued monitoring enhancement projects (implemented from 1996 to 1998) for bull trout (*Salvelinus confluentus*), westslope cutthroat (*Oncorhynchus clarki lewisi*) and largemouth bass (*Micropterus salmoides*). Additional baseline fish population and habitat assessments were conducted, in 2002, in tributaries to the Pend Oreille River. Further habitat and fish population enhancement projects were also implemented in 2002.

Acknowledgments

We would like to thank Glen Nenema (Chairman, Kalispel Tribal Council), the Kalispel Tribal Council and members of the Tribe for providing the support and the opportunity to conduct this project. Special thanks goes to Joe Maroney (KNRD Fisheries Program Manager) for technical and administrative support and assistance. The U.S. Department of Energy, Bonneville Power Administration, provided financial support for this project, contract number 95-B1-37227. Special thanks also to Ron Morinaka (Contracting Officer Technical Representative). The Kalispel Natural Resource Department provided field support and equipment.

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INTRODUCTION

Fire history, past timber harvest activities, and dams have influenced the landscape in the Lower Pend Oreille Subbasin. The subbasin was first logged from 1915 to 1930 and much of the old-growth timber was removed. Logging railroad and log flumes were used on the mainstem Pend Oreille River and several of its tributaries. Log flumes were common, simplified the instream habitat, and decreased the recruitment source of large woody debris. In more recent years, road construction and maintenance, timber harvest, and cattle grazing have degraded stream habitat conditions. Numerous forest fires occurred between 1910 and 1929 and impacted many watersheds. From 1917 to 1929, an estimated 60 to 70% of the LeClerc Creek watershed burned. The largest fire in the LeClerc Creek watershed occurred in 1929.

The fish assemblage existing today in the subbasin is drastically different from pre-dam development. Due to the construction of Grand Coulee Dam, anadromous fish have been extirpated and over 1,140 linear miles of spawning and rearing habitat in the Upper Columbia River System were eliminated (Scholz et al. 1985). The five dams on the lower Pend Oreille River are also believed to be a significant reason for the decline of native salmonid populations. These dams include Waneta (Canada), Seven Mile (Canada), Boundary (U.S.), Box Canyon (U.S.), and Albeni Falls (U.S.). None of these dams were built with fish passage facilities. Other dams and diversions such as Cedar Creek Dam, Sullivan Lake Dam, Mill Pond Dam, North Fork Sullivan Creek Dam, and Calispell Pumps were constructed in Pend Oreille River tributaries and further fragmented the connectivity of native salmonid populations.

In an attempt to partially mitigate for the resident and anadromous fish losses caused by hydropower development and operation, the Northwest Power Planning Council (Council) called for recommendations to develop a program that would provide measures to protect, mitigate and enhance fish and wildlife affected by the construction and operation of hydroelectric facilities located on the Columbia River and its tributaries. The Tribe, in conjunction with the Upper Columbia United Tribes (UCUT) Fisheries Center, undertook a three-year assessment of the fishery opportunities in the Pend Oreille River (Ashe et al. 1991) to provide the Council with recommendations. Assessment findings indicated that trout species were rare in the reservoir and compose less than 1% of the total abundance. Brown trout (*Salmo trutta)* were the most abundant trout species. Factors limiting trout production in the reservoir were identified as warm water temperatures, lack of habitat diversity and food availability. Trout were more abundant in the tributaries to the reservoir, which mostly supports brook trout *(Salvelinus fontinalis)* and brown trout; however, westslope cutthroat *(Oncorhynchus clarki lewisi)*, rainbow *(O. mykiss)*, and bull trout *(Salvelinus confluentus)* were also captured.

Ashe et al. (1991) also found that largemouth bass *(Micropterus salmoides)* comprised approximately 3-4 percent of the total fish population in the reservoir. Results indicate that growth rates of largemouth bass during the first four years in the Box Canyon Reservoir were lower than bass from other locations of the northern United States. The slower growth rates combined with a high rate of juvenile mortality associated with lack of overwintering habitat have reduced the potential for the bass population in the reservoir.

Bennett and Liter (1991) described the fish communities in Box Canyon Reservoir, the sloughs, and tributaries and examined factors that could limit game fish production. Their findings determined that factors such as warm water temperatures and thermal barriers at the mouths of sloughs limited native trout. They estimated that overwinter survival of age 0^+ largemouth bass in Box Canyon Reservoir ranged from 0.4-3.9%. It was suspected that poor overwinter survival is partially due to the lack of cover during the winter months.

Ashe et al. (1991) provided recommendations based upon these findings for enhancing fishery opportunities. Recommendations include: 1) construct an off-site rearing facility to supplement the number of juvenile largemouth bass within the Box Canyon Reservoir; 2) enhance tributary populations of native trout, and; 3) increase the amount of overwinter habitat in the reservoir. Bennett and Liter (1991) suggested similar management possibilities in the Box Canyon Reservoir such as supplementation of largemouth bass to enhance recruitment and introduction of a predator species to take advantage of the extensive forage base.

The recommendations from Ashe et al. (1991) were adopted and incorporated into the 1994 resident fish and wildlife section of the Council's Program and were further revised in the Council's 1995 Program. These recommendations called for:

1) Restoring tributary populations of native cutthroat and bull trout, and

2) Enhancing the largemouth bass population to provide a quality sport and subsistence fishery in the reservoir.

These goals may appear to conflict, but there is a dramatic difference in habitat between the tributaries and Box Canyon Reservoir. The Box Canyon reach of the Pend Oreille River was formed in 1955 by the construction of Box Canyon Dam. The dam changed the riverine habitat in this reach to habitat typical of a broad, shallow reservoir. The resulting high summer water temperatures exceeded Washington Department of Ecology temperature standards on a regular basis. This change in habitat made favorable conditions for warmwater species. Ashe et al. (1991) and Bennett and Liter (1991) concluded that yellow perch is the most abundant species in Box Canyon Reservoir. The other species in descending order based on relative abundance are pumpkinseed, tench, and largemouth bass. Trout species are rare and of the trout species present, brown trout are the most abundant. Tributary trapping data suggests that brown trout is the only trout species in Box Canyon Reservoir having an adfluvial population (KNRD et al., 2001). Temperature conditions limit the distribution of native trout in the reservoir. Bull trout have optimal rearing temperatures of 7-8^{0}C (Goetz, 1989) and temperatures exceeding 15^{0}C are thought to limit distribution (Fraley and Shepard, 1989, Goetz, 1991, Pratt 1985). In Box Canyon reservoir, bull trout are limited to microhabitats in cold water springs, or metalimnion areas. Bull trout require spawning areas with clean gravel and temperatures ranging from 5-9^{0}C; these conditions do not exist in the reservoir. Conversely, largemouth bass have optimum temperatures of 13-26^{0}C and will select habitats in the littoral zone where temperatures exceed the optimum for bull trout. Thus, habitat overlap between native trout and largemouth bass is unlikely and interaction very unlikely (NEPA Doc, 1996).

Cutthroat and bull trout populations residing in the tributaries need to be protected since these appear to be the remaining populations in the Lower Pend Oreille Subbasin. The greatest impacts to these populations include: 1) habitat degradation from past land use activities; 2) habitat fragmentation and loss of connectivity due to man made structures; and 3) hybridization and competition from introduced species. Genetic analysis conducted by the Washington Department of Fish and Wildlife (WDFW) showed that Pend Oreille River tributary populations of westslope cutthroat trout were genetically distinct from one another (Shaklee and Young 2000). Of the eight tributaries surveyed in the initial year of the project, none have been stocked with hatchery fish since 1978. Four of the eight have not been stocked since the 1940's. Although relative abundance is low, genetic analysis and stocking records suggest these cutthroat trout populations are sustained without hatchery supplementation.

Isolation due to the fragmentation of native populations is likely to increase the risk of extinction through both environmental stochasticity and lack of genetic variation (Rieman and McIntyre 1993; Lacy 1987). Degraded habitat resulting in poor complexity further increases the risk of extinction for small, isolated populations because refugia from extreme environmental events are lacking (Pearsons et al. 1992, Saunders et al. 1990; Sedell et al. 1990). Hilderbrand and Kershner (2000) estimated that 8 km of stream length are required to sustain an isolated population of cutthroat trout with high abundance (0.3 fish/m).

Interactions with non-native species have also had an impact on resident populations of westslope cutthroat and bull trout. Brook trout X bull trout hybridization appears to be the most prevalent problem in isolated populations (Markle 1992). Competitive interactions with introduced species (mainly brook trout) have likely contributed to depressed cutthroat trout populations in the Lower Pend Oreille Subbasin. Of the streams surveyed by the Kalispel Natural Resource Department (KNRD) in the Lower Pend Oreille Subbasin, the highest cutthroat trout densities have been observed in streams and headwater reaches where brook trout were absent. Several studies indicate that abiotic factors (e.g. water temperature and velocity) may determine which trout species will be dominant in a given length of stream (De Staso and Rahel 1994; Griffith 1988).

The habitat restoration portion of this project primarily addresses factors that limit native tributary populations. Our in-channel restoration increases habitat complexity which provides refugia during extreme environmental events and, therefore, lowers the extinction risk for the targeted populations. The Kalispel Tribe (Tribe) recognizes that instream habitat restoration is a temporary solution to habitat degradation and that recovery will only occur when future human impacts are minimized and watershed processes are restored. The Tribe has and will pursue opportunities for watershed restoration projects. However, watershed restoration will not yield significant improvements for years or decades. The Tribe also recognizes that some of the native fish populations in the Lower Pend Oreille sub-basin will not persist for years or decades. In some watersheds, individual native fish sightings are rare or populations are isolated in small tributaries. Restoration attempts to increase the habitat attributes that are limiting while the brook trout removal portion of this project will eliminate the threats associated with competition and hybridization with the native populations.

In summary, KNRD's plan for recovering native salmonid populations is:

1. Perform baseline stream habitat and fish population assessments to determine current distribution and abundance and identify core watersheds where recovery efforts will be focused.
2. Work to protect existing native populations and good habitat through participation in regional policy setting groups and consultation with area land, fish, and wildlife management agencies.

3. Pursue funding from various sources and participate jointly with other agencies in watershed restoration projects.
4. Implement instream and riparian restoration in identified recovery areas.
5. In recovery areas with non-native populations: 1) capture and relocate native fish, 2) treat streams to remove non-native species, and 3) translocate genetically identical or similar native fish from sister watersheds.
6. Monitor restoration and adapt management plans if needed.

The Kalispel Resident Fish Project began in 1995 with the selection of the study tributaries, habitat assessments, and assessment of fish populations in those tributaries. These baseline surveys showed that fish habitat is generally poor due to a lack of large woody debris, lack of pool type habitat, and high volumes of fine sediment. As a result of these conditions, rearing, spawning, and winter habitat were identified as limiting factors to fish populations in most reaches.

Based on the assessments taken during that initial field season, a process was developed to filter out the reaches of those tributaries that contained the most numerous limiting factors to fish habitat quality and quantity (KNRD & WDFW 1997a). A set of recommended enhancement measures was subsequently developed for each of these reaches that are intended to address the specific habitat shortcomings. This list of recommendations was implemented during field season 1996 and became the core for additional recommendations for 1997 and 1998. Field season 1998 was the last year of implementation for recommended enhancement measures on the seven designated study tributaries. Post assessments of habitat and fish populations were conducted the year following implementation and on an annual basis thereafter.

2002 marked the fourth, fifth, and sixth years of conducting monitoring and evaluation on structures that were implemented from 1996 to 1998. Comparative analyses of changes in habitat attributes and changes in fish abundance using graphical displays were conducted following the 2002 field season. Also, the monitoring data has been examined for trends that may indicate which specific types of enhancement measures provide the greatest increase in habitat quality and quantity. However, at this point in the project no detailed analysis and interpretations have been performed and past annual reports have only discussed trends. It is difficult to distinguish the effects of the restoration among many interacting factors and great natural variability within the physical and biological components of the ecosystem. Also, much of the restoration implemented may not yield results for several years or decades. More monitoring needs be performed to minimize the variability in both habitat and fish abundance data.

The Upper Columbia United Tribes Fisheries Center conducted a three-year baseline study to assess the fishery improvement opportunities on the Pend Oreille River (Ashe 1994). Based on earlier estimates of aquatic macrophyte community composition (Falter et al. 1991) and limited overwinter survival of 0^+ largemouth bass (Bennett and Liter 1991), they suggested that the winter reduction in macrophyte communities created higher predation rates on 0^+ bass. This led to their recommendation for the construction and placement of artificial cover structures to increase the amount of winter cover available in the reservoir. Baseline species abundance were determined by electrofishing the selected treatment and control sloughs prior to structure placement. In 1997 100 Berkley artificial structures and 100 Pradco artificial structures were constructed and placed in the study sloughs. Treatment and control sloughs have been sampled twice annually since implementation of the habitat structures. In 2002, data continued to be examined to determine: 1) if artificial structures may provide the missing winter cover component, and 2) if a difference exists between the efficacy of the Pradco and Berkley structures.

TRIBUTARY HABITAT AND FISH POPULATION ASSESSMENTS

DESCRIPTION OF STUDY AREA

Habitat and snorkel surveys were conducted in Tacoma Creek and eight of its tributaries (Figures 1 and 2). The watershed is located on the west side of the Pend Oreille River and Tacoma Creek flows into the river approximately 5.5 Km north of the town of Cusick, Washington. During periods of high flow, up to 5 Km of the lower Tacoma Creek channel and floodplain are inundated due to backwater effects of the Pend Oreille River. Tacoma Creek has a drainage area of 186 Km^2; the third largest watershed in the Box Canyon reach of the Pend Oreille River. Mean annual flow in the lower creek is 1.0 m^3/s. The dominant geology in the upper watershed is Philips Lake granodiorite while the middle and lower watershed are mostly comprised of glacial and alluvial deposits.

METHODS

Stream and fish population survey methodologies used within the Box Canyon Reach were similar to those developed by Espinosa (1988) and further revised by Huntington and Murphy (1995). Habitat data survey were collected in two ways: 1) at a transect directly perpendicular to the stream thalweg, and 2) in the 30 m interval that separated adjacent transects. Primary pools, spawning habitat, unstable banks, and acting woody debris were identified and enumerated in the entire length of each 30 m stream segment between two transects. Data for the remainder of the habitat attributes (Table 1) were collected at the end of each 30 m segment: the actual transect site. Reaches were defined by lengths of stream channel with common confinement, gradient, and substrate (Rosgen, 1994). Breaks between two homogeneous areas defined a new reach. Reach overviews were completed at the end of each reach; these contained written descriptions of prominent features and/or potential impacts to habitat quality. Each reach was permanently marked, flagged and geo-referenced using a Trimble Geo-explorer III receiver.

Temperature loggers were placed in the lower portion of each stream and recorded temperature on hourly intervals. Loggers were also placed in the middle and/or upper sections of some of the larger streams.

Fish density estimates for baseline surveys were collected using standard snorkel survey techniques (Espinosa 1988). Sampling was conducted during the period from July 15 through September 30. Population density was addressed by number, size (age class) and species of fish per 100 m^2. The standard size/age classes for salmonid species (Table 3) were determined according to Espinosa (1988). Lengths of baseline snorkel stations were 100 m and selected so that the area snorkeled is representative of the reach. Fish stations were permanently marked and flagged using aluminum tags and flagging.

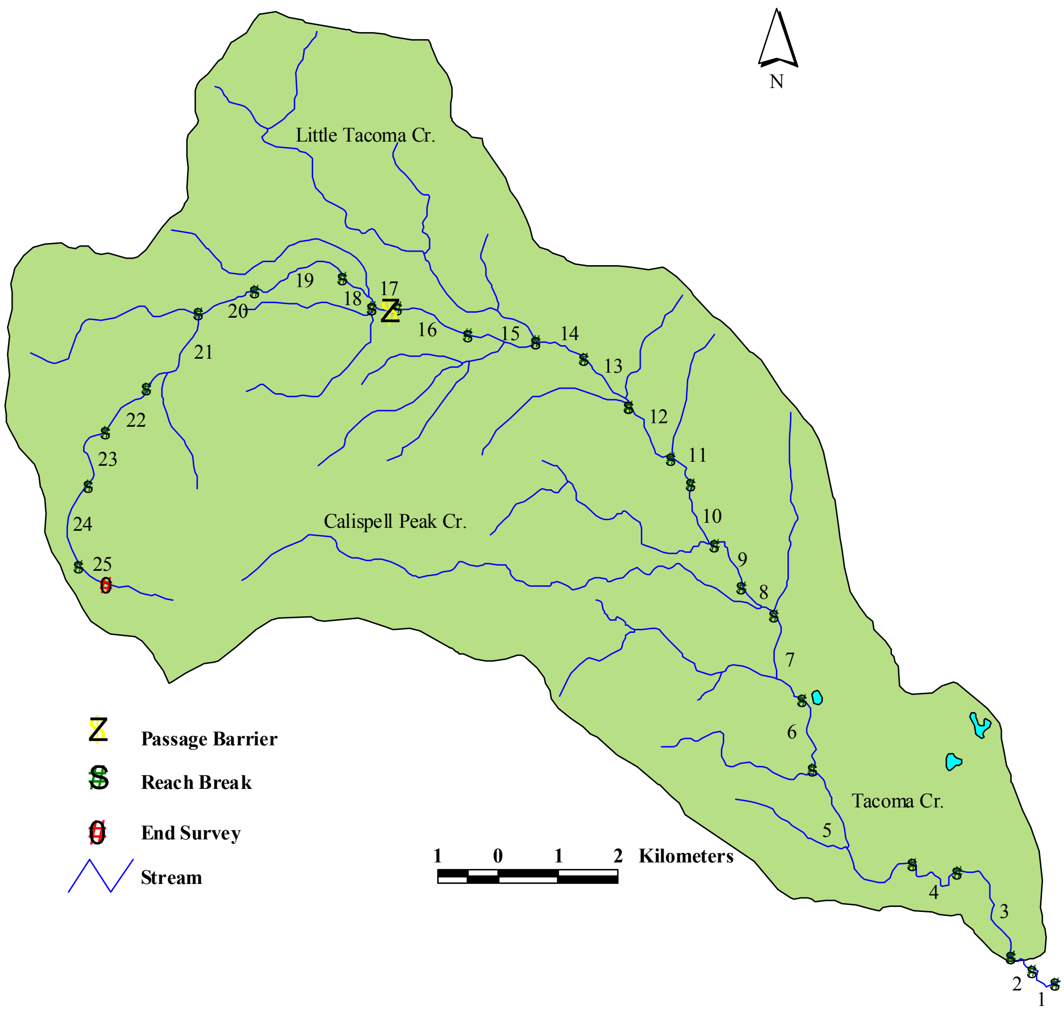

Figure 1. Location of the reaches surveyed in Tacoma Creek.

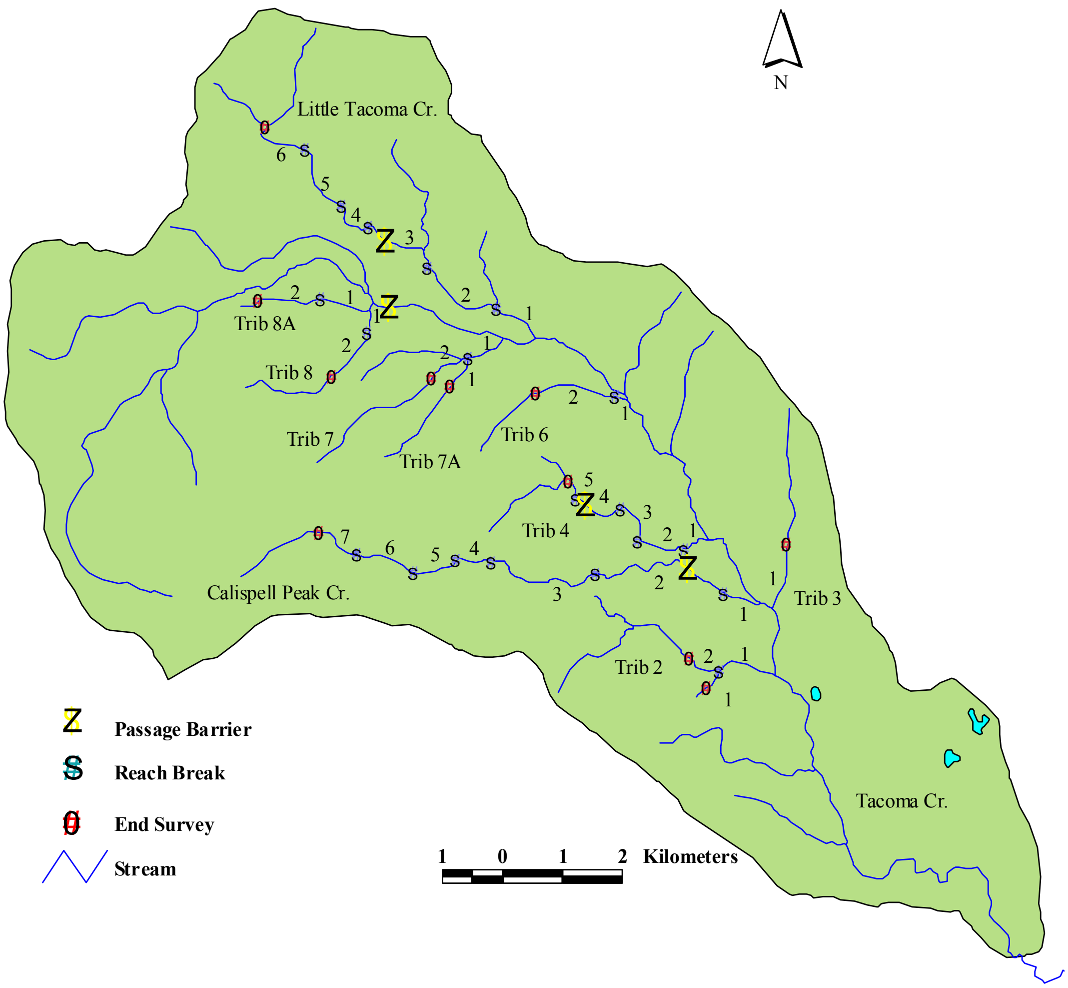

Figure 2. Location of Tacoma Creek tributaries and the reaches surveyed.

Table 1. Transect variables and method of collection.

Variable	Method of collection
Habitat Type	Visually determine habitat types (i.e., pool, riffle, glide, pocketwater, run, alcove).
Dominant Substrate Size	Visually determine largest percentage of substrate for that habitat type (i.e., silt, sand, gravel, cobble, boulder, bedrock).
Habitat Function	Visually determine habitat functions (i.e., winter, summer, spawning or unusable).
Spawning Gravel Amount and Quality	Estimate potential square meters of spawning gravels between transects and rate quality (i.e. gravel size, location and current velocity Kalispel internal doc.1-95) Good = All criteria met. Fair = 2 criteria met. Poor = 1 criteria met.
Stream Depths	Measure depth at 1/4, 1/2, 3/4 across channel to the nearest cm.
Habitat Widths	Measure each specific habitat type in a transect to the nearest 0.1m.
Primary Pools	Number of pools with length or width greater than the avg. width of stream channel between transects.
Pool Quality	Rating based upon collection of length, width, depth, and cover.
Pool Creator	Identify item creating the pool (e.g., large woody debris, boulders, beaver, enhancement, other).
Cobble Embeddedness	Visual estimate of the percentage fine or coarse sediment surrounding substrate at transect. Actual measurement was recorded with an embed meter approximately every 20 transects. Regression of the estimated numbers with the actual measurements calculated a correction factor for all estimated values.

Table 1. *continued*

Variable	Method of collection
Bank Stability	Visual estimate of the length of unstable bank between transects for possible sediment source.
Instream Cover Rating	Percent of the stream surface covered by large woody debris, aquatic vegetation, bank vegetation in or near the surface of the water / Amount of cover provided by undercuts, root wads, boulders or turbulence.
Dominant/Subdominant Riparian Vegetation	Visual estimate of dominant vegetation and of subdominant vegetation species.
Stream Channel Gradient	Using a clinometer measure percent slope.
Acting Woody Debris	Number of woody debris with a diameter >10cm and a length >1m within the wetted channel.
Potential Debris Recruitment	Number of trees within the transect that could potentially fall into the stream > 10 cm and a length > 1m.
Measurements for Residual Pool Depth	Measure average pool depth at the deepest portion of the pool and at the pool tailout. Measure to the nearest cm.
USFS Large Woody Debris	Number of woody debris with a diameter >30cm and a length >10m with some portion within the wetted channel.

RESULTS

Tacoma Creek

Reach 1

Reach 1 was 900 m in length and classified as a C5 channel (Table 2). Most of this reach is contained within the backwater slough created when the Pend Oreille River floods during the spring. Substrate embeddedness was high (98%, Table 3); however, high levels of fine sediment are a characteristic of low gradient C type channels. Acting large woody debris (LWD) was almost non-existent in reach 1 (0.1 pieces/100 m, Table 4). The lack of large substrate and LWD resulted in a low instream cover rating (1.1), and a lack of pool habitat (15% pools, 1.1 primary pools/Km). Although located within a pasture, the streambanks were relatively stable (97%) in reach 1. Cattle access to the riparian area was hampered by a thick growth of Douglas' spiraea *(Spiraea douglasii)*. Poor habitat in reach 1 resulted in low fish densities (Figure 3). Total fish density (1.5 fish/100 m^2) was lower than any other reach in Tacoma Creek. One brook trout, one cutthroat trout, one brown trout, and six mountain whitefish *(Prosopium williamsoni)* were observed in the 100 m snorkel station.

Reach 2

Reach 2 was a C6 type channel that was 960 m in length. Damming by beavers created long ponds and resulted in the high bankfull width to depth ratio of 25.7. An old concrete dam was present in reach 2 and appeared to be used primarily as a vehicle crossing (Figure 4). Substrate embeddedness was characteristically high at 98%. Instream cover was low (1.5 rating) as a result of the lack of large substrate and LWD (1.3 pieces/Km). Douglas' spiraea also dominated the riparian area in reach 2 and precluded cattle access to the streambanks. The pool to riffle ratio was 0.0 due to the complete absence of riffle habitat at the surveyed transects. Brook trout, brown trout, and mountain whitefish were the only fish species observed in reach 2. Brook (0.9 fish/100 m^2) and brown (1.3 fish/100 m^2) trout densities were relatively low.

Reach 3

Reach 3 was classified as an E5 type channel and was 1920 m long. Beaver ponds were also present in the reach. LWD frequency, 12.1 pieces/100 m, was relatively low but a large increase from the lower two reaches. 13.0 m^2 of spawning gravel was observed, a large amount relative to the other reaches in Tacoma Creek. Although the primary pool frequency was low (2.1 pools/Km), those pools present were relatively deep and long. The average residual pool depth of the primary pools was 211 cm. Reach 3 had a relatively high total density of fish (12.6 fish/100 m^2). However, nearly all fish were non-native brook trout (n=71) and brown trout (n=30). One native cutthroat trout and one sculpin *(Cottus ssp.)* were also observed in the snorkel station.

Table 2. Rosgen (1994) channel classifications and reach scale attributes for reaches surveyed in Tacoma Creek.

Tacoma Creek				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	C5	1.1	Sand	16.5
2	C6	0.9	Silt	25.7
3	E5	1.3	Sand	10.3
4	B3a	4.0	Rubble	18.3
5	C4	1.9	Gravel	17.0
6	C3	1.4	Cobble	18.5
7	B3c	2.0	Rubble	22.1
8	C4b	2.0	Gravel	32.6
9	B4	2.6	Gravel	13.4
10	B5	2.3	Sand	14.2
11	B3	2.8	Cobble	13.9
12	B3	3.0	Cobble	16.5
13	B3	3.0	Cobble	19.0
14	B3	3.0	Rubble	11.2
15	B3	3.1	Cobble	11.4
16	B3	3.3	Cobble	13.2
17	A2	5.2	Boulder	6.3
18	B3	3.0	Cobble	6.8
19	B3	3.5	Cobble	6.1
20	A3	5.4	Rubble	4.6
21	A3	5.2	Cobble	6.8
22	A3b	3.5	Cobble	3.0
23	A3	5.9	Rubble	5.7
24	A3	4.9	Rubble	4.5
25	A4	7.1	Gravel	3

Table 3. Tacoma Creek limiting factor attributes.

Tacoma Creek							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	98	97	1.4	1.1	3.0	0.0	1.1
2	98	98	1.4	1.5	0.0	0.0	5.2
3	93	100	1.2	1.6	6.3	13.0	2.1
4	64	99	1.3	3.1	0.2	0.0	1.3
5	87	100	1.6	1.5	1.2	28.5	4.8
6	72	100	1.4	1.4	0.5	1.0	0.0
7	69	100	1.4	1.8	0.5	3.5	1.9
8	77	100	1.4	1.5	1.3	8.5	2.6
9	63	100	1.5	1.8	0.5	0.0	2.3
10	81	100	1.8	1.6	0.8	18.5	0.9
11	77	100	1.2	2.5	0.2	1.0	3.7
12	64	100	1.8	2.2	1.3	3.5	0.8
13	63	100	1.7	1.7	0.5	9.0	1.0
14	72	100	1.0	5.0	0.1	2.0	2.9
15	83	100	1.1	4.7	0.1	10.5	3.0
16	84	100	1.0	5.6	0.2	31.0	6.0
17	62	100	1.0	4.6	0.9	0.0	6.3
18	79	100	1.0	4.7	0.1	6.0	3.7
19	72	100	1.0	4.9	0.2	10.0	3.2
20	81	100	1.0	4.9	0.3	6.0	3.0
21	76	100	1.0	5.0	0.2	4.0	3.0
22	88	100	1.1	4.8	0.2	6.0	3.9
23	71	100	1.0	5.0	0.1	4.0	2.8
24	85	100	1.0	5.0	0.1	1.5	2.7
25	77	100	1.0	4.9	0.1	0.0	7.8

Table 4. Habitat attributes for reaches surveyed in Tacoma Creek.

Tacoma Creek							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	49	7.3	34	15	5	0	0.1
2	73	10.5	149	51	0	0	1.3
3	69	10.9	211	44	7	0	12.1
4	37	9.0	64	7	40	1	13.5
5	44	7.1	110	26	21	0	15.1
6	36	7.4	0	16	35	0	24.6
7	31	6.8	105	22	43	0	33.1
8	37	7.6	84	25	19	0	29.7
9	29	6.5	65	13	26	1	32.6
10	27	6.5	50	15	18	0	23.0
11	29	5.9	75	5	21	0	48.3
12	27	5.6	50	26	20	0	26.6
13	25	6.6	50	9	19	0	32.7
14	30	5.0	75	6	41	0	32.9
15	28	5.4	45	7	70	1	38.9
16	27	6.1	53	12	53	0	51.5
17	33	4.1	57	44	50	0	32.3
18	26	4.8	42	7	72	0	68.9
19	27	5.0	66	16	65	0	59.7
20	33	4.1	73	15	48	0	46.9
21	24	4.0	47	13	63	0	64.7
22	24	3.9	51	10	48	0	65.5
23	20	3.1	51	8	69	0	51.0
24	15	2.4	39	9	82	0	50.7
25	15	2.4	41	11	81	0	82.4

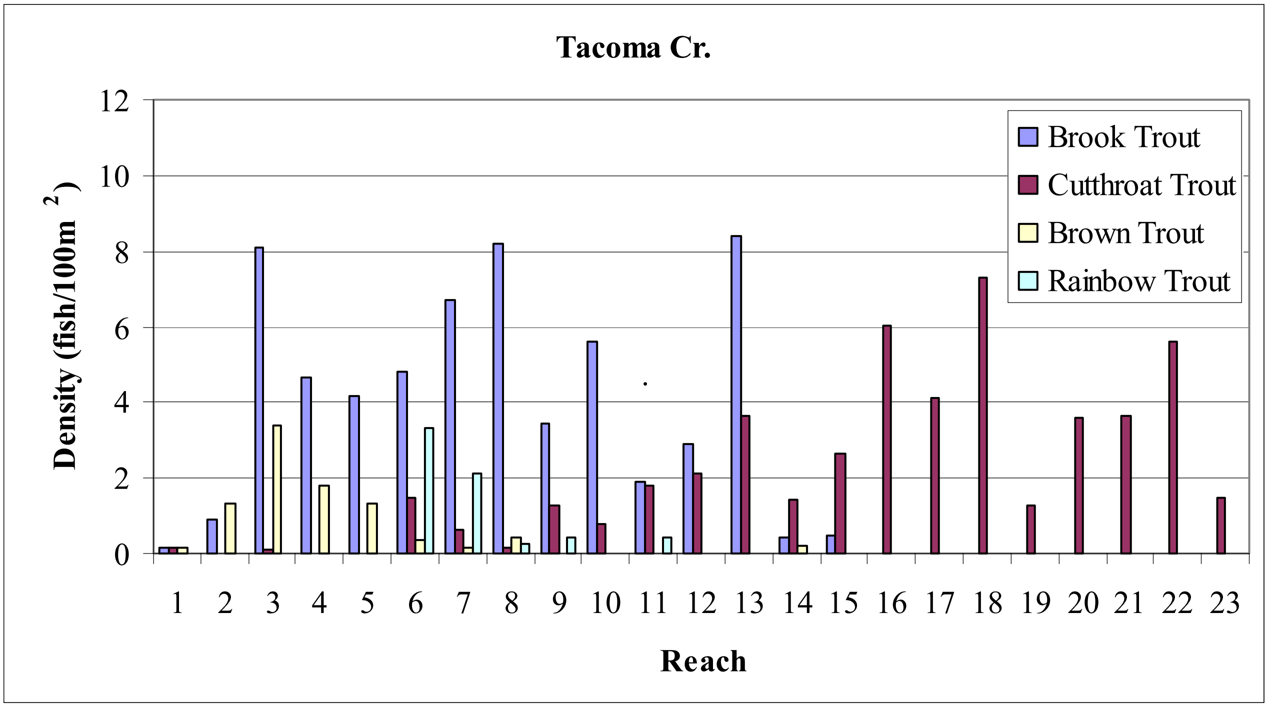

Figure 3. Fish densities for reaches surveyed in Tacoma Creek.

Figure 4. Concrete road crossing with 2 culverts in reach 2 of Tacoma Creek.

Reach 4

The channel gradient and valley confinement increased in reach 4 resulting in the B3a type classification. Reach 4 was 1530 m in length. Little pool type habitat was observed; pool habitat at the transects comprised 7% and the primary pool frequency was 1.3 pools/Km. The lack of pool habitat may have been a result of the relatively low LWD density (13.5 pieces/100 m). Brook trout (4.6 fish/100 m^2) and brown trout (1.8 fish/100 m^2) were the only fish species observed in the snorkel station.

Reach 5

Reach 5 was 3150 m in length and was classified as a C4 channel type. Although substrate embeddedness was high (87%), gravel was the dominant substrate and a relatively high amount of spawning gravel (28.5 m^2) was observed. The LWD density remained relatively low; however, primary pool frequency was relatively high. Generally, primary pools were formed by lateral scouring at stream channel meanders. Fish densities were similar to reach 4; brook and brown trout densities were 4.2 and 1.3 fish/100 m^2, respectively.

Reach 6

Reach 6 was a C3 channel that was 1050 m in length. No primary pools were observed in reach 6. Low pool habitat composition (16%) resulted in a low pool to riffle ratio (0.4). Only 1.0 m^2 of gravel was classified as spawning habitat. Increased LWD frequency (24.6 pieces/100 m) did not translate to an increase in pool habitat in reach 6. Although the habitat appeared to be relatively poor in reach 6, total fish density was relatively high (10 fish/100 m^2). Brook, cutthroat, brown, and rainbow trout were all observed in the snorkel station in reach 6.

Reach 7

Reach 7 was classified as a B3c channel and was 1080 m in length. Beaver activity was present, but minimal, in reach 7. Deposits of silt were observed throughout the reach. However, reach 7 had one of the lowest embeddedness values (69%) in Tacoma Creek. The primary pool frequency was relatively low (1.9 pools/Km); however, residual pool depths were relatively high (105 cm) and pool type habitat was moderate (22%). Total fish density in reach 7 was relatively high (9.6 fish/100 m^2) and brook, cutthroat, brown, and rainbow trout were all observed.

