Fish Habitat Assessment and Selected Rehabilitation Prescriptions within the Zymoetz Watershed

By

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For

Ministry of Environment, Lands and Parks Watershed Restoration Program

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Acknowledgments

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Executive Summary

A Level 2 Fish and Fish Habitat Assessment was performed on the first 3 sub-units (Skeena/Copper, West Copper, and Clore) within the Zymoetz (Copper) watershed by the Terrace Salmonid Enhancement Society, in partnership with the Gitselasu Band Council, the Steelhead Society of British Columbia (Northwest Chapter) and Skeena Cellulose Inc. It was funded by the Provincial Government through Forest Renewal British Columbia's Watershed Restoration Program. The goals of this Level 2 assessment were to provide appropriate restoration options and priorities as well as detailed site information needed to prepare rehabilitation prescriptions based on the Level 1 assessment completed by R.J.A. Forestry in 1996.

Between November 1997 and April 1998, a total of 42 sites (previously identified by R.J.A. Forestry) were examined in detail for habitat suitability (gravel size and amount, presence of cover, large woody debris and resting pools, pH), fish presence and size, channel and stream length and width, stream and bank gradient. Aerial photos were taken and used as overview and conceptual drawing aides.

Based on the results obtained in this assessment, the following have been created: charts displaying fork length frequencies of coho, rainbow trout and char; age class structures for all species trapped in the Zymoetz side channels, Elf Creek, Thomas Creek and Fiddle Creek; relative abundance of coho, rainbow trout and char; and a table and photo mosaics displaying the location of redds, spawning and holding adults. As well, Universal Transverse Mercator codes have been provided for each impact site.

Prescriptions, including conceptual work sketches, objectives, cost breakdown and method and material, have been created. All impacted sites were placed into one of three categories depending on the rehabilitation required. Four sites studied were found to have no significant impact, thus, requiring no restoration. Sixteen sites were found to have isolated impacts on the drainage that require a non-professional prescription and were placed in category 1. Twenty-two sites that have sub-basins and/or reaches where the impacts are more cumulative in nature and require an overall prescription were placed in category 2. A list of priority sites has been provided: the Clore slide (impact site 214B), located at 9 km on the Clore FSR, was found to have the largest impact on the Zymoetz River and is fast approaching emergency status due to the high amount of sediment being displaced into the Clore River; Swan Creek, impact site 95 in category 2, has lost all water flow and therefore has been given emergency status.

Funding for rehabilitation at all impacted sites within the first three sub-units of the Zymoetz watershed has been carefully estimated at $466,529.

1.0 Introduction

This Level 2 Fish and Fish Habitat Assessment was performed by the Terrace Salmonid Enhancement Society (TSES) in partnership with the Gitselasu Band Council, the Steelhead Society of British Columbia (Northwest Chapter) and Skeena Cellulose Inc. (SCI). It was funded by the Provincial Government through Forest Renewal British Columbia's (FRBC) Watershed Restoration Program (WRP). SCI currently holds the forest tenure for the area under Tree Farm License number 1 (TFL 1) and has an allowable annual cut of 720,000 m^3/year. The TSES is now the lead-proponent for all in stream watershed restoration work within the Zymoetz watershed taking over from SCI. The British Columbia Ministry of Forests (MOF) is the lead proponent for all up slope rehabilitation within the watershed.

1.1 Purpose

The goals of this Level 2 Detailed Habitat Assessment are to provide conceptual restoration prescriptions and priorities as well as gather detailed site information needed to prepare rehabilitation prescriptions based on the Level 1 assessment completed by R.J.A. Forestry Ltd. in 1996.

1.2 Scope

The areas eligible for rehabilitation, for the purpose of this assessment, are those that have been directly impacted by past harvesting practices on non private lands within the Zymoetz watershed system. Many changes have occurred in the watershed since the Level 1 assessment, increasing rehabilitation urgency. Therefore, the areas studied were directed by, but not limited to those recommended by SCI, R.J.A. Forestry, and reviewed and prioritized by the Steering Committee.

1.3 Zymoetz Watershed Description

1.3.1 General

The Zymoetz River, locally known as the Copper River, is found within the Kalum Forest District. It flows south-west into the Skeena River approximately 8 km north-east of Terrace, British Columbia. Its has a total length of 124.2 km and drains an area of approximately 320,000 ha. The headwaters of this river system are made up of three lakes: McDonell, Dennis and Aldrich. The Zymoetz watershed is comprised of 7 sub-units: (1) Skeena/Copper, (2) West Copper, (3) Clore, (4) Kitnayakwa, (5) Mattock, (6) Limonite and (7) NoGold. All sub-units except NoGold can be assessed by the Copper Forest Service Road (FSR) on the south side of the river; NoGold is accessed from the Kleanza FSR. Some areas on the north side of the river can only be accessed by boat while others are accessed from the North Copper FSR. Due to the time constraints involved with this assessment, the area of study was the Skeena/Copper, West Copper and Clore sub-units only; the latter two of which are within SCI's TFL.

1.3.2 Fisheries

The fish species currently inhabiting the Zymoetz watershed system are as follows: all species of Pacific salmon including sockeye (*Oncorhynchus nerka*), coho (*O. kisutch*), pink (*O. gorbuscha*), chum (*O. keta*), chinook (*O. tshawytscha*), winter, summer and spring run steelhead (*O. mykiss*), and cutthroat (*O. clarki*); Lake trout (*Salvelinus namaycush*); Dolly Varden char (*S. malma*); Rocky Mountain whitefish (*Prosopium williamsoni*); burbot (*Lota lota*); sculpins (*Cottus* spp.); Longnose dace (*Rhinichthys cataractae*); resident sockeye (kokanee) (*O. nerka*); and resident rainbow trout (*O. myskiss*).

At different times throughout the year, the anadromous species of fish enter the watershed in order to find suitable habitat for spawning. Sockeye enter the stream in July and do the majority of their spawning in late August and September. Coho enter in early August but don't begin to spawn until September continuing through to December. Pink and chum enter the watershed in August and spawn from September to October. Chinook spawn from the middle of August to the end of September after arriving in late June. Summer run steelhead arrive from July to November, and spawn in late May or early June of the following year. According to local anglers, there is also a fall run that enters in late November and a spring run that enters late February through March.

The juveniles of each species begin seaward migration in the spring and early summer. The fry of sockeye rear in the lakes of the watershed for one to two years before smoltification and migration to the sea. As well, before migration, coho rear for several years throughout the Zymoetz. The fry of both pink and chum begin their seaward migration immediately after emerging from the spawning gravel.