Reach 8

Reach 8 was 780 m long and was a C4b channel type. Undeveloped campsites were present in reach 8 and some soil compaction and erosion of the streambanks was observed next to these sites. Overall, the habitat was good and habitat attribute values were moderate. Brook trout was the dominant fish species (8.2 fish/100 m^2) in the station snorkeled in reach 8. Cutthroat, brown, and rainbow trout were also observed, but at densities of less than 1.0 fish/100 m^2.

Reach 9

Reach 9 was a B4 type channel and 870 m in length. Substrate embeddedness was 63%; one of the lowest values in Tacoma Creek. No spawning gravel was observed in reach 9. Total fish density was moderate at 5.1 fish/100 m^2. Brook trout were again dominant (3.4 fish/100 m^2); however, cutthroat trout (1.3 fish/100 m^2) made up a larger portion of total fish density. Rainbow trout were also observed (0.4 fish/100 m^2).

Reach 10

The channel in reach 10 was classified as a B5 type and was 1170 m long. Sand was the dominant substrate class and embeddedness was high (81%). The primary pool frequency was low (0.9 pools/Km) and residual pool depth was relatively low (50 cm) indicating that fine sediment may be filling in pools. Spawning habitat was fairly abundant; 18.5 m^2 of gravel was classified as spawning habitat. Brook trout and cutthroat trout (with densities of 5.6 and 0.8 fish/100 m^2, respectively) were the only fish species observed in the reach 10 snorkel station.

Reach 11

Reach 11 was a B3 channel and was 540 m long. Although the primary pool density was moderate (3.7 pools/Km) and LWD frequency was relatively high (48.3 pieces/100 m), pool type habitat was low (5%). Substrate embeddedness was high (77%) for a channel with 2.8% gradient. Brook trout (1.9 fish/100 m^2) and cutthroat trout (1.8 fish/100 m^2) densities were nearly equal in reach 11. Rainbow trout were observed at a low density (0.4 fish/100 m^2).

Reach 12

Reach 12 was a B3 type channel that was 1200 m in length. Substrate embeddedness was 64%. The primary pool frequency (0.8 pools/Km) was relatively low. However, pool type habitat comprised 26% of the survey transects. Fish densities were relatively moderate; brook trout and cutthroat trout densities were 2.9 and 2.1 fish/100 m^2, respectively.

Reach 13

Reach 13 was 1050 m in length and was classified as a B3 channel. Pend Oreille County Road 2389 ran adjacent to the channel for much of the length of the reach. Pool type habitat (9%) and primary pool frequency (1.0 pools/Km) were relatively low. Substrate embeddedness, however, was relatively low at 63%. A temperature logger was placed in reach 13 on July 8. The highest water temperatures (+14^{o}C) occurred in late

July (Figure 5). Fish densities in the reach 13 snorkel station were relatively high. Brook trout density was 8.4 fish/100 m^2 and cutthroat trout density was 3.6 fish/100 m^2.

Reach 14

Reach 14 was a B3 type channel that was 690 m in length. Three man made log structures which created backwater pools were observed in the reach. However, pool type habitat was scarce (6%) and resulted in a low pool to riffle ratio (0.1). Total fish density was low (2.0 fish/100 m^2). In addition to brook trout and cutthroat trout, one brown trout was observed in the reach 14 snorkel station.

Reach 15

Reach 15 was classified as a B3 channel and was 1320 m in length. Less flow existed because the bottom of the reach was located at the confluence of Little Tacoma Creek. Pool habitat appeared to be limited in this reach. Pool habitat was observed at 7% of the transect area. Primary pool frequency was relatively moderate (3.0 pools/Km). Brook trout (0.5 fish/100 m^2) and cutthroat trout (2.6 fish/100 m^2) were the only fish species observed in the snorkel station.

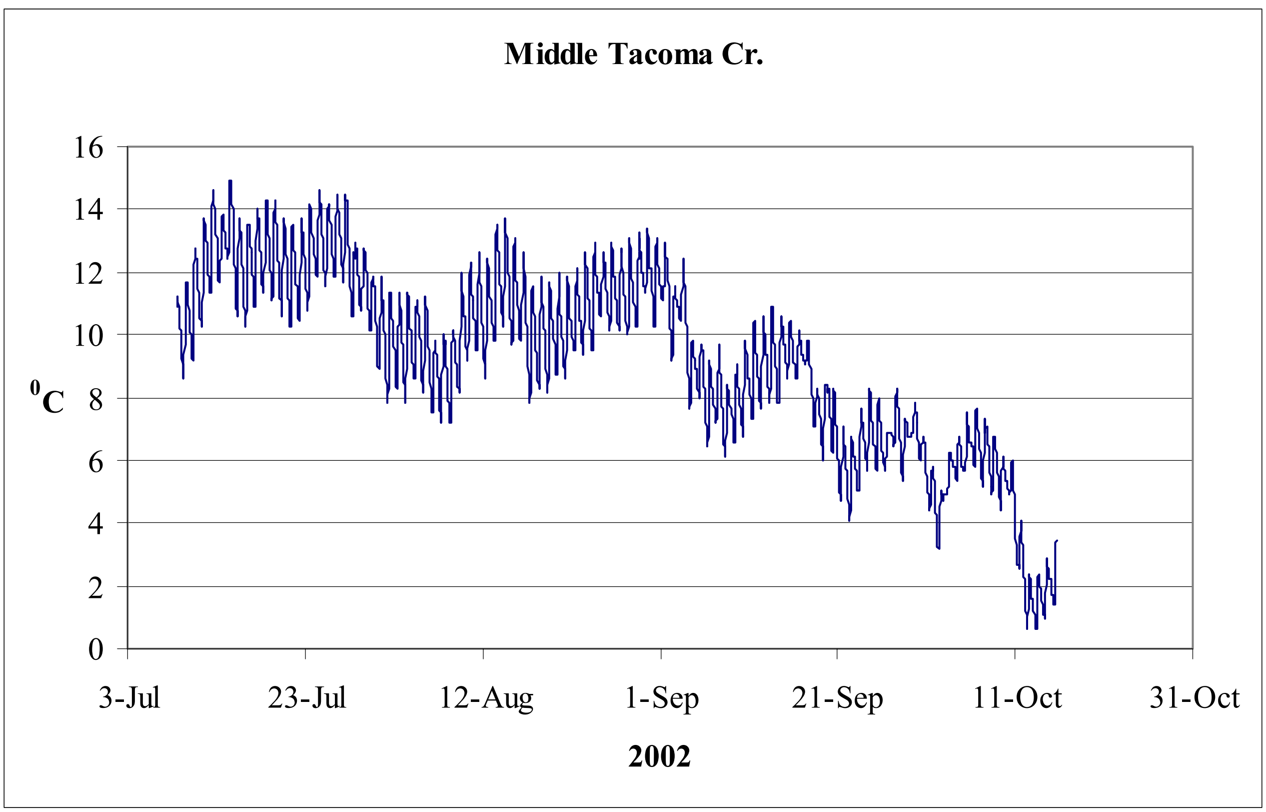

Figure 5. Water temperatures in reach 13 of Tacoma Creek from July 8 to October 14.

Reach 16

Reach 16 was a B3 type channel and was 1500 m in length. A fish passage barrier was observed which precluded upstream passage of non-native fish (Figure 6). The LWD density (51.5 pieces/100 m) and primary pool frequency (6.0 pools/Km) were relatively high. However, substrate embeddedness was high for a channel with 3.3% gradient. Spawning gravel was abundant in reach 16; 31.0 m^2 of gravel was classified as spawning habitat. The population of cutthroat trout upstream of the barrier is isolated from downstream populations of fish. Therefore, cutthroat trout were the only fish species observed; density was 6.0 fish/100 m^2.

Figure 6. Fish passage barrier located in reach 16 of Tacoma Creek. Barrier isolates native cutthroat trout above.

Reach 17

Reach 17 was classified as an A2 channel and was 480 m long. Another large fish passage barrier (waterfall) was observed in this reach. Boulder and cobble were the dominant substrate. However, embeddedness was 62% which is high given the average channel gradient of 5.2%. Cutthroat trout density in reach 17 was 4.1 fish/100 m^2.

Reach 18

Reach 18 was a B3 type channel and was 810 m in length. The LWD density was relatively high (68.9 pieces/100 m); however little pool habitat was present (7%). Substrate embeddedness was also high (79%). Reach 17 had the highest density of cutthroat trout in Tacoma Creek at 7.3 fish/100 m^2.

Reach 19

Reach 19 was classified as a B3 type channel and was 1560 m in length. Substrate embeddedness (72%) again was high. The LWD density was relatively high (59.7 pieces/100 m) but pool composition (16%) and primary pool frequency (3.2 pools/Km) were relatively moderate. The cutthroat trout density was low (1.3 fish/100 m^2) relative to the other reaches with isolated cutthroat trout.

Reach 20

Reach 20 was 990 m in length and was classified as an A3 channel. Portions of the channel appear to be located in an old beaver dam complex. In these areas, some channel splitting was noted. Embeddedness was high (81%), particularly given the average channel gradient of 5.4%. The primary pool frequency was relatively moderate (3.0 pools/Km); however, primary pool residual depth was high (73 cm) for the reaches located upstream of the confluence of Little Tacoma Creek. Cutthroat trout density in the reach 20 snorkel station was 3.6 fish/100 m^2.

Reach 21

Reach 21 was an A3 channel that was 1650 m in length. The riparian area was dominated by old growth cedar and hemlock. Substrate embeddedness was again high (76%) in a relatively high gradient channel (5.2%). Cutthroat trout density was 3.6 fish/100 m^2.

Reach 22

Reach 22 was 1020 m long and classified as an A3b type channel. Historic timber harvest has occurred up to the edge of the stream. Surveyors again noted high amounts of depositional sand and silt. Substrate embeddedness was high (88%) and LWD was numerous (65.5 pieces/100 m). Cutthroat trout density was relatively high in reach 22 (5.6 fish/100 m^2).

Reach 23

Reach 23 was an A3 channel and was 1080 m in length. Recent timber harvest just outside of the riparian area occurred throughout the reach. Excess fine sediment deposition also occurred in reach 23. Substrate embeddedness was high (71%) in a stream channel with an average gradient of 5.9%. Pools comprised only 8% of the habitat. Cutthroat density was relatively low (1.5 fish/100 m^2).

Reach 24

Reach 24 was 1470 m long and classified as an A3 channel type. Most of the reach was located in an historic clearcut that was harvested up to the edge of the stream. Substrate embeddedness was high (85%) and pool composition was only 9%. A snorkel survey did not occur in reach 24 because of limited depth. In July, electrofishing was conducted in reach 24 for the purpose of collecting westslope cutthroat fin tissue samples for genetic analysis (BPA Project No. 2002043); however, despite extensive effort, no fish were collected.

Reach 25

Reach 25 was an A4 channel that was 510 m in length. This reach was also located in an old clearcut. The riparian area was harvested when this area was clear-cut. Despite the 7.1% average channel gradient, fine sediment deposition occurred throughout the reach. Substrate embeddedness was 77%. The high deposition may have been due to numerous LWD (82.4 pieces/100 m), which were higher than any other reach in Tacoma Creek. A culvert located at the end of the survey appeared to be under-sized. No snorkeling occurred in reach 25 due to limited depth.

Tributary 2

Reach 1

Reach 1 was an A5 channel that was 1080 m in length (Table 5). A potential fish passage barrier was observed in the reach. Substrate embeddedness was high (88%, Table 6) for a channel with an average gradient of 6.7%. Spawning gravel was relatively abundant (6.5 m^2) for the small size of the stream. A temperature logger was placed in Tributary 2 near the confluence with Tacoma Creek. However, the logger could not be located at the time of retrieval. Total fish density was relatively high (19.1 fish/100 m^2, Figure 7); brook trout and cutthroat trout were the only fish species observed.

Reach 2

Reach 2 was 660 m in length and classified as a C3b type channel. A small barrier was observed in reach 2 that may preclude fish passage. Substrate embeddedness was high (87%), but the primary pool frequency (15.2 pools/Km) and pool composition (27%, Table 7) were also relatively high. Fish sampling in reach 2 did not occur due to the lack of depth.

Table 5. Channel characteristics reaches surveyed in Tributary 2 and 2A.

Tacoma Creek Tributary 2 and 2A				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	A5	6.7	Sand	10.3
2	C3b	3.9	Cobble	8.0
Trib 2A				
1	B4	3.1	Gravel	13.6

Table 6. Limiting factor habitat attributes for reaches surveyed in Tributary 2.

Tacoma Creek Tributary 2							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	88	100	3.1	3.4	1.1	6.5	6.5
2	87	100	3.8	3.6	0.7	0.0	15.2

Table 7. Habitat attribute values for reaches surveyed in Tributary 2.

Tacoma Creek Tributary 2							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	15	2.1	24	36	32	0	18.3
2	14	1.6	25	27	36	0	18.3

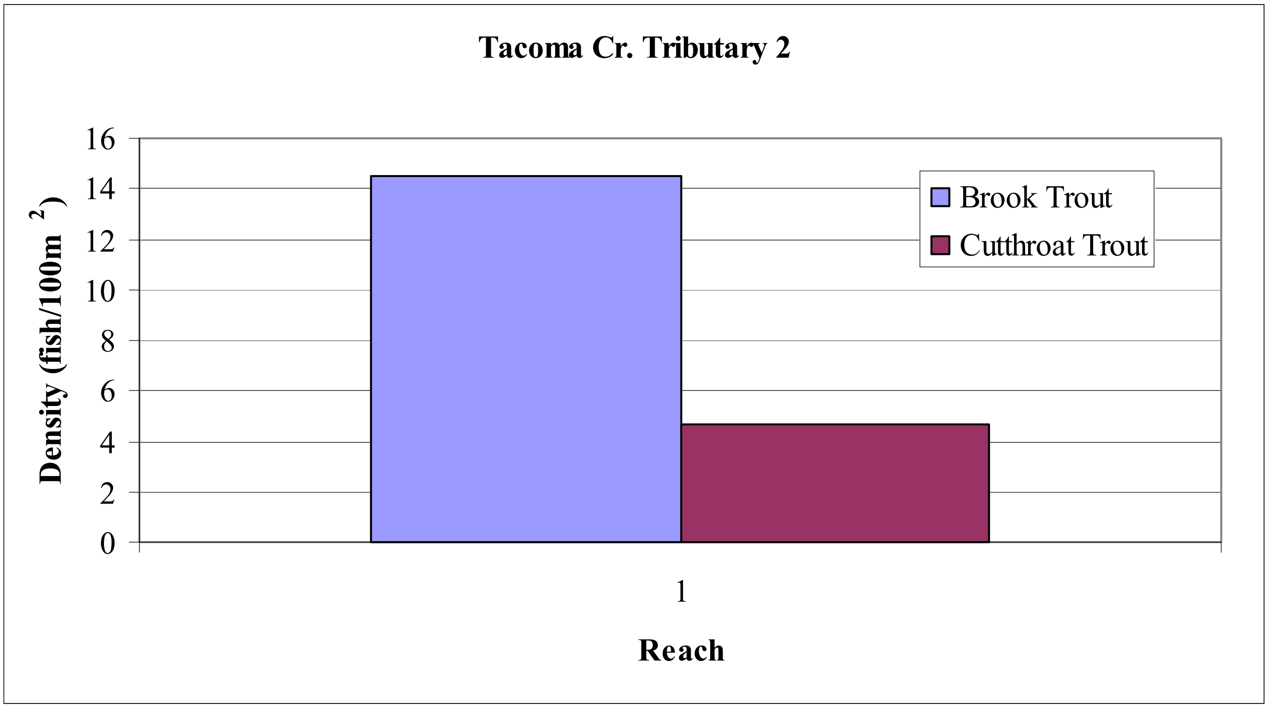

Figure 7. Fish densities for 100-m snorkel stations in Tributary 2.

Tributary 2A

Reach 1

Reach 1 was classified as a B4 type channel and was 450 m long. Substrate embeddedness was high (98%, Table 8) for a B type channel. This was a small tributary with an average depth of 9-cm and width of 1.2 m (Table 9). Therefore, no snorkeling was conducted in Tributary 2A. A temperature logger was placed in the stream near the end-point of the survey. Summer maximum water temperature did not exceed 14^{o}C (Figure 8).

Table 8. Limiting factor habitat attributes for one reach in Tributary 2A.

Tacoma Creek Tributary 2A							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	98	100	3.9	2.5	0.8	0.0	13.3

Table 9. Habitat attribute values for reaches surveyed in Tributary 2A.

Tacoma Creek Tributary 2A							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	9	1.2	23	33	41	0	18.0

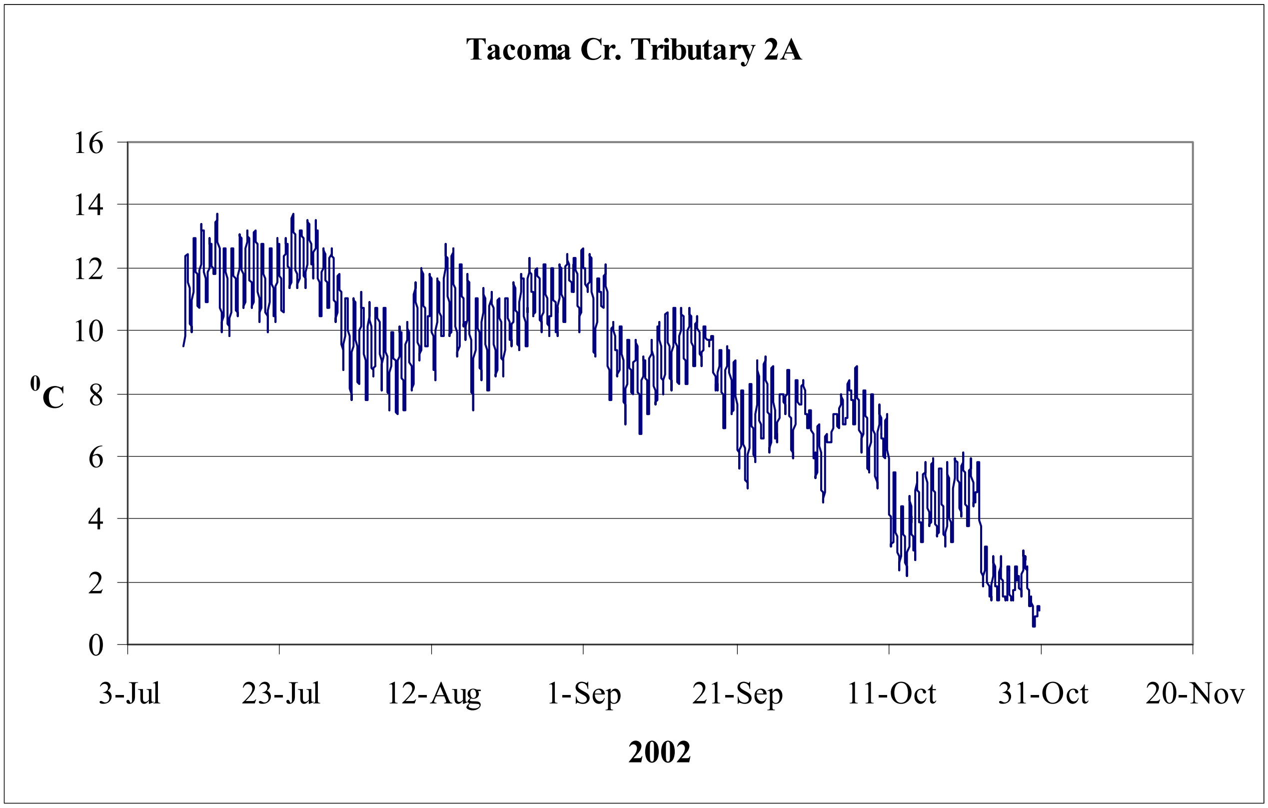

Figure 8. Stream temperatures for Tributary 2A. Temperature was recorded hourly.

Tacoma Creek Tributary 3

<u>*Reach 1*</u>

Reach 1 was a B4 channel that was 1230 m in length (Table 10). Substrate embeddedness (58%, Table 11) was low relative to all other stream reaches in the Tacoma Creek watershed. Tributary 3 was another small stream; the average depth and width were 8.9-cm and 1.5 m, respectively (Table 12). Fish were only observed by the habitat surveyors in the lowest 200 m of stream channel. However, no snorkeling was conducted due to a lack of adequate depth. Stream temperatures were recorded with a temperature logger starting on July 8. Several of the smaller tributaries to Tacoma Creek dried up in August and no longer had surface flow. On August 13, the logger in Tributary 3 lost contact with the stream. Up to that date, stream temperatures often exceeded 14^{o}C (Figure 9).

Table 10. Channel characteristics for one reach surveyed in Tributary 3.

Tacoma Creek Tributary 3				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	B4	2.8	Gravel	11.2

Table 11. Limiting Factor habitat attributes for Tributary 3.

Tacoma Creek Tributary 3							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	58	99	2.6	2.2	1.1	1.5	8.9

Table 12. Habitat attribute values for reaches surveyed in Tributary 3.

Tacoma Creek Tributary 3							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	9	1.5	27	29	26	0	25.0

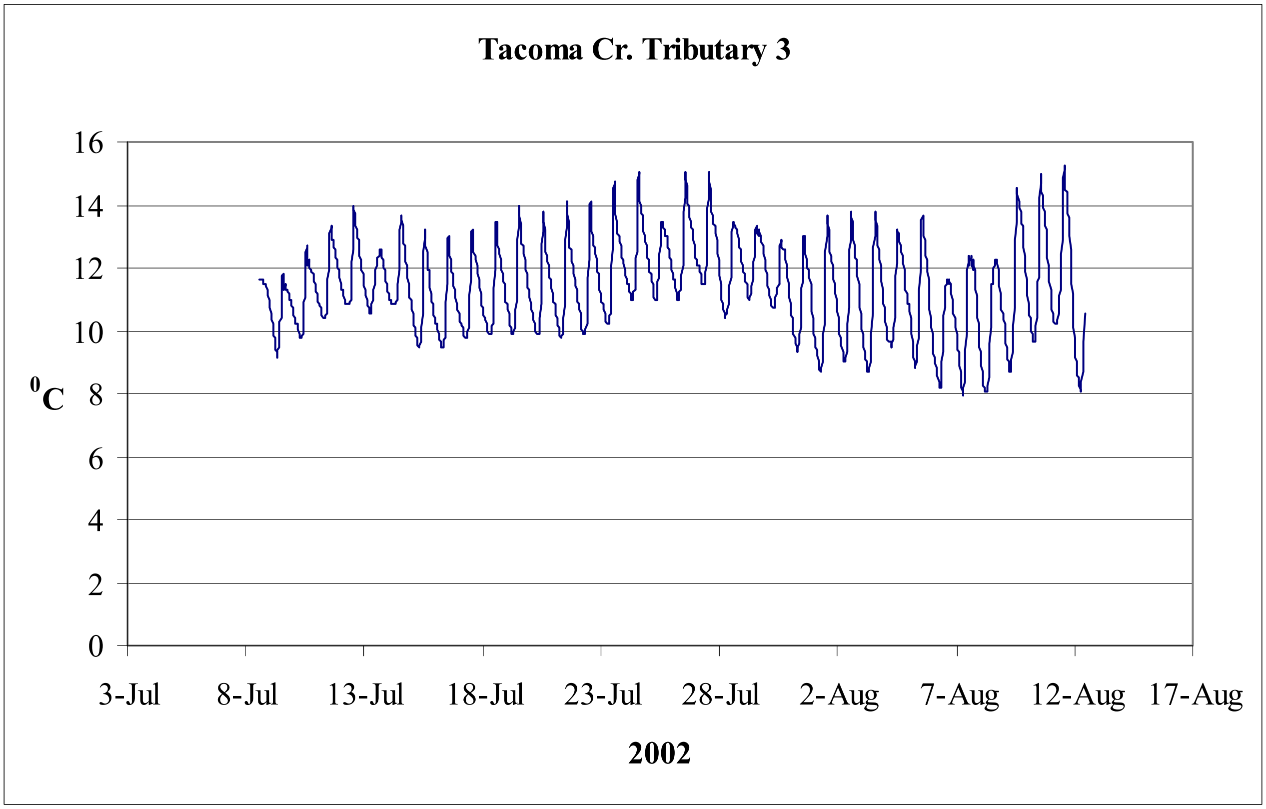

Figure 9. Stream temperatures, recorded hourly, for lower Tributary 3.

Tributary 4

Reach 1

Reach 1 was a B3 type channel that was 420 m in length (Table 13). The primary pool density was low (7.1 pools/Km, Table 14) due to the low frequency of LWD (4.0 pieces/100 m, Table 15). The riparian area was thick with shrubs and forbs while little coniferous overstory was present. Brook trout (8.6 fish/100 m^2) and cutthroat trout (3.0 fish/100 m^2) were observed in reach 1 (Figure 10). A temperature logger was sited in the lower end of reach 1 from May 22 to mid October. On August 9, the logger went dry as streamflow became intermittent. Therefore, temperature data beyond August 9 is not presented. Prior to August 9, the warmest stream temperatures were measured in the period from July 11 to July 27; daily maximum temperatures exceeded 14^0C every day during the period (Figure 11).

Reach 2

Reach 2 was 1020 m long and classified as an A5 type channel. The primary pool frequency was relatively high; 40.2 pools/Km were observed. Substrate embeddedness was 64%, levels of fine sediment were high relative to channel gradient (mean = 6.3%) and sand was the dominant substrate. Snorkeling was not completed in reach 2 due to limited depth. In fact, in mid August when snorkel surveys were being conducted flows were mostly sub-surface from reach 2 upstream to the headwaters. Therefore, in reach 2, six minnow traps were placed in pools that contained water. After approximately 24 hours, the traps were retrieved and eleven brook trout were captured in the six traps (Table 16).

Table 13. Channel characteristics for reaches surveyed in Tributary 4.

Tacoma Creek Tributary 4				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	B3	3.5	Cobble	8.2
2	A5	6.3	Sand	9.7
3	C5b	3.7	Sand	33.5
4	A3	6.0	Cobble	11.7
5	B6	4.1	Silt	11.4

Table 14. Limiting factors habitat attributes for reaches surveyed in Tributary 4.

Tacoma Creek Tributary 4							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	69	100	3.4	2.3	0.3	1.0	7.1
2	64	100	2.1	3.0	0.5	4.0	40.2
3	96	100	4.7	4.6	7.6	6.5	11.6
4	64	100	3.0	3.2	0.9	31.0	63.0
5	92	99	1.7	3.8	31.3	19.0	41.2

Table 15. Habitat attribute values for reaches surveyed in Tributary 4.

Tacoma Creek Tributary 4							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	12	1.7	33	16	60	0	4.0
2	18	1.9	37	24	48	0	17.7
3	28	9.6	43	46	6	0	19.1
4	15	1.5	38	42	45	0	13.8
5	22	9.3	40	94	3	0	20.8

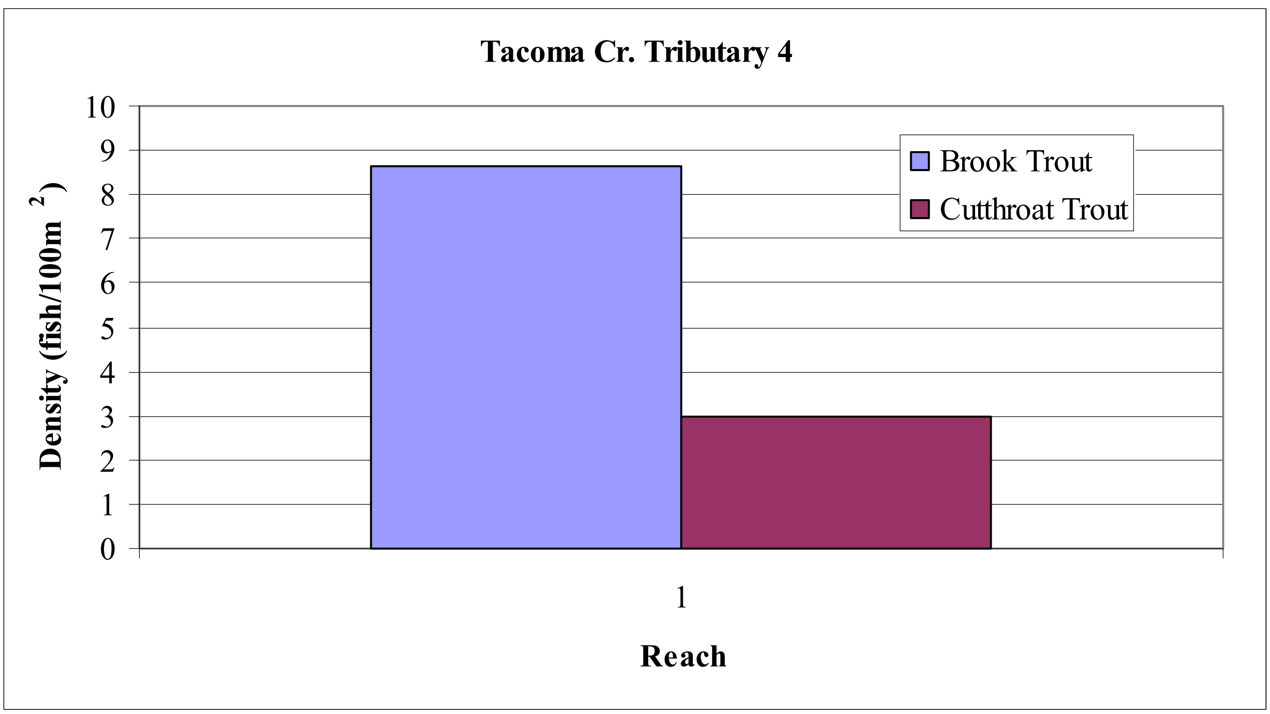

Figure 10. Fish densities for reach 1 of Tributary 4.

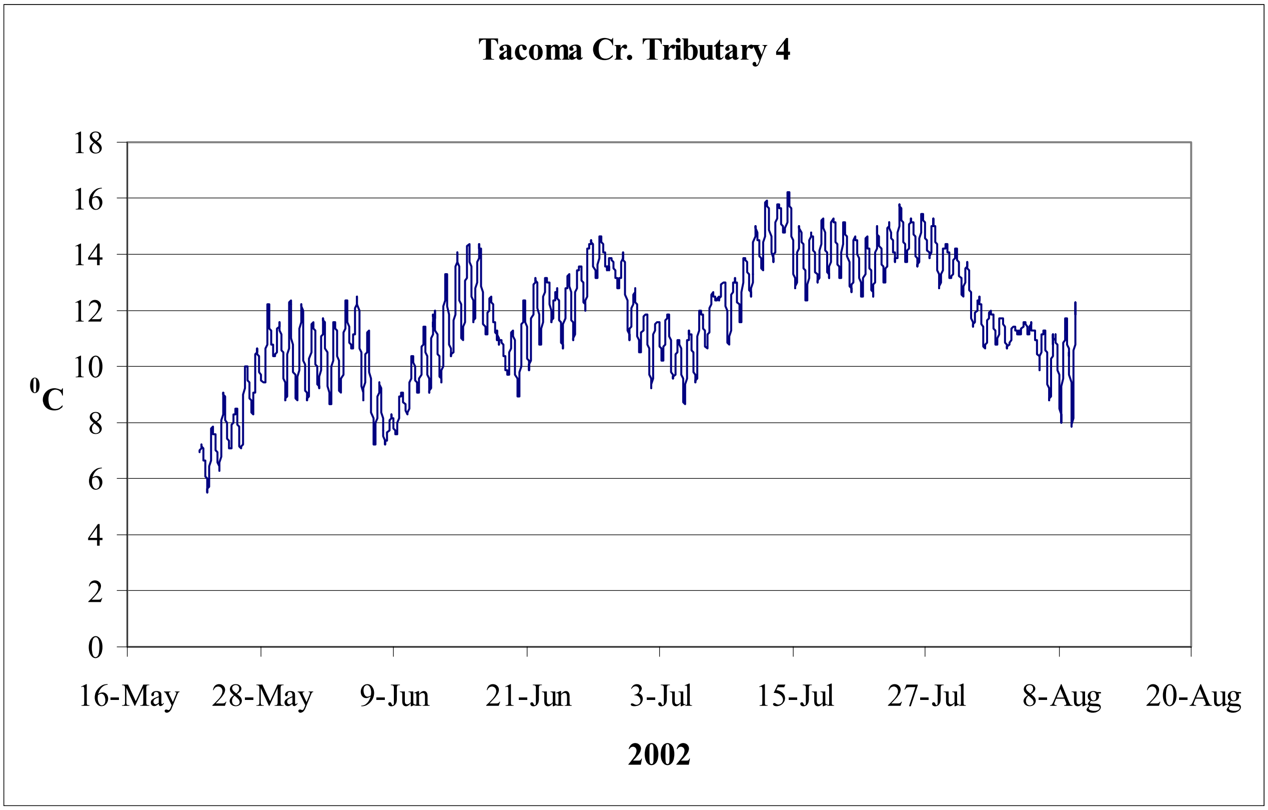

Figure 11. Stream temperatures recorded hourly by a thermograph placed in lower Tributary 4.

Table 16. Results from minnow trapping sites where snorkeling could not be conducted.

			No. Captured	
Stream	Reach	No. Traps Set	Brook Trout	Cutthroat Trout
Tacoma Cr. Tributary 4	2	6	11	0
Tacoma Cr. Tributary 4	3	6	11	0
Tacoma Cr. Tributary 4	4	6	0	0
Tacoma Cr. Tributary 4	5	6	4	0
Tacoma Cr. Tributary 6	1	6	6	0
Tacoma Cr. Tributary 8	1	3	0	0
Tacoma Cr. Tributary 8	2	3	0	1

Reach 3

Reach 3 was a C5b type channel that was 690 m long. Most of the stream channel in the reach was either currently dammed by beavers or had been dammed in the past. Given the predominance of depositional areas, substrate embeddedness was high at 96%. Eleven brook trout were captured in the six minnow traps deployed in reach 3.

Reach 4

Reach 4 was 810 m in length and classified as an A3 channel. Two fish passage barriers were observed in the reach. However, fish were captured above the barriers. An old (approximately 10 years) slope failure appeared to have caused a small debris torrent that traveled 50 m down the channel. Habitat in reach 4 was relatively good. Primary pool frequency was high at 63.0 pools/Km. Spawning habitat was abundant; 31.0 m^2 of gravel was classified as spawning habitat. Despite the good habitat, no fish were captured in the six minnow traps.

Reach 5

Reach 5 was a B6 type channel that was 510 m in length. Most of the reach was moderately confined within a valley bottom with some steep slopes. However, the top of the reach was located in old beaver ponds that were mostly filled in with sediment and riparian forbs and grasses. Fine substrate was high and embeddedness was 92%. However, pools were relatively common (41.2 pools/Km). No minnow traps were set in reach 5 due to a lack of surface flow, even in pools.

Tributary 6

Reach 1

Reach 1 was a C4 channel type that was 390 m long (Table 17). Substrate embeddedness was relatively low (57%, Table 18) for a low gradient (2.1%) channel. The riparian area was dominated by a thick growth of alder. Although gravel was the dominant substrate, no gravels were classified as spawning habitat due mostly to low velocities. LWD density was relatively high (55.1 pieces/100 m, Table 19). Six brook trout were captured in the six minnow traps that were deployed for 24 hours. A temperature logger was situated in reach 1 from May 23 to mid October. However, the logger went dry on July 10 as the stream went intermittent. During the recording period, stream temperatures never exceeded 14^0C (Figure 12).

Reach 2

Reach 2 was a 1440 m A4 type channel. Forest stand thinning has occurred along the entire length of the reach on the slope above one side of the channel. No fish were observed upstream of the first 200 m of reach 2 and a possible fish passage barrier was observed approximately 250 m further upstream. Substrate embeddedness was relatively high (74%) despite the moderately high gradient (5.5%). Minnow trapping did not occur; suitable sites to place the traps were lacking due to intermittent flows.

Table 17. Channel characteristics for reaches surveyed in Tributary 6.

Tacoma Creek Tributary 6				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	C4	2.1	Gravel	14.5
2	A4	5.5	Gravel	7.1

Table 18. Limiting factor habitat attributes for two reaches surveyed in Tributary 6.

Tacoma Creek Tributary 6							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	57	100	3.5	2.8	0.5	0.0	20.5
2	74	99	2.2	2.3	1.9	1.0	11.8

Table 19. Habitat attribute values for reaches surveyed in Tributary 6.

Tacoma Creek Tributary 6							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	13	1.6	39	24	46	0	55.1
2	18	1.8	41	36	19	0	34.7

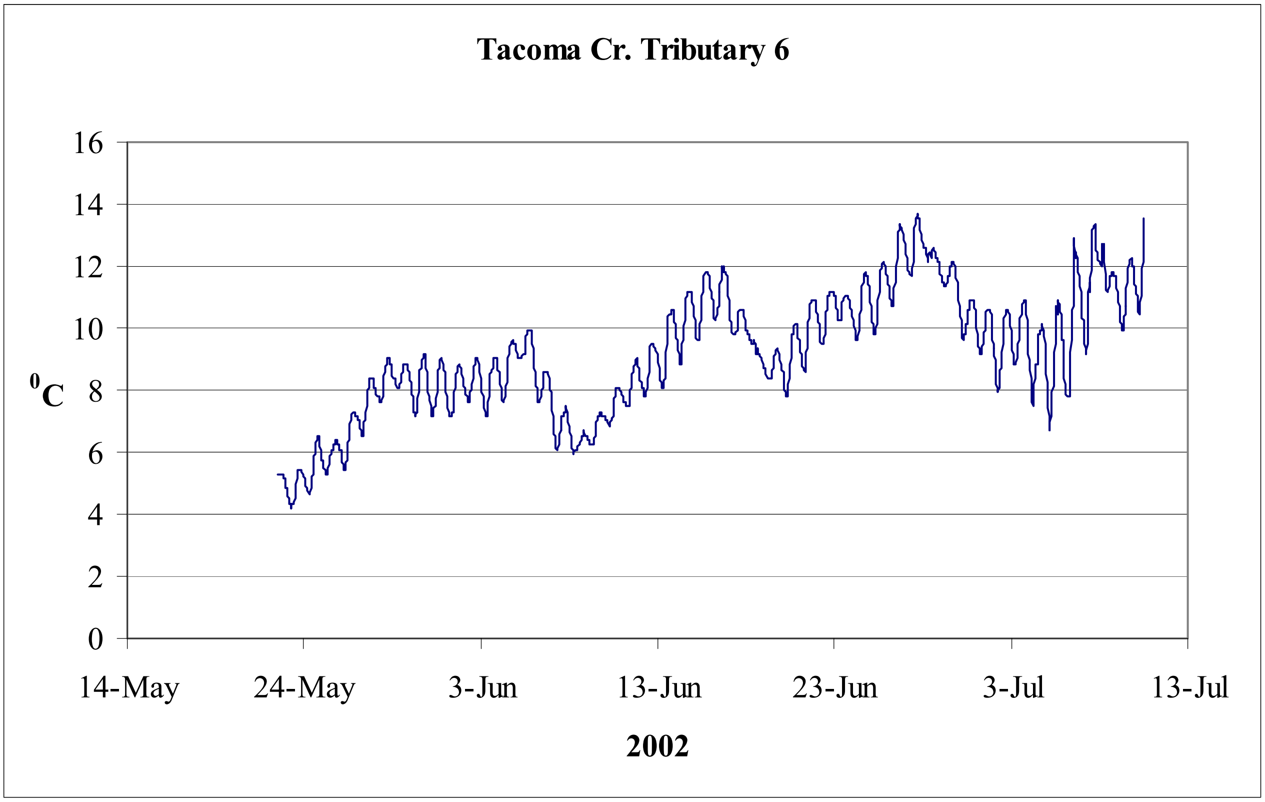

Figure 12. Stream temperatures recorded in lower Tributary 6.

Tributary 7

Reach 1

Reach 1 was a 720 m long B3 type channel (Table 20). Habitat in reach 1 was relatively good. Substrate embeddedness (62%, Table 21), primary pool frequency (19.4 pools/Km), and spawning habitat (11.0 m^2) levels were all relatively moderate to good. Brook and rainbow trout were observed in reach 1 at densities of 5.5 and 7.6 fish/100 m^2, respectively (Figure 13). A temperature logger was deployed in reach 1 from July 5 to October 30. Stream temperatures rarely exceeded 12^{0}C over the course of the summer (Figure 14).

Reach 2

Reach 2 was 750 m in length and classified as an A3 channel. Despite the high gradient (9.8%), substrate embeddedness was 51%. Surveyors noted sediment being delivered from the road at the end of the reach.

Table 20. Channel characteristics for reaches surveyed in Tributary 7 and Tributary 7A.

Tacoma Creek Tributary 7 and 7A				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	B3	3.1	Cobble	12.8
2	A3	9.8	Rubble	13.5
Trib 7A				
1	A3	8.2	Cobble	16.1

Table 21. Values for limiting factor attributes surveyed in Tributary 7.

Tacoma Creek Tributary 7							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	62	100	2.0	3.6	0.2	11.0	19.4
2	51	100	1.6	3.8	0.6	7.0	17.3

Table 22. Habitat attribute values for two reaches surveyed in Tributary 7.

Tacoma Creek Tributary 7							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	16	2.3	35	10	65	0	40.0
2	15	2.0	32	34	57	0	37.6

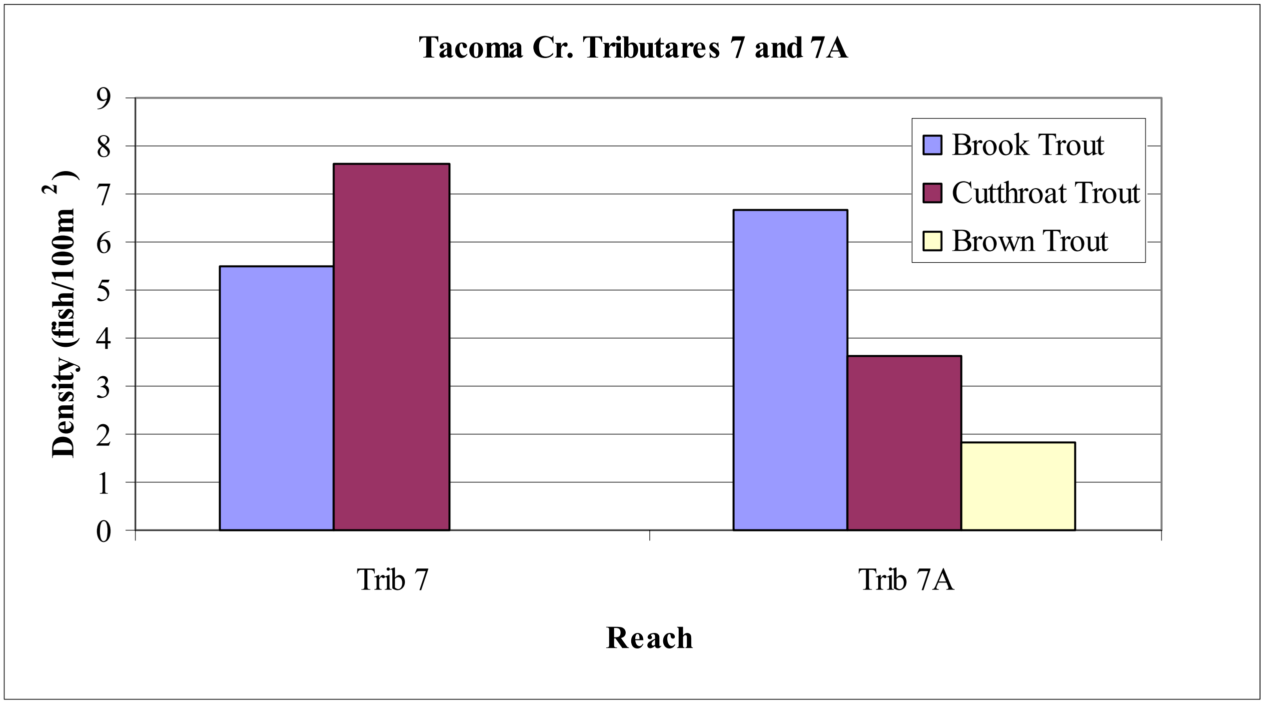

Figure 13. Species densities in Tributary 7 and Tributary 7A.

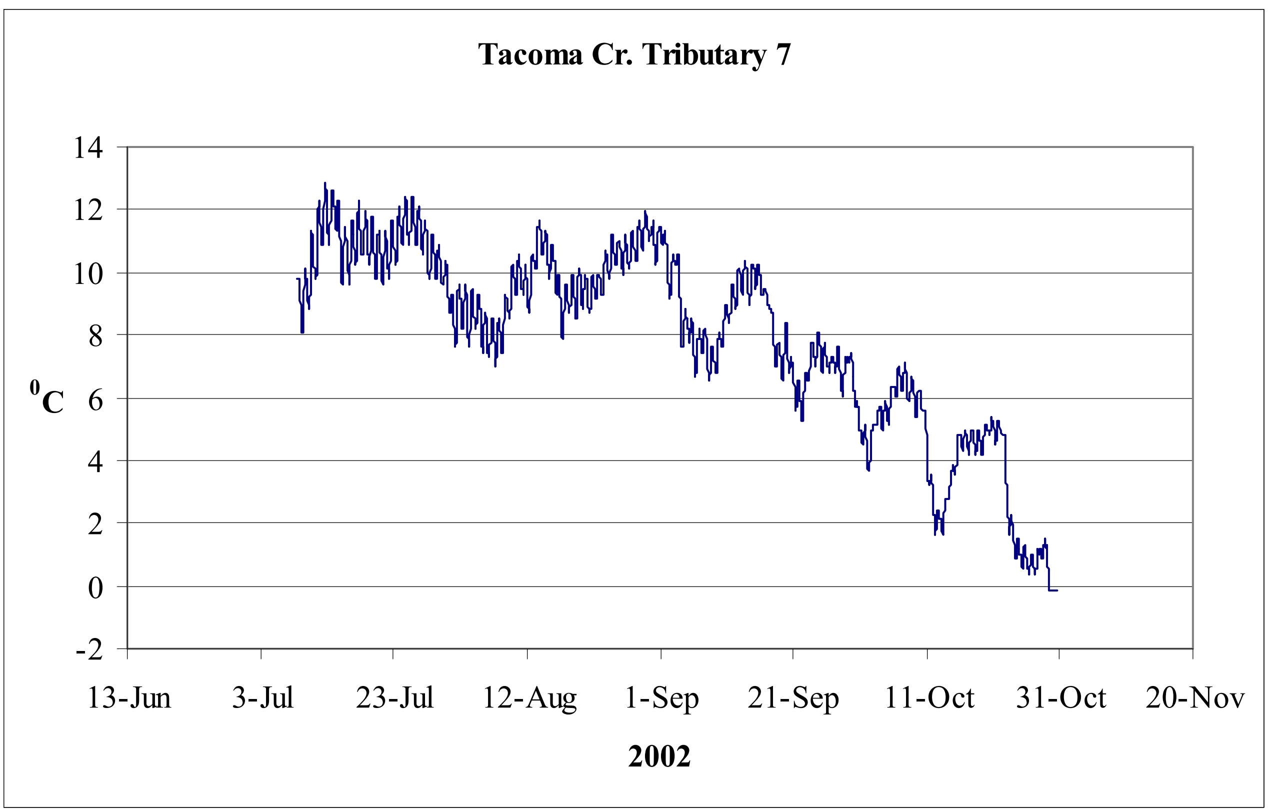

Figure 14. Stream temperatures, recorded hourly, for lower Tributary 7.

Tributary 7A

Reach 1

The one reach surveyed in Tributary 7A was an A3 type channel that was 600 m in length. The primary pool frequency was relatively high at 26.7 pools/Km (Table 23). Bank cover was sparse (1.4 rating) because dense conifers prevented understory growth. A temperature logger was placed in Tributary 7A on June 3 and retrieved on October 30; summer maximum stream temperatures never exceeded 14^0C (Figure 15). Brook, cutthroat, and brown trout were all observed in the snorkel station.

Table 23. Limiting factor attributes for Tributary 7A.

Tacoma Creek Tributary 7A							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	47	100	1.4	3.4	1.0	3.5	26.7

Table 24. Values for habitat attributes surveyed in Tributary 7A.

Tacoma Creek Tributary 7A							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	16	1.6	34	35	36	0	35.8

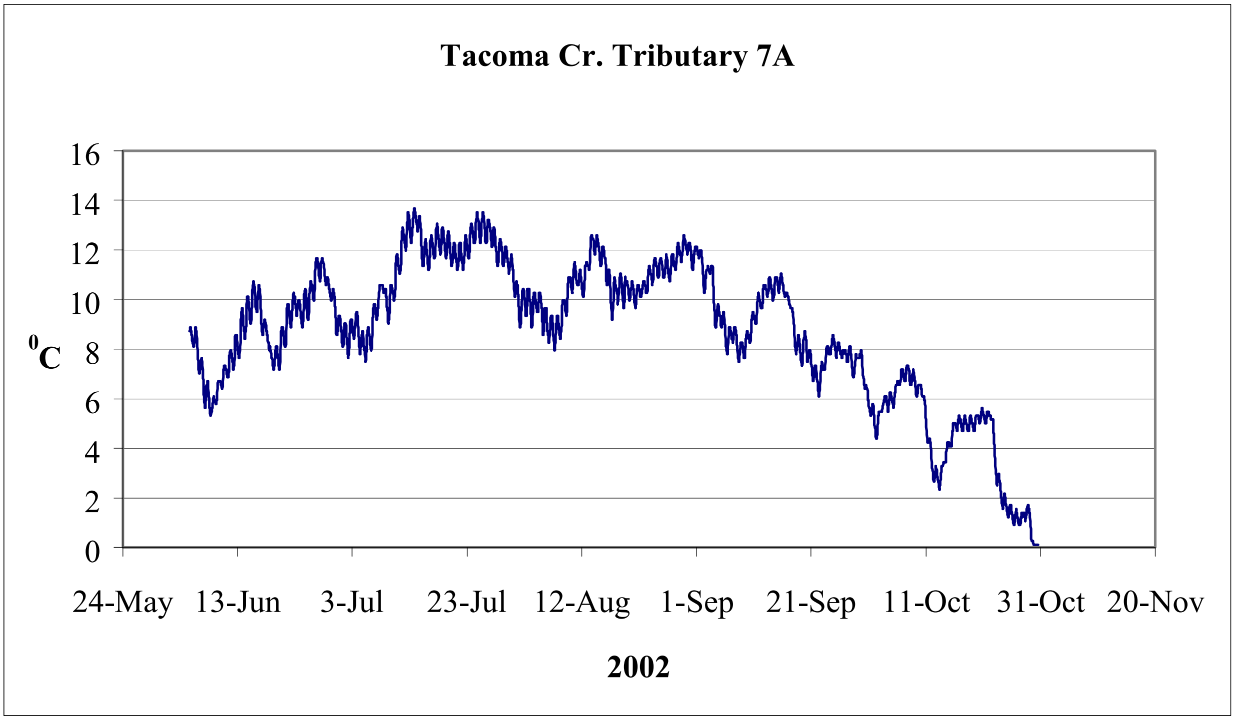

Figure 15. 2002 stream temperatures in Tributary 7A.

Tributary 8

Reach 1

Reach 1 was a B3a type channel that was 480 m in length (Table 25). The primary pool frequency was low (8.1 pools/Km, Table 26). However, acting LWD numbers were higher in reach 1 (119.8 pieces/100 m, Table 27) than any other reach surveyed in the Tacoma Creek watershed. Numerous LWD did not translate to high numbers of primary pools mostly due to pool filling with fine sediment (substrate embeddedness was 81%). A temperature logger was deployed in reach 1 from June 14 to October 31. Stream temperatures in Tributary 8 were relatively cold; daily maximum temperatures seldom exceeded 10^0C over the summer (Figure 16). Three minnow traps were set in reach 1 for a 24 hour period; however, no fish were caught in the traps.

Reach 2

Reach 2 was classified as an A3 type channel and was 1110 m in length. High levels of sediment were also observed in reach 2; substrate embeddedness (90%) was very high for an A type channel. Again, the LWD density was high (79.2 pieces/100 m) but only resulted in 18.8 primary pools/Km. In reach 2, three minnow traps were set for 24 hours and 1 cutthroat trout was captured.

Table 25. Channel characteristics of reaches surveyed in Tributary 8 and Tributary 8A.

Tacoma Creek Tributary 8 and 8A				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	B3a	4.2	Cobble	11.6
2	A3	5.0	Cobble	8.8
Trib 8A				
1	B5	4.0	Sand	7.2
2	B5a	4.1	Sand	5.3

Table 26. Limiting factors attributes for reaches surveyed in Tributary 8.

Tacoma Creek Tributary 8							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	81	100	1.0	5.0	0.5	1.0	8.1
2	90	100	1.0	5.0	0.4	0.0	18.8

Table 27. Habitat attributes for two reaches surveyed in Tributary 8.

Tacoma Creek Tributary 8							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	24	3.2	33	25	48	0	119.8
2	17	2.3	33	20	47	0	79.2

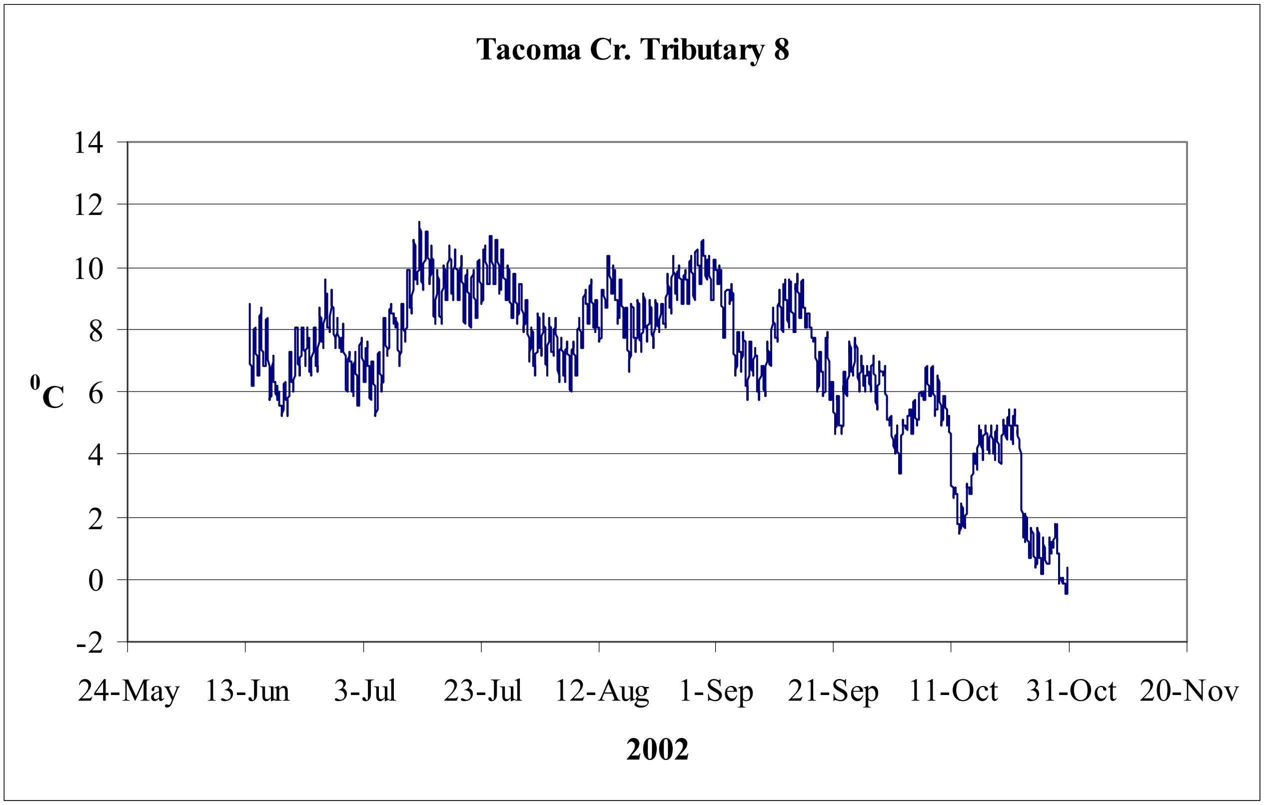

Figure 16. Stream temperature, recorded hourly, in lower Tributary 8.

Tributary 8A

Reach 1

Reach 1 was a B5 type channel that was 750 m in length. Historic beaver activity in some areas caused channel braiding where the stream flowed through old pond beds. Sediment levels were high in reach 1; substrate embeddedness was 100% (Table 28). Although the LWD density was relatively good (57.5 pieces/100 m, Table 29), the primary pool frequency was low (5.3 pools/Km) due to filling of fine sediment. The riparian area was intact and comprised of mature conifers. However, evidence of old timber harvest were apparent throughout the reach.

Reach 2

Reach 2 was 780 m long and classified as a B5a type channel. High levels of fine sediment were also observed in reach 2; substrate embeddedness was 100%. Sediment had filled in pools and resulted in a low primary pool frequency (6.4 pools/Km). No minnow traps were deployed in reach 2; however, habitat surveyors noted numerous cutthroat trout adults and juveniles.

Table 28. Limiting factor attribute values for two reaches surveyed in Tributary 8A.

Tacoma Creek Tributary 8A							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	100	100	1.3	4.5	0.4	0.0	5.3
2	100	100	1.2	4.1	1.3	0.0	6.4

Table 29. Values of habitat attributes surveyed in Tributary 8A.

Tacoma Creek Tributary 8A							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	15	1.3	39	16	37	0	57.5
2	13	1.1	30	40	30	0	51.2

Calispell Peak Creek

<u>Reach 1</u>

Reach 1 was a B4 type channel that was 600 m in length (Table 30). The primary pool frequency was low (3.3 pools/Km, Table 31). Pool type habitat was also low; only 5% of the habitat at each transect was classified as pool (Table 32). However, overall fish density was relatively high in reach 1. Brook trout density was 23.8 fish/100 m^2 and the observed cutthroat trout density was 1.4 fish/100 m^2 (Figure 17). Stream temperature was measured every hour with a temperature logger from May 23 to October 17. Daily maximum temperatures exceeded 14^0C on only 5 days over the summer (Figure 18).

<u>Reach 2</u>

Reach 2 was 2700 m in length and classified as an A3 type channel. Three fish passage barriers were observed in the reach. Two clearcuts were adjacent to the stream channel. Primary pools (8.9 pools/Km) and pool type habitat (6%) were lacking in reach 2. Substrate embeddedness was high (51%) given the relatively high mean channel gradient (6.7%). Brook trout was the dominant fish species observed in the snorkel station. Brook trout density was 10.9 fish/100 m^2 and the brown trout density was 0.3 fish/100 m^2).

Table 30. Channel characteristics for the seven reaches surveyed in Calispell Peak Creek.

Calispell Peak Creek				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	B4	3.3	Gravel	15.8
2	A3	6.7	Cobble	13.2
3	A3	7.1	Cobble	12.0
4	A3	5.4	Cobble	11.2
5	A2a+	15.5	Boulder	11.5
6	C6b	2.1	Silt	12.7
7	A3	10.2	Cobble	10.8

Table 31. Limiting factor attribute values for reaches of Calispell Peak Creek.

Calispell Peak Creek							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	64	99	3.5	3.6	0.1	2.5	3.3
2	51	99	2.8	3.7	0.1	6.0	8.9
3	51	100	3.3	3.6	0.3	1.0	10.2
4	61	100	3.5	3.3	0.1	0.0	4.2
5	61	100	3.2	3.5	0.1	0.0	11.1
6	74	100	3.9	3.2	0.7	2.5	6.3
7	38	100	3.1	3.1	0.2	0.0	6.5

Table 32. Habitat attribute values for reaches surveyed in Calispell Peak Creek.

Calispell Peak Creek							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	27	3.2	50	5	62	0	43.7
2	24	3.4	42	6	71	0	48.4
3	22	3.4	43	19	58	0	53.8
4	16	3.7	32	3	75	0	65.4
5	23	3.6	40	7	68	0	67.8
6	22	5.0	56	20	28	0	75.9
7	16	2.9	40	12	68	0	56.3

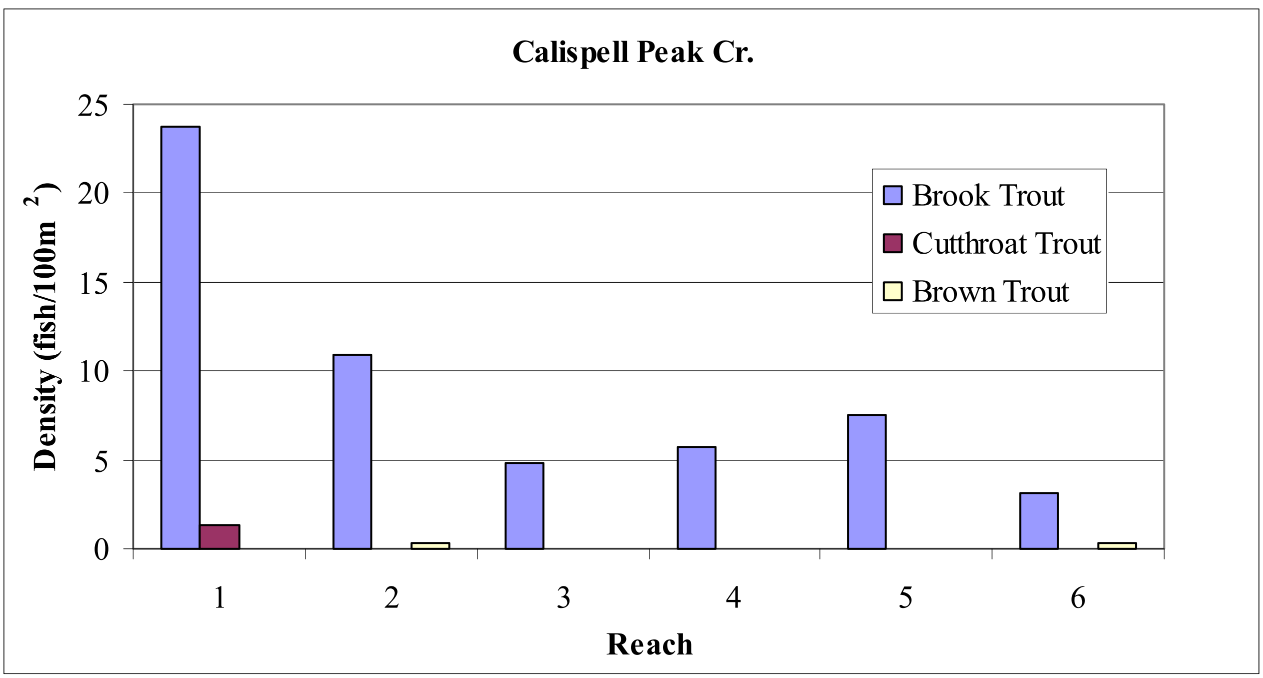

Figure 17. Fish densities in reaches snorkeled in Calispell Peak Creek.

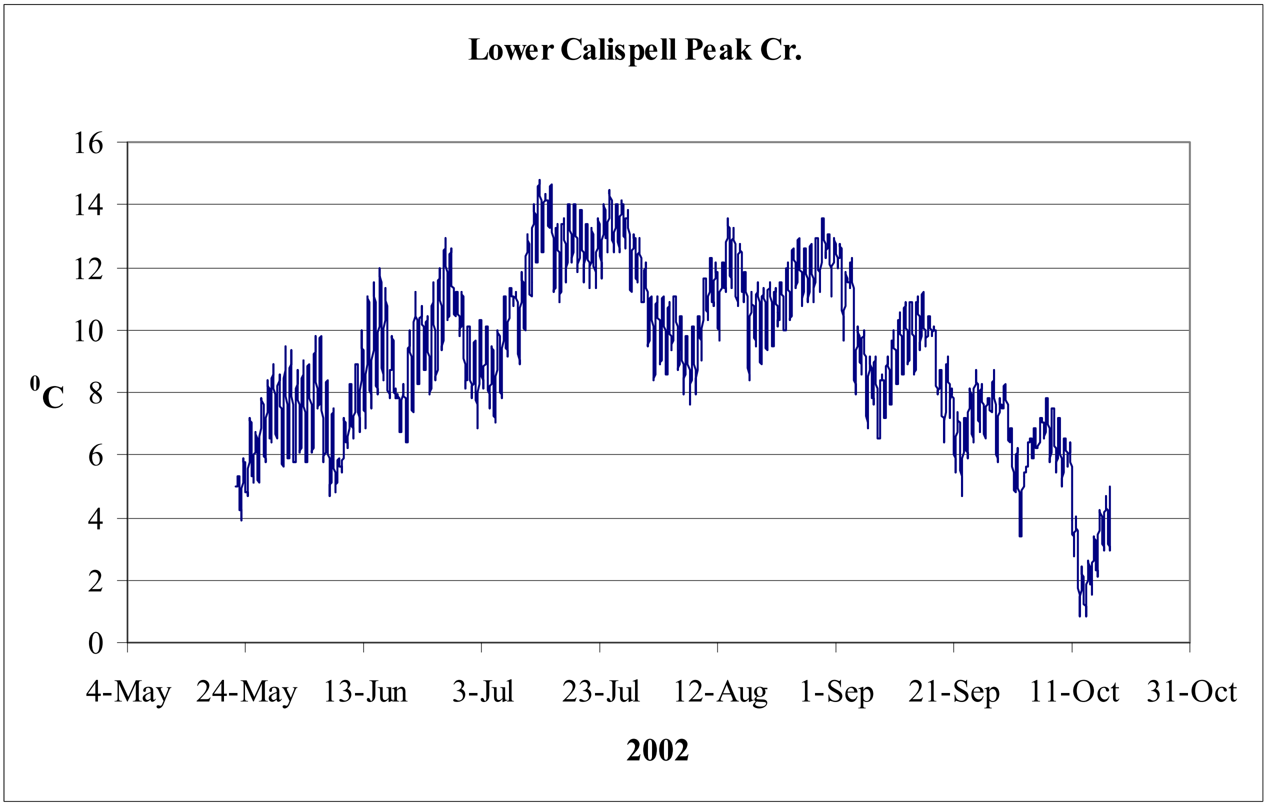

Figure 18. Hourly stream temperatures in lower Calispell Peak Creek.

Reach 3

Reach 3 was an A3 channel type and was 2250 m long. Two possible fish passage barriers were identified. Past timber harvest activities along the uplands had occurred throughout the reach. Hill-slope gradients were relatively high. The primary pool frequency (10.2 pools/Km) and pool composition (19%) were moderately good compared to the other reaches surveyed in Calispell Peak Creek. However, despite good numbers of LWD (53.8/100 m), sediment levels remained high (51% embeddedness) and resulted in pool filling. Fish density was low in reach 3 and brook trout was the only species observed (4.8 fish/100 m^2).

Reach 4

Reach 4 was 720 m in length and was classified as an A3 type channel. Roads associated with timber harvest were located throughout the uplands in reach 4. Extensive harvest has occurred throughout the upper watershed. Pool habitat was lacking in reach 4; the primary pool frequency was 4.2 pools/Km and only 3% of the habitat was composed of pools. Spawning habitat was absent from the reach. Substrate embeddedness was high (61%) for the respective channel type. Brook trout were observed in the snorkel station at a density of 5.8 fish/100 m^2.

Reach 5

Reach 5 was a steep (mean gradient of 15.5%) A2a+ type channel that was 810 m in length. Extensive timber harvest has occurred throughout the uplands but has left a riparian buffer. However, heavy volumes of blown down timber from the extant riparian area were encountered. Pool type habitat (7%), primary pools (11.1 pools/Km), and spawning gravel (0.0 m^2) were all lacking. Although channel gradient was steep, substrate embeddedness was high (61%). Brook trout was the only fish species observed and density was low (7.5 fish/100 m^2).

Reach 6

Reach 6 was a C6b type channel and was 1110 m in length. Old beaver ponds existed throughout the reach. Channel braiding was prevalent through old pond beds and resulted in an average width (5.0 m) higher than any other reach. The primary pool frequency remained relatively low (6.3 pools/Km); however, mean residual pool depth in reach 6 was higher than any other reach. Fish density was low in reach 6; brook trout and brown trout were observed at densities of 3.1 and 0.3 fish/100 m^2, respectively. A temperature logger was placed in the lower end of reach 6 from May 23 to October 18. Maximum daily stream temperature only exceeded 14^0C once during the sampling period (Figure 19).

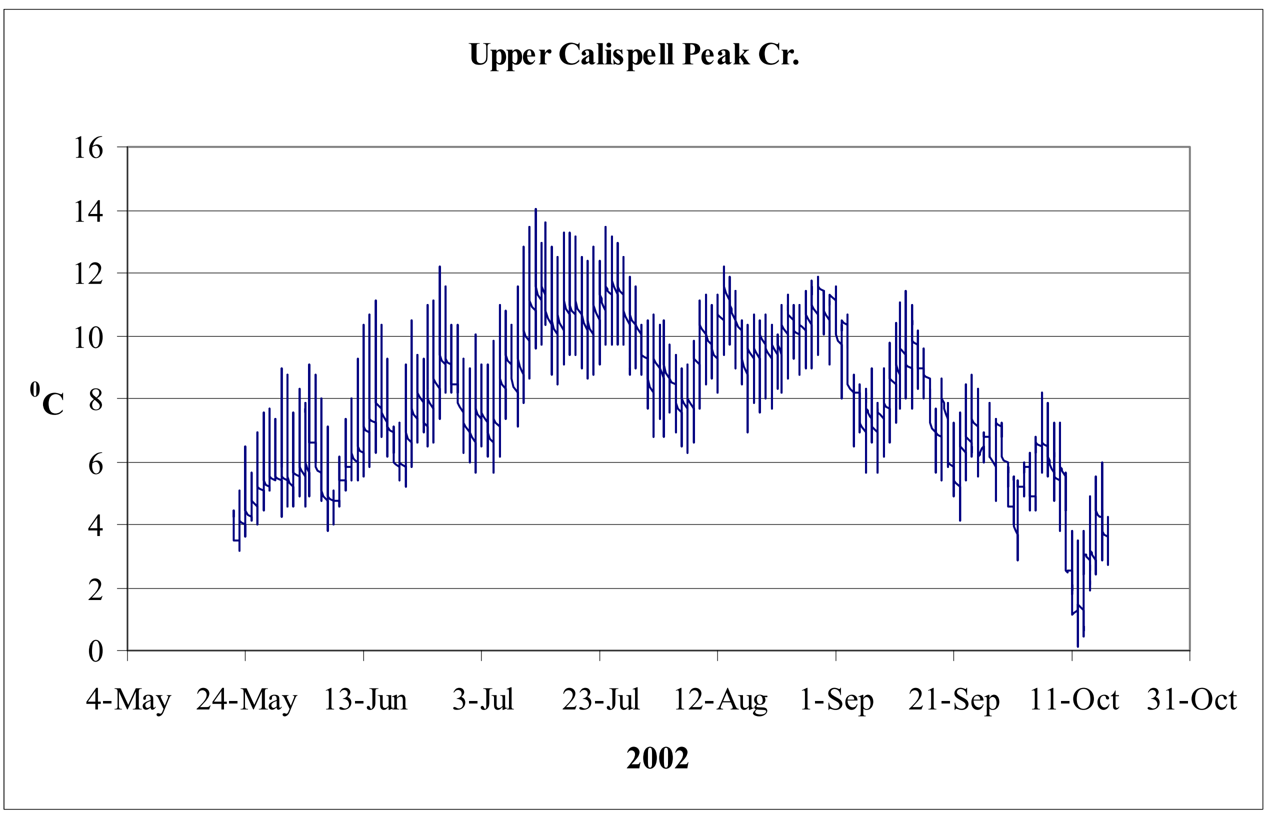

Figure 19. 2002 stream temperatures in upper Calispell Peak Creek.

Reach 7

Reach 7 was classified as an A3 channel and was 930 m long. Two tributaries entered the channel in this reach so flows upstream were reduced. Extensive timber harvest has occurred upstream in the watershed and road crossings are common. However, substrate embeddedness was relatively low in this reach (38%). Reach 7 was not snorkeled due to a lack of depth.