1.3.3 Forestry

In the early 1960's, large scale timber harvesting began within the Zymoetz River watershed. Throughout the 1960's a total of 66 cut-blocks comprising of 408 ha of forest were taken. The area harvested increased between 1970 to 1979 to a total of 2253 ha cut within 45 blocks. A further increase occurred during the 80's with 3616 ha in 68 blocks cut. Between 1990 and 1993, 1442 ha of forest was harvested from 38 blocks. By the end of 1995, approximately 8440 ha was estimated to be harvested from the watershed (Sterling Wood Group Inc., 1996). In 1996 and 1997, a total of 193 ha in the West Copper and 139 ha in the Clore sub-units were clear-cut (Brouwer et al., 1996). As well, 17.2 km of road and one bridge in the West Copper sub-unit and 15 km of road and one bridge in the Clore sub-unit were constructed (Brouwer et al., 1996).

Between the years 1998 and 2001, SCI proposes to clear-cut 608 ha in the West Copper sub-unit and 639 ha in the Clore sub-unit within 16 and 20 cut-blocks respectively (Brouwer et al., 1996). In order to reach these suggested areas SCI has planned the construction of 36.6 km of road with 2 bridges through the West Copper and just over 15.5 km of road through the Clore requiring 7 bridges (Brouwer et al., 1996).

1.3.4 Other Developments

A new highway bridge constructed over the Skeena/Copper sub-unit of the Zymoetz River in 1964 (Schwab, 1996) has resulted in the scouring and channelization over the river delta. The dikes installed at the same time as the installation of the have destroyed much of the spawning habitat above the bridge for about 0.5 km and in the delta area below the bridge.

Since the installation of a gas line by Pacific Northern Gas (PNG) in the 1980's, flooding induced pipeline reconstruction, pipeline relocation and rip-rapping of the line has caused damage to fish habitat in the mainstream of the Zymoetz River and tributaries. As well, roads and utility corridors constructed by PNG, BC Hydro, and BC Telephone Company Ltd. have caused some past erosion and the other habitat damage to the watershed.

2.0 Study Area

Figure 1 shows the location of the Zymoetz River on a BC Provincial Area Map. Also, see maps in Appendix I for the location of impact sites and sub-units Skeena Copper (A), West Copper (B & C) and Clore (C, D, & E).

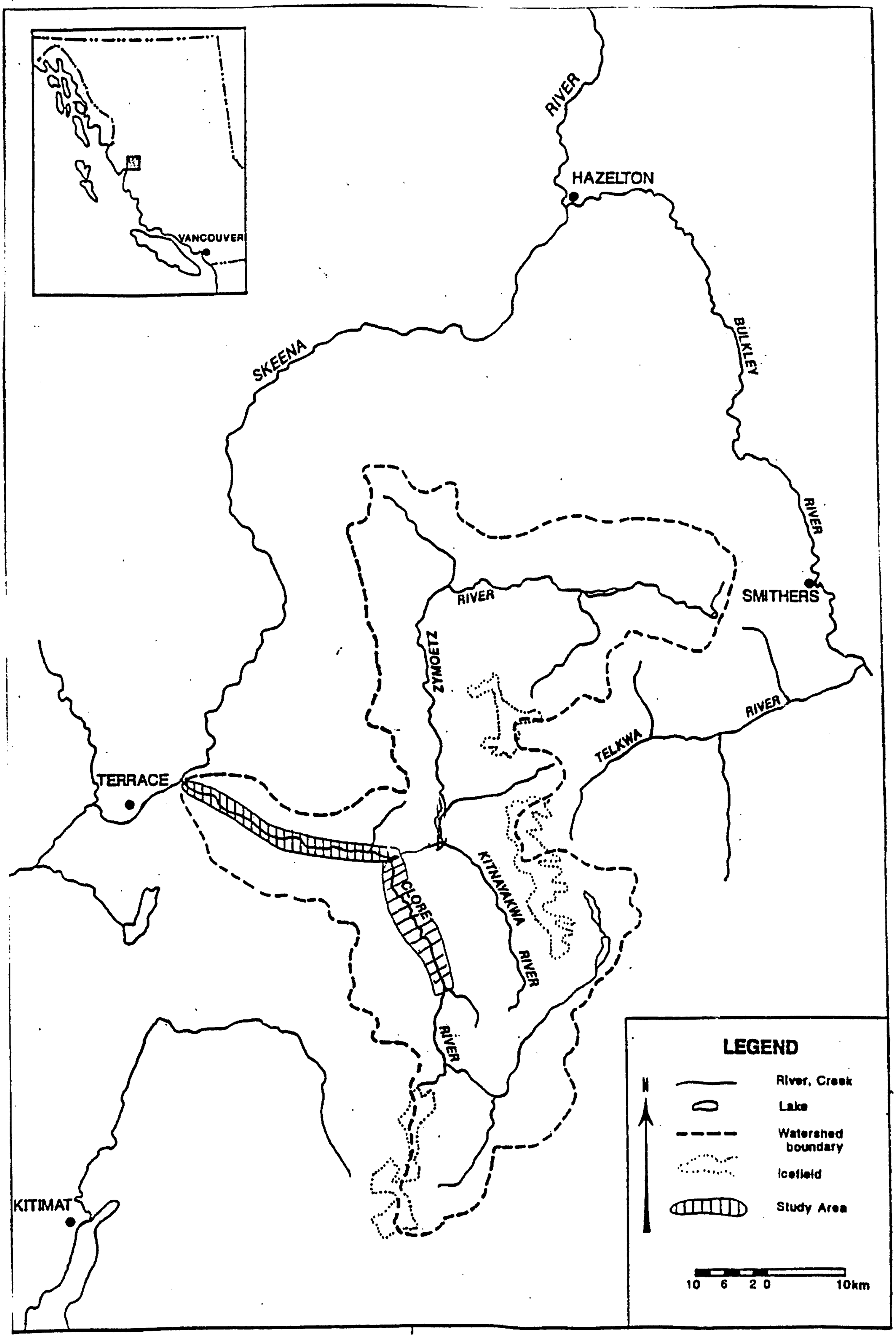


Figure 1. Study area. (Schwab, 1996)

3.0 Methodology

3.1 General

Each impact site was inspected on foot at least once between November 7, 1997 and April 3, 1998. Observations made by one or more experienced crew members were recorded at each site. Also, video and still photos were taken at most impact sites. Where necessary, qualitative and quantitative measurements of the following were recorded on our own field data form for the Zymoetz Fish and Fish Habitat Level 2 Assessment:

- pH using an OAKTON waterproof pHTestr 5-0008;
- stream length and channel width using a CHAINMAN II hip chain;
- gradients of streams and banks using a Suunto clinometer PM-51360 PC;
- fish presence, abundance and fork length by visual observation and minnow trapping using Gee traps and roe, anesthetized with Alka Seltzer tablets;
- relative habitat suitability (gravel size and quantity, availability of resting pools, cover, small and large woody debris) by visual observation.

3.2 Aerial Photographs

Low elevation aerial photographs used to determine possible habitat impacts were taken at about 1500 feet above the ground at a speed of 75 miles per hour of all the most important impact sites using Kodak Royal Gold 400 and 200 ASA film and a Pentax Super MA camera. Each picture was manually timed every three seconds. These, as well as photo mosaics created by R.J.A. Forestry, were used to create conceptual drawings of rehabilitation work. Also, using the mosaics and the 1:20,000 Forest Cover Map series, Universal Transverse Mercator (UTM) codes were found for each impact site.

3.3 Calculations

3.3.1 Relative Abundance

To determine relative abundance of fish at each site, where trapping occurred, was calculated by dividing the total number of fish trapped by the total number of trapping hours.

3.4 Stream Names

Where possible, the gazetted names of streams have been used. Those stream names designated with an asterisk (*) are local, or nongazetted names.

3.5 Source of Error

3.5.1 Fish Identification

Throughout this report, we have reported the finding of rainbow trout at a number of sites within the Zymoetz watershed. While resident rainbow do exist within the watershed, we believe that a majority of these fish trapped are actually steelhead. The same difficulty in exists with Dolly Varden char and Bull trout; they are hard to distinguish. Therefore, we have simply reported the finding of char.

4.0 Results & Discussion

4.1 Individual Site Descriptions and Prescriptions

Each individual impact site has been designated with a number by Pollard et al. (1996). Some have been eliminated as impacts sites by this Level 2 assessment or by Pollard's Level 1 assessment, due to their non-forestry related cause or if the impact was considered insignificant. As well, during the course of this assessment, several new sites, not discovered by Pollard, have been added as significant impacts. Refer to Appendices I (Study Area Maps), II (Photo Mosaics), III (Fish Distribution Data Forms 5), IV (Rock Vee/Weir Construction), V (Spawning Requirements of Salmonids), VI (Groyne Construction), VII (Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment), and VIII (Priority of Rehabilitation and Timing Windows for 1998/99 Work), and IX (Geomorphologist Recommendations by Alan Gilchrist, Ph.D.) for the raw data and information incorporated into the following sections.

4.1.1 Sub-Unit One-Skeena/Copper

Impact Site 8B (UTM 9.5352.60428)

Location:
This creek (Mocha Creek*) is found within reach 1 on the south side of the Zymoetz River at 1.75 km on the Copper FSR. Access is by road.

Description of Site & Impact:
This creek has a steep gradient at its confluence with the river. It provides some woody debris and large boulders for shade and cover. Extensive impact from logging and the construction and maintenance of Copper FSR that was the original Highway 16 (photo 1).

Data & Observations:
This creek is likely passable to adult fish during high water but no sign of adult spawners or redds have previously been seen in the creek. At the time of inspection, the top layer was covered with ice and water was flowing underneath.

Photo 1: Looking above the Copper FSR at Mocha Creek amongst a logged off area.

Prescription

Objective:
This small creek was effected by the earliest logging in the Zymoetz River valley and the construction of the original Highway 16. The plan is to improve fish access into Mocha Creek and rehabilitate the habitat to mimic the original stream as much as possible.

Method & Materials:
The outlet into the river needs to be stepped by constructing a series of small pools using larger rocks that are anchored into the substrate along the side of the channel. Within the channel upstream rock vees should be constructed from the native rocks and be spaced about a meter apart. Only time will tell if these steps will withstand flood flows from the Zymoetz River.

For the habitat in the creek proper, the plan is to establish a series of pools and riffles with woody debris for shelter and protection. The pools, where none currently exist, would be formed by log dams using hemlock dug into the substrate or constructing upstream rock vees or rock dams. Small pads of spawning gravel of graded substrate could be installed upstream of the dams. No plans are in place to do anything with the habitat above the road other than to clean any debris (cans, bottles, etc.) from the pond area. Signs should be made stating the creek is fish habitat and posted around the pond. The contractor carrying out this work should take note of any additional rehabilitation that is required and make a recommendation to the project manager for additional restoration of the Mocha Creek habitat.

Expected Benefits:
Cutthroat, char and juvenile coho are likely the fish to benefit from the rehabilitation of this habitat. The benefits will be small in comparison to benefits from larger projects; however, it is part of the bigger picture. The many tiny creeks that have had their habitat altered will, collectively, following rehabilitation make an important contribution of new productive or restored habitat.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	3	320	960
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	5	220	1100
Jr. Field Tech.	persons	10	180	1800
Secretarial	1 person	0.5	180	90
Equipment: chain saw hand tools power winch	 days days days	 5 5 5	 25 10 50	 125 50 250
Transportation: 4x4 crew cab	 lump sum			 384
Materials: cable, steel pins	 at cost			 50
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 6	 25	 125 100 125 200
			Total cost	5959
			Overhead and Administration (3%)	179
			GST	30
			Total Contract Value	6168

Impact Site 9 (UTM 9.5358.60426)

Location:
This side channel is located within reach 1 on the south bank of the Zymoetz River between 2 km and 3 km on the Copper FSR. Access via the Copper FSR and by a PNG/BC Hydro service road located at 3 km.

Description of Site & Impact:
This side channel runs east to west for approximately 755 m with an average gradient of approximately 2% (photo 2 and 3). On the south side of the channel is a cleared gas pipeline corridor and BC Hydro tower where trees have been cleared, but some deciduous shrubbery remains. Located on the north side of the channel are an elevated gravel bar, an area of mixed coniferous and deciduous vegetation and another BC Hydro tower. Currently, there are two ground water supplies and seasonal sub-surface and surface water to the area due to a series of floods blocking off continuous surface water flow to the channel. As a result, there is poor access for adult salmon, however, some isolated pools exist created by low level beaver dams blocking off the ground water flow in the channel (photo 4). This site could provide an excellent spawning area for all species particularly chum and coho salmon and rearing for coho, steelhead, char, whitefish and cutthroat trout.

Data & Observations:
On November 14, 1997, one minnow trap set in an isolated pool yielded 2 juvenile coho with fork lengths of 60 mm and 65 mm. Two days previous, two coho redds were observed in a ground water pond at the west end of the channel (photo 5). On December 2, 1997, a pH reading of 8.6 was taken. The relative abundance of fish at this site is 0.02. Four test holes were dug on March 31, 1998, by a rubber tired back hoe (photo 6 and 7). At the first hole, 100 m from the Zymoetz River, water was reached at 1.5 m and flowed faster than the back hoe could bucket it out. Water was reached at slightly less than 2 m for the second hole, 200 m from the Zymoetz. Water from the third hole, 300 m from the river, was found at a depth of 2.2 m. Water was found at just over 1 m in the fourth hole, 400 m from the river; there was excellent flows at hole one and four. At the time of digging, the Zymoetz River was within a few centimeters of the lowest seasonal flow seen in 20 years.

Photo 2: Looking upstream in the dry channel.

Photo 3: Looking downstream mid-channel below the ground water creek inlet.

Photo 4: Mid-channel pool at old bridge.

Photo 5: Coho redd in lower channel.

Photo 6: Digging test hole one in the upper channel.

Photo 7: Sub-surface water reached at 1.5 m in test hole one.

Prescription

Objective:
This site, prior to the 1978 flood, had a constant flow of river water through it and was a spawning area for pink, chum and likely summer coho and winter steelhead. As well, it was a productive rearing habitat. The objective is to re-establish the spawning capability which is now very marginal because of low flows and deposition of sand and sediment. The intent is to develop a sub-surface water supply into the channel. If that is unsuccessful then a controlled flow of river water should be developed as the alternative source.