Little Tacoma Creek

Reach 1

Reach 1 started at the confluence with Tacoma Creek. The channel was classified as a B3a type and was 870 m in length (Table 33). No spawning habitat was observed in the reach (Table 34). Primary pool frequency was relatively moderate (19.5 pools/Km), but pool composition was relatively low (22%, Table 35). The channel in reach 1 was relatively wide and shallow resulting in a high bankfull width to depth ratio. The LWD density (18.5 pieces/100 m) was lower than any other reach in Little Tacoma Creek. Overall fish density was relatively low; brook and cutthroat trout had densities of 2.0 and 1.7 fish/100 m^2, respectively (Figure 20).

Reach 2

Reach 2 was a B5 type channel and was 1800 m in length. Substrate embeddedness was very high at 91%. However, primary pools (22.2 pools/Km), spawning habitat (12.5 m^2), and pool type habitat (50%) were all relatively common. Most fish observed in the snorkel station were brook trout. Brook and cutthroat trout had respective densities of 7.3 and 0.4 fish/100 m^2.

Reach 3

Reach 3 was a C6b channel type that was 1530 m in length. Near the end of the reach, a short section (~ 200 m) of channel was highly confined and steep (>30%) and fish passage barriers were likely present. However, most of the reach was low gradient (1-2%) and beaver dams/ponds were common throughout the reach. An old corduroy road was constructed over the channel for most of the reach (Figures 21 and 22). Positive identification of passage barriers in the steep section was hindered by the corduroy road which was relatively intact and obscured the channel; however, only cutthroat trout were observed in upstream reaches. The beaver ponds were retaining sediment and substrate embeddedness was high (80%). Although primary pool frequency was relatively low (10.5 pools/Km), pools were generally long and created by beaver damming. Brook trout was the only fish species observed in the reach 3 snorkel station (8.2 fish/100 m^2).

Reach 4

Reach 4 was 960 m in length and classified as a C5 type channel. Most of the reach was influenced by beaver activity. Substrate embeddedness was high (98%) and no spawning habitat was observed. Remnants of the corduroy road were noted in the reach. Mean residual pool depth was relatively high (56 cm) due to numerous beaver dam pools. It appears that native westslope cutthroat trout are isolated above the steep channel section observed in reach 3. Cutthroat trout was the only fish species observed in the snorkel station and density was 12.2 fish/100 m^2.

Reach 5

Reach 5 was an E5 type channel that was 1290 m long. The old corduroy road existed over much of the channel. Numerous springs were contributing to flow in reach 5. Substrate embeddedness was high (91%) and spawning habitat was sparse (1.5 m^2). Cutthroat trout were observed at a density of 12.6 fish/100 m^2.

Reach 6

Reach 6 was a B3a channel and was 870 m in length. Remnants of the corduroy road still existed. Due to spring flows in reach 5 and lower reach 6, streamflow in reach 6 was much reduced. The average depth decreased over 50% from 19 cm in reach 5 to 8 cm in reach 6. Average width also showed a corresponding decrease. As a result of decreased channel size and flow, the primary pool frequency was low (4.6 pools/Km). A temperature logger was deployed at the top end of reach 6 on June 9 and retrieved on October 30. Variance in daily stream temperatures was relatively high (Figure 23) and temperatures often exceeded 14^0C in mid-June through late July. A shallow pond was located approximately 400 m upstream from the site of the thermograph. The high variation and high temperatures likely resulted from daily warming and cooling of the ponded water. Data from the temperature logger deployed in lower Little Tacoma Creek was irretrievable. However, due to the volume of streamflow contributed by downstream springs, stream temperatures in most of Little Tacoma Creek may be within a good range. Cutthroat trout density was low in reach 6 (0.7 fish/100 m^2); however, depths were minimal and an accurate count may not have been attained.

Table 33. Channel characteristics for reaches surveyed in Little Tacoma Creek.

Little Tacoma Creek				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	B3a	6.4	Cobble	22.5
2	B5	2.2	Sand	7.8
3	C6b	4.5	Silt	18.3
4	C5	1.2	Sand	9.3
5	E5	0.9	Sand	7.9
6	B3a	6.6	Cobble	11.4

Table 34. Limiting factor attribute values for six reaches surveyed in Little Tacoma Creek.

Little Tacoma Creek							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	67	99	2.2	4.0	0.4	0.0	19.5
2	91	100	4.4	4.3	1.6	12.5	22.2
3	80	100	3.2	3.7	1.7	2.0	10.5
4	98	100	4.0	4.1	2.4	0.0	17.7
5	91	100	4.1	4.2	1.3	1.5	14.0
6	46	100	3.4	2.4	0.4	0.0	4.6

Table 35. Reach-scale values for habitat attributes surveyed in Little Tacoma Creek.

Little Tacoma Creek							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	18	3.6	35	22	61	4	18.5
2	21	2.9	36	50	32	0	30.9
3	23	4.2	47	54	32	2	31.7
4	27	3.0	56	44	18	0	27.4
5	19	2.5	43	29	23	0	31.2
6	8	1.7	39	22	51	0	23.2

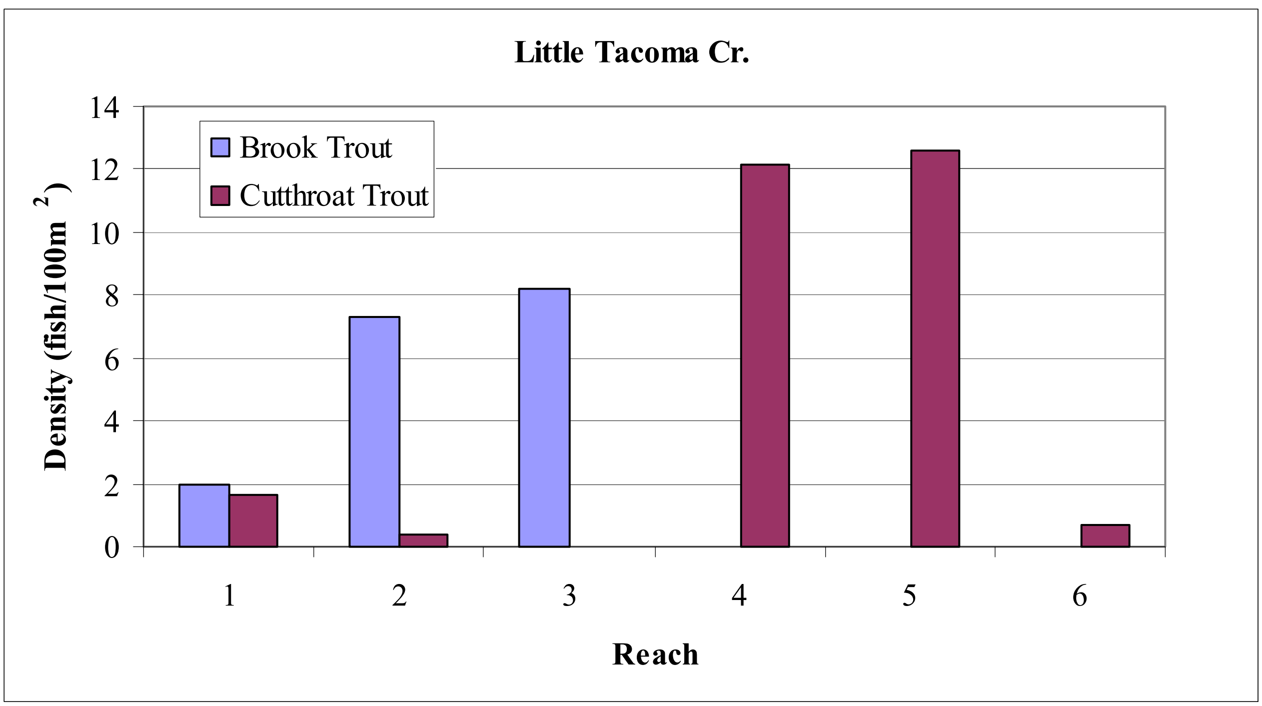

Figure 20. Brook trout and cutthroat trout densities in Little Tacoma Creek.

Figure 21. Old corduroy road that existed over the channel through much of Little Tacoma Creek.

Figure 22. Remnants of the old corduroy road running over the channel.

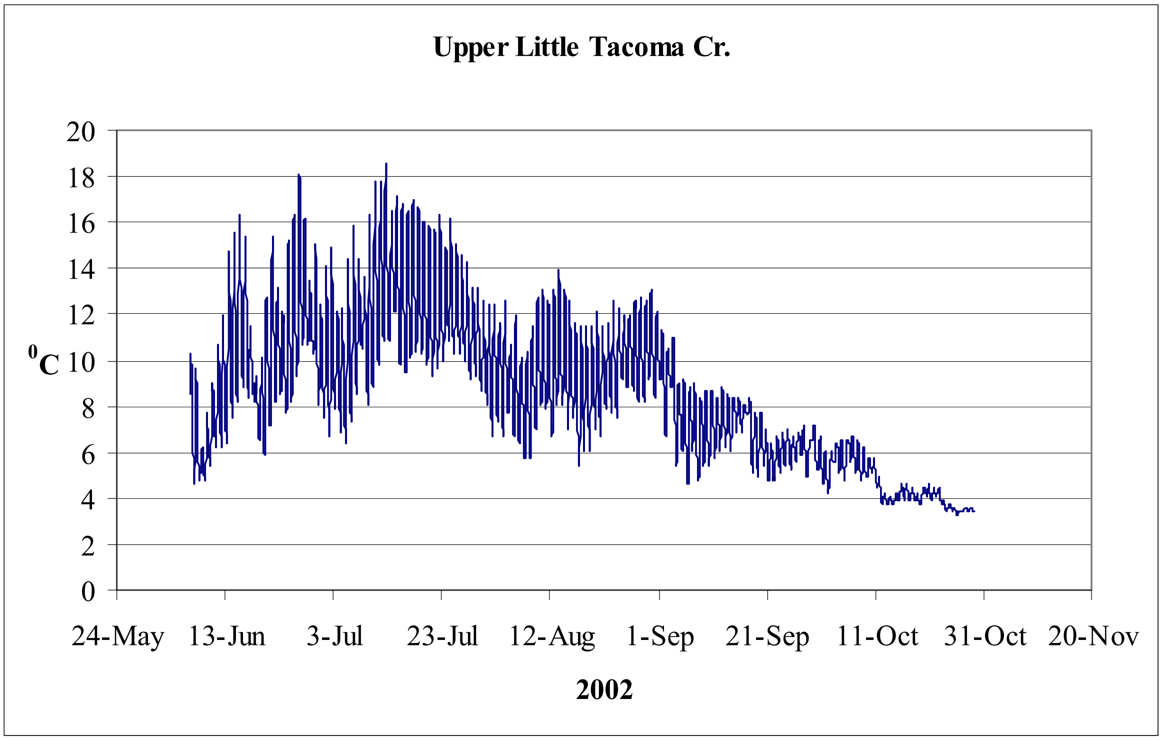

Figure 23. Stream temperatures, recorded hourly, for upper Little Tacoma Creek.

DISCUSSION

High quantities of fine sediment were observed throughout the Tacoma Creek watershed. Although high levels may be expected given the dominant parent geology (granodiorite), it appears that intensive management activities have increased sediment to levels beyond channel capacities. Channels with gradients of 5-10% often had substrate embeddedness levels greater than 70%.

Similar streams (in geology and watershed size) that the Tribe has previously surveyed include North Fork (N.F.) Calispell Creek (Andersen and Maroney, 2001) and West Branch (W.B.) LeClerc Creek (Maroney and Andersen, 2000b). Comparisons of habitat attributes with the similar streams indicate that excess sediment is impacting fish habitat and populations. In Tacoma Creek, averages of substrate embeddedness in A and B type channels were up to 2.5 times higher than averages from similar streams (Table 36). Acting LWD densities in Tacoma Creek were nearly double the densities in N.F. Calispell Creek and W.B. LeClerc Creek. However, rather than functioning as scour elements (i.e. pool formation) the LWD in Tacoma Creek are acting as sediment storage reservoirs with little remaining capacity. As a result, the primary pool frequency in Tacoma Creek was less than 50% of the frequency observed in the comparable streams

Table 36. Habitat attribute and fish density values for Tacoma Creek and two similar streams.

Stream	Acting LWD (No./100 m)		Embeddedness (%)		Spawning Gravel (m^2)		Primary Pools (No./Km)		Total Fish Density (No./100m^2)	
	A*	B	A	B	A	B	A	B	A	B
N.F. Calispell Cr.	25.2	19.9	30	48	16.6	43.8	18.1	17.8	19.5	28.5
W.B. LeClerc Cr.	16.0	19.4	47	60	4.8	18.5	9.0	5.5	20.7	14.3
Tacoma Cr.	56.2	38.4	77	72	3.0	7.9	4.2	2.5	5.7	2.4

*Data were pooled for A and B type channels.

for A and B channel types. Spawning habitat also appears to be impacted by the high levels of fine sediment. Mean spawning gravels per reach type were considerably lower. Consequentially, degraded habitat in Tacoma Creek appears to have effected the fish populations. Fish densities throughout the watershed were relatively low. In fact, mean total fish densities were over 300% and nearly 600% lower in A and B type channels, respectively, than in N.F. Calispell Creek and W.B. LeClerc Creek.

Wood is a primary factor in determining stream channel complexity. LWD provides many important functions to fish populations and stream channels. LWD has a critical role in modifying and maintaining channel morphology, trapping transported sediment, and stabilizing stream banks. Fish use wood for cover and wood provides refugia during extreme flow events. Jakober et al (1998) found bull trout and cutthroat trout preferred habitat with large woody debris. However, the high levels of sediment in Tacoma Creek appear to be overriding the benefits associated with the high LWD densities.

High substrate embeddedness decreases the amount of cover available to overwintering fish (Griffith and Smith 1993). Increased fine sediment in streams can also fill in pools, backwater habitat, and side channels that are important to rearing and overwintering bull trout and cutthroat trout.

Although stream degradation is detrimental to native salmonids, it generally favors introduced salmonid species which are more tolerant to lower quality habitat conditions. Behnke (1979) described how clearcutting along two streams in the Smith River drainage of Montana increased erosion, sediment loads and water temperatures. The westslope cutthroat population was eliminated in the disturbed area and brook trout became the principle species. However, a small area in the headwaters of one stream was not logged and an indigenous cutthroat population still dominated in that reach. Platts (1974) also reported that cutthroat were common only in undisturbed reaches of streams in the Salmon River drainage of Idaho. Novinger and Rahel (1999) examined the competitive effects of brook trout on cutthroat trout in Colorado. Their findings indicated that age 0^+ brook trout had negative effects on growth and survival of age 0^+ cutthroat when held sympatrically in enclosures.

Cutthroat trout in Tacoma Creek have clearly been impacted by interactions with non-native fish species. The mean cutthroat trout density in reaches located downstream of fish passage barriers in Tacoma and Little Tacoma creeks was 1.0 fish/100 m^2 (n=18). In reaches located upstream of the barriers where cutthroat trout were allopatric, mean cutthroat trout density was 5.3 fish/100 m^2 (n=11).

However, degraded habitat also appears to effect these isolated populations. Middle Creek, located approximately 10 miles east of Little Tacoma Creek, also has an allopatric population of cutthroat trout. Mean density of cutthroat trout in Middle Creek is 12.6 fish/100^2 (Maroney and Andersen, 2000a); over twice the mean density of isolated cutthroat trout in the Tacoma Creek watershed.

The high in-stream sediment levels appear to result from extensive timber harvest activities in the watershed, particularly in the headwaters. Sections of private land ownership are concentrated in the headwaters of Tacoma Creek and it tributaries. Relatively recent timber harvest activities have been concentrated in these privately held lands and road densities appear to be relatively high. The primary road in the lower to mid watershed often runs adjacent to Tacoma Creek.

Roads located throughout the watershed appear to be contributing large volumes of sediment to the streams due to poor design. The roadbeds are often in-sloped with ditches running down the up-slope side of the road. On occasion, ditches terminated at perennial or intermittent stream channel crossings with the transported sediment deposited directly in the channel (Figure 24). Culverts were placed in low areas to pass surface water under the roadbed. Many of the gullies downslope of these culverts are filled with fine sediment (Figure 25). Fine sediment delivered by these culverts eventually makes it to perennial streams as evidenced by depositional areas along the length of the gully and up to the edge of the stream. In some instances, while walking upstream, habitat surveyors could predict an upcoming sediment-filled gully because of a noticeable increase in sediment.

Habitat restoration in Tacoma Creek and its tributaries should be focused on a reduction of in-channel fine sediment. Over-winter habitat (i.e. primary pools) and spawning habitat appeared to be the primary limiting factors. The components for these types of habitats were present (e.g. high density of LWD, gravels); however, they were rendered functionless due to the high levels of sediment.

Figure 24. Sediment laden runoff diverted to an intermittent gully.

Figure 25. Gully with sediment deposition downslope of a culvert. Sediment extends to the edge of perennial stream.

Due to the high cost and lack of funding for relocating and rehabilitating roads (on federal ground) and the limitations of liability required of private landholders, we recommend site-specific projects to limit sediment delivery to streams. Sediment basins could be constructed in areas similar to Figure 26 to trap sediment delivered from roads. The basins would be constructed using logs and straw bales. A log sill would be constructed across a gully, with the ends of the logs toed into the banks. Straw bales would be placed in front of the sill and anchored with re-bar. One or more basins could be constructed for each gully.

Figure 26. Sediment was transported through gullies and deposited behind LWD.

BULL TROUT AND CUTTHROAT TROUT HABITAT ENHANCEMENT MONITORING

DESCRIPTION OF STUDY AREA

The Pend Oreille River begins at the outlet of Pend Oreille Lake, Idaho, and flows in a westerly direction to approximately Dalkena, Washington (Figure 27). From Dalkena the river turns and flows north into British Columbia where it joins the Columbia River. The approximate drainage area at the international border is 65,300 km^2 (Barber et al. 1990). The normal high flow month is June with a mean discharge of 61,858 cfs, the normal low flow month is August with a mean discharge of 11,897 cfs (Barber et al. 1990). The Box Canyon Reservoir has 47 tributaries and covers 90 river kilometers of the Pend Oreille River, from Albeni Falls Dam at the southern border to Box Canyon Dam at the northern border.

Cee Cee Ah Creek has a drainage basin area of 63.5 km^2, with 14.6 km of stream (Figure 28). Cee Cee Ah has a diverse morphology with varied gradient. Cee Cee Ah has an intermediate gradient on top, a flat gradient in the middle, a steep gradient in the lower section with a 25 m waterfall, and a low gradient for the last 2 km of stream. This creek has an extensive slough system for the last 1km before it's confluence with the Pend Oreille River. Cee Cee Ah Creek empties into the Pend Oreille River at river kilometer 130.

Browns Creek is a major tributary of Cee Cee Ah Creek. Originating from springs fed by Browns Lake, the creek flows approximately 3.4 miles from the origin to the confluence with Cee Cee Ah Creek. Browns Creek begins in a series of beaver ponds in the headwaters and runs through relatively undisturbed forests to another series of beaver ponds in the middle reach. The lower portion runs through mature forests with fairly consistent gradient. The drainage basin area for Browns Creek is approximately 21.5 km^2.

LeClerc Creek is the largest drainage of the three priority tributaries. LeClerc Creek’s drainage basin is 161 km^2 (Figure 29). The LeClerc system is split into three separate branches (East, West, and Middle). There is approximately 93 km of stream in the LeClerc system. This is one of the largest tributary systems in the Box Canyon Reservoir. Tributaries to the LeClerc system are, Mineral and Whiteman Creeks (tributaries to the West Branch of LeClerc), and Fourth of July Creek (tributary to East Branch of LeClerc Creek). The East and Middle branch flow together 5 km above the confluence with the Pend Oreille River. The main branch is formed by the merging of the East and West branches 2.5 km above the Pend Oreille River. LeClerc Creek flows into the Pend Oreille River at approximately river kilometer 90.

Indian Creek has the smallest drainage basin of all the tributaries surveyed at 20 km^2 and is one of the shortest tributaries with 3.84 km of stream (Figure 30). This stream has no secondary tributaries and is spring fed. This stream flows through relatively low gradients and is generally wide and shallow. A series of beaver dams are constructed at the mouth of this stream creating potential migration barriers. The stream flows into the Pend Oreille River on the East side at river kilometer 140.

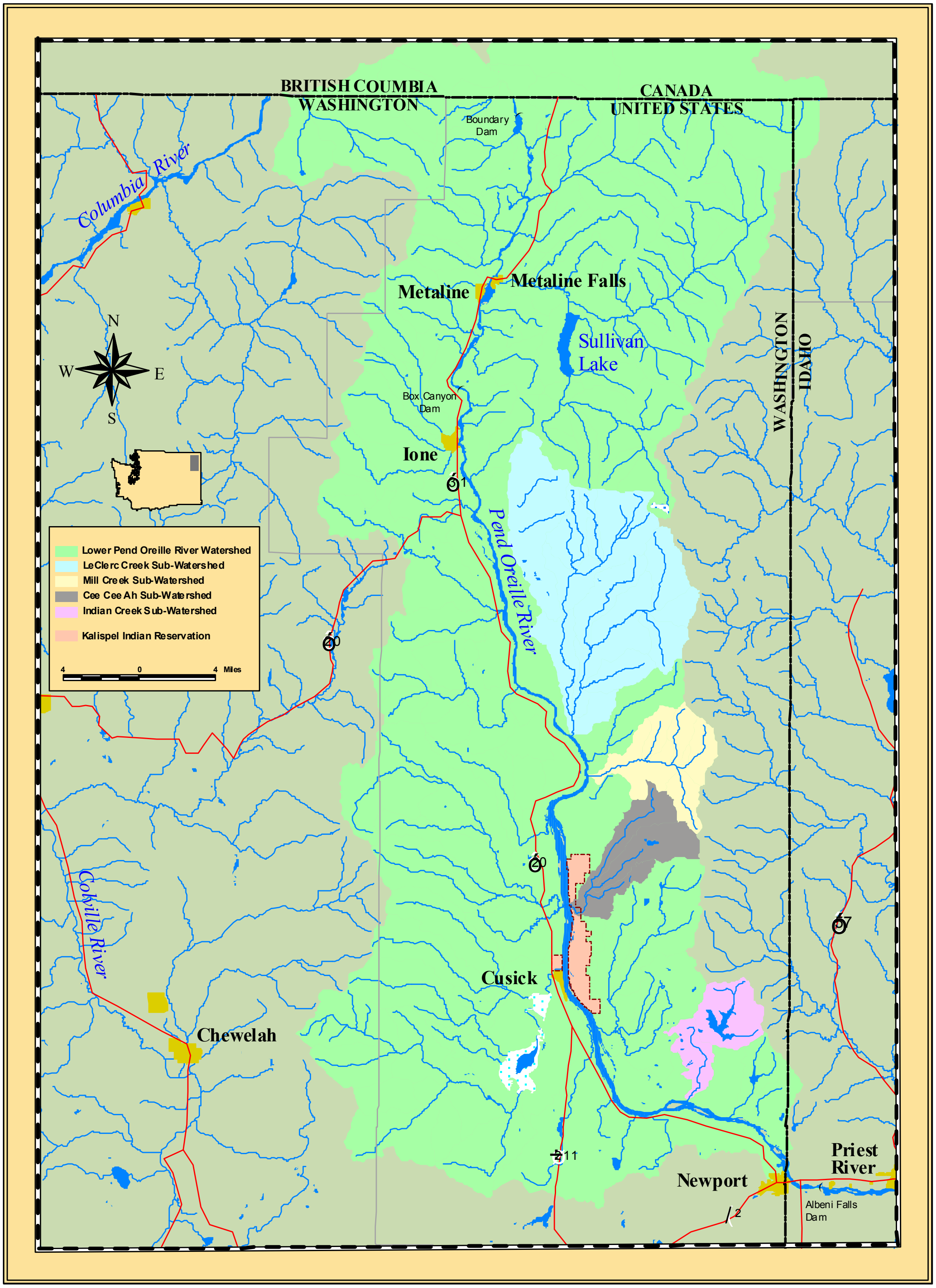

Figure 27. Map of study area including Pend Oreille River watershed and sub-watersheds where enhancement activity has been implemented.

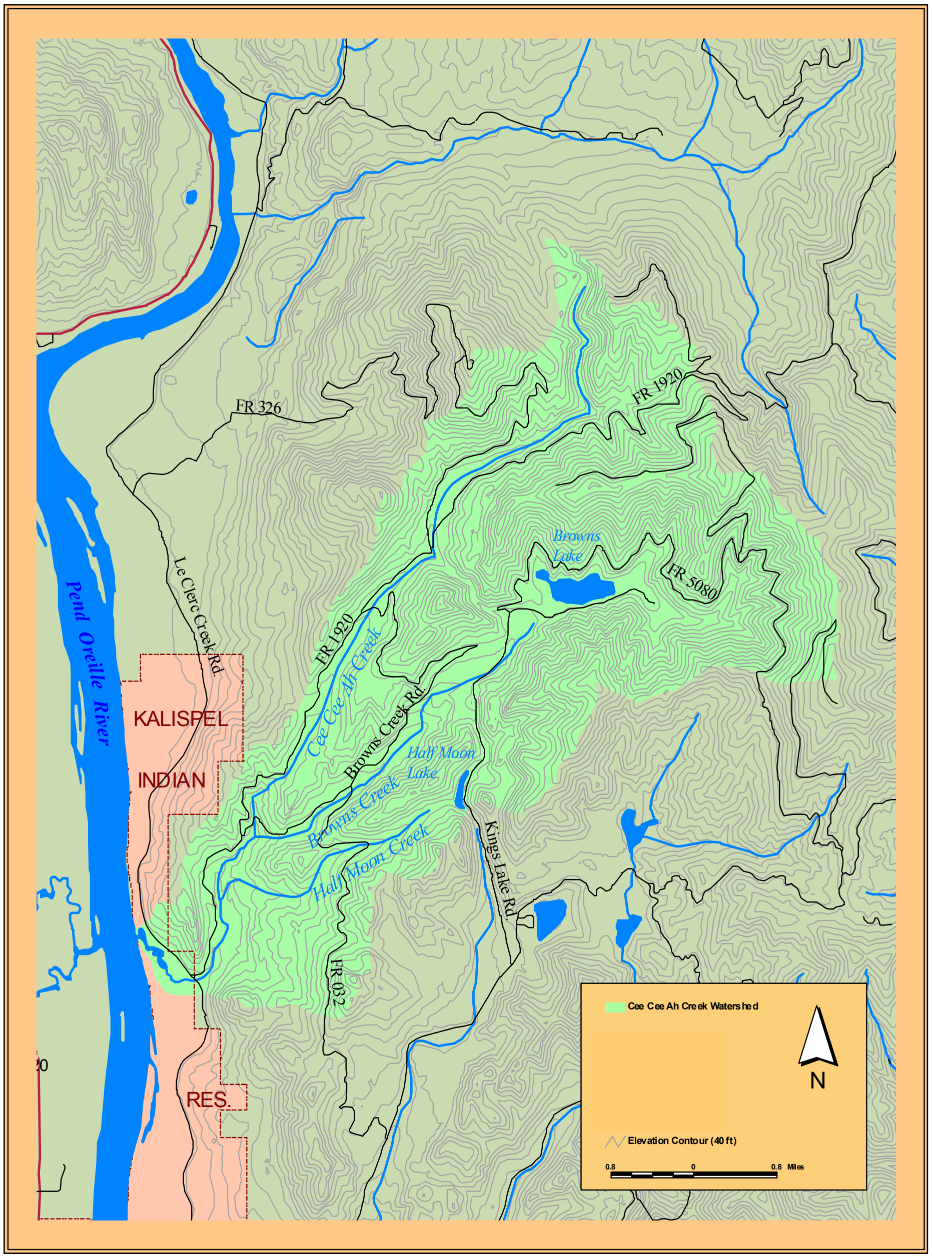

Figure 28. Map of Cee Cee Ah Creek watershed and Browns Creek sub-watershed where habitat enhancement was implemented in 1996, 1997 and 1998.

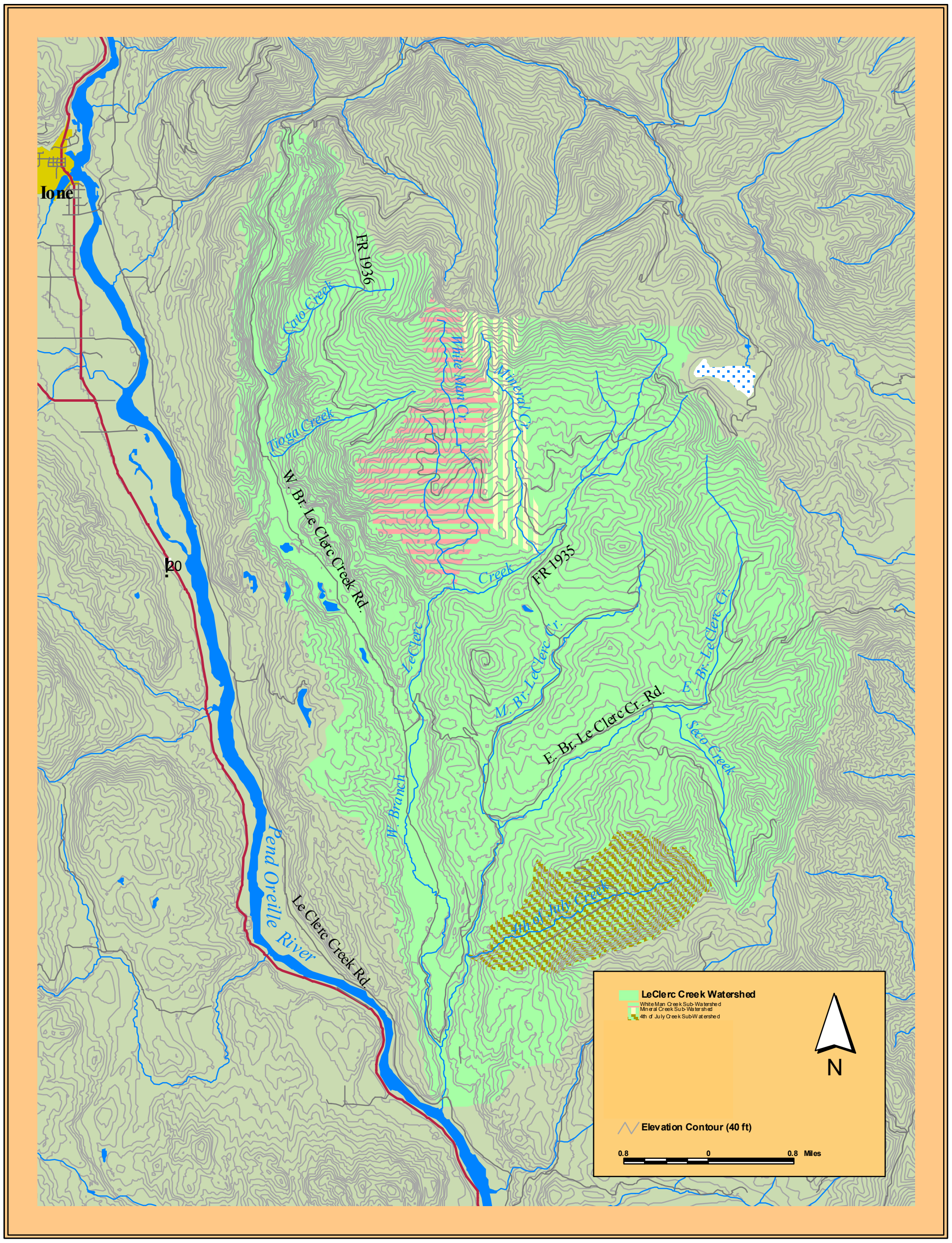

Figure 29. Map of LeClerc Creek watershed and highlighted sub-watersheds where habitat enhancement was implemented in 1996, 1997 and 1998.

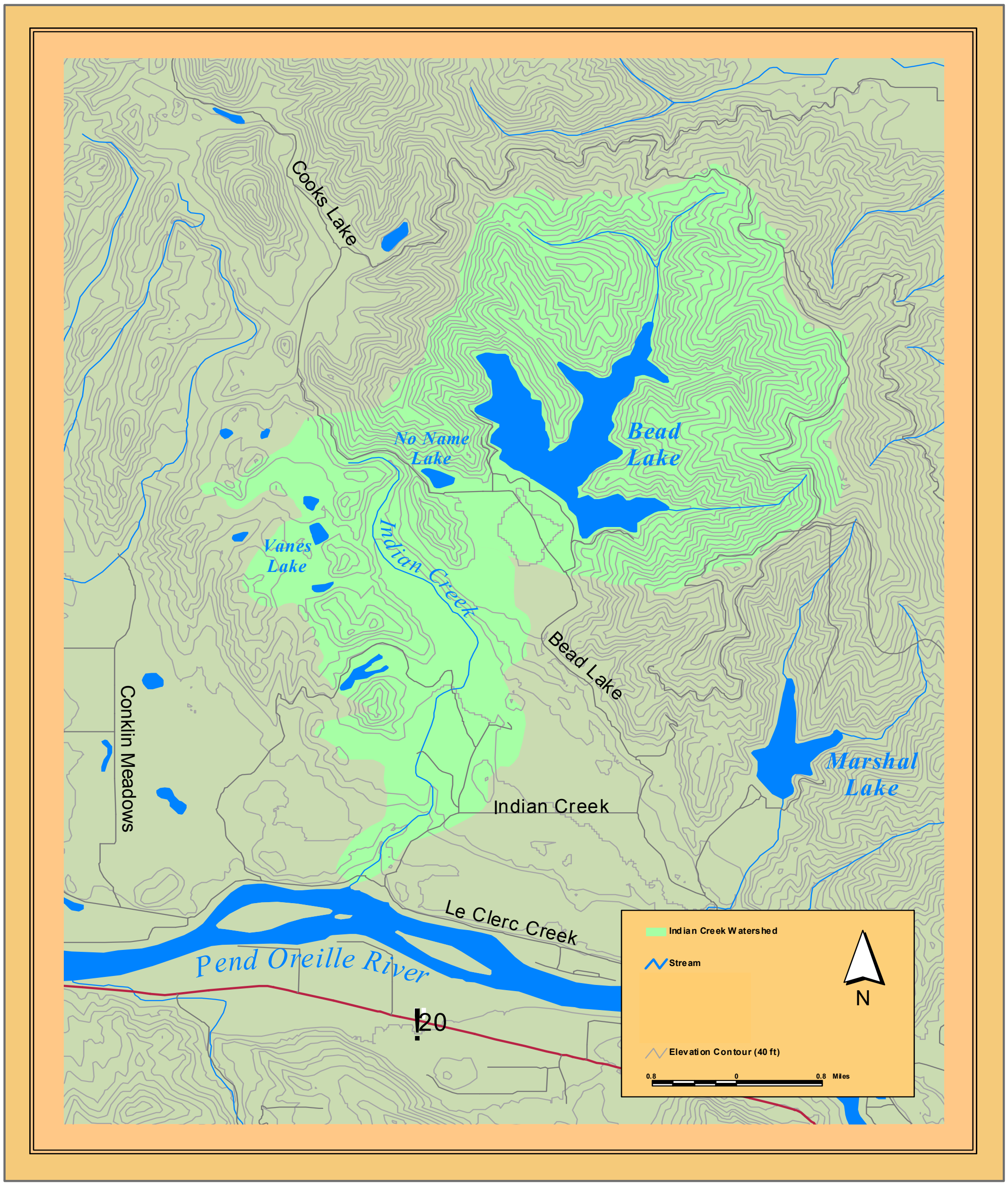

Figure 30. Map of Indian Creek watershed where habitat enhancement was implemented in 1996, 1997 and 1998.

METHODS

Baseline fish habitat data, collected in 1995, were analyzed to determine where enhancement would take place. For each surveyed stream, an inter-reach comparison was conducted using the mean attribute values for each reach. This was the fundamental unit of comparison to determine specific reaches for enhancement projects. Threshold values were established for embeddedness, bank stability, bank cover, instream cover, pool-riffle ratio, spawning gravel and primary pools (Table 37). All threshold values were obtained from Hunter (1991) and/or MacDonald et al. (1991). The mean data for each reach was analyzed by using these threshold criteria. Each habitat value that did not fall within the threshold was counted as habitat that is unsatisfactory for quality or quantity. The reaches with the highest number of unsatisfactory habitat values were identified as potential enhancement sites for that particular stream. Snorkel surveys were used to determine fish population densities and age class distribution for all salmonid populations within each stream. Information from the snorkel surveys and the inter-reach comparisons was used to draw conclusions on the effects of degraded habitat quality and non-native salmonids on native salmonid species. Conclusions were used to aid in more informed restoration recommendations.