Method & Materials:
Sub-surface water was flowing through the top section of the channel during the field trip on November 10, 1997. On subsequent trips, coinciding with the drop in the water level in the Zymoetz River, the sub-surface water flow slowly dried up then stopped. With this natural flow of ground water there is confidence that an excavation lower than the minimum water level of the river will provide a constant flow of sub-surface water into the channel. This was substantiated with the four test holes dug on March 31, 1998. The intent is to proceed into full excavation at about the 200 m location on the upper channel upstream to about the 75 m point to a depth of about 2 m. Assuming that a substantial flow of water will be encountered, continue downstream at the same depth. A temporary berm will need to be constructed to hold back the water flow while the excavation is proceeding to the 400 m point on the channel. The 490E John Deere excavator is ideal for such a project because of its maneuverability through tight spots within the channel.

The proposed channel design is for the bottom of the channel to be about 6 m wide for the top 200 m and vary with the bankfull shape to the end of the excavation. The banks should be sloped back at a gradient ratio of 1.5 horizontal to 1 vertical or about 70% (Slaney and Zaldokas, 1997) (Figure 2). The gravel substrate is likely to be level or with a slight gradient. The goal is to create a substrate of spawning size gravel (2 to 64 mm) for most of the channel. It is too much to expect that the ideal size gravel will be available for the channel length, as a result, it will be necessary to grade by hand or using a large grader and a front-end loader or excavator to drop the gravel onto the grader bars. Only the large rocks over 64 mm will be removed. Smaller pebbles and course sand should be retained as filters to keep out fine sand and sediments and reduce the size of cavities to prevent the build up of organic material which creates a high demand for oxygen (Slaney and Zaldokas, 1997). The sides of the excavated channel need to be lined with rip-rap or boulders (20 to 50 cm) to prevent erosion by spawning fish.

Protection of the channel is necessary from Zymoetz River floods of the intermediate or medium large size. Because large floods (50 to 100 year events) require room within the flood plane, the dike or berm at the head of the channel should be low enough that the major flood waters can flow over top but the smaller, more common, floods (5 to 25 year event) will be stopped from entering the channel. This barrier would be a log cribbing berm with one layer laid into and excavated trench with cross bracing to a second layer of cribbing. Both ends of the cribbing are to be tied into the south-east bank and gravel bar on the opposite north-west side of the channel. The space between the cribbing walls would have excess gravel from the channel placed inside as ballast. The size of the cribbing dike would be about 3 m wide and 2 m high above the original bed of the dry channel with a length of about 9 m. A gravel dike or berm will extend past the cribbing along the gravel bar to the log jam a distance of 125 m and be protected with salvaged course rock and shot rock from along the Copper FSR and an old quarry. Some shot rock needs to be placed along the bank of the river upstream of the log cribbing and flush with the cribbing.

Some complexing for cover in the spawning section of the channel should be placed in strategic locations so that adult salmon have some sheltered holding areas. LWD would be placed in a cluster formation in two or three locations which will be attractive to juveniles as shelter areas. A pool of about 1 to 2 m should be excavated and covered in strategic locations with LWD. The size of LWD should vary between 20 and 50 cm in diameter and be long enough to cover the width of the channel. Additional complexing in the way of LWD, root wads and boulders should be placed in strategic locations throughout the mid-section of the channel to improve its habitat diversity and provide additional shade and shelter for juveniles.

The tail-out of the pool area is the current primary spawning area in the site. The gravel substrate needs to be graded, cleaned and enlarged using the existing substrate. Most of the grading can be carried out by using hand rakes with long teeth. Depending upon the water flow created by the introduction of ground water, there is a need to provide an improved access route through the rocky area between the river and the channel. The fine and course sand deposited between the 400 and 650 m points has reduced the size and diversity of the rearing habitat in the lower section of channel. As much of the sand and sediment should be removed by the excavator and moved, by a front end loader, to the top of the large gravel bar and spread out across the bar as a sandy section.

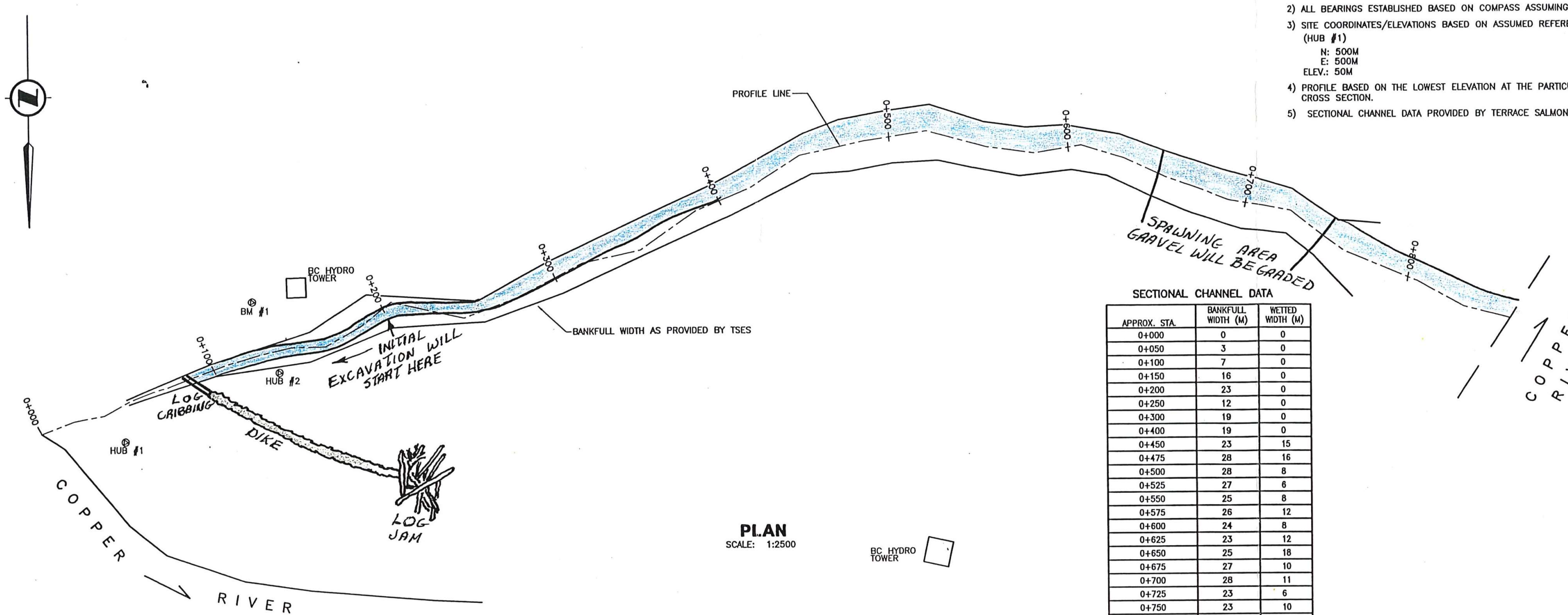
Expected Benefits:
The focus of rehabilitating and enhancing the habitat of this site is to help rebuild chum and summer coho stocks which, as discussed previously, are in serious decline in the Zymoetz watershed. If the introduction of sub-surface water is successful, chum and coho will increase in numbers relative to the productivity of the channel. Both of these species prefer ground water channels and typically respond more positively to them (Slaney and Zaldokas, 1997); however, it will take time for coho and chum to colonize the channel and they may need a boost for one cycle through artificial propagation using the Deep Creek Hatchery or another incubation facility, for example, an incubation box at the site.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	6	320	1920
Sr. Biologist	1 person	2	440	880
Jr. Biologist	1 person	4	200	800
Sr. Field Tech.	1 person	13	220	2860
Jr. Field Tech.	persons	24	180	4320
Bookkeeper	1 person	1	180	180
Equipment:				
Moxy truck	hours	16	125	2000
490E John Deere excavator	hours	48	101	4848
966 Caterpillar	hours	32	95	3040
loader	days	3	50	150
gravel grader	days	12	10	120
hand tools	days	6	25	150
chain saw	days	2	50	100
power winch	days	5	50	250
generator	hours	2	95	190
low bed	days	5	15	75
Transportation: 4x4 crew cab	lump sum			938
Materials: cables, steel pins, filter cloth	at cost			200
Travel Expenses (Sr. Biologist/ Fisheries Engineer)	at cost			3000
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	14	25	350
misc.	lump sum			500
			Total cost	27096
			GST	765
			Overhead and Administration (3%)	813
			Total Contract Value	28674