Data from the specific reaches identified in the inter-reach comparison was evaluated in a flowchart to provide a list of possible options for the types of structures or measures used in enhancement (Figure 31). The flow chart took into account gradient, embeddedness, and pool to riffle ratio. Each structure was designed to perform specific functions and required specific habitat placement (Table 38). Structure selection was made by reviewing the list of options for enhancement and choosing the structure that addresses the limiting factors for each particular reach of enhancement. Reach accessibility was also considered when choosing between structures with similar function but varying levels of effort in their construction. Specific placement was determined by the transects within each reach that were in the habitat type for which each structure was designed.

Prior to implementation, all sites selected as areas for enhancement were pre-assessed using an intense version of the standard transect methodology. The same methodology was used for both pre and post assessments. The only modification to the standard transect methodology was a shortening of the length between transects. Riparian project areas were assessed with 10 m transects for each kilometer where fencing and planting occurred. Instream structures were assessed using 5 m transect spacing; the assessment was conducted from 30 m above (upstream) the structure site to 30 m below (downstream).

Fish monitoring stations for riparian restoration were calculated to be one 30 m snorkel station per 250 m of stream. A minimum sample size of three snorkel stations for each restoration area was conducted, unless the area was less than or equal to 90 m long, in which case the entire area was snorkeled. Assuming the lowest known bull trout population density (0.075 bull trout/30 m) in the state of Washington (Hillman and Platts 1993), we were 95% confident that if bull trout were in the stretch of the stream we would observe them at this rate of sampling. Bull trout were used to determine the sample size because they are the least abundant native salmonid species in the area. Each monitoring station was benchmarked at the upper and lower boundary with labeled aluminum tags attached to rebar stakes. Data from snorkel stations will be used to determine densities of all fish species present.

Fish monitoring for instream structures was conducted annually to determine the fish numbers and species within the enhancement area. The stream length snorkeled, from 30 m below to 30 m above the stream section where structures were placed, was identical to where habitat monitoring occurs.

All in-stream structure enhancement areas were monitored annually. Riparian planting and cattle exclusion fence sites are intended to provide longer term rehabilitation over an extended time schedule. The rate of post-assessment sampling for these sites was every third year.

Post assessment data in 14 reaches were compared to pre-assessment data for structures implemented from 1996 to 1998. Comparisons were limited to the following stream survey attributes: 1) substrate embeddedness, 2) percent pool habitat, 3) average depth, 4) average width, 5) number of primary pools, and 6) spawning gravel. These survey attributes were chosen for comparison because they have the best potential to reflect short term changes in habitat that may result from the restoration structures. Also, these were the attributes identified in the baseline surveys as limiting fish populations. Since no control reaches were sampled, changes to habitat attributes were assumed to be the result of the restoration structures.

Changes to the spawning gravel assessment were made prior to the 2001 sampling season. Previous assessments of spring spawning gravel included areas that were underwater during the spring but dry at base flows (generally starting in July or August), while fall spawning gravel was evaluated at base flow conditions. In 2000, local resident cutthroat trout were observed spawning in mid July at base flows. It appears that previous fall spawning habitat assessments more accurately reflected available spring spawning habitat, as well as fall spawning habitat. Therefore, starting in 2001 evaluation of spawning habitat only considered gravels within the base flow wetted channel. Since there appears to be little local difference between the spawning habitat of spring and fall spawners, no distinction between fall and spring spawning habitat was made in 2001 and later habitat post assessments. Comparisons of 2001 and later spawning habitat data were made with previous years' fall spawning habitat since it appears to more accurately represent actual spawning habitat.

Table 37. Interreach comparison threshold values (after Hunter 1991; MacDonald 1991).

Limiting Factor	Threshold Value
Embeddedness	Any value ≥ .30 or ≤ .70
Bank Stability	Any value ≤ 75%
Bank Cover	Any value ≤ 2.5
Instream Cover	Any value ≤ 2.0
Pool - Riffle Ratio	Any value ≤ .5:1 or ≥ 1.5:1
Spawning Gravel	Three lowest cumulative values
Primary Pools	Three lowest values

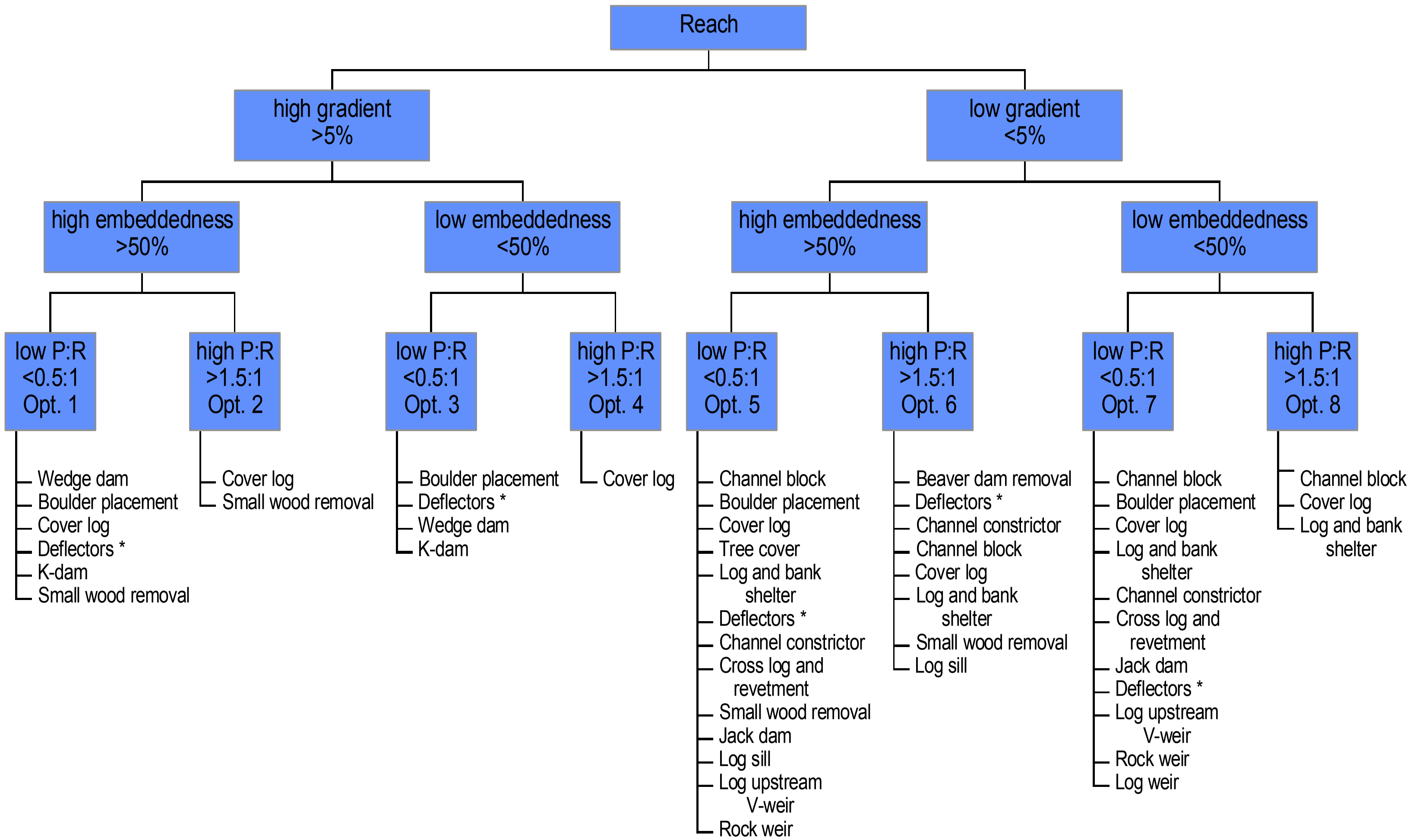

Figure 31. Flowchart for identified reaches of enhancement and the possible structures available for enhancement. Values derived after Harrelson et al. 1994, Macdonald 1991 and Hunter 1991.

Table 38. Instream structures and the descriptions for placement requirements, functions and impacts.

Structure	Habitat	Stream Requirements	Purpose	Impacts
Wedge dam	Riffles Runs	Well defined stream banks. Stream < 30 ft. wide. Gradient >5%. Substrate consisting of: Rubble, cobble and gravel Ideal locations are at a break In gradient with a steeper section Immediately upstream.	Creates a fair to excellent scour pool. Creates spawning gravel at tail-out of pool	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Boulder placement	Riffles Runs Glides Open Pools	Greatest benefits in currents Exceeding 2 feet per Second. Suitable for any size stream.	Provides overhead cover and resting areas. Creates natural appearance.	+ Creates pocketwater behind boulder. + Added depth is also created by the scouring resulting from reduced channel capacity and increased current velocity.
Cover log	Open Pools Runs	Works best in meanders or in conjunction with deflectors. Requires adequate water depth (at least 8" deep.) Suitable for any size stream.	Provides optimum cover.	+ Creates overhead cover. + Directs current away from meander. - May cause unwanted bank cutting.
Single-Wing Deflector	Riffles Glides Runs	When possible, divert water into a Relatively stable section of stream Bank	Constricts and diverts water flow so that Pools are formed by	+ Constricts and diverts water flow. +/- May cause deposition of sediment just below Structure towards bank

Table 38. *continued*

Structure	Habitat	Stream Requirements	Purpose	Impacts
Double-Wing Deflector	Riffles Runs Glides	Especially suitable for shallow sections of stream where the gradient is too steep for effective deflector and cover log.	Creates mid-channel pools through scouring. Creates spawning gravel at tail-out of pool.	+ Narrows channel. + Scours a pool below structure. +/- May cause deposition of sediment just below structure towards bank. - May cause unwanted bank cutting.
Channel Constrictor	Riffles Runs Glides	Provides best results when placed in long, straight, low-gradient stretches of stream.	Provides overhead cover. Narrows channel. Scour and deepen streambed.	+ Scours the streambed. + Increases velocity. + Helps transport sediment. - May concentrate sediment below structure. +/- Incises the channel.
Log Deflector	Riffles Glides Runs	When possible, divert water into a relatively stable section of stream bank. Suitable for a variety of sites. Most suitable in wide shallow riffles.	Constricts and diverts water flow so that pools are formed by scouring. Creates spawning gravel	+ Constricts and diverts water flow. +/- May cause deposition of sediment just below structure towards bank. + Directs meander.

Table 38. *continued*

Structure	Habitat	Stream Requirements	Purpose	Impacts
Log Paired Deflector	Riffles Runs Glides	Especially suitable for shallow sections of stream where the gradient is too steep for effective deflector and cover log.	Creates mid-channel pools through scouring. Creates spawning gravel at tail-out of pool.	+ Narrows channel + Scours a pool below structure. +/- May cause deposition of sediment just below structure towards bank.
Rock Deflector	Riffles Runs Glides	When possible, divert water into a relatively stable section of stream bank. Suitable for a variety of sites. Most suitable in wide shallow riffles.	Directs flow from cut bank. Directs meander. Scours pool.	+ Constricts and diverts water flow. +/- May cause deposition of sediment just below structure towards bank. + Directs meander.
Boulder Paired Deflector	Riffle Runs Glides	Especially suitable for shallow sections of stream where the gradient is too steep for effective deflector and cover log.	Creates mid-channel pools through scouring. Creates spawning gravel at tail-out of pool.	+ Narrows channel. + Scours a pool below structure. +/- May cause deposition of sediment just below structure towards bank.

Table 38. *continued*

Structure	Habitat	Stream Requirements	Purpose	Impacts
K – Dam	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient >5%. Substrate consisting of: rubble, cobble and gravel. Ideal locations are at a break in gradient with a steeper section immediately upstream.	Creates a fair to excellent scour pool. Creates spawning gravel at tail-out of pool.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment. - Prone to undercutting of structure.
Small Wood Removal	Riffles Glides Runs	Small wood must be acting as a silt trap or inhibiting fish migration in order to be removed. Typically used to increase velocity and transport sediment.	Typically used to increase velocity and transport sediment. Helps expose substrate.	+ Increases velocity. + Transports sediment. + Exposes substrate. + Narrows channel.

Structure	Habitat	Stream Requirements	Purpose	Impacts
Channel Block	Braided Channel	Braided channel that is virtually unusable.	Consolidates flow . into a single, deeper channel.	+ Concentrates flow into a single deeper channel. + May increase velocity. - May concentrate sediment deposition downstream.

Table 38. *continued*

Structure	Habitat	Stream Requirements	Purpose	Impacts
Tree Cover	Riffles Runs Glides	Suitable for a variety of sites. Greatest benefits probably occur in wide shallow streams with sand or gravel substrate.	Provides excellent overhead cover. Increases stream velocity. Transports sediment.	+ Constricts wide shallow channels. + Increases stream velocity. + Transports sediment.
Log & Bank Shelter	Open Pools	Suitable for use in low gradient. Stream bends or meanders. Can be used with a deflector.	Provides overhead cover. Provides some streambank protection.	+ Creates overhead cover. + Directs current away from meander.
Cross Log & Revetment	Riffles Runs	Structure works best in low gradient sections of the stream. Works even better at the beginning of wide, shallow bends with marginal pools or cover.	Creates scour pool. Creates overhead cover. Protects the bank.	+ Creates a scour pool. + Protects bank.
Jack Dam	Riffles Runs	High banks. Moderate to steep gradient.	Produces deep scour pools.	+/- Creates calmer water above the structure. + Creates scour pool.

Table 38. *continued*

Structure	Habitat	Stream Requirements	Purpose	Impacts
Log Sill	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient <5%.	Creates scour pool. May create spawning gravel.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Structure	Habitat	Stream Requirements	Purpose	Impacts
Log Upstream V-Weir	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient <5%. Works well in sand and gravel substrate.	Creates deep plunge pool. Creates spawning gravel at tail-out of pool.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Rock Weir	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient <5%.	Creates scour pool.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Log Weir	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient <5%.	Creates scour pool.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Beaver dam removal	Long Pools	A beaver dam in the in the lower 2/3 of the stream . A beaver dam that may inhibit fish passage.	Narrows channel. Exposes substrate.	- Releases a large volume of sediment downstream. +/- Incises the channel . + Decreases sediment upstream. + May expose substrate such as cobble, gravel and boulders.

RESULTS

Cee Cee Ah Creek

Reach 4

In 1996, three K-dams were constructed in reach 4 following the pre-assessment. Inter-annual trends have been variable; however, substrate embeddedness decreased from 48% in the pre-assessment to 40% in 2002 (Table 39). Embeddedness ranged from 32% in 2000 to 60% in 1999. Spawning gravel was high in the pre-assessment (8.1 m^2), but no substrate was classified as spawning gravel in 4 of the 6 years of post assessment and only 0.5 m^2 was observed in 2002. The percent of pool habitat increased from 7% in the 1996 pre-assessment to a high of 38% in 2001; however, pool composition dropped to 18% in 2002. Average depths have increased from 12.1 cm in the pre-assessment to 21.2 cm in 2002. Generally, increased average widths were observed through 2002. Primary pools increased from 2 in the 1996 pre-assessment to 5 in 1999; however, only 1 pool was classified as primary in 2002.

In the 1997 implementation site, four K-dams were constructed following the pre-assessment. Substrate embeddedness has remained relatively constant, with a high of 48% in the 1997 pre-assessment to a low of 32% in 1998 (Table 40). Spawning gravels have been absent in all of the assessments. Percent pool habitat increased; pools comprised 17% of the habitat in 1997 and 19% in 2001. Average depth decreased from 31.9 cm in 1997 to 18.6 cm in 2002. Average width has varied annually. Primary pool numbers increased; no primary pools were observed in the pre-assessment and 5 primary pools were identified in 2001; however, the primary pool number dropped to 1 in 2002.

Five structures were implemented in 1998. Substrate embeddedness has been fairly constant through the monitoring period; pre-assessed embeddedness was 45% and 2002 embeddedness was 42% (Table 41). No spawning gravel was observed in the pre-assessment, and spawning gravel was classified in only one post assessment (0.5 m^2 in 2000). Percent pool habitat has increased substantially. No habitat was classified as pool in the 1998 pre-assessment and 50% of the habitat was classified as pool in 2002. Average depth decreased from 31.6 cm in 1998 to 23.6 cm in 2002. Average width also decreased; width was 4.5 m in the 1998 pre-assessment and 4.0 m in 2002. The number of primary pools has increased from 1 in the pre-assessment to a high of 5 in 2001; 2 pools were classified as primary in 2002.

Brook trout were the only fish species observed in the structures implemented in reach 4. From pre-assessment to 2002, fish densities increased in the 1997 and 1998 implementation sites (Figure 32). However, after three years of decreases, fish density in the 1996 site was relatively unchanged. No snorkel data were collected in reach 4 during the 1999 field season because of a U.S. Forest Service area closure due to safety concerns with a helicopter logging operation and heavy log truck traffic.

Table 39. Annual Cee Cee Ah Creek reach 4 habitat attributes from the 1996 implementation site.

	96 Structures						
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	48	52	38	60	32	40	40
Pool/Riffle	0.4	0.4	0.7	0.3	0.3	0.5	0.3
Spawning Gravel (m^2)	8.1	0.0	4.5	0.0	0.0	0.0	0.5
% Pool	7	5	5	19	24	38	18
% Riffle	65	61	50	48	69	51	65
% Run	11	20	26	33	5	11	16
% Pocketwater	15	14	19	0	0	0	0
% Glide	1	0	0	0	2	0	0
Avg Depth (cm)	12.1	24.6	30.2	21.6	19.5	20.2	21.2
Avg Width (m)	3.1	3.3	3.8	3.6	3.8	3.0	3.5
# Primary Pools	2	1	2	5	2	2	1

Table 40. Annual Cee Cee Ah Creek reach 4 habitat attributes from the 1997 implementation site.

	97 Structures					
Attribute	Pre '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	48	32	45	34	44	46
Pool/Riffle	0.7	0.6	0.4	1.0	0.4	0.3
Spawning Gravel (m^2)	0.0	0.0	0.0	0.0	0.0	0.0
% Pool	17	10	22	42	31	19
% Riffle	56	30	60	49	69	53
% Run	8	44	18	8	0	28
% Pocketwater	18	16	0	0	0	0
% Glide	0	0	0	0	0	0
Avg Depth (cm)	31.9	29.8	16.8	21.2	16.1	18.6
Avg Width (m)	3.7	4.2	3.3	3.7	3.2	3.5
# Primary Pools	0	3	1	2	5	1

Table 41. Annual Cee Cee Ah Creek reach 4 habitat attributes from the 1998 implementation site.

	98 Structures				
Attribute	Pre '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	45	59	43	41	42
Pool/Riffle	0.4	0.8	1.5	0.3	1.1
Spawning Gravel (m^2)	0.0	0.0	0.5	0.0	0.0
% Pool	0	33	51	27	50
% Riffle	67	35	45	59	40
% Run	16	32	3	14	10
% Pocketwater	13	0	0	0	0
% Glide	0	0	0	0	0
Avg Depth (cm)	31.6	23.8	21.2	15.5	23.6
Avg Width (m)	4.5	3.6	4.4	3.5	4.0
# Primary Pools	1	4	3	5	2

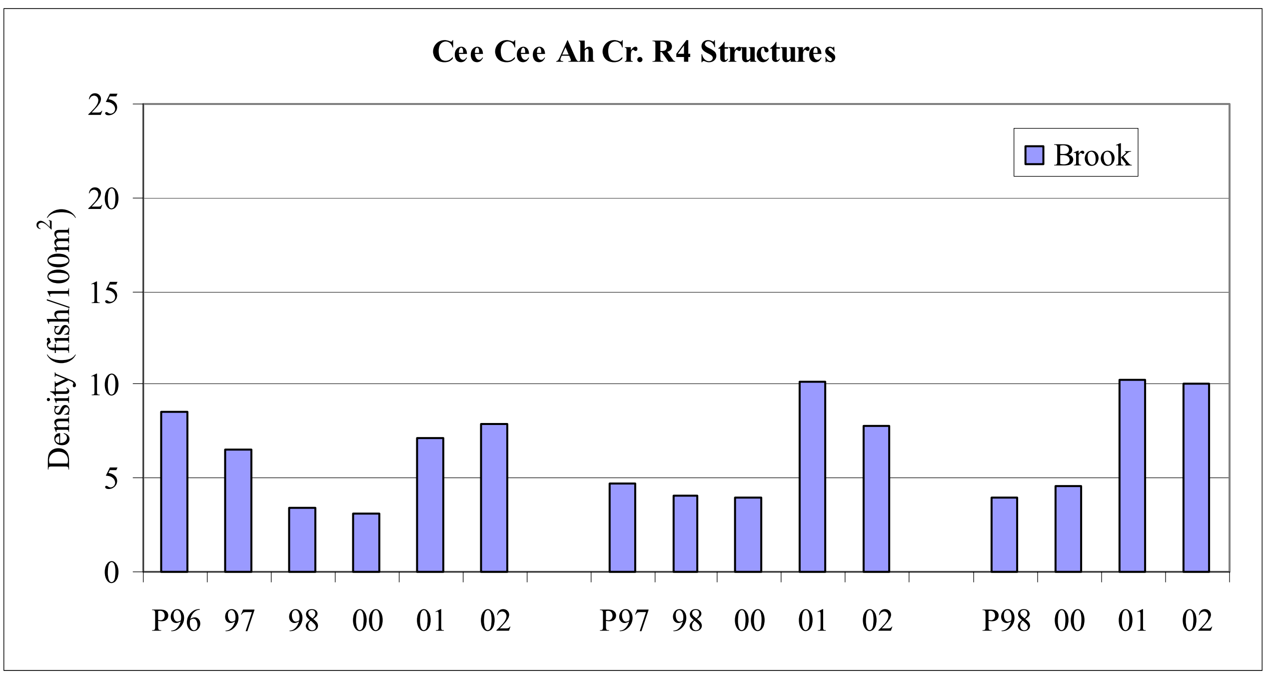

Figure 32. Annual Cee Cee Ah Creek reach 4 fish densities from the 1996, 1997, and 1998 implementation sites.

Reach 5

In reach 5, three cross log revetments were constructed in 1996 to create scour pools. Substrate embeddedness in the 1996 implementation site decreased from 77% to 51% in 2002 (Table 42). No spawning gravel was identified in the pre-assessment or in three of the post assessment years; however, 1.5 m^2 of spawning habitat was observed in 2002. Pool habitat was not observed in the 1996 pre-assessment; however, 20% of the habitat was classified as pool in 2001. Average depth was greater in all post assessment years except 2001 where it was unchanged at 16.2 cm. Average widths were high in the initial three years of post assessment; however, the width in 2002 (3.0 m) was relatively unchanged from the pre-assessment width (3.1 m).

In the 1997 implementation site of reach 5, four cross log revetments were constructed to create scour pools. Annually, substrate embeddedness was variable but was relatively unchanged; embeddedness was 61% and 59% in the pre-assessment (1997) and in 2002, respectively (Table 43). The only spawning gravel identified in the assessments was in 2000 (1.0 m^2). Pool habitat increased from 8% in 1997 to 43% in 2002. Average depth increased from the 1997 pre-assessment (26.7 cm) to 1998 (32.4 cm); however, average depths were less in the successive years. Average widths have been annually variable. The pre-assessment primary pool number was 1; post assessment primary pool number varied annually from a high of 4 in 1999 to 2 in 1998 and 2001.

Four structures were implemented in reach 5 in 1998. Embeddedness decreased from 62% in the pre-assessment to 48% in 2002 (Table 44). No spawning gravels were observed in 1998, 1999, or 2001; however, 1.0 m^2 was observed in 2000 and in 2002. Percent pool habitat increased from 20% in 1998 to a high of 56% in 2000; however, only 18% of the habitat was classified as pool in 2002. Average depth decreased annually while average widths have been variable. One primary pool was classified in the 1998 pre-assessment and as many as 5 were identified in 2000; however, only 1 pool was classified as primary in 2002.

In reach 5, post implementation brook trout densities increased in the 1996 site (Figure 33). Brook trout density increased from 6.2 fish/100 m^2 to 22.5 fish/100 m^2 in 2002. Cutthroat trout (n=1) were only observed at this site in 1996. For the reach 5 site implemented in 1997, brook trout density increased from 8.5 fish/100 m^2 to 12.8 fish/100 m^2 in 2001. Density has been variable in this site with a high of 14.5 fish/100 m^2 in 1999 and a low of 3.8 fish/100 m^2 in 2000. Annual variability in brook trout density has occurred in the 1998 implementation. Density declined from 14.6 fish/100 m^2 in 1998 to a low of 7.4 fish/100 m^2 in 2000. In 2002, brook trout density was 13.5 fish/100 m^2 and the first cutthroat trout was observed in this site.

Table 42. Cee Cee Ah Creek reach 5 habitat attribute values from the 1996 implementation site.

	96 Structures						
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	77	56	47	58	43	38	51
Pool/Riffle	0.2	0.2	0.2	0.2	0.8	0.6	0.2
Spawning Gravel (m^2)	0.0	0.0	0.0	0.5	1.0	0.0	1.5
% Pool	0	7	0	19	43	38	20
% Riffle	66	53	57	67	41	56	58
% Run	21	34	32	13	11	2	18
% Pocketwater	13	6	11	0	0	0	0
% Glide	0	0	0	0	4	4	3
Avg Depth (cm)	16.2	21.5	25.7	18.1	18.1	16.2	18.6
Avg Width (m)	3.1	3.2	4.0	3.2	2.6	3.3	3.0
# Primary Pools	2	3	5	2	7	5	3

Table 43. Cee Cee Ah Creek reach 5 habitat attribute values from the 1997 implementation site.

	97 Structures					
Attribute	Pre '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	61	44	62	46	27	59
Pool/Riffle	0.6	0.7	0.5	5.0	1.3	0.6
Spawning Gravel (m^2)	0.0	0.0	0.0	1.0	0.0	0.0
% Pool	8	7	26	80	52	43
% Riffle	49	18	54	11	38	57
% Run	30	64	19	9	0	0
% Pocketwater	13	8	0	0	0	0
% Glide	0	2	0	0	10	0
Avg Depth (cm)	26.7	32.4	19.2	23.0	18.2	20.1
Avg Width (m)	3.6	4.7	4.1	2.6	3.7	4.7
# Primary Pools	1	2	4	3	2	3

Table 44. Cee Cee Ah Creek reach 5 habitat attribute values from the 1998 implementation site.

	98 Structures				
Attribute	Pre '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	62	68	52	48	48
Pool/Riffle	0.3	0.7	1.5	1.0	0.5
Spawning Gravel (m^2)	0.0	0.0	1.0	0.0	1.0
% Pool	20	25	56	44	18
% Riffle	52	50	44	56	39
% Run	21	26	0	0	43
% Pocketwater	7	0	0	0	0
% Glide	0	0	0	0	0
Avg Depth (cm)	31.9	22.7	21.0	16.5	20.9
Avg Width (m)	4.0	4.7	3.0	4.4	3.0
# Primary Pools	1	2	5	2	1

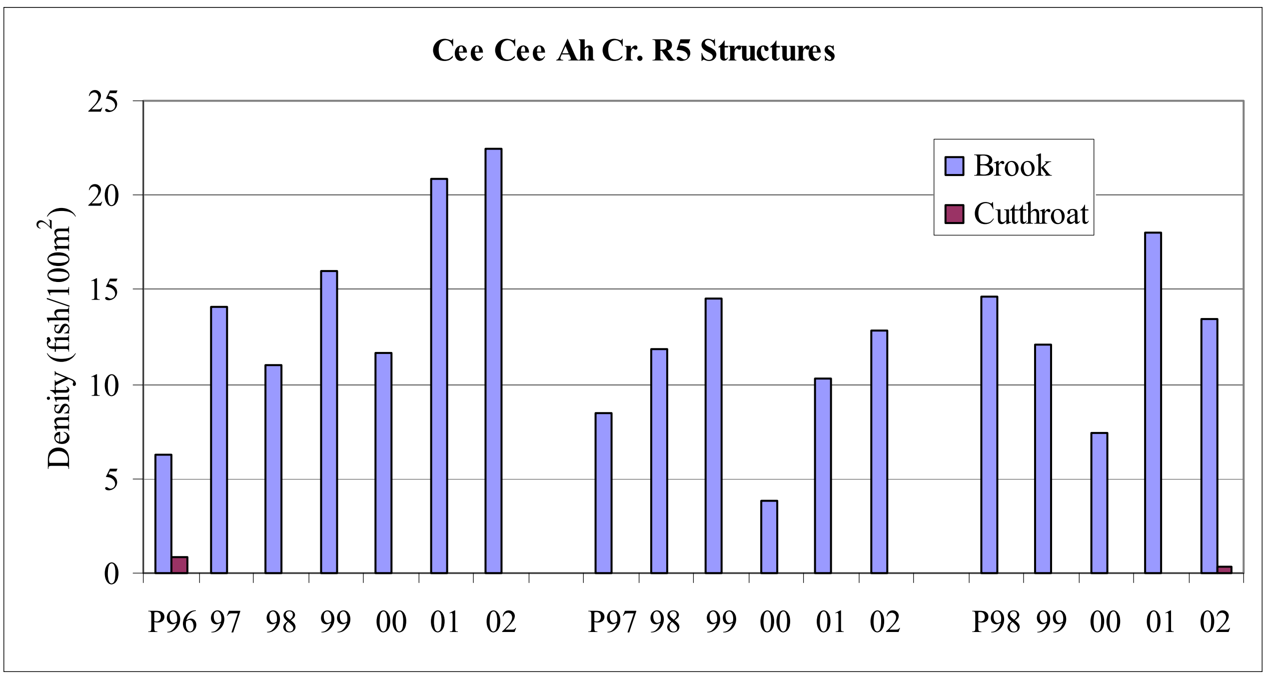

Figure 33. Annual Cee Cee Ah Creek reach 5 fish densities from the 1996, 1997, and 1998 implementation sites.

Reach 6

In 1996, three upstream v-weirs were constructed to create pool habitat and recruit spawning gravel. Substrate embeddedness in this implementation has been variable. Pre-assessed embeddedness was 59% and 2002 embeddedness was 64% (Table 45). A decrease in spawning gravel was observed. 6.4 m^2 was identified in the 1996 pre-assessment while post assessment spawning gravel ranged from 0.0 m^2 in 1997 and 1998 to 3.8 m^2 in 2002. Pool habitat has increased in the 1996 implementation site. Pre-assessed pool habitat composition was 9% and increased to 51% in 2000; a slight decrease was observed in 2002 to 46%. Post assessment average depths were mostly greater than the pre-assessed average depth (18.7 cm); average depth in 2002 was 21.1 cm. Average widths increased from 2.5 m in 1996 to 2.9 m in 2002 with a high of 3.2 m in 1998 and 1999. The number of primary pools has decreased or remained unchanged over the monitoring period. 5 primary pools were identified in 1996 and 3 pools were classified as primary in 2002.

Four upstream v-weirs were constructed in reach 6 in 1997. Substrate embeddedness was 67% in 1997 (pre-assessment) and decreased to 54% in 2001 (Table 46). Spawning gravel appeared to increase; no gravel was observed in the pre-assessment while 3.0 m^2 of spawning gravel was identified in 2002. Pool habitat increased from 5% in 1997 to 43% in 2001. The pre-assessed depth was 34.3 cm in 1997 and has been less in each of the monitoring years. Excluding 2000, average widths were relatively unchanged (3.3 m to 3.5 m, while 2000 was 2.5 m). Primary pool number initially increased from 2 in 1997 to 4 in 2000 and 2001; however, only 1 pool was classified as a primary pool in 2002.

In 1998, three structures were implemented to increase pool habitat and recruit spawning gravel. Substrate embeddedness decreased from 63% in 1998 to 45% in 2002 (Table 47). Spawning gravel appeared to increase from 0.5 m^2 in 1998 to 2.5 m^2 in 2002. No pool habitat was classified in the pre-assessment and 37% of the habitat was classified as pool in 2002. Average depth decreased from 31.1 cm in 1998 to 20.1 cm in 2002. Average width also decreased. The pre-assessed average width was 3.6 m and decreased to 2.5 m in 2002. Primary pools have increased in this site. Pre-assessed primary pool number was, increased to a high of 5 in 2000 and 2001, and was 3 in 2002.

In reach 6, brook trout densities were relatively stable (with the exception of 2000, Figure 34). Pre-implementation density was 16.6 fish/100 m^2; density remained relatively unchanged up to 2000 when 5.6 fish/100 m^2 were observed. However, brook trout density increased to 21.7 fish/100 m^2 in 2001 and then decreased in 2002 to 17.1 fish/100 m^2. Brook trout density in the 1997 implementation site had doubled from 1997 to 2001. However, density in 2002 was relatively unchanged from the pre-assessment density (11.4 and 11.5 fish/100 m^2, respectively). In the 1998 restoration site, brook trout density increased 200% from 4.3 fish/100 m^2 to 9.3 fish/100 m^2 in 2002. In reach 6, cutthroat trout (n=1) were only observed in the 1997 pre-implementation site.

Table 45. Cee Cee Ah Creek reach 6 habitat attribute values from the 1996 implementation site.

	96 Structures						
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	59	61	41	57	49	41	64
Pool/Riffle	0.2	0.5	0.7	0.7	1.0	0.9	1.0
Spawning Gravel (m^2)	6.4	0.0	0.0	1.0	1.0	0.5	3.8
% Pool	9	12	17	38	51	49	46
% Riffle	45	35	51	49	35	51	39
% Run	39	49	24	3	7	0	15
% Pocketwater	2	4	8	1	0	0	0
% Glide	4	0	0	8	4	0	0
Avg Depth (cm)	18.7	23.9	31.7	19.9	21.6	17.4	21.1
Avg Width (m)	2.5	2.9	3.2	3.2	2.6	3.0	2.9
# Primary Pools	5	4	0	4	5	4	3

Table 46. Cee Cee Ah Creek reach 6 habitat attribute values from the 1997 implementation site.

	97 Structures					
Attribute	Pre '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	67	47	67	45	36	54
Pool/Riffle	0.6	0.7	0.7	1.6	0.7	1.2
Spawning Gravel (m^2)	0.0	1.0	1.5	0.0	0.0	3.0
% Pool	5	7	39	61	36	43
% Riffle	53	60	43	32	64	29
% Run	21	19	9	7	0	28
% Pocketwater	21	14	0	0	0	0
% Glide	0	0	8	0	0	0
Avg Depth (cm)	34.3	29.9	19.6	21.9	17.5	23.8
Avg Width (m)	3.3	3.5	3.3	2.5	3.4	3.3
# Primary Pools	2	2	3	4	4	1

Table 47. Cee Cee Ah Creek reach 6 habitat attribute values from the 1998 implementation site.

	98 Structures				
Attribute	Pre '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	63	46	45	37	45
Pool/Riffle	0.3	0.4	0.8	0.8	0.7
Spawning Gravel (m^2)	0.5	0.0	0.5	0.0	2.5
% Pool	0	25	48	53	37
% Riffle	65	58	44	47	28
% Run	20	5	8	0	35
% Pocketwater	13	0	0	0	0
% Glide	0	12	0	0	0
Avg Depth (cm)	31.1	18.4	20.6	17.2	20.1
Avg Width (m)	3.6	3.2	2.5	3.1	2.5
# Primary Pools	1	2	5	5	3

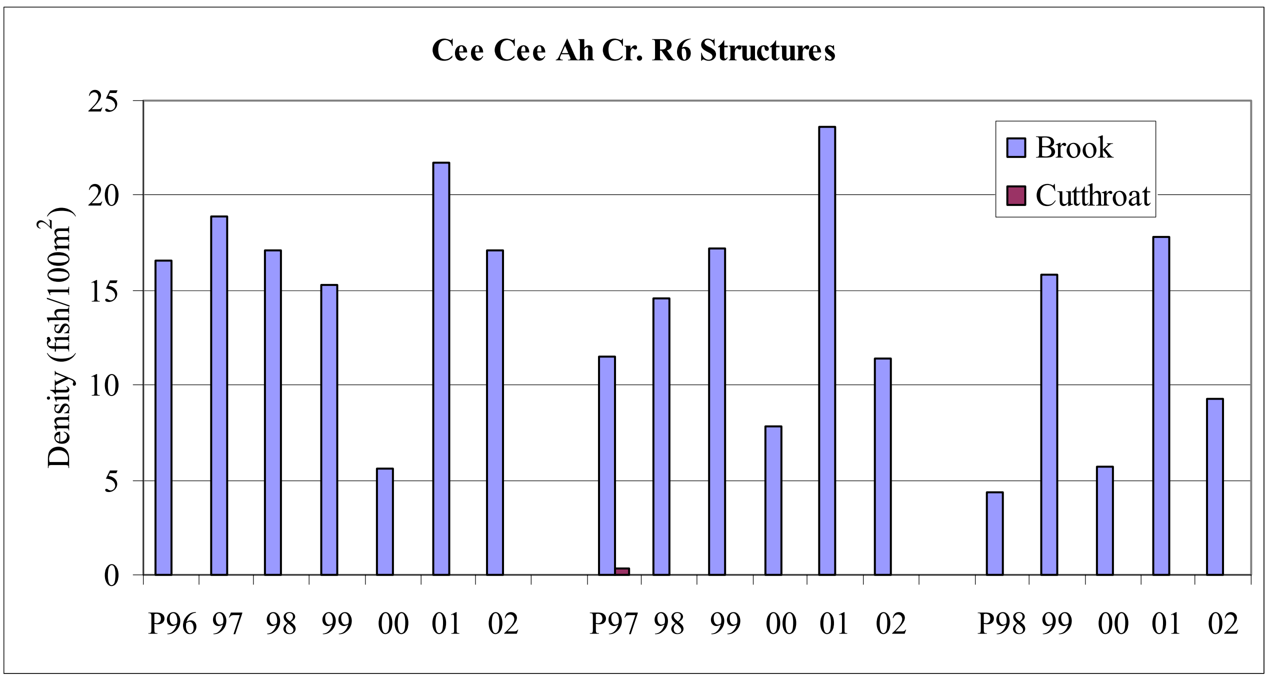

Figure 34. Annual Cee Cee Ah Creek reach 6 fish densities from the 1996, 1997, and 1998 implementation sites.

Indian Creek

Reach 3

In 1996, three double-wing deflectors were constructed in reach 3 following the pre-assessment. Post implementation substrate embeddedness in reach 3 was lower in all years of monitoring (Table 48). Pre-implementation embeddedness was 80 percent and monitoring values ranged from 76% in 2002 to 53% in 2001. Spawning gravel progressively declined from the pre-assessed estimate of 23 m^2; no spawning gravel was observed in 2001 or in 2002. Pool type habitat has been extremely variable. In the 1996 pre-assessment 0% of the habitat was classified as pool. Post assessment pool composition has ranged from 0% in 1997 and 1998 to 51% in 2000. However, the differences in pool composition appear to be mostly due to observer variability in classifying slow water habitats since fast water habitat (i.e. riffle) is lower in all monitoring years. Average depths in monitoring years were all greater than the 1996 pre-assessment value. In 1996, the average depth was 17.9 cm and post assessments depths ranged from 22.0 cm in 2001 to 41.7 cm in 1997. Annual average widths increased over the pre-assessed value with the lowest post assessment average width recorded in 2001. Primary pool numbers were variable; no primary pools were identified in 1996 or 2002 and up to 5 pools were observed in years between.

Fish densities in reach 3 appeared to decline from pre-assessment in 1996 to 2002 (Figure 35). Cutthroat trout were not observed in the pre-assessment or in the 2000 to 2002 period; they were initially observed in 1997 and densities decreased annually in 1998 and 1999. The brook trout density varied annually; pre-assessment density was 6.0 fish/100 m^2, the high was 7.2 fish/100 m^2 in 2002, and the low of 2.0 fish/100 m^2 was observed in 2000. Brown trout density was highest during the pre-assessment (5.0 fish/100 m^2) and 1997 was the low (0.8 fish/100 m^2).

Table 48. Indian Creek reach 3 habitat attribute values from the 1996 implementation site.

	96 Structures						
Attribute	Pre '96	Post '97	Post '98	Post '99	Post ‘00	Post ‘01	Post ‘02
Embeddedness (%)	80	56	75	67	68	53	76
Pool/Riffle	0.2	0.8	0.6	0.5	2.0	1.0	0.1
Spawning Gravel (m^2)	23.0	14.0	9.0	1.5	0.5	0.0	0.0
% Pool	0	0	0	5	51	50	4
% Riffle	64	33	35	25	27	48	32
% Run	26	47	56	66	19	2	64
% Pocketwater	7	19	9	3	0	0	0
% Glide	2	0	0	0	2	0	0
Avg Depth (cm)	17.9	41.7	29.1	38.3	26.7	22.0	22.3
Avg Width (m)	2.9	4.8	5.0	4.7	4.3	4.2	4.3
# Primary Pools	0	2	0	1	5	3	0

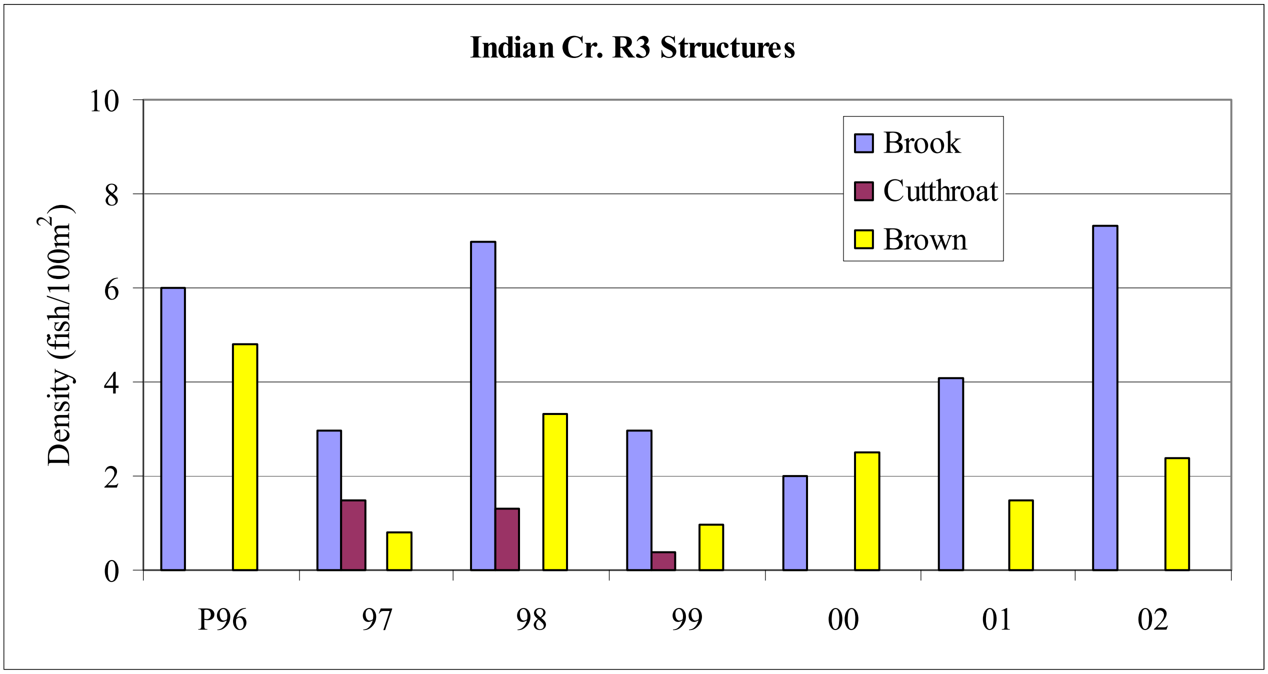

Figure 35. Annual Indian Creek reach 3 fish densities from the 1996 implementation site.

Reach 4

In reach 4, three log weirs were constructed to provide scour pools and recruit spawning gravel. Substrate embeddedness decreased from a 1996 pre-assessed value of 82% to 45% in 2002 (Table 49). Spawning habitat has been variable throughout the monitoring period. In 1996, pre-assessed spawning gravel was estimated at 9.0 m^2, monitoring estimates ranged from 1.5 m^2 in 2000 to 19.5 m^2 in 2002. No pool type habitat was classified in the pre-assessment survey in 1996. Pool habitat has been variable with a range of 23% in 2001 to 1% in 1999. Average widths and depths increased in years following the pre-assessment. The pre-assessed average depth was 10.9 cm; in subsequent monitoring years, average depths ranged from 16.9 cm in 2002 to 28.7 cm in 1997. The pre-assessed average width was 2.1 m; post assessment average widths decreased to 3.6 m by 2002. Primary pool numbers have been variable; 4 primary pools were identified in 2001 but no pools were observed in 2002.

Changes to fish densities in reach 4 were variable (Figure 36). Cutthroat density increased over 300% from 1996 to 2000. However, no cutthroat trout were observed in 2001 or 2002. The highest densities of brook and brown trout occurred in 2001 at 6.1 fish/100 m^2 and 5.5 fish/100 m^2, respectively. The only bull trout observed (in 1997) was believed to be an adfluvial fish from Lake Pend Oreille since it was fin clipped. This fish was previously captured and passed in a downstream trap.

Table 49. Indian Creek reach 4 habitat attribute values from the 1996 implementation site.

	96 Structures						
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	82	16	33	50	38	33	45
Pool/Riffle	0.1	0.2	0.1	0.0	0.3	0.3	0.1
Spawning Gravel (m^2)	9.0	5.5	10.0	2.5	1.5	4.0	19.5
% Pool	0	4	2	1	15	23	5
% Riffle	85	82	90	94	80	77	82
% Run	8	4	1	5	0	0	9
% Pocketwater	6	10	7	0	4	0	4
% Glide	0	0	0	0	1	0	0
Avg Depth (cm)	10.9	28.7	22.1	26.5	19.8	17.7	16.9
Avg Width (m)	2.1	4.3	4.2	4.2	3.8	3.7	3.6
# Primary Pools	0	3	0	0	3	4	0

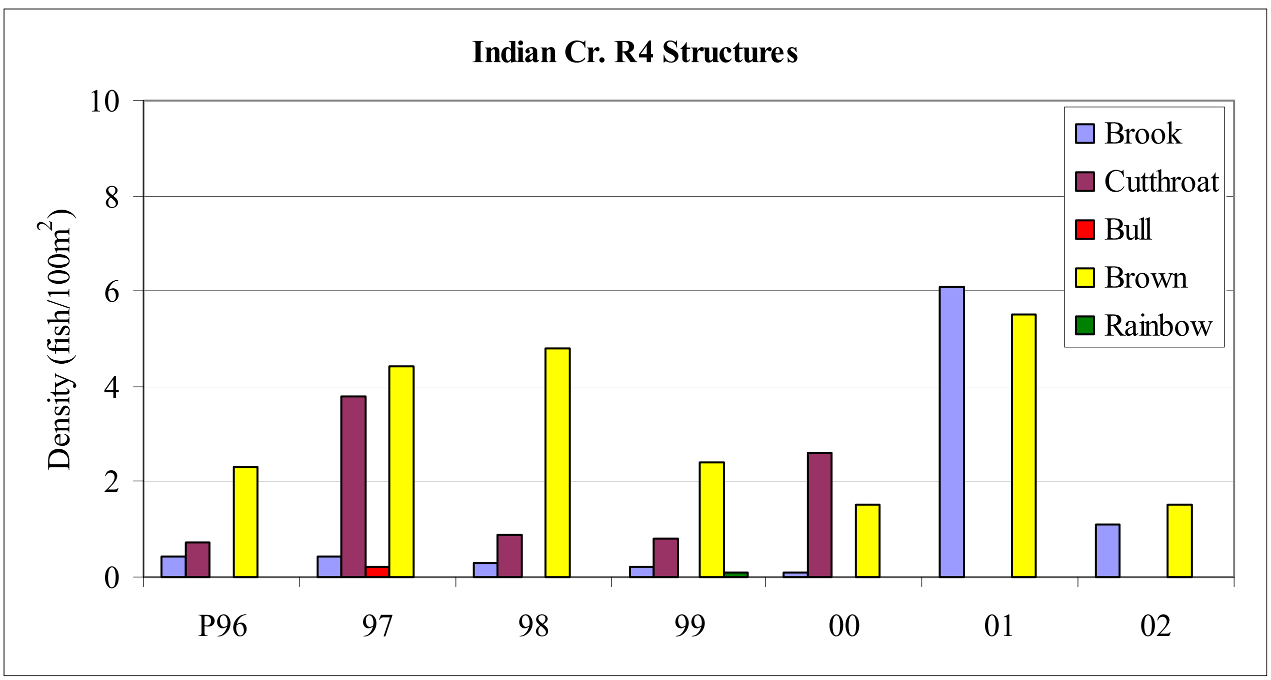

Figure 36 Annual Indian Creek reach 4 fish densities from the 1996 implementation site.

Browns Creek

<u>Reach 4</u>

Three K-dams were constructed in reach 4 in 1997. Pre-assessed substrate embeddedness was 31% and increased to 49% in 2002 (Table 50). Spawning gravels in monitoring years appeared to decrease markedly over pre-assessed estimates. 1997 pre-assessed spawning gravel was estimated at 12.5 m^2; no gravel was classified as spawning habitat in the 2002 post assessment. The percent of pre-assessed habitat classified as pool was 3% and showed increases every year through 2001. In 2002, no pool habitat was identified; however, all of the slow water habitat was classified as run (24%). Average depth decreased from 25.7 cm in 1997 to 17.8 cm in 2002. In 2002, wetted width was unchanged from a pre-assessed average of 4.9 m. In the 1998 post assessment, surveyors classified three pools as primary pools. No primary pools were observed in 1997, 1999, or 2000, and 1 pool was classified as primary in 2001 and in 2002.

Three additional structures were built in reach 4 in 1998. Embeddedness in this site increased from 28% in the pre-assessment to 53% in 2002 (Table 51). Pre-assessed spawning gravel was 4.5 m^2; no spawning gravel was observed in 1999, 2001, or 2002. Pool type habitat increased in this restoration reach. No habitat was classified as pool in the 1998 pre-assessment and the 1999 post assessment. However, up to 33% of the habitat was classified as pool since that time. Average depths decreased annually to a low of 15.4 cm in 2001 and then increased to 19.9 in 2002. Average width has been highly variable. The pre-assessed width was 4.0 m; post assessment widths ranged from 3.9 m in 2001 to 7.2 m in 1999. No pools were classified as primary during the pre-assessment in 1998 or in 2002.

Post implementation brown trout densities generally have increased over pre-implementation densities in reach 4 (Figure 37). In the 1997 implementation site, brown trout densities increased from 4.2 fish/100 m^2 in 1997 to 9.2 fish/100 m^2 in 2001. However, density was back down to 3.9 fish/100 m^2 in 2002. Pre-assessment brook trout density was 0.2 fish/100 m^2 and increased to 0.7 fish/100 m^2 in 2002. Brown and brook trout densities also increased in the 1998 implementation site. Brook trout density increased from 0.2 fish/100 m^2 in 1998 (pre-assessment) to 0.4 fish/100 m^2 in 2002. Brown trout increased from 4.1 fish/100 m^2 in 1998 to 8.6 fish/100 m^2 in 2002. Only one cutthroat trout was observed in reach 4 and that fish was seen during the 1998 pre-assessment.

Table 50. Browns Creek reach 4 habitat attribute values from the 1997 implementation site.

	97 Structures					
Attribute	Pre '97	Post '98	Post '99	Post '00	Post ‘01	Post ‘02
Embeddedness (%)	31	41	47		29	49
Pool/Riffle	0.1	0.3	0.1	0.3	0.2	0.0
Spawning Gravel (m^2)	12.5	4.5	0.0	1.5	0.0	0.0
% Pool	3	6	3	19	17	0
% Riffle	88	76	84	79	75	76
% Run	2	9	13	3	3	24
% Pocketwater	6	9	0	0	0	0
% Glide	0	0	0	0	5	0
Avg Depth (cm)	25.7	22.4	24.2	19.7	13.1	17.8
Avg Width (m)	4.9	5.2	4.7	4.1	4.8	4.9
# Primary Pools	0	3	0	0	1	1

Table 51. Browns Creek reach 4 habitat attribute values from the 1998 implementation site.

	98 Structures				
Attribute	Pre '98	Post '99	Post '00	Post ‘01	Post ‘02
Embeddedness (%)	28	52	41	29	53
Pool/Riffle	0.0	0.0	0.5	0.1	0.1
Spawning Gravel (m^2)	4.5	0.0	3.0	0.0	0.0
% Pool	0	0	33	9	6
% Riffle	92	87	67	80	66
% Run	2	12	0	11	28
% Pocketwater	5	1	0	0	0
% Glide	0	0	0	0	0
Avg Depth (cm)	26.5	26.2	19.8	15.4	19.9
Avg Width (m)	4.0	7.2	3.9	3.9	4.3
# Primary Pools	0	0	2	4	0

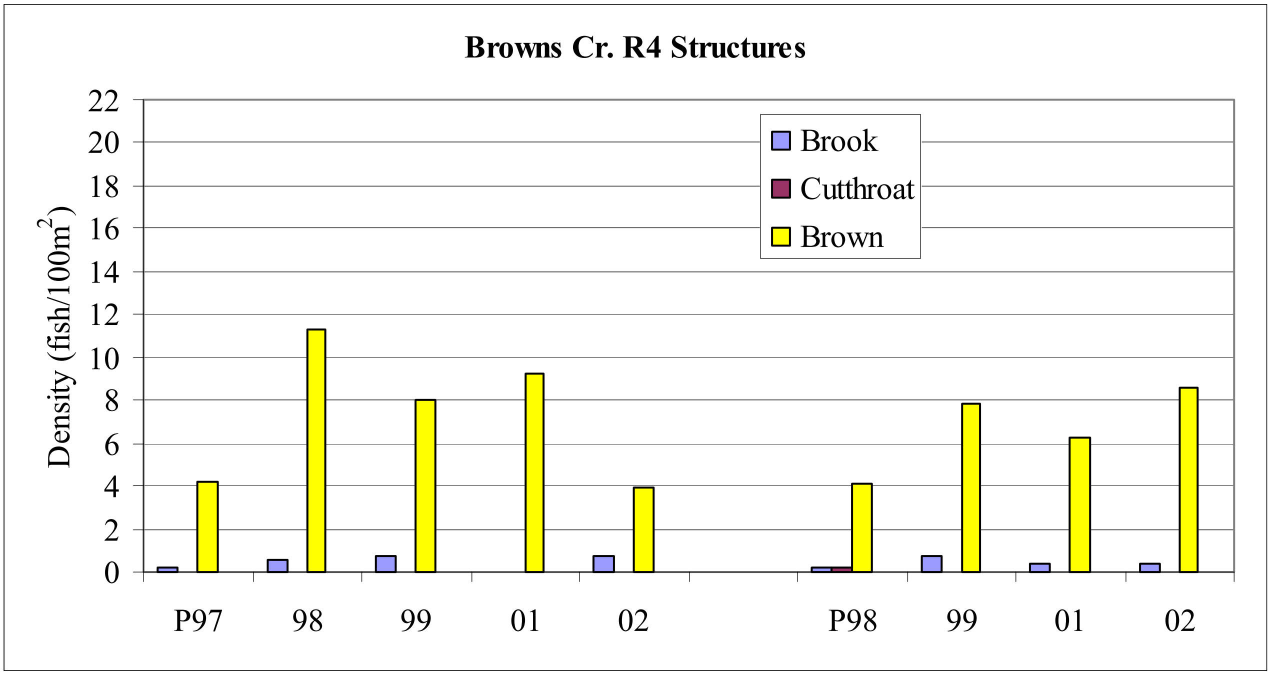

Figure 37. Annual Browns Creek reach 4 fish densities from the 1997 and 1998 implementation site.

Fourth of July Creek

Reach 8

In 1997, three wedge dams and three log weirs were constructed in reach 8 of Fourth of July Creek. 1997 pre-assessment substrate embeddedness in reach 8 was 82% (Table 52). Lower embeddedness values were observed in subsequent years of monitoring. Spawning gravels increased from 9.0 m^2 in 1997 to 10.0 m^2 in 1998. However, no spawning gravel was identified during the 1999 or 2002 monitoring survey and only 0.5 m^2 was observed in 2000 and 2001. No habitat was classified as pool in 1997 and 1998. However, pool composition has increased to a high of 36 % in 2001. Average depth increased from 12.5 cm in 1997 to 16.0 cm in 1998, but has decreased in succeeding years to 10.8 cm in 2002. Average width also decreased; the 1997 pre-assessed width was 2.4 m and the 2002 average width was 1.8 m. No primary pools were identified in the 1997 pre-assessment or the 1998 and 2002 post assessments. Surveyors counted one primary pool in 1999 and 6 in the 2000 and 2001 post assessments.

Cutthroat trout (density of 8.0 fish/100 m^2) and brook trout (density of 3.0 fish/100 m^2) were observed in the 1997 pre-implementation snorkel survey (Figure 38). In 1998, cutthroat trout density declined to 5.0 fish/100 m^2, brook trout density increased to 5.0 fish/100 m^2, and bull trout and brown trout were also observed (densities of 1 fish/100 m^2). Cutthroat trout densities increased 700% in 1999 to 35.0 fish/100 m^2. Bull trout and brown trout were also observed in 1999 (densities of 1 fish/100 m^2); however, no brook trout were present. In 2000, the cutthroat density declined to 9.3 fish/100 m^2 while the brook trout density increased to 22.2 fish /100 m^2. From 2000 to 2002, cutthroat and brook trout densities declined. In 2002, cutthroat trout and brook trout densities (4.2 and 1.7 fish /100 m^2, respectively) were nearly half the 1997 pre-implementation densities.

Table 52. Fourth of July Creek reach 8 habitat attribute values from the 1997 implementation site.

	97 Structures					
Attribute	Pre '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	82	60	71	20	53	70
Pool/Riffle	0.1	0.4	0.3	0.5	0.6	0.2
Spawning Gravel (m^2)	9.0	10.0	0.0	0.5	0.5	0.0
% Pool	0	0	12	32	36	12
% Riffle	85	59	51	61	61	67
% Run	8	19	37	3	0	8
% Pocketwater	6	21	0	1	3	13
% Glide	0	0	0	0	0	0
Avg Depth (cm)	12.5	16.0	14.2	11.8	11.3	10.8
Avg Width (m)	2.4	3.0	2.3	1.9	1.8	1.8
# Primary Pools	0	0	1	6	6	0

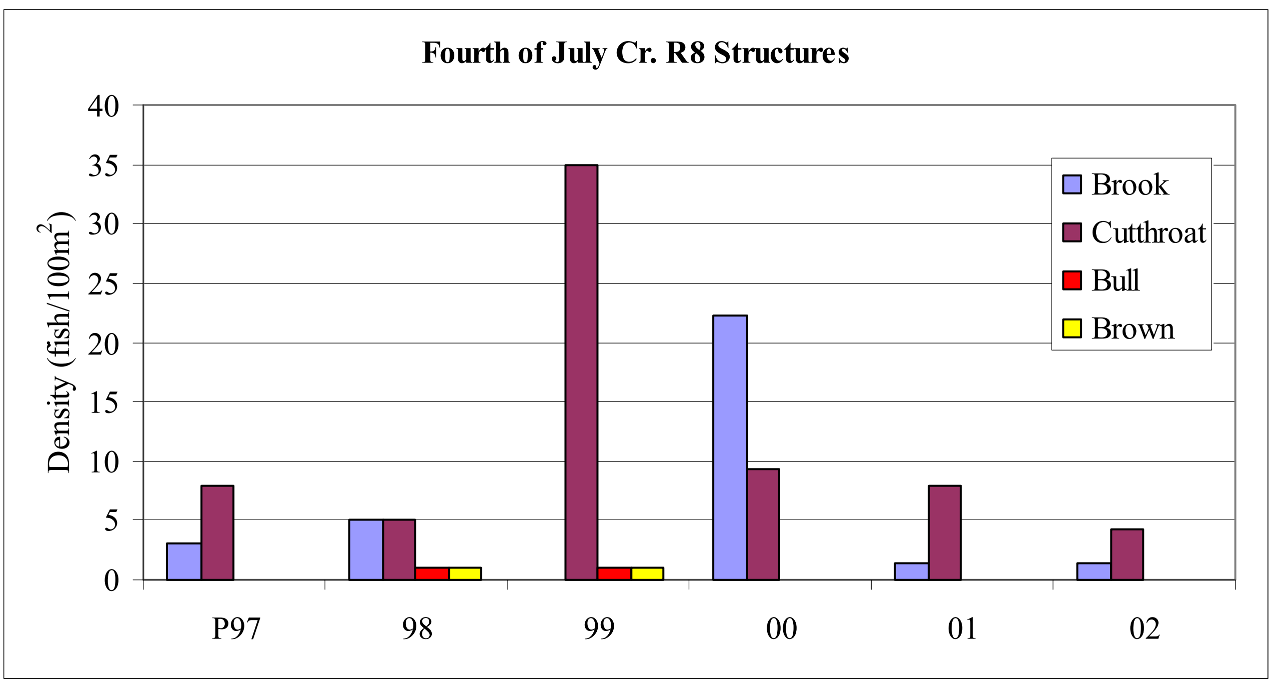

Figure 38. Annual Fourth of July Creek reach 8 fish densities from the 1997 implementation site.

Mineral Creek

<u>*Reach 1*</u>

A total of ten double wing deflectors were implemented in reach 1 of Mineral Creek from 1996 to 1998. Pre-assessment substrate embeddedness was 53% in the 1996 site, and has been annually variable with a high of 61% in 2000 and a low of 32% in 2001 (Table 53). 1996 pre-assessed spawning gravel was 15.3 m^2. Gravel was classified as spawning habitat in only one post assessment survey (2000 with 0.5 m^2). Percent pool type habitat increased from 4% in 1996 to 16% in 2002. Average depths in the 1996 implementation area increased annually through 1999, decreased in 2000 and 2001, and then increased again in 2002. The 1996 pre-assessed average depth was 16.4 cm, the greatest depth was 25.3 cm in 1999 and the lowest average depth was 13.4 cm in 2001. Average widths also increased annually up to 2000. The average pre-assessment width was 2.6 m and the 2002 width was 3.3 m. Four pools were classified as primary during the 1996 pre-assessment and decreased to 2 pools in the 2002 post assessment.

In reach 1 where structures were implemented in 1997, pre-assessed substrate embeddedness was 71% and declined to 58% in 2002 (Table 54). Spawning gravel increased from 1.0 m^2 in the 1997 pre-assessment to 2.5 m^2 in 2001; however, no gravel was classified as spawning habitat in 2002. Percent pool habitat has been variable with a range of 8% in 2002 to 43% in 2000. Depths decreased from the pre-assessed average of 43.6 cm in 1997 to 18.0 in 2001. Average width also decreased; the pre-assessed width averaged 3.5 m and width was 3.2 m in the 2002 post assessment. The number of pools classified as primary has been annually variable. Two primary pools were present in the pre-assessment while 2002 was the first year that no pools were classified as primary.

Embeddedness in the 1998 restoration site was relatively unchanged in 2002 (Table 55). Spawning gravel remained fairly constant with 1.0 m^2 identified in the pre-assessment, and in the 2000 and 2001 post assessments. Percent pool type habitat increased from 15% in 1998 to 49% in 2002. Average depth and width decreased in 2002 relative to 1998 pre-assessment values. Average depth decreased from 34.0 cm to 23.2 cm, while average width decreased from 3.6 m to 3.0 m. No primary pools were identified in the pre-assessment and 2 were observed in the 2002 post assessment.

Generally, cutthroat trout have declined in the Mineral Creek structures while brook trout densities have increased. For the 1996 implemented structures, post assessment cutthroat trout densities have declined from pre-assessment densities (Figure 39). The 1996 brook trout density was 6.0 fish/100 m^2 and increased to 10.8 fish/100 m^2 in 2002. Pre-assessed cutthroat density was 14.0 fish/100 m^2 and declined to 7.9 fish/100 m^2 in 2001. Fish densities in the 1997 implementation site showed a declining trend. The 1997 pre-assessed cutthroat trout density was 20.0 fish/100 m^2 and declined to 6.2 fish/100 m^2 in 2002. Cutthroat density in the 1998 restoration site has been relatively unchanged. The pre-assessed density was 5.0 fish/100 m^2 and the 2002 density was 5.2 fish/100 m^2. Brook trout density has been increasing in the 1998 implementation site. No brook trout were observed in the 1998 pre-assessment and density has increased annually to 5.2 fish/100 m^2 in 2002.

Table 53. Mineral Creek reach 1 habitat attribute values from the 1996 implementation site.

		96 Structures					
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	53	35	45		61	32	50
Pool/Riffle	0.5	0.3	0.6	0.1	0.8	0.5	0.2
Spawning Gravel (m^2)	15.3	0.0	0.0	0.0	0.5	0.0	0.0
% Pool	4	0	21	4	32	14	16
% Riffle	61	67	57	92	52	65	75
% Run	16	21	3	3	0	3	9
% Pocketwater	19	12	19	1	12	15	0
% Glide	1	0	0	0	4	3	0
Avg Depth (cm)	16.4	19.0	23.7	25.3	14.4	13.4	20.8
Avg Width (m)	2.6	2.9	3.4	3.7	2.5	2.8	3.3
# Primary Pools	4	0	2	0	3	4	2

Table 54. Mineral Creek reach 1 habitat attribute values from the 1997 implementation site.

		97 Structures				
Attribute	Pre '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	71	62	52	69	46	58
Pool/Riffle	0.3	0.8	0.1	0.6	0.2	0.1
Spawning Gravel (m^2)	1.0	0.0	0.0	4.5	2.5	0.0
% Pool	19	24	10	43	26	8
% Riffle	62	50	48	40	71	49
% Run	13	16	42	0	0	43
% Pocketwater	5	9	0	0	0	0
% Glide	0	0	0	17	3	0
Avg Depth (cm)	43.6	25.6	31.1	15.0	13.2	18.0
Avg Width (m)	3.5	2.9	3.4	2.6	2.4	3.2
# Primary Pools	2	1	2	3	2	0

Table 55. Mineral Creek reach 1 habitat attribute values from the 1998 implementation site.

	98 Structures				
Attribute	Pre '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	54		64	36	53
Pool/Riffle	0.3	0.6	0.8	1.1	1.0
Spawning Gravel (m^2)	1.0	0.0	1.0	1.0	0.0
% Pool	15	17	33	48	49
% Riffle	71	57	52	46	33
% Run	5	23	0	6	18
% Pocketwater	6	3	14	0	0
% Glide	0	0	0	0	0
Avg Depth (cm)	34.0	34.4	15.2	21.4	23.2
Avg Width (m)	3.6	3.6	2.1	2.8	3.0
# Primary Pools	0	0	1	4	2

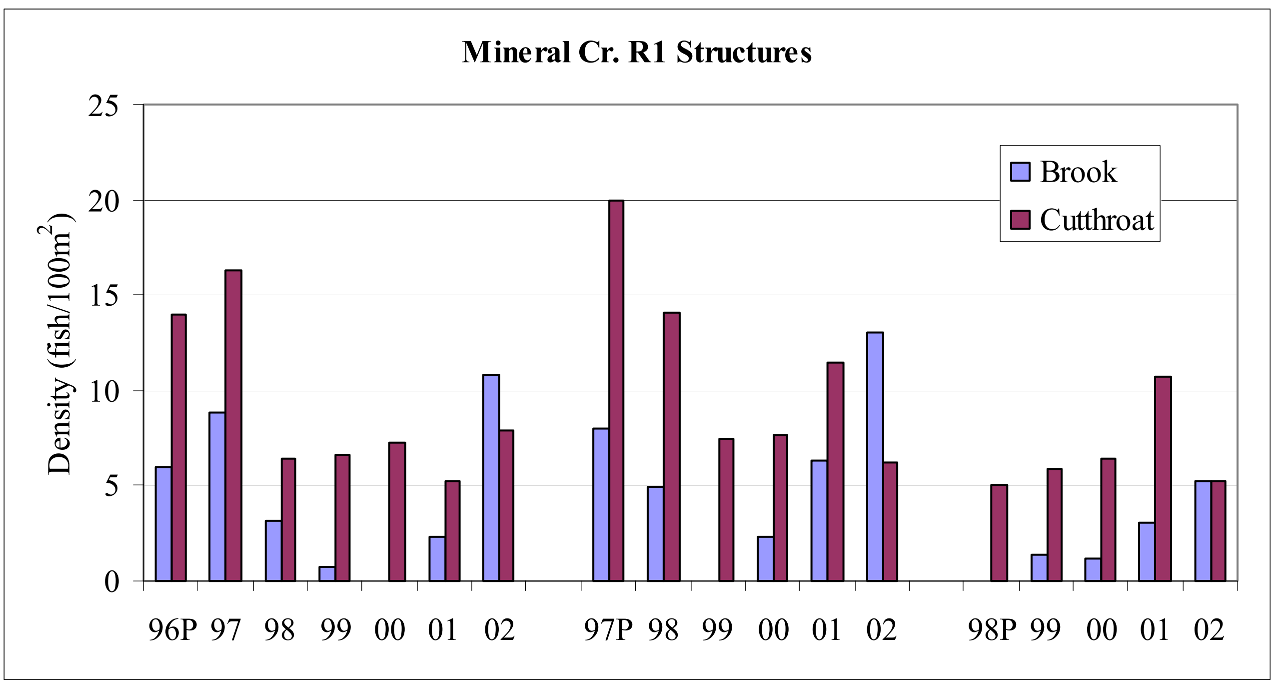

Figure 39. Annual Mineral Creek reach 1 fish densities from the 1996, 1997 and 1998 implementation sites.

Whiteman Creek

Reach 4

In 1997, channel blocks were constructed in three sections where the channel was braided. Also, six log structures were created to provide cover and direct flow from unstable banks. This entire restoration site is enclosed by a fencing project completed in 1996. Following implementation, substrate embeddedness was relatively high and unchanged in reach 4. 1997 pre-assessed substrate embeddedness was 95% and in 2002 embeddedness was 89% (Table 56). Bank stability appeared to increase dramatically; the pre-assessed bank stability was 51% and increased to 100% in 2002. 4.0 m^2 of spawning gravel was observed in 1997 and increased to 17.5 m^2 in 2000. However, in 2002 spawning gravel declined to 0.0 m^2. Pool composition increased from 7% in the 1997 pre-assessment to 35% in 2002. Average depth has been higher in every post assessment year except in 2000 (2002 depth was relatively unchanged). The pre-assessed average depth was 34.0 cm and was 33.9 cm in 2001. Average depth ranged from 25.5 cm in 2000 to 48.2 cm in 1999. Average width increased from 3.1 m in 1997 to a high of 4.1 m in 1999. The average width in 2002 was 2.8 m. One pool was classified as primary in 1997 and again in 1998. 10 primary pools were observed in 2002; a high of 21 primary pools were identified in 2000.

Brook trout was the only species observed in reach 4 through 2000. Post implementation brook trout densities were higher than the pre-implementation density (Figure 40). Brook trout densities in 1998 (45.0 fish/100 m^2), 2000 (44.5 fish/100 m^2), and 2002 (44.8 fish/100 m^2), were over double the 1997 pre-assessed density (20.0 fish/ 100 m^2). Cutthroat trout were first observed (at low densities) in 2001 and then again in 2002.

Table 56. Whiteman Creek reach 4 habitat attribute values from the 1997 implementation site.