GENERAL NOTES

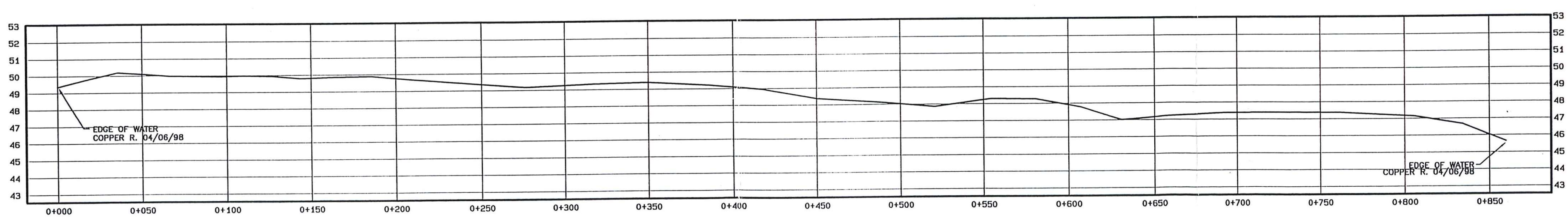
1) SITE SURVEY PERFORMED NOV. 1997 BY McELHANNEY CONSULTING SERVICES LTD. UPDATED MARCH 24, 1998 – PROFILE EXTENSION
2) ALL BEARINGS ESTABLISHED BASED ON COMPASS ASSUMING 0° DEC.
3) SITE COORDINATES/ELEVATIONS BASED ON ASSUMED REFERENCE POINT (HUB #1)
   N: 500M
   E: 500M
   ELEV.: 50M
4) PROFILE BASED ON THE LOWEST ELEVATION AT THE PARTICULAR CHANNEL CROSS SECTION.
5) SECTIONAL CHANNEL DATA PROVIDED BY TERRACE SALMONID ENHANCEMENT SOCIETY



PLAN
SCALE: 1:2500

SECTIONAL CHANNEL DATA

APPROX. STA.	BANKFULL WIDTH (M)	WETTED WIDTH (M)
0+000	0	0
0+050	3	0
0+100	7	0
0+150	16	0
0+200	23	0
0+250	12	0
0+300	19	0
0+400	19	0
0+450	23	15
0+475	28	16
0+500	28	8
0+525	27	6
0+550	25	8
0+575	26	12
0+600	24	8
0+625	23	12
0+650	25	18
0+675	27	10
0+700	28	11
0+725	23	6
0+750	23	10
0+775	42	14



PROFILE
SCALE: 1:2500 HOR.
1:250 VER.

NO.	DATE	REVISION LIST	BY

McElhanney

McELHANNEY CONSULTING SERVICES LTD.
Suite #1–5008 Pohle Avenue, Terrace, B.C., Canada, V8G–4S8
Tel: (250)–635–7163, Fax: (250)–635–9586

TERRACE SALMONID ENHANCEMENT SOCIETY
ZYMOETZ (COPPER) RIVER
3KM SIDE CHANNEL
SITE 9 - PLAN / PROFILE

SURVEYED: [signature]
DESIGN: [signature]
DRAWN: [signature]
CHECKED: [signature]
SCALE: AS NOTED

DATE: APRIL 1998
FILE: 2321-00391-0
TASK: 2001
DRAWING No. 3KM
REV. 1

Figure 2: Center line survey and work proposed at impact site 9.

Impact Site 12 (UTM 9.5364.60426)

Location:
This side channel is found in reach 1 on the north side of the Zymoetz River at 1 km on the North Copper FSR. Access via short walk from the road along a trail starting at 0.75 km on the Copper FSR.

Description of Site & Impact:
This channel spans about 150 m, meeting both sites 14A and 14B (to be discussed later) on the east end. It is adjacent to the Zymoetz River and during high water becomes part of the river system. However, in low flows, the site becomes almost completely dry risking over winter freezing. There is some ideal spawning gravel at this site.

Data & Observations:
At the times of observation, this channel contained only a few isolated pools of water about one half meter or less in depth. Because of this, no minnow trapping was carried out. One possible chum redd was seen on November 12, 1997, located in a small puddle of water, already beginning to freeze. On December 10, 1997, six new coho redds and one new chinook redd from fall 1997 spawning were observed. These could not be seen previous to December 10 due to higher water flows.

Similarly to most of the river and its fish habitat, this site has changed in a substantial way since 1974 as a result of five major floods (Schwab, 1996). It is part of the main river and remains a spawning area for a small number of pink, chum, coho, chinook salmon and steelhead. As well, it provides a rearing habitat for salmonids. Little can be done to make it a more productive fishery habitat because any changes would likely be altered by flood flows. It is recommended that habitat restoration work should be directed toward another site with more potential.

Impact Site 14B (UTM 9.5366.60427)

Location:
This side channel is found on the north side of the Zymoetz River in reach 1 between 1 km and 1.5 km on the North Copper FSR. Access via short walk off the road along a trail starting at 0.75 km on the North Copper FSR through site 12 about 100 m to the east.