	97 Structures					
Attribute	Pre '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	95	84	94	88	94	89
Pool/Riffle	0.0	0.0	0.0	2.8	4.3	1.9
Spawning Gravel (m^2)	4.0	10.5	0.0	17.5	5.0	0.0
% Pool	7	0	14	66	64	35
% Riffle	0	13	0	20	11	14
% Run	92	84	86	9	24	44
% Pocketwater	0	0	0	1	1	0
% Glide	0	0	0	4	1	7
Avg Depth (cm)	34.0	41.9	45.5	25.5	43.7	33.9
Avg Width (m)	3.1	4.0	4.1	2.4	3.2	2.8
# Primary Pools	1	1	2	21	10	10

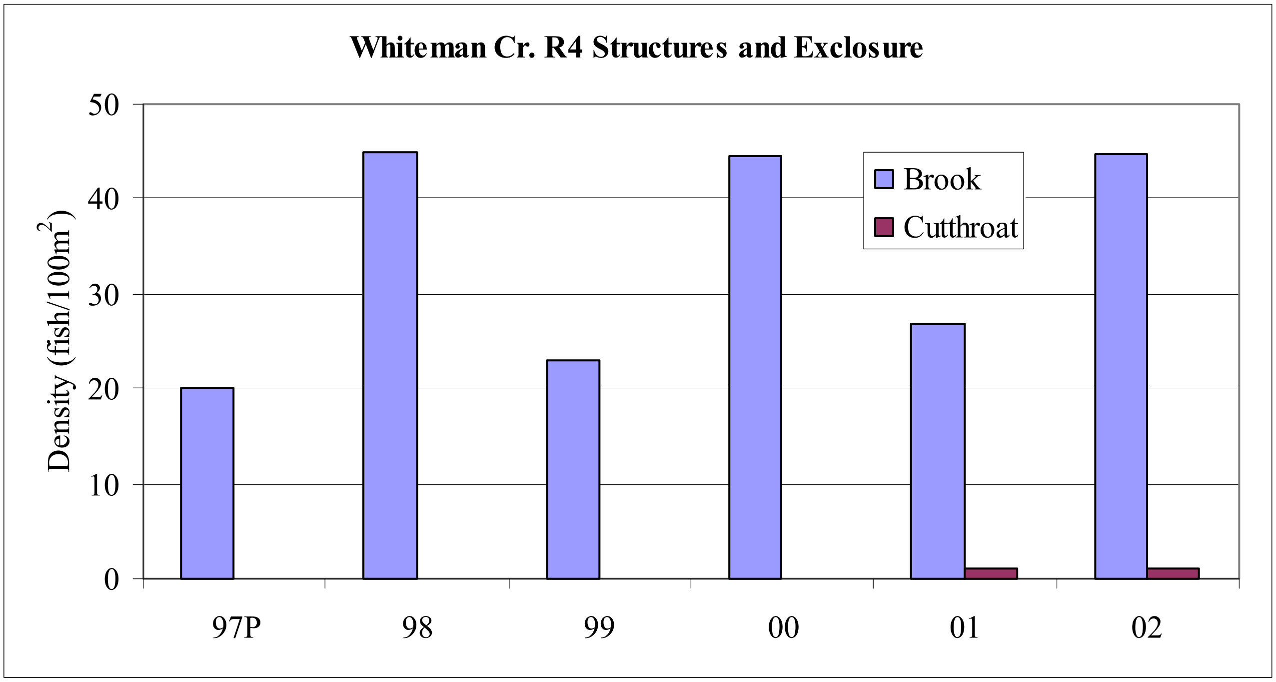

Figure 40. Brook and cutthroat trout densities in reach 4 of Whiteman Creek where instream structures and a riparian exclosure were constructed in 1996.

Reach 5

In 1996, boulder structures were placed in reach 5 to create pool habitat. Percent embeddedness has been variable with a high of 67% in 1997 to a low of 34% in 2001 (Table 57). Spawning gravel was absent from the assessment area for all years except in 2001 where 0.5 m^2 of gravel was classified as spawning habitat. Pool habitat increased from 7% in 1996 to 42% in 2002. Post assessed average depths increased from the pre-assessed average depth of 13.3 cm. Post assessed average depths ranged from 15.5 cm in 2000 to 24.5 cm in 2002. Average widths also increased from the pre-assessed width of 2.6 m. Average width ranged from 4.7 m in 1998 to 3.3 m in 2000. The number of primary pools increased from 0 in 1996 to a high of 8 in 1999. However, the primary pool number was 3 in 2002.

In reach 5, cutthroat densities were relatively low and unchanged through 1999 (Figure 41). Cutthroat density in the pre-assessment was 0.5 fish/100 m^2. The cutthroat density increased to 1.2 fish/100 m^2 in 2000 and 2.0 fish/100 m^2 in 2001. However, no cutthroat trout were observed in 2002. Brook trout densities in reach 5 have increased from a pre-implementation density of 6.0 fish/100 m^2 in 1996 to 9.9 fish/100 m^2 in 2002.

Table 57. Whiteman Creek reach 5 habitat attribute values from the 1996 implementation site.

	96 Structures						
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	54	67	47	49	48	34	58
Pool/Riffle	0.2	0.4	0.5	0.6	1.1	1.8	0.8
Spawning Gravel (m^2)	0.0	0.0	0.0	0.0	0.0	0.5	0.0
% Pool	7	0	24	21	39	50	42
% Riffle	82	61	57	57	43	33	35
% Run	6	10	15	11	2	0	23
% Pocketwater	6	29	4	11	15	14	0
% Glide	0	0	0	0	0	3	0
Avg Depth (cm)	13.3	21.5	19.9	17.5	15.5	15.6	24.5
Avg Width (m)	2.6	4.1	4.7	3.5	3.3	3.6	3.7
# Primary Pools	0	1	1	8	2	4	3

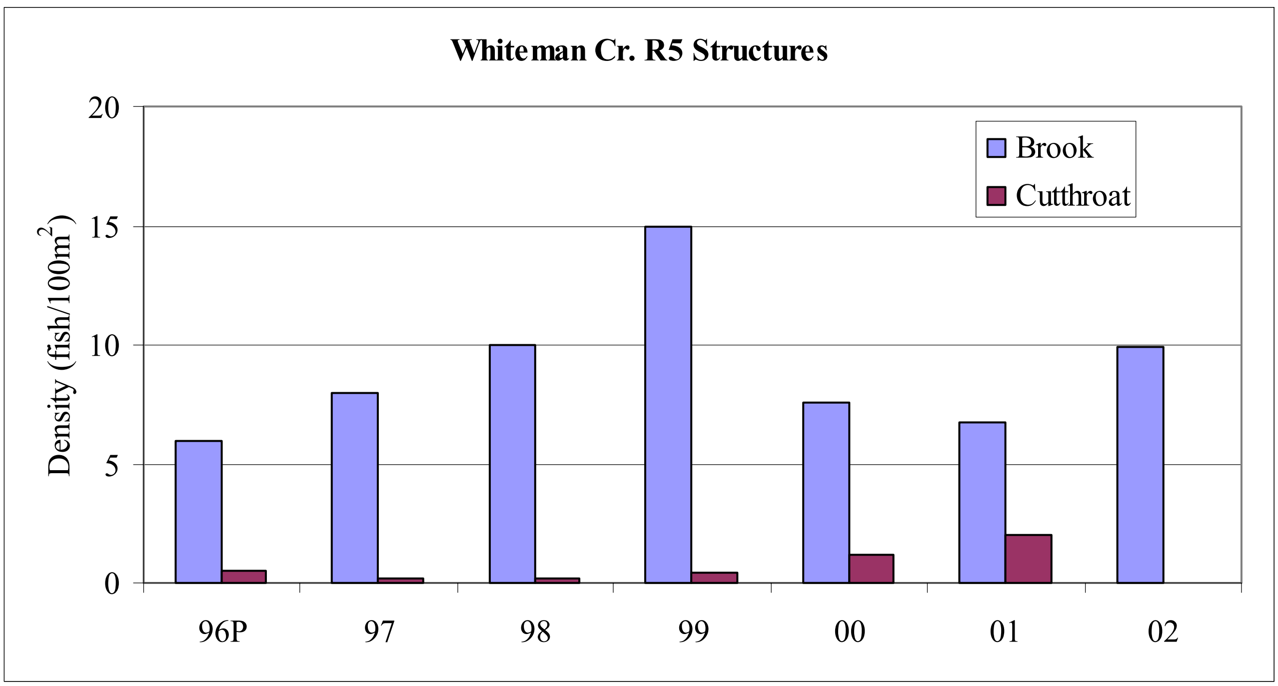

Figure 41. Annual Whiteman Creek reach 5 fish densities from the 1996 implementation site.

Reach 6

Boulder structures were also placed in reach 6 to create pool habitat. Post assessment substrate embeddedness decreased from the pre-assessed embeddedness of 73% (Table 58). Post assessed embeddedness ranged from a low of 29% in 2001 to a high of 60% in 1999. 2.0 m^2 of spawning habitat was observed in the pre-assessment. Spawning substrate increased to 4.5 m^2 in 1997 and 2.5 m^2 in 1998. However, no spawning gravel was identified in 1999, 2000, or 2002. Pool habitat increased annually from 0% in the 1996 pre-assessment to 46% in the 2001 post assessment. However, pool composition dropped in 2002 to 5%. Pre-assessed (1996) average depth was 23.4 cm and increased to 27.5 cm in 1997. Average depths decreased in subsequent years and ranged from 14.3 cm in 1999 to 18.8 cm in 2001. Average widths increased in the first two years of post assessment. The pre-assessed width was 3.8 m; width increased to 4.6 m in 1997 and 6.4 m in 1998. However, average widths from 1999 to 2002 have been less than the pre-assessed value. No primary pools were observed in the 1996 pre-assessment and the 1997 and 1998 post assessments. Primary pool number increased to 2 in 1999 and 3 in 2000 and 2001. However, no primary pools were identified in 2002.

Cutthroat densities in reach 6 have increased from the 1996 pre-assessed density of 0.5 fish/100 m^2 to 0.9 fish/100 m^2 in 2002 (Figure 42). Post assessed brook trout densities were variable. The 1996 pre-assessed brook trout density was 14.0 fish/100 m^2; density decreased to 10.0 fish/100 m^2 in 1997 and then increased to 16 fish/100 m^2 and 17 fish/100 m^2 in 1998 and 1999, respectively. Brook trout density was 14.1 fish/100 m^2 in 2002.

Table 58. Whiteman Creek reach 6 habitat attribute values from the 1996 implementation site.

	96 Structures						
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00	Post '01	Post '02
Embeddedness (%)	73	55	38	60	55	29	48
Pool/Riffle	0.3	0.4	0.1	0.8	0.9	1.1	0.1
Spawning Gravel (m^2)	2.0	4.5	2.5	0.0	0.0	1.5	0.0
% Pool	0	4	4	32	38	46	5
% Riffle	73	51	83	51	54	46	79
% Run	12	30	10	3	0	0	16
% Pocketwater	14	15	3	14	7	6	0
% Glide	0	0	0	0	0	2	0
Avg Depth (cm)	23.4	27.5	18.5	14.3	15.6	18.8	17.2
Avg Width (m)	3.8	4.6	6.4	3.2	2.7	3.3	3.6
# Primary Pools	0	0	0	2	3	3	0

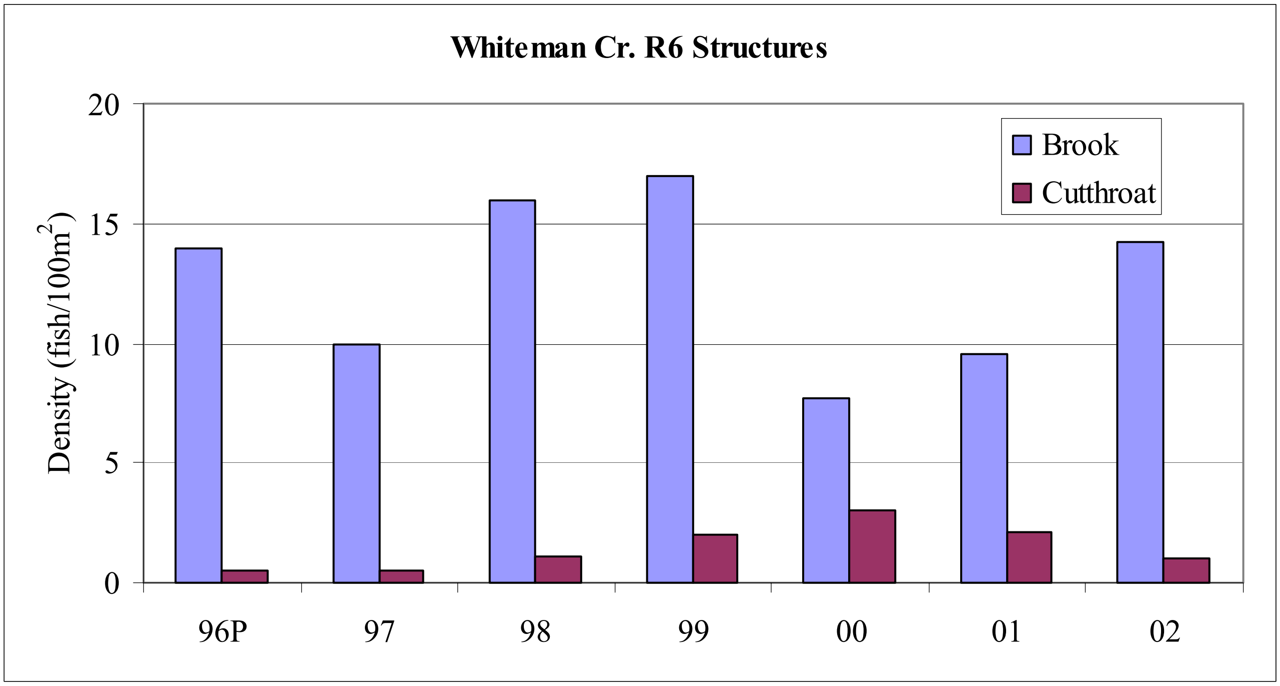

Figure 42. Annual Whiteman Creek reach 6 fish densities from the 1996 implementation site.

DISCUSSION

Results from baseline surveys of area streams conducted in 1995 and 1996 showed a general trend: large woody debris densities were relatively low and substrate embeddedness was high. LWD is a primary component of stream channel complexity. Woody debris provides many important functions to fish populations and stream channels. Wood has a critical role in modifying and maintaining channel morphology, trapping transported sediment, and stabilizing stream banks. Large wood provides yearlong cover and is used as refugia during extreme flow events. Jakober et al (1998) found bull trout and cutthroat trout preferred habitat with large woody debris. High substrate embeddedness decreases the amount of cover available to overwintering fish (Griffith and Smith 1993). Increased fine sediment in streams can also fill in pools, backwater habitat, and side channels that are important to rearing and overwintering bull trout and cutthroat trout.

Difficulty arises when trying to distinguish the effects of restoration among the many interacting factors and great natural variability within the physical and biological components of the ecosystem. Aside from catastrophic events, stream processes are generally slow and diminutive. Therefore, much of the restoration implemented may not yield measurable results for several years or decades (Heede 1986). Observer classification of habitat types also introduces further variability (Roper and Scarnecchia 1995). Among KNRD surveyors, a distinct difference in the way habitats with certain characteristics (e.g. velocity, channel shape, and surface turbulence) were consistently classified by different observers was noted. The tendencies were for some observers to classify a habitat as a run while other observers classified the same habitat as a pool. For example, pool composition decreased in restoration sites in reach 4 of Browns Creek; however, run composition was nearly double any other years composition. While differences in habitat classification (observer variability) likely occurred to a lesser degree in all assessments, we have observed a decrease in riffle habitat suggesting that pool habitat is, in fact, increasing.

Overall, 2002 substrate embeddedness was lower than pre-assessed values in 16 of the 20 implementation sites (Table 59). Percent pool habitat has increased in 16 of the sites. Primary pool frequency has increased in 9 sites, decreased in 5 sites, and was unchanged in 6 sites. Total fish densities in 2002 have increased over 10% in 10 of the 20 sites relative to pre-assessment densities.

In Cee Cee Ah Creek, limiting factors were identified as overwintering habitat (pools) and spawning habitat (KNRD 1997b). Log structures were implemented to create pools and recruit spawning gravel in the tail-outs. Pool habitat appears to be increasing in nearly all of the restoration sites in Cee Cee Ah Creek. In reaches 4, 5, and 6, nine restoration sites were implemented from 1996 to 1998. Five sites had increases in the number of primary pools, three sites had decreases, and one site was unchanged. The percent of pool type habitat increased in all but one implementation site. Total fish density increased in 6 of the 9 restoration sites in Cee Cee Ah Creek. Only three cutthroat trout have been observed in these sites; one cutthroat was observed during pre-assessment snorkeling surveys in 1996 and in 1997 and one in 2002.

Pool habitat and substrate embeddedness were identified as limiting factors in reaches 3 and 4 in Indian Creek. In 2002, a slight increase in percent pool habitat was observed. Substrate embeddedness was relatively unchanged in reach 3 and has decreased substantially in reach 4. Spawning habitat appeared to decrease considerably, from 23.0 m^2 to 0.0 m^2, in reach 3. Gravels are still present in reach 3 of Indian Creek; however, none of the gravel was characterized as spawning habitat. The double wing deflectors constructed in reach 3 of Indian Creek appear to have had little effect on channel scour, but, nonetheless, are concentrating flow to mid-channel. Areas of low velocity are created upstream and downstream of the structures. Water velocities in these areas are too low to categorize the gravels as spawning habitat. Indian Creek is mostly groundwater fed with relatively little watershed in relation to actual stream size. As a result, the hydrograph is relatively muted and annual peak discharges are not great enough to scour out the desired pools. Systematic streamflow data collection in Indian Creek was started in the fall of 2001. Discharge in 2002 ranged from a low of 0.086 m^2/s to 0.278 m^2/s. Although, extensive spring flooding occurred throughout the basin in 2002, the maximum annual discharge in Indian Creek was in November and flows stayed within the bankfull channel. In Indian Creek, stream power does not appear to be effective at moving bedload and scouring out pools. Therefore, further work (e.g. manually digging out pools or creating dam pools) may be required to further increase pool habitat in reach 3. However, ownership of the land adjacent to the restoration sites has recently changed hands. The new landowner has been reluctant to allow additional work.

Table 59. Summary of pre implementation and 2002 limiting habitat attribute values and fish densities.

Stream/Reach	Year*	Embedded % Pre	Embedded % 2002	Pools % Pre	Pools % 2002	Primary Pools Pre	Primary Pools 2002	Cutthroat Density Pre	Cutthroat Density 2002	Total Fish Density Pre	Total Fish Density 2002
Cee Cee Ah Cr. Reach 4	1996	48	40	7	18	2	1	0.0	0.0	8.6	7.9
	1997	48	46	17	19	0	1	0.0	0.0	4.7	7.8
	1998	45	42	0	50	1	2	0.0	0.0	3.9	10.0
Cee Cee Ah Cr. Reach 5	1996	77	51	0	20	2	3	0.8	0.0	7.0	22.5
	1997	61	59	8	43	1	3	0.0	0.0	8.5	12.8
	1998	62	48	20	18	1	1	0.0	0.3	14.6	13.8
Cee Cee Ah Cr. Reach 6	1996	59	64	9	46	5	3	0.0	0.0	16.6	17.1
	1997	67	54	5	43	2	1	0.3	0.0	11.8	11.4
	1998	63	45	0	37	1	3	0.0	0.0	4.3	9.3
Indian Cr. Reach 3	1996	80	76	0	4	0	0	0.0	0.0	10.8	9.7
Indian Cr. Reach 4	1996	82	45	0	5	0	0	0.7	0.0	3.4	2.6
Browns Cr. Reach 4	1997	31	49	3	0	0	1	0.0	0.0	4.4	4.6
	1998	28	53	0	6	0	0	0.2	0.0	4.5	9.0
Fourth of July Cr. Reach 8	1996	82	70	0	12	0	0	8.0	4.2	11.0	5.6
Mineral Cr. Reach 1	1996	53	50	4	16	4	2	14.0	7.9	20.0	18.7
	1997	71	58	19	8	2	0	20.0	6.2	28.0	19.2
	1998	54	53	15	49	0	2	5.0	5.2	5.0	10.4
Whiteman Cr. Reach 4	1996	95	89	7	35	1	10	0.0	0.3	20.0	45.1
Whiteman Cr. Reach 5	1996	54	58	7	42	0	3	0.5	0.0	6.5	9.9
Whiteman Cr. Reach 6	1996	73	48	0	5	0	0	0.5	0.9	14.5	14.3

*Year of implementation

Other factors not identified in the stream survey may also be limiting fish populations in Indian Creek. The KNRD operated adfluvial fish traps on 11 tributaries in the Box Canyon reach of the Pend Orielle River. Of those 11 traps, the Indian Creek trap had the most fish captured in 1998. Adfluvial fish likely represent a portion of the sampled population. Therefore, if a portion of the population is adfluvial, there may be other factors outside of the project watershed influencing the population (e.g. limiting factors for salmonids in Box Canyon Reservoir).

A lack of pool habitat was identified as limiting fish populations in reach 4 of Browns Creek (KNRD 1997b). Pool habitat remains low in both restoration sites. In the 1997 implementation site, pool habitat decreased from 3% to 0% while run habitat increased from 2% to 24% in 2002. However, only one primary pool was present in 2002. A slight increase in pool habitat and primary pool number has been observed in the 1998 restoration site throughout the monitoring years. However, pool habitat in these two sites remained relatively low in 2002. Browns Creek is characterized as a spring creek since it emerges from underground approximately 1 Km from Browns Lake. Most of the watershed area is situated above Browns Lake. Therefore, seasonal discharges lack the magnitude of peak flow events usually generated in a stream of the same size. Like Indian Creek, stream power does not appear adequate to scour out the desired pools. Future work in these sites needs to consider these characteristics.

Single wing deflectors were constructed in reach 1 of Mineral Creek in 1996 and 1997. High substrate embeddedness and low pool habitat were the limiting factors identified from the baseline survey. In the 1996 and 1997 sites, cutthroat trout densities have declined while brook trout densities have increased. Cutthroat density has been mostly unchanged in the 1998 site; however, brook trout density is on the rise. In 2002, brook trout densities were greater or equal to cutthroat densities in all three sites; in the six years prior, brook trout density was seldom greater than 50% the cutthroat density. However, intensive electrofishing to remove brook trout was conducted after the 2002 monitoring took place.

A lack of overwinter habitat (pools) and low depths due to channel braiding were identified as the limiting factors in reach 4 of Whiteman Creek. The percent of unstable banks were high and were likely contributing to substrate embeddedness in downstream reaches. Structures were implemented in 1997 to concentrate flows in mid-channel. Reach 4 is also enclosed in a riparian fence that was constructed in 1996. The improved habitat appears to have resulted in increased fish density. Brook trout was the only species observed in reach 4 from 1995 to 2000. In 2001 and 2002 cutthroat trout were observed in low numbers. All post assessment brook trout densities were higher that the pre-assessment density.

Pool habitat was identified as the limiting factor in reach 5 of Whiteman Creek. Boulder structures were implemented to create pool habitat. From 1996 to 2002, percent pool habitat increased from 7% to 50% and the number of primary pools increased from 0 to 3. Brook trout density increased from 6.0 fish per m^2 in the pre-assessment to 9.9 fish per 100 m^2 in 2002. While brook trout density increased, for the first time no cutthroat trout were observed in the reach 5 site. Brook trout appear to be limiting cutthroat numbers in Whiteman Creek.

Boulder structures were placed in Whiteman Creek reach 6 as pool habitat was also identified as the limiting factor. From 1996 to 2001 pool habitat increased from 0%

to 46% and primary pools increased from 0 to 3. In 2002, however, pool composition dropped to 5% and no primary pools were identified. It appears that the boulder structures have been displaced by high spring flows. Although ratios of brook trout to cutthroat trout declined to nearly 2 in 2000, brook trout density increased while cutthroat declined in subsequent years.

LARGEMOUTH BASS HABITAT ENHANCEMENT MONITORING

DESCRIPTION OF STUDY AREA

The bass habitat enhancement study was located in zero flow areas of the reservoir (i.e. adjacent to and within sloughs). Four sloughs were used for the study:

1) Campbell slough adjacent to the Pend Oreille Wetlands Wildlife Mitigation Project, located on the east side of the Box Canyon Reservoir, at river km 99 (Figure 43).

2) No Name slough located directly across the reservoir from Campbell slough, on the west side of the reservoir, at river kilometer 99.

3) Cee Cee Ah slough, located within the Kalispel Reservation on the east side of the reservoir, at river km 109.

4) Old Dike slough, contained within the Kalispel Reservation and located on the east side of the reservoir, at river km 107.

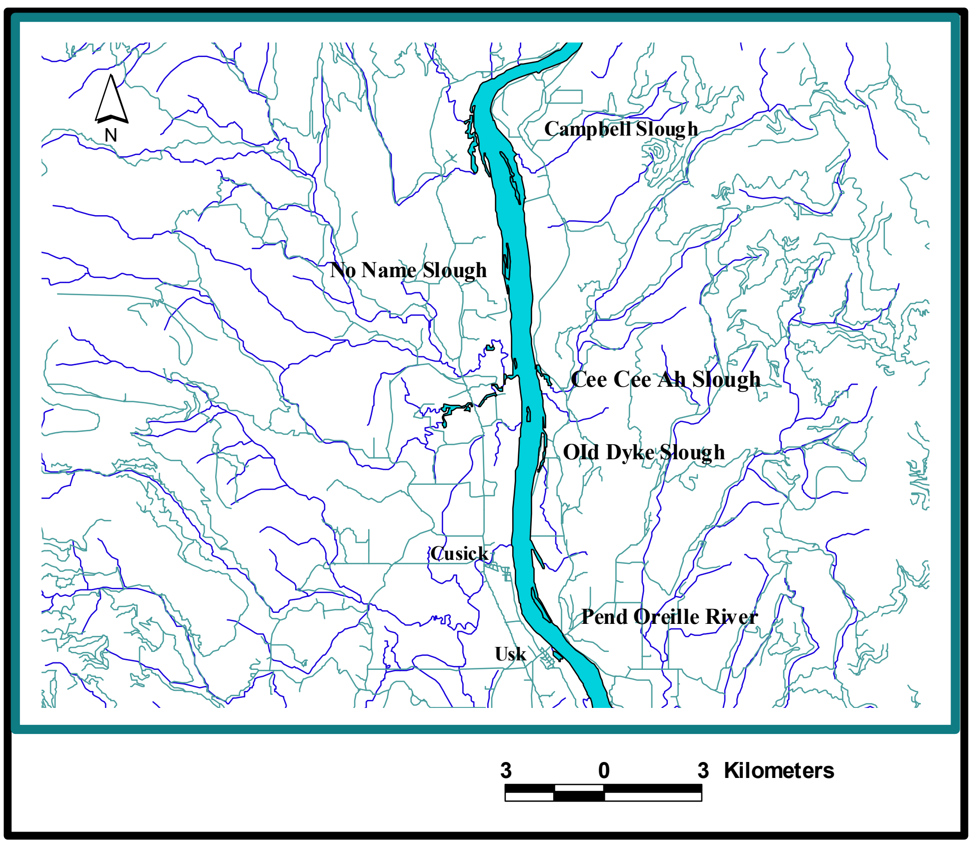

Figure 43. Location of the bass habitat enhancement sites.

METHODS

Selection of the sloughs used in the bass habitat study was based on the two types of sloughs available within the reservoir. The sloughs are either backwater stream mouths or dead end river backwater. Four sloughs were selected: one stream fed treatment slough, one stream fed control slough, one backwater treatment slough and one backwater control slough.

Two types of artificial structures were used in the treatment sloughs. The Berkley structures are 4-ft. cubes of plastic slats that provide cover in the interstitial spaces. The Pradco structures resemble palm trees and provide cover under the palms. The placement of each type was alternated between the two treatment sloughs (Berkley in the mouth transect in one slough and in the inland transect of the second slough).

Each slough was sampled prior to artificial habitat installation. Two 75 m sampling transects were established for each slough. Between the transects, a 75 m buffer was established to avoid data collection overlap. Each transect was then electrofished for a period of 300 seconds and all fish were collected. Bass total lengths and abundance were recorded; all other fish were recorded as total numbers by species.

In the spring and fall, each transect is electrofished annually. Relative abundance (CPUE) and species composition are calculated for each transect. Analysis will include whether the structures increase the abundance of juvenile largemouth bass.

RESULTS

From 1997 (pre-assessment) to fall 2002, largemouth bass relative abundance increased at every sampling site with the exception of Cee Cee Ah Slough #1 which was unchanged. Sampling of the largemouth bass enhancement sites did not occur in the fall of 1998 or 2000. Early sub-freezing temperatures iced the sloughs over in early November and the ice remained throughout the month. In Cee Cee Ah Slough #1, largemouth bass relative abundance was 2 in the fall of 1997 and again in the fall of 2002 (Figure 44). In Cee Cee Ah Slough #2, largemouth bass were only present in the catch in the fall of 1999 (n=2, Figure 45) and in 2002 (n=1).

In No Name Slough #1, largemouth bass relative abundance appeared to increase significantly in the fall of 1999 when 14 were collected (Figure 46). No largemouth bass were collected in the 1997 pre-assessment or the 1999 to 2002 spring post assessments. Three largemouth bass were collected at this site in the fall of 2002. No bass were present in the 1997 pre-assessment sample in No Name Slough #2 (Figure 47). Two bass were collected in the spring of 1998 and four bass were collected in the fall 1999 sample. No fish were collected in the 1999, 2000, or 2001 spring sampling periods and 6 largemouth bass were present in the 2001 and 2002 fall samples.

In Old Dyke #1, two bass were captured in the 1997 pre-assessment (Figure 48). Prior to fall of 2002, largemouth bass were collected in only three other sampling periods: one in the fall of 1999 and 3 in the fall of 2001. No largemouth bass were present in the catch in any of the spring sampling periods. However, in the 2002 fall sampling period 39 largemouth were captured in Old Dyke #1. In Old Dyke #2, largemouth bass were present in the catch in all sample periods except in the spring of 2001 (Figure 49). One bass was captured in the 1997 pre-assessment and three were captured in the fall of 2001. Twenty largemouth bass were captured in 2002; an increase of 333% over any other sampling period.

In Campbell Slough #1, largemouth bass have been present in the catches of all sampling periods. Largemouth bass relative abundance increased dramatically from pre-assessment (n=1) to fall 2002 (n=24)(Figure 50). Largemouth bass abundance in the spring of 1998 and 2001 was also relatively high with 19 and 17 bass captured, respectively. Largemouth bass relative abundance initially increased in Campbell Slough #2 (Figure 51). The 1997 pre-assessed abundance was 1. Large increases were observed in spring 1998 (n=19) and spring 1999 (n=18). Five largemouth bass were captured in fall 1999. Bass numbers declined in the fall of 1999 (n=5) and spring of 2000 (n=1). However in 2001 and 2002, fall largemouth bass relative abundance was relatively high at 30 and 23, respectively.

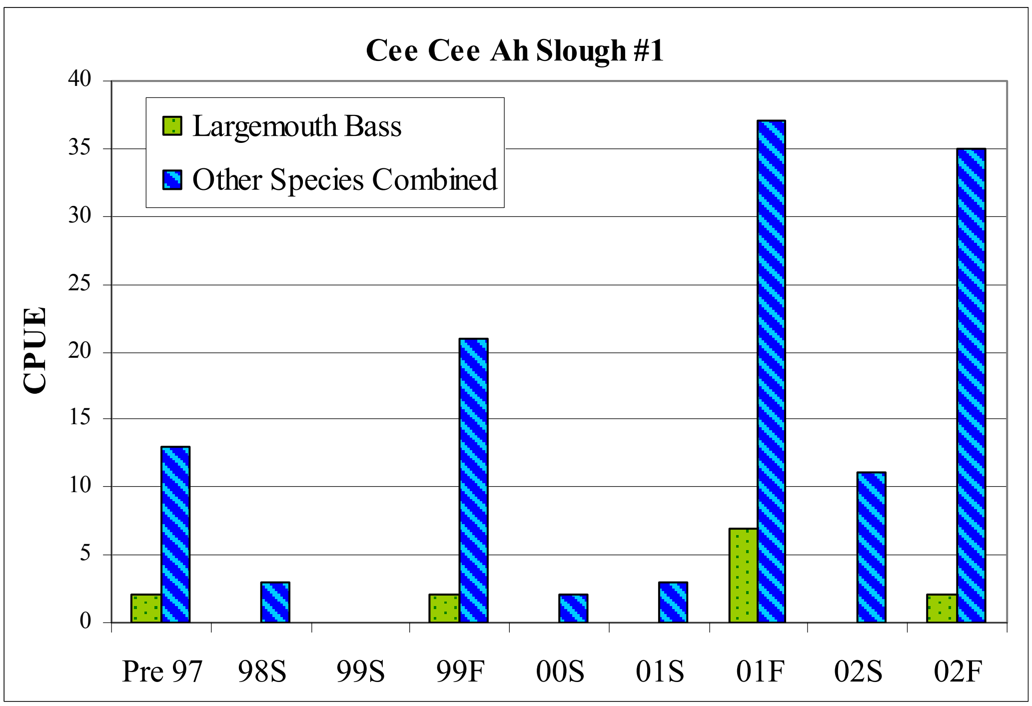

Figure 44. Largemouth bass and combined fish relative abundance for transects in Cee Cee Ah Slough #1.

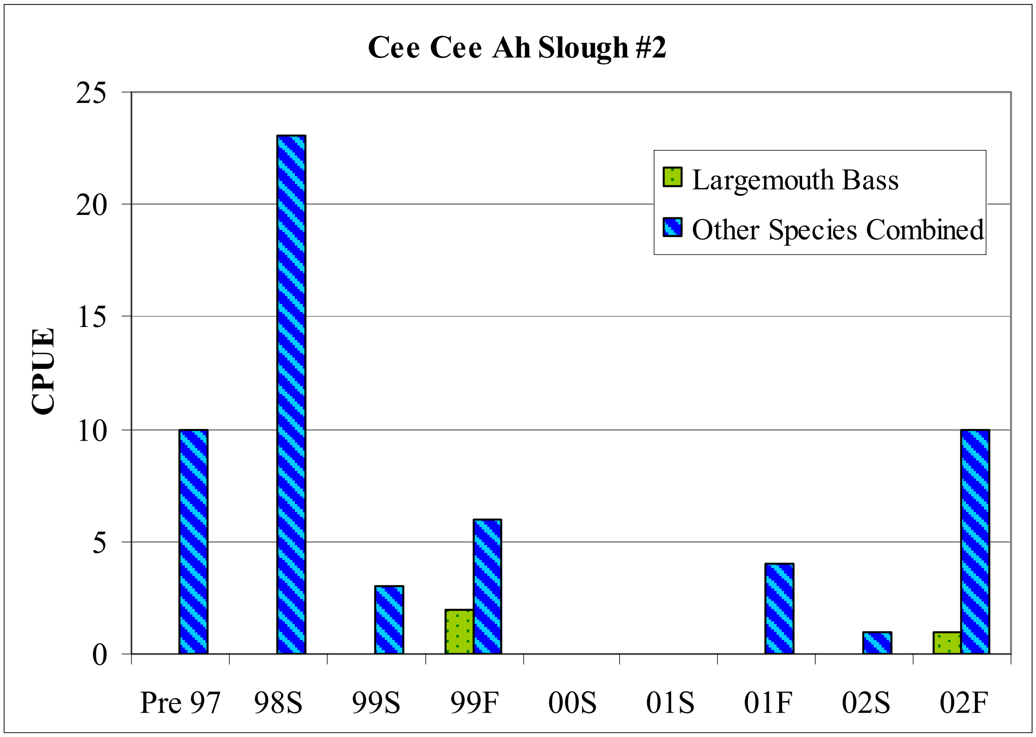

Figure 45. Largemouth bass and combined fish relative abundance for transects in Cee Cee Ah Slough #2.