Description of Site & Impacts:
This side channel's length is 810 m with an average gradient of about 2%. The channel is mainly fed by, what appears to be, a perennial flow of ground water resulting in four isolated pools when the water table recedes below the elevation of the channel bed (photo 8 and 9). The water flow changes to sub-surface after leaving the fourth pool. There is sufficient water flow during the late summer and fall months for coho and pink or chum salmon to enter the channel. The channel is surrounded by mainly deciduous

vegetation on high banks. Its bed is composed of gravel, cobble and boulders, deep pools and LWD. The gravel appears to be suitable for spawning.

Data & Observations:
On November 12, 1997, three baited minnow traps placed in deep isolated pools captured 96 coho (co), 2 rainbow trout (rbt) and 7 sculpin. The relative abundance calculated for this site is 2.18. An average pH reading of 8.5 was recorded. As well, 4 coho redds, 2 apparently false coho redds, 2 possible pink redds and 1 adult coho carcass were found at this site. The chart below displays the fork length frequencies for the juvenile salmonids trapped in the channel. On March 28, 1998 flowing water at the top pool was observed; this could be either ground water or sub-surface water. As well, fish were seen throughout the channel.

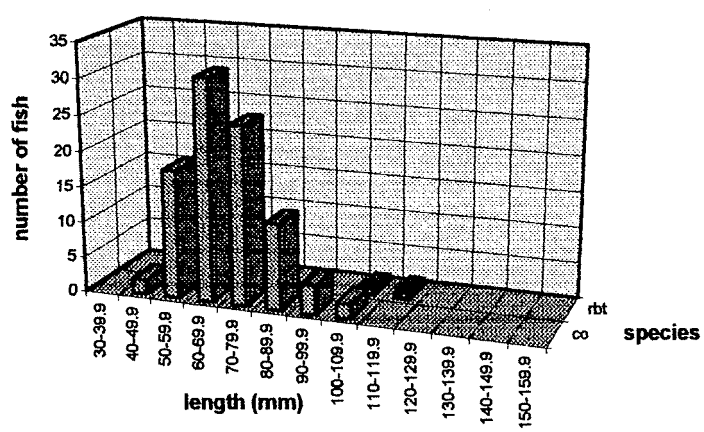


Figure 3: Fork length frequencies for fish trapped at site 14B.

Photo 8: Pool just past mid-channel with sub-surface water flow.

Photo 9: Pool mid-channel, coho spawned at the tail-out.

Prescription

Objective:
The proposal is to increase the sub-surface water supply into this side channel and improve the amount of useable gravel for spawning. On March 31, 1998, during the lowest water level of the Zymoetz River, there was still a flow of sub-surface or ground water at the top of the channel. After careful analysis, it would appear feasible that more sub-surface water should be available.

Method & Materials:
The first work that has to be undertaken is to find the most environmentally acceptable route to the site. Once a route is agreed upon, it should be brushed out and where necessary an excavator may have to do so.ne leveling and shaping so that a Moxy style truck can gain access to the site (Figure 4). Upon completion of the work, the road needs to be blocked off or trenched so that vehicles cannot use it for access to the river.

A monitoring of the channel should take place during the high to low flow period on the Zymoetz River which would be May to November. The increased water level in the river could influence the flow of sub-surface water. Pink and chum salmon spawn in part of the lower channel during later August and September and coho spawn in the channel during October and November limiting the period when work can be carried out in the channel.

Due to the complexity of developing increased sub-surface water into this channel there is the need for an experienced Fisheries Engineer such as Rheal Finnegan to determine if the water supply can be increased to the channel. Should a collective decision be made by Rheal Finnegan, Dave Marshall, Senior Biologist for TSES, and the TSES Project Manager for enhancement of the channel habitat, a design for the channel development should go ahead.

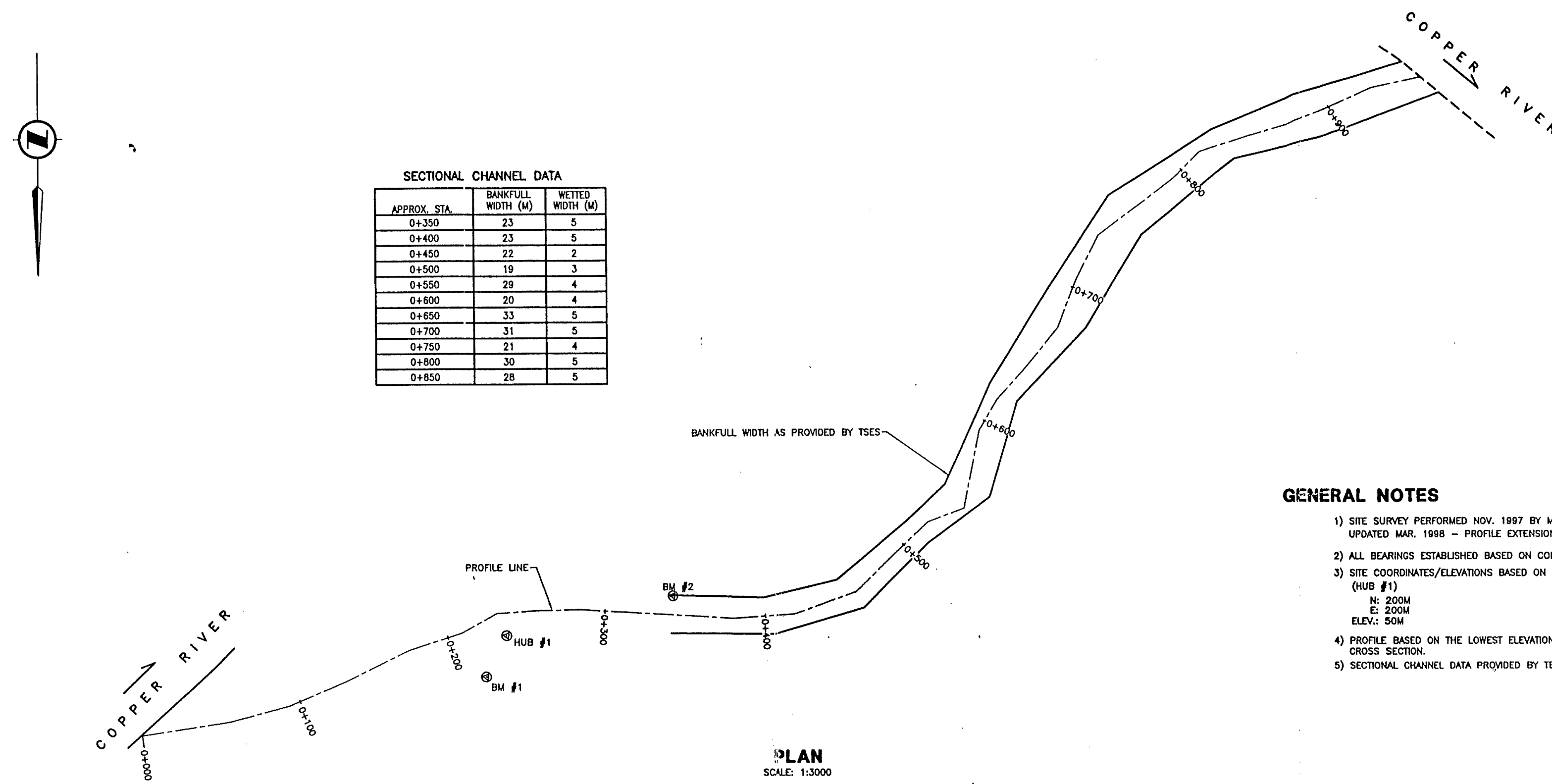
Expected Benefits:
If a sub-surface water channel is successfully developed, there are a number of potential benefits. Summer coho and chum salmon, both on the edge of survival, will benefit. For chums, in combination with other habitat rehabilitation, this project could be the key to their survival in the Zymoetz River system. If a controlled surface water supply is developed, pink, also at risk, and chinook will likely be two other species to take advantage of a stable habitat.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	4	320	1280
Sr. Biologist	1 person	2	440	880
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	7	220	1540
Jr. Field Tech.	persons	10	180	1800
Bookkeeper	1 person	0.5	180	90
Equipment: 490E John Deere excavator hand tools chain saws low bed	 hours days days hours	 8 5 2x5=10 2	 101 10 25 95	 808 50 250 190
Transportation: 4x4 crew cab	 lump sum			 455
Travel Expenses	at cost			1000
Sundry: report production communication (radio tel) misc.	 at cost days lump sum	 7 	 25 	 100 175 200
			Total cost	9418
			GST	91
			Overhead and Administration (3%)	283
			Total Contract Value	9782

SECTIONAL CHANNEL DATA

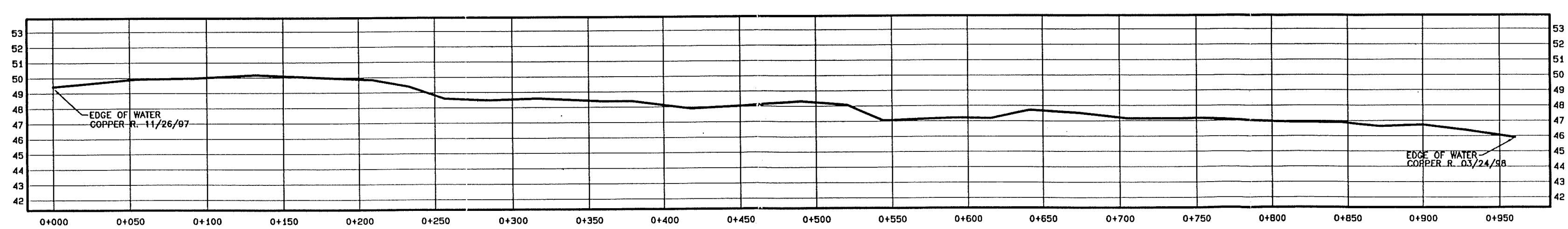
APPROX. STA.	BANKFULL WIDTH (M)	WETTED WIDTH (M)
0+350	23	5
0+400	23	5
0+450	22	2
0+500	19	3
0+550	29	4
0+600	20	4
0+650	33	5
0+700	31	5
0+750	21	4
0+800	30	5
0+850	28	5



PLAN
SCALE: 1:3000

GENERAL NOTES

1) SITE SURVEY PERFORMED NOV. 1997 BY McELHANNEY CONSULTING SERVICES LTD. UPDATED MAR. 1998 – PROFILE EXTENSION
2) ALL BEARINGS ESTABLISHED BASED ON COMPASS ASSUMING 0° DEC.
3) SITE COORDINATES/ELEVATIONS BASED ON ASSUMED REFERENCE POINT (HUB #1)
   N: 200M
   E: 200M
   ELEV.: 50M
4) PROFILE BASED ON THE LOWEST ELEVATION AT THE PARTICULAR CHANNEL CROSS SECTION.
5) SECTIONAL CHANNEL DATA PROVIDED BY TERRACE SALMONID ENHANCEMENT SOCIETY.



PROFILE
SCALE: 1:3000 HOR.
1:300 VER.

NO.	DATE	REVISION LIST	BY

McElhanney

McELHANNEY CONSULTING SERVICES LTD.
Suite #1-5008 Pohle Avenue, Terrace, B.C., Canada, V8G-4S8
Tel: (250)-635-7163, Fax: (250)-635-9586

TERRACE SALMONID ENHANCEMENT SOCIETY
ZYMOETZ (COPPER) RIVER
NORTH COPPER SIDE CHANNEL
SITE 14B - PLAN / PROFILE

SURVEYED:	
DESIGN:	
DRAWN:	
CHECKED:	
SCALE:	AS NOTED
DATE:	APRIL 1998
FILE:	2321-00391-0
TASK:	2001
DRAWING No.	NCOP
REV.	1

Figure 4: Center line survey and work proposed at impact site 14B.

Impact Site 14A (UTM 9.5366.60427)

Location:
This side channel is located in reach 1 on the north side of the Zymoetz River between 1 km and 1.5 km on the North Copper FSR. Access is via short walk along trail starting at 0.75 km on the North Copper FSR through site 12 about 100 m to the east.

Description of Site & Impact:
This side channel is located at the east end of site 12 running parallel to site 14A for its length of 370 m. At its west end is a creek from which water flows to the immediate east and west at an average gradient of 3%. The water running to the east disappears into the ground leaving most of the channel length dry with an average gradient of 2% and an average width of 8 m. The stream banks are composed of 100% fines with abundant deciduous cover and LWD providing excellent cover.

The main issue at this site is a large debris jam consisting of second growth alders and other SWD. Pollard et al. (1996) reports that this jam was caused by decreased bank stability due to logging that took place 40 years previous; however, we believe this jam was created by the 1978 flood with the two floods in 1991 and 1992 having added woody debris. The small debris trapped within the jam is acting as a net accumulating further debris and impeding what water flow does exist.

Data & Observations:
The presence of springboard notches in the stumps at this site makes the occurrence of very old past logging indisputable. No other data could be collected due to the lack of water flow. On March 28, 1998, the substrate was found to consist mostly of fines and sediment. Therefore, further assessment of suitable spawning substrate is necessary before any further recommendations can be made.

Prescription

Objective:
If sub-surface water flow is increased through channel 14B it could be tapped to flow through channel 14A which branches off to the west about half way along channel 14B. The primary objective in this low gradient channel is to improve the quality of the spawning substrate and rearing habitat in the channel which is currently made up of fine sediments. The plan would be to develop a control flow mechanism in the dike structure across the entrance of the channel and to remove fines and replace them with spawning size gravel.

Method & Materials:
If a water supply is accessed into impact site 14B in sufficient quantities for a controlled flow to be provided for this side channel, it is proposed that a log cribbing berm be constructed at the entrance of the channel. The berm would have 120 cm opening in the

middle of it, with stop logs that fit into slotted sides to control the water flow. The cribbing should be constructed with cedar logs that can be salvaged from the log jams across from site 14B. The width of the log cribbing will be 2 m and the height even with the top of the banks. To complete the cribbing it needs to be filled between the two walls with channel gravel substrate that has been excavated and stock piled during the development of impact site 14B (Figure 4).