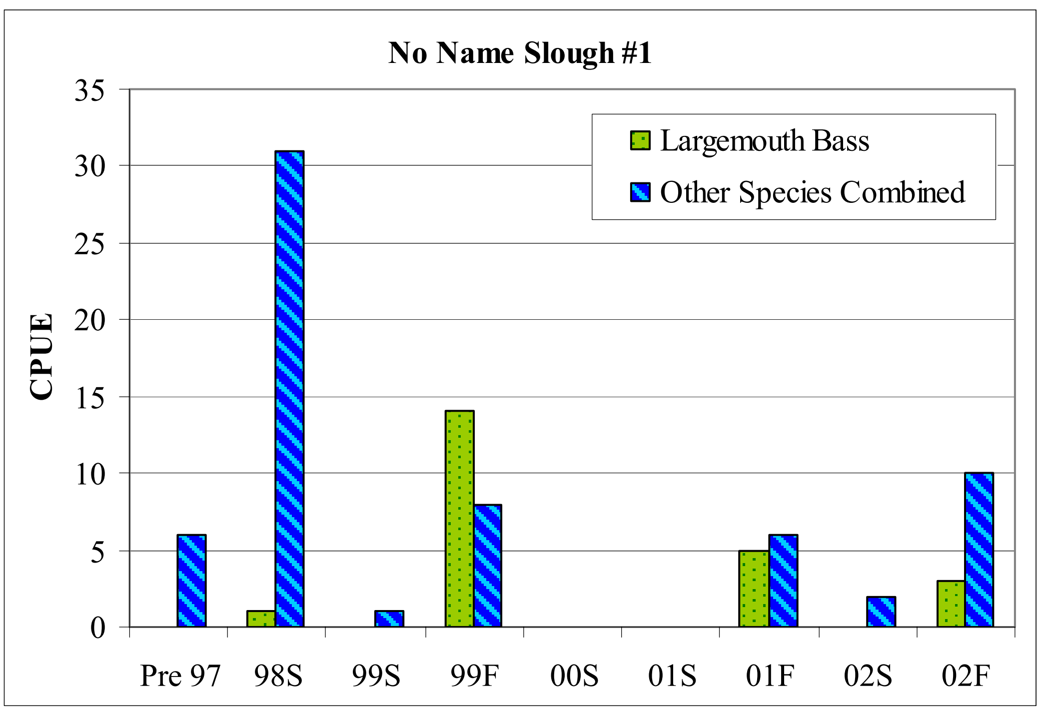

Figure 46. Largemouth bass and combined fish relative abundance for transects in No Name Slough #1.

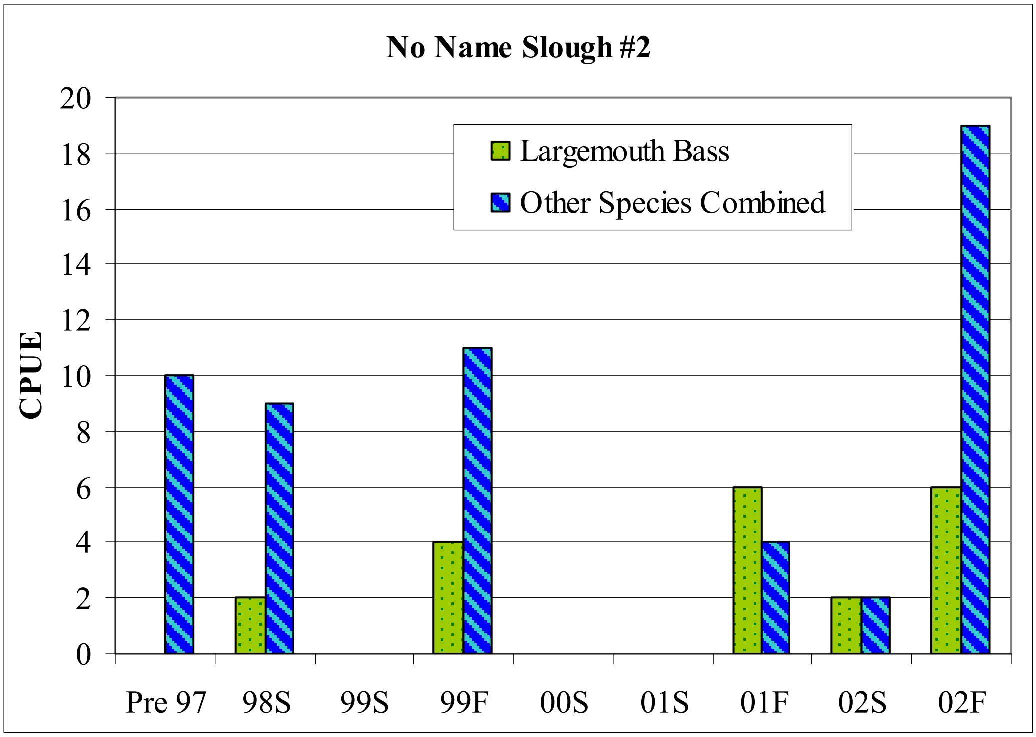

Figure 47. Largemouth bass and combined fish relative abundance for transects in No Name Slough #2.

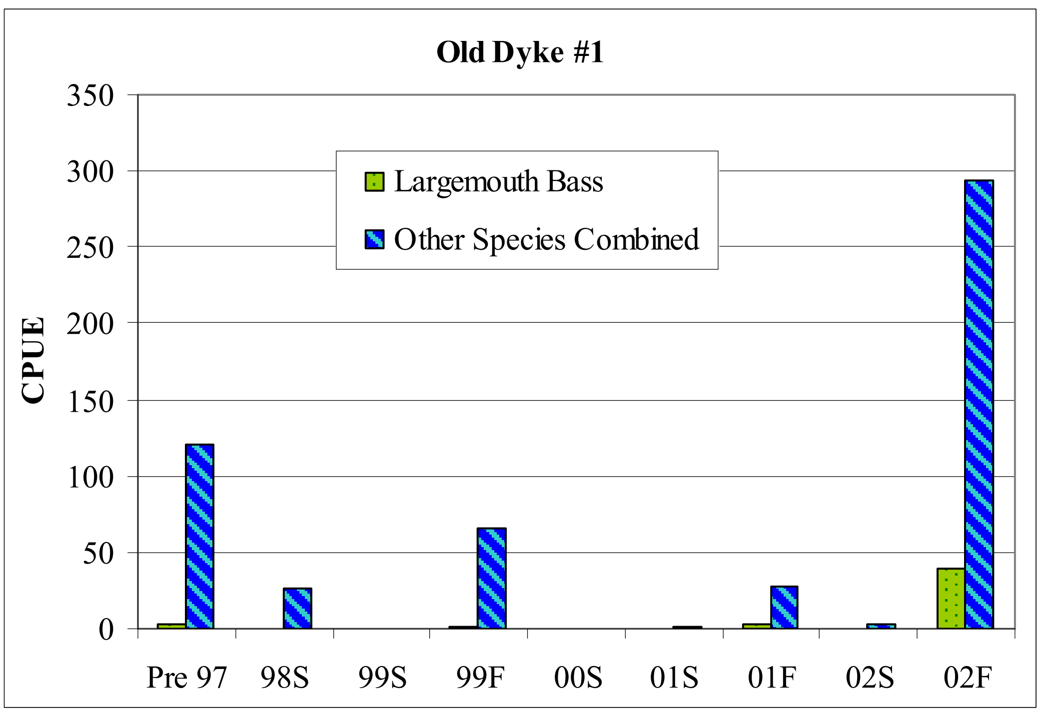

Figure 48. Largemouth bass and combined fish relative abundance for transects in Old Dyke Slough #1.

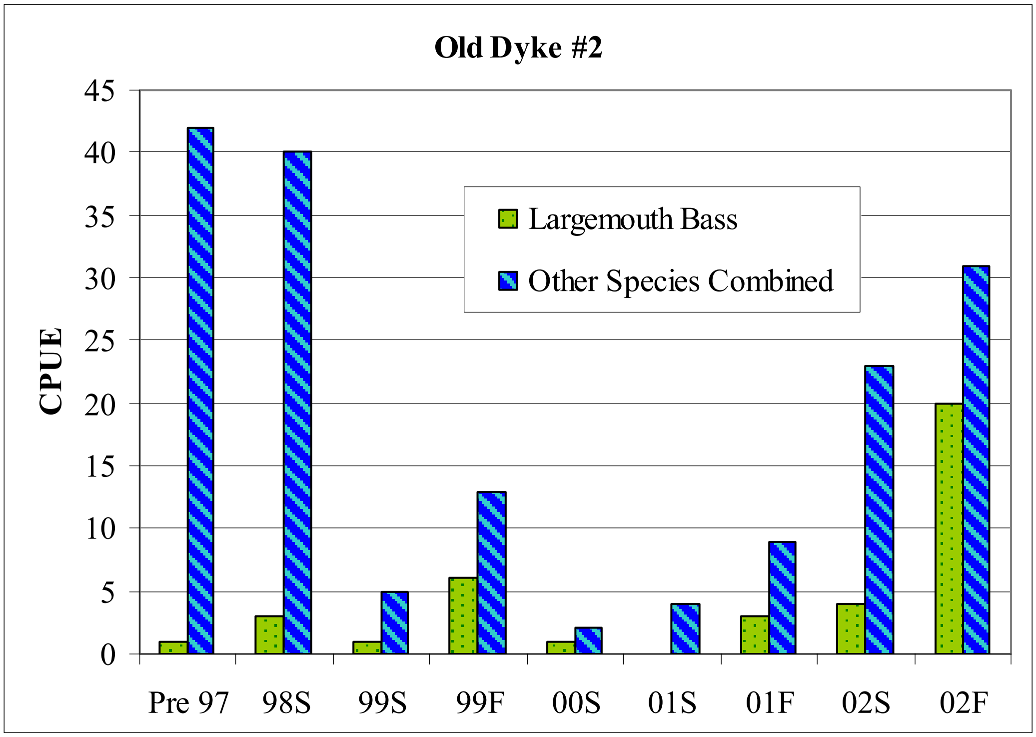

Figure 49. Largemouth bass and combined fish relative abundance for transects in Old Dyke Slough #2.

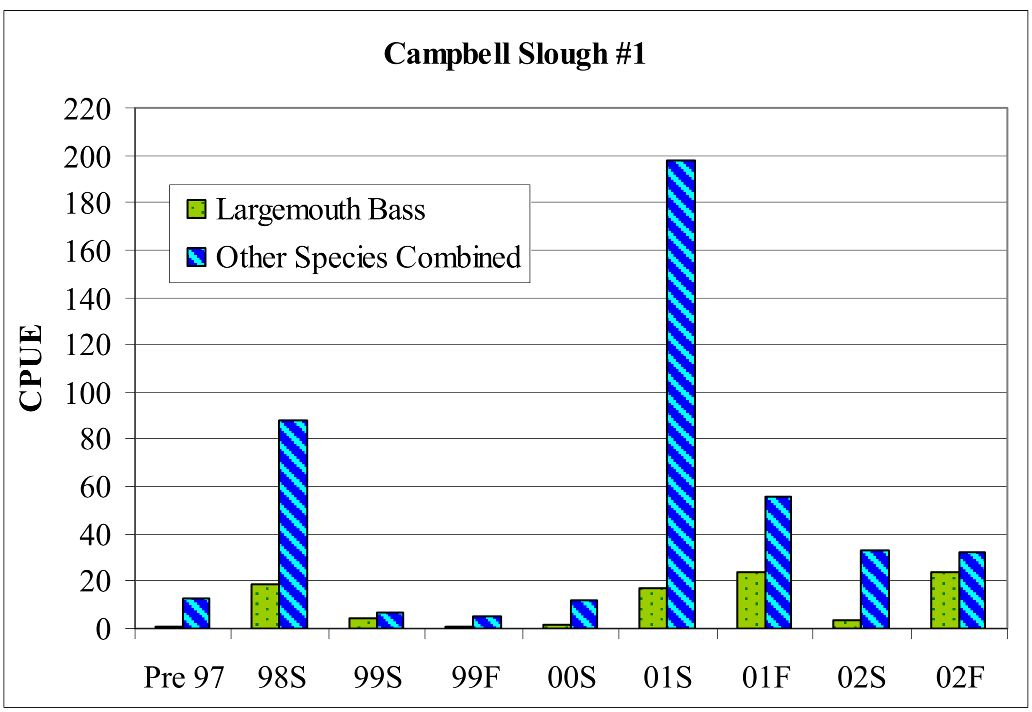

Figure 50. Largemouth bass and combined fish relative abundance for transects in Campbell slough #1.

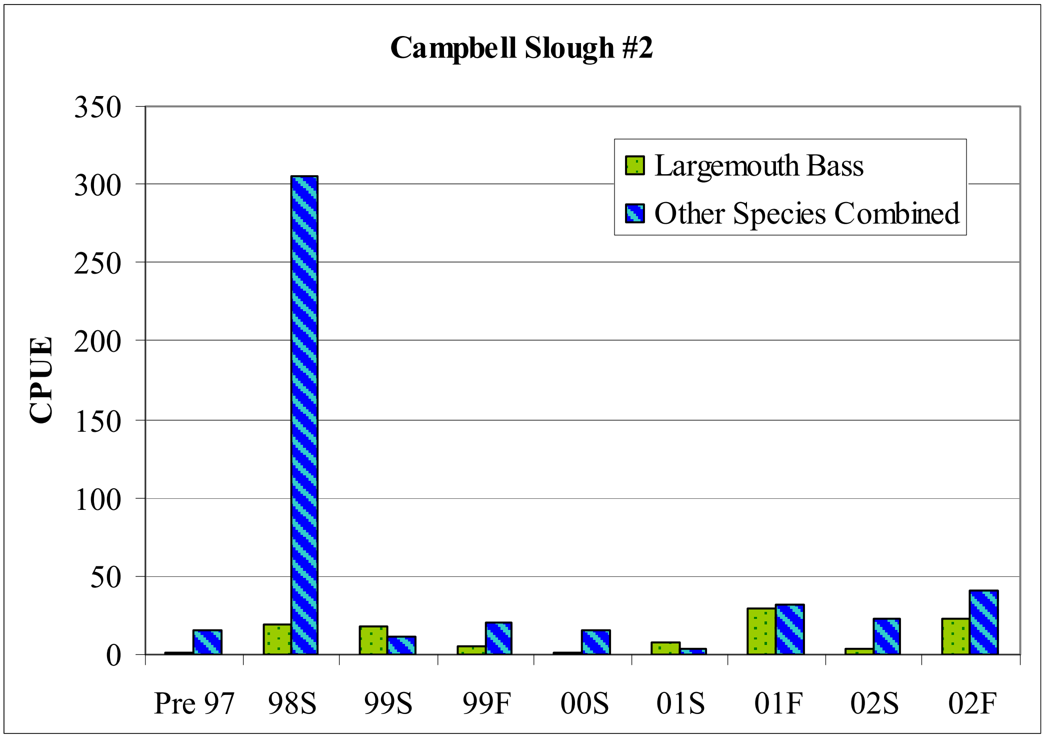

Figure 51. Largemouth bass and combined fish relative abundance for transects in Campbell Slough #2.

DISCUSSION

The mean size of largemouth bass was significantly different for fish captured in the fall and spring (P<0.0001). Juvenile largemouth bass are more likely to be present in the catch in the fall while larger adults are captured more frequently in the spring (Figure 52). The length frequency graph appears to have distinct modes for age 0+ and age 1+ largemouth bass. The means were 66 mm and 146 mm for age 0+ and age 1+ fish, respectively. Dampening of the length frequency modes occurred for fish older than 1+.

In the fall of 1997, before any bass structures had been placed (pre-assessment), no adult largemouth bass were captured in any of the sample sloughs. In 2002, seven adults were captured in the fall sampling period (Figure 53). A total of seven juvenile largemouth bass were captured in the pre-assessments of fall 1997. Juvenile numbers increased in successive fall sampling periods and a total of 115 age 0+ and 1+ largemouth bass were captured in 2002.

The percent of the catch has increased for all bass combined (Figure 54). Largemouth bass comprised 3.5% of the catch in the 1997 pre-assessment. Percent of catch was higher in all post assessment samples and ranged from 7.7% in the spring of 1998 to 44% in the spring of 1999.

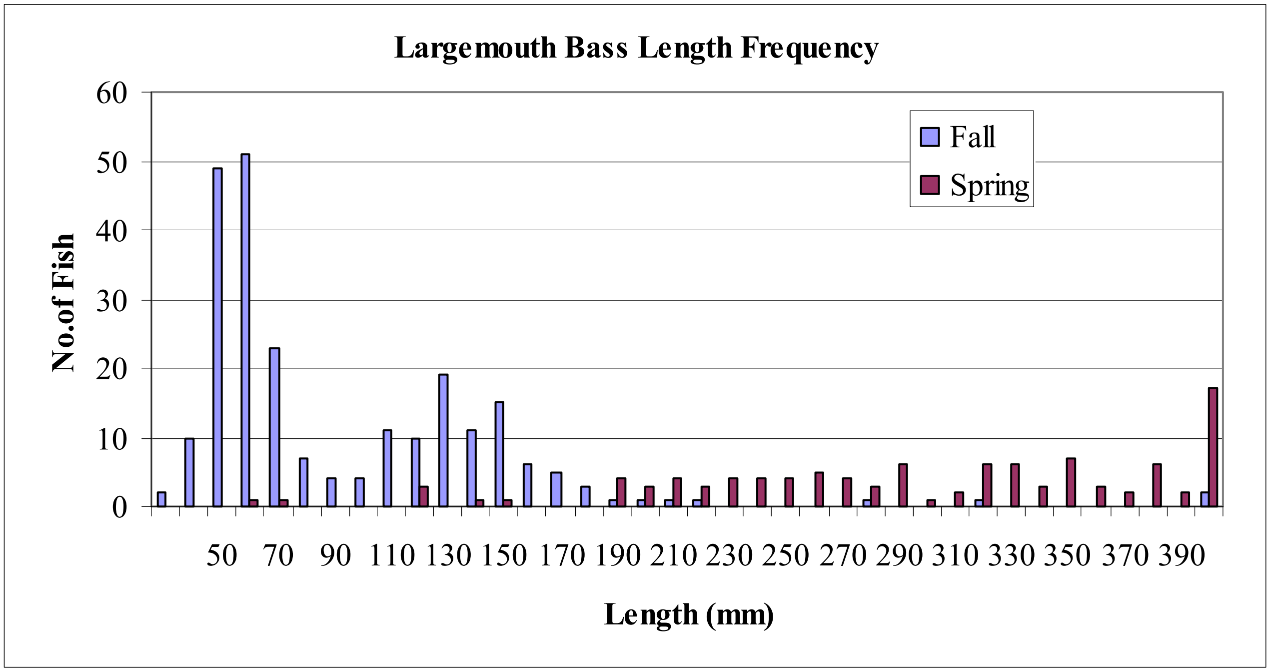

Figure 52. Largemouth bass length frequency for all stations sampled from 1997 to 2001.

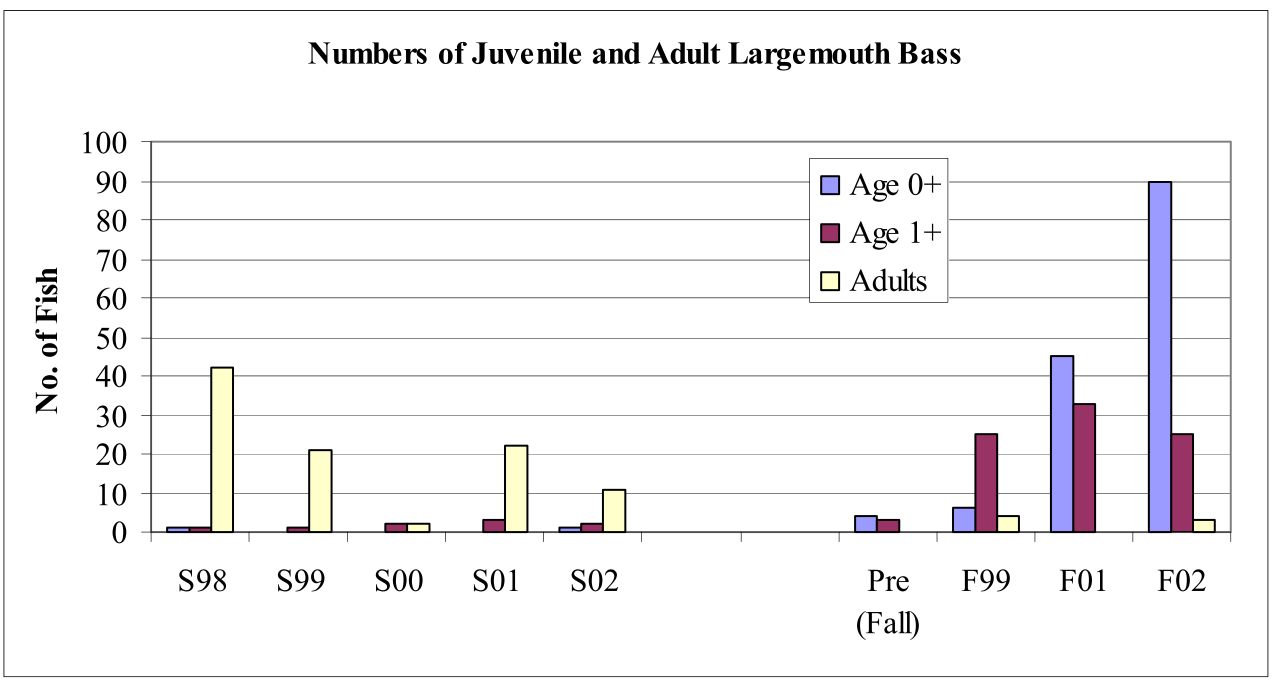

Figure 53. Numbers of juvenile and adult largemouth bass captured during spring and fall sampling periods from 1997 to 2001.

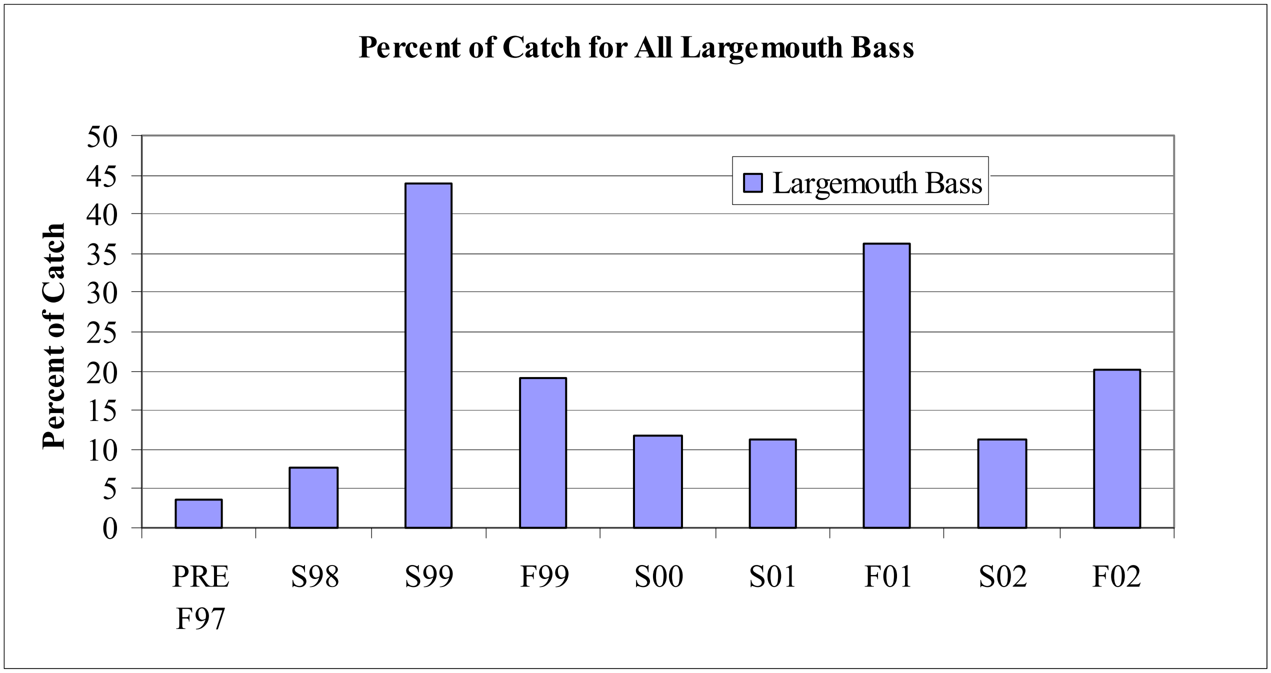

Figure 54. Annual percent of the catch of largemouth bass for all sampling transects.

Overall, largemouth bass CPUE and percent of catch have increased since bass habitat enhancement structures were implemented in 1997. However, distinct differences in seasonal utilization of the structures by juvenile and adult largemouth bass were apparent. 81% of the bass captured in the spring were adults while 97% of the bass captured in the fall were juveniles. The goal for this project is to provide overwinter cover to juvenile largemouth bass. Juvenile bass appear to have relatively low utilization of the structures in the spring. However, total juvenile relative abundance has increased from 7 in the fall of 1997 to 115 in the fall of 2001. In November, macrophytes in the sloughs and mainstem of the Pend Oreille River are likely providing significant cover for largemouth bass. However, in the spring, macrophytes have decomposed and the artificial structures may then be the primary cover component. Adult largemouth bass may seek out the cover of the structures and displace the juvenile bass which are vulnerable to predation. It is not known when the shift between juvenile and adult largemouth bass utilization of the structures takes place. However, given the increase in fall juvenile relative abundance, it appears that the enhancement structures may be resulting in increased overwinter survival for juvenile largemouth bass.

2002 TRIBUTARY ENHANCEMENT AND NON-NATIVE FISH REMOVAL

DESCRIPTION OF STUDY AREA

Mineral Creek is a headwater tributary to West Branch LeClerc Creek. The non-native fish removal project started approximately 350 m upstream from the confluence at an elevation of 1036 m (Figure 55). The removal project was terminated 3.7 Km upstream near an elevation of 1240 m. The culvert removal project was located in the same stream section at an elevation of 1050 m. Fish and habitat surveys were conducted in Mineral Creek in 1995; the average gradient was 7% and the average width was 2.6 m (Kalispel Natural Resource Department and Washington Department of Fish and Wildlife, 1997a)

Eight instream structures were constructed in reach 14 of West Branch LeClerc Creek (Figure 56). The restoration site was located approximately 1.4 Km upstream from the confluence of the East Branch LeClerc Creek. Restoration was recommended for reach 14 after habitat in West Branch LeClerc Creek was surveyed in 1999 (Maroney and Andersen, 2000). Reach 14 was classified as a B4 channel and pool habitat appeared to be limiting. In reach 14, the pool to riffle ratio was 0.2 and primary pool frequency was 3.3 pools/Km.

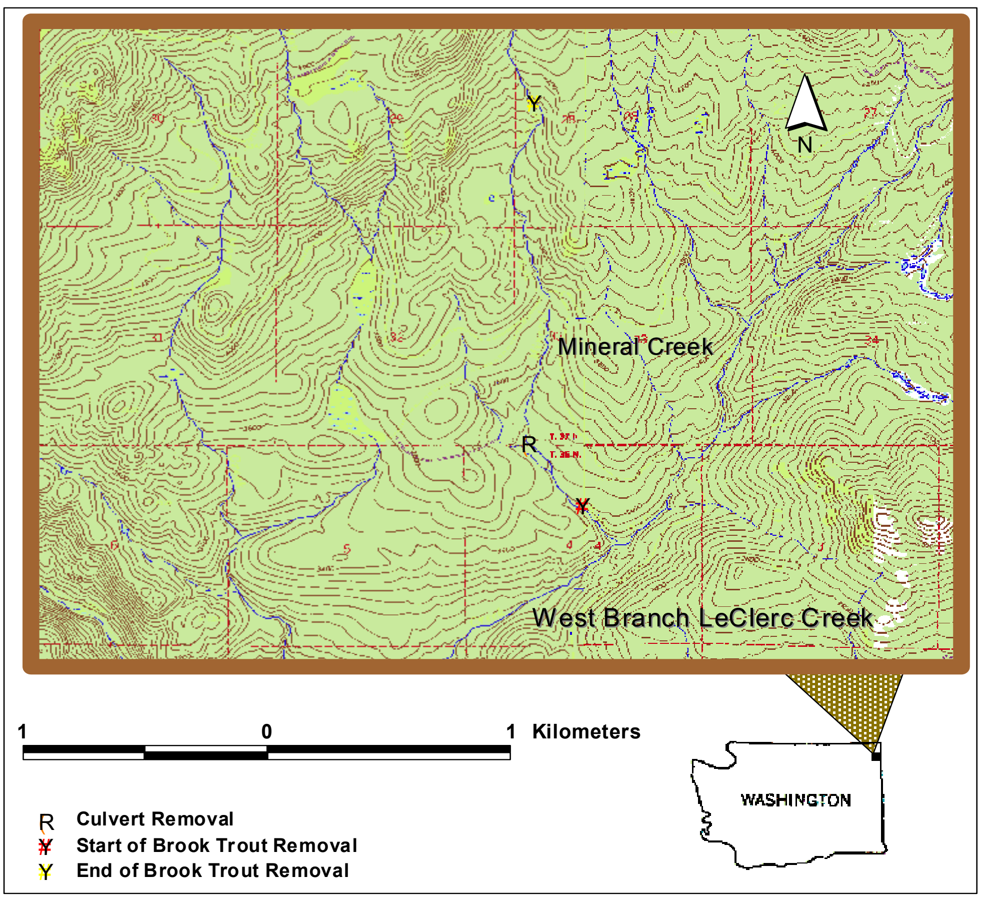

Figure 55. Location of Mineral Creek non-native fish removal and culvert removal projects.

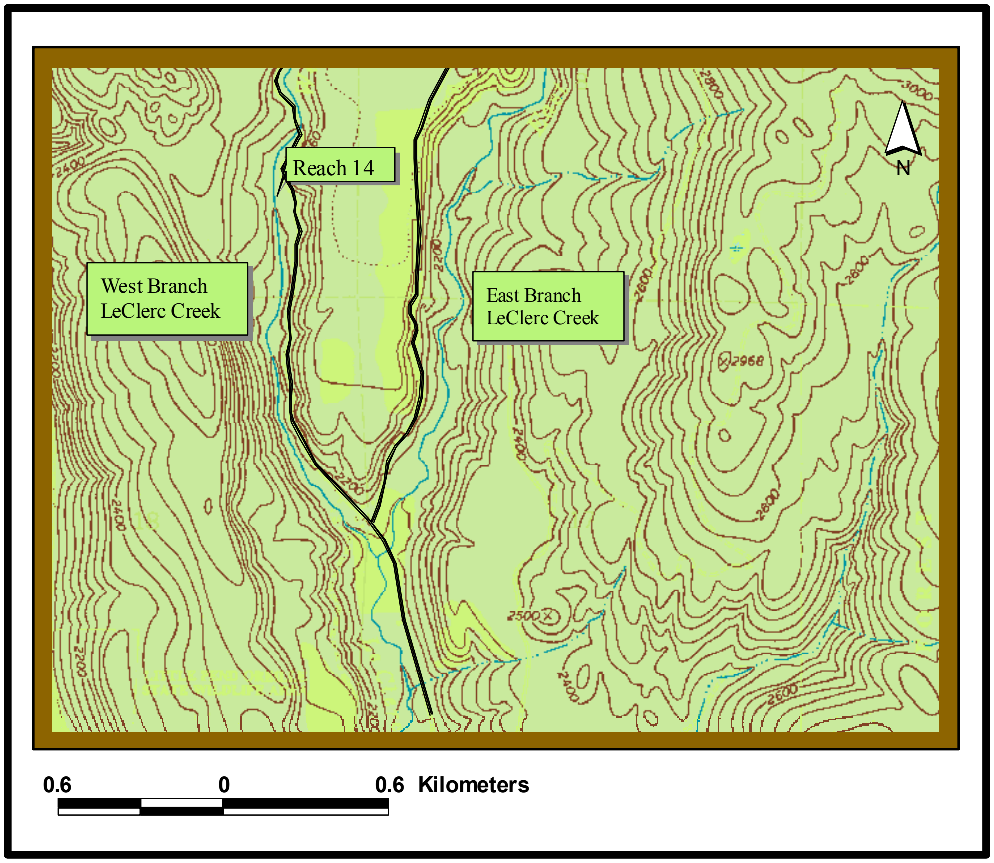

Figure 56. Reach 14 habitat restoration site located in West Branch LeClerc Creek.

METHODS

Non-native Fish Removal

Mineral Creek was electrofished using a battery operated Smith-Root LR-24 electrofishing backpack unit with an auto set-up system that is able to detect the right voltage setting for the present water conditions. To avoid imminent re-invasion by brook trout, electrofishing commenced at point in the channel where fish passage was difficult if not impossible (Figure 57). The stream was partitioned into 100 m reaches using 1-cm mesh block nets at both ends of the reach to prevent immigration or emigration of fish before and during electrofishing. All passes were electrofished with relatively constant effort and care was taken to remove all possible stunned fish. Three passes were made for each 100 m section. All fish captured in each pass were removed from the electrofished

Figure 57. Fish passage barrier where brook trout removal started.

section, anesthetized with MS-222, and total lengths were measured to the nearest mm. Captured cutthroat trout were then released in the adjacent, downstream section (which had previously been electrofished). Captured brook trout were transported in a holding tank to another location and released. Electrofishing occurred upstream until brook trout were absent in the catch in three consecutive 100 m sections.

Mineral Creek Culvert Removal Site Restoration

In August of 2002, the U.S.D.A. Forest Service removed a culvert in Mineral Creek. The culvert was located in a road that has been abandoned for several years. The culvert was undersized, at risk of failure, and appeared to be a fish passage barrier. Once the Forest Service removed the culvert and excavated enough roadbed to allow for a properly functioning channel, the Tribe completed the restoration work. The work was completed using manual and power operated hand tools.

West Branch LeClerc Creek Reach 14 Restoration

A flowchart (Figure 30) was used to determine the types of structures that could appropriately be utilized in reach 14. Specific structure type and placement were determined in the field. Restoration in reach 14 was also completed with hand tools.

RESULTS

Non-native Fish Removal

Thirty-seven 100 m sections of Mineral Creek were electrofished to remove non-native fish. Brook trout were not captured in the last three sections. A total of 2941 brook trout were captured and relocated to the Pend Oreille River (Table 60). Westslope cutthroat trout were less abundant; 880 cutthroat trout were captured and returned to Mineral Creek.

Table 60. Numbers of fish captured during electrofishing removals in Mineral Creek.

Mineral Cr. Brook Trout Removal		
Pass No.	No. Brook Trout Captured	No. Cutthroat Trout Captured
1	1867	574
2	671	177
3	403	129
TOTAL	2941	880

Mineral Creek Culvert Removal Site Restoration

The resulting channel section after culvert and roadbed removal was too wide and shallow (bankfull), relative to upstream and downstream sections (Figures 58 and 59). The channel just upstream of the old roadbed was also over-widened due to backwater that was created at high flows because the culvert was undersized. Therefore, the row of boulders that was originally placed to anchor the bankfull channel was moved further into the existing channel (Figure 60). The streambanks needed immediate restoration due to trampling by cattle and impending spring flows. Debris fences were created to divert cattle away from the newly created banks. Root wads were placed in one bank for stabilization and to create habitat. The banks were seeded, mulched, and planted with alder stakes. One single wing log deflector was placed at the top of the new channel (at the downstream end of the backflow area) to concentrate flow into an appropriately sized channel.

West Branch LeClerc Creek Reach 14 Restoration

The following eight instream structures were built to create pool habitat and/or trap fine sediment:

2 single wing log deflectors
2 sites with alder stake debris traps
2 single wing boulder deflectors
1 log weir
1 double wing boulder deflector

All structures were designed to create pool habitat. Structures were designed to enhance existing formative features. The debris traps were constructed in areas where deposition and stabilization of fine sediment will narrow the channel and result in pool habitat.

DISCUSSION

Non-native Fish Removal

The second phase of brook trout removal in Mineral Creek will need to occur to determine effectiveness. Because they are more difficult to sight and capture, Age-0 brook trout can have relatively low removal efficiencies (Thompson and Rahel, 1996). Therefore, Mineral Creek will be electrofished again, with one pass, in 2003.

The ratio of cutthroat trout to brook trout in Mineral Creek indicates that the brook trout may have been negatively affecting the native cutthroat trout population. 30 m stations snorkeled in 1995 (KNRD, 1997a) and 1998 (KNRD, unpublished data) showed cutthroat to brook trout ratios of 0.58 and 1.09, respectively. In 2002, the ratio attained by electrofishing in those same areas was 0.17. Monitoring of the reach 1 structures also indicated an increasing trend for abundance of brook trout. Therefore, we anticipate that with the removal of the brook trout, cutthroat trout densities should increase.

Figure 58. Downstream view of culvert removal project. Arrow indicates likely bankfull point if boulders were not relocated.

Figure 59. Upstream view of culvert removal site.

Figure 60. Banks prior to placement of debris fence and alder plantings.

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