Upon completion of the dike and the ability to shut off the water supply into it, a small track type excavator should remove as much of the fines in the channel as possible and where necessary and appropriate replace the fines with spawning size gravel. The stock piled gravel should be used after the large cobble has been separated from the sand and spawning size gravel. The grading can be carried out using manual labour and a grader if jobs are going to be created (Culp, 1997). If speed and volume are the goal then a loader and a large grader are the way to go. It is anticipated that, if feasible, the lower channel is where most of the gravel pads would be constructed. It may be necessary to construct a log or rock dam that can be shaped into a slight upstream vee that will hold back the gravel while funneling the flow to the center which will scour a pool downstream. The sediment excavated from the channel will have to be trucked from the channel to a flat area where it can be blended with the surroundings. The most logical location is in the large gravel area south of the two channels.

Monitoring of site 14B (if more water is accessed) is necessary to determine if it is feasible to proceed with development in this channel. It may be necessary to construct the dike and the control flow structure between the two channels to assure that the water flow is not lost in the lower half of site 14B.

Expected Benefits:
The benefits are the same as for impact site 14B.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	6	320	1920
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	17	220	3740
Jr. Field Tech.	persons	30	180	5400
Bookkeeper	1 person	1	180	180
Equipment: 490E John Deere excavator gravel grader hand tools chain saw power winch	 hours days days days days	 24 10 15 15 5	 101 25 10 25 50	 2424 250 150 375 250
Transportation: 4x4 crew cab	lump sum			1235
Materials: cables, steel pins	at cost			100
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 17	 25	 125 100 425 200
			Total cost	17474
			GST	248
			Overhead and Administration (3%)	524
			Total Contract Value	18246

Cost Breakdown for Evaluating and Monitoring:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	3	320	960
Jr. Biologist	1 person	1	200	200
Sr. Field Tech.	persons	2	220	440
Bookkeeper	1 person	0.5	180	90
Transportation: 4x4 crew cab	lump sum			133
Sundry: film & video report production misc.	 at cost at cost lump sum			 55 50 100
			Total cost	2028
			Overhead and Administration (10%)	203
			Total Contract Value	2231

Impact Site 24C (UTM 9.5380.60425)

Location:
This stream (Something Creek*) is found within reach 1 on the north side of the Zymoetz River at 3 km on the North Copper FSR. Access via North Copper FSR.

Description of Site & Impact:
This stream crosses the North Copper FSR with a gradient of approximately 24% above (reach 2) and 6% below (reach 1) the bridge (photo 10 and 11). A few meters above the position of the existing bridge lies the remnants of the old bridge. The mouth of this creek meets with site 24B side channel (photo 12). Prior to the new bridge being constructed, vehicles drove through the creek. The area adjacent to the creek was logged.

Data & Observations:
On November 12, 1997, minnow trapping below the bridge revealed the presence of 1 coho with a fork length of 45 mm. One 1997 coho redd is present in the lower part of the creek 20 m upstream of the Zymoetz confluence. As well, 1 coho and 1 chum redd from 1997 is present on the gravel bar 30 m below the creek mouth. The relative abundance of fish at this site is 0.02.

Photo 10: Looking upstream to the bridge.

Photo 11: Something Creek between the bridge and the fan.

Photo 12: The fan of Something Creek running through site 24B side channel.

Prescription

Objective:
The goal is to create more spawning and rearing habitat for pink, coho, and steelhead in the section of creek from the waterfall just upstream of the forestry access road to the confluence with the Zymoetz River. There is a need to slow the flow of creek water by stepping it through the construction of log dams and upstream rock vees to create a series of pools and riffles. LWD needs to be placed in strategic locations to provide shade and shelter for both adult and juvenile salmonids.

Method & Materials:
About 2 m above the access bridge, at the steepest section of the creek that is accessible to anadromous fish, an upstream rock vee will be constructed to slow the water flow and create a pool (Figure 5). A shallow pool will be made by a second upstream vee, about four channel widths downstream, followed by a short pool along the south bank that would be formed by a third rock upstream vee approximately 2 m downstream. A fourth rock upstream vee at the tail-out of the pool where the creek curves to the west. Two more vees, four channel widths apart, are required between the corner and the river. Large woody debris placed in the second pool along the west bank and third pool along the south bank will provide shelter and shade for holding adults.

The upstream rock vees will be constructed with shot rock or rough, sharp edged in stream rocks that lock together. Round, smooth rocks are unsuitable as they will roll causing the structure to break apart. The construction of this vee requires an excavator to dig a trench or a hole for each rock so that about half of the rock is buried. The size of rocks that will make up the main structure (the anchor rocks) should be large enough to prevent scouring and displacement during a flood. Rocks 0.8 to 1 m in diameter will provide the weight and size necessary to hold the main structure. Smaller rocks 0.2 to 0.5 m in diameter will be placed in the spaces between the anchor rocks. Smaller spawning size gravel 2 to 64 mm will be placed upstream of the vee to a depth that allows 15 to 20 cm from the water surface to the top of the substrate.

The gravel substrate should extend upstream about 2 m from the bottom of the vee with the first meter being placed in a relatively flat position. The second and fourth vee may require the north bank wings to be slightly shorter than the south bank wings so that the water flow is directed more to the north bank because the vees are on a bend. For the last two vees located within the fan, the anchor rocks could be a smaller diameter because of the reduced gradient. Three or four vees may be required in the fan.

The stream channel located in the fan downstream of the fourth vee requires some larger rocks (30 to 50 cm) to be placed in a trench along the channel edge with rocks placed on top and tapered back to provide some armoring to limit erosion from spawning fish and scouring from high Zymoetz River water flows.

The size of the LWD could be variable in diameter (20 to 50 cm). Their length would extend along the south bank of pool number two, from the bridge along the tree bank for about 3 to 4 m. The butt end of each log needs to be anchored by a dead-man below the bridge. A cluster would be formed (3 to 5 logs) that could be cabled, if necessary, to the live trees along the bank. For the third pool, the same number, size and configuration for the logs would prevail (Figure 5).

Expected Benefits:
One summer coho redd found in the fan of the creek provides some hope that once a more favorable spawning and rearing habitat is created, with the slowing of water flow and the addition of shelter and holding water will result in a gradual increase in fish production. This will contribute to an overall increase in these under-populated species within the lower Zymoetz and its tributaries below the first canyon.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	5	320	1600
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	10	220	2200
Jr. Field Tech.	persons	16	180	2880
Bookkeeper	1 person	0.25	180	45
Equipment: mini excavator chain saw power winch hand tools	 hours days days days	 32 8 4 8	 62 25 50 10	 1984 200 200 80
Transportation: 4x4 crew cab	 lump sum			 780
Materials: cables, steel pins filter cloth, sand bags etc.	 at cost			 200
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 10	 25	 125 100 250 300
			Total cost	11544
			GST	172
			Overhead and Administration (3%)	346
			Total Contract Value	12062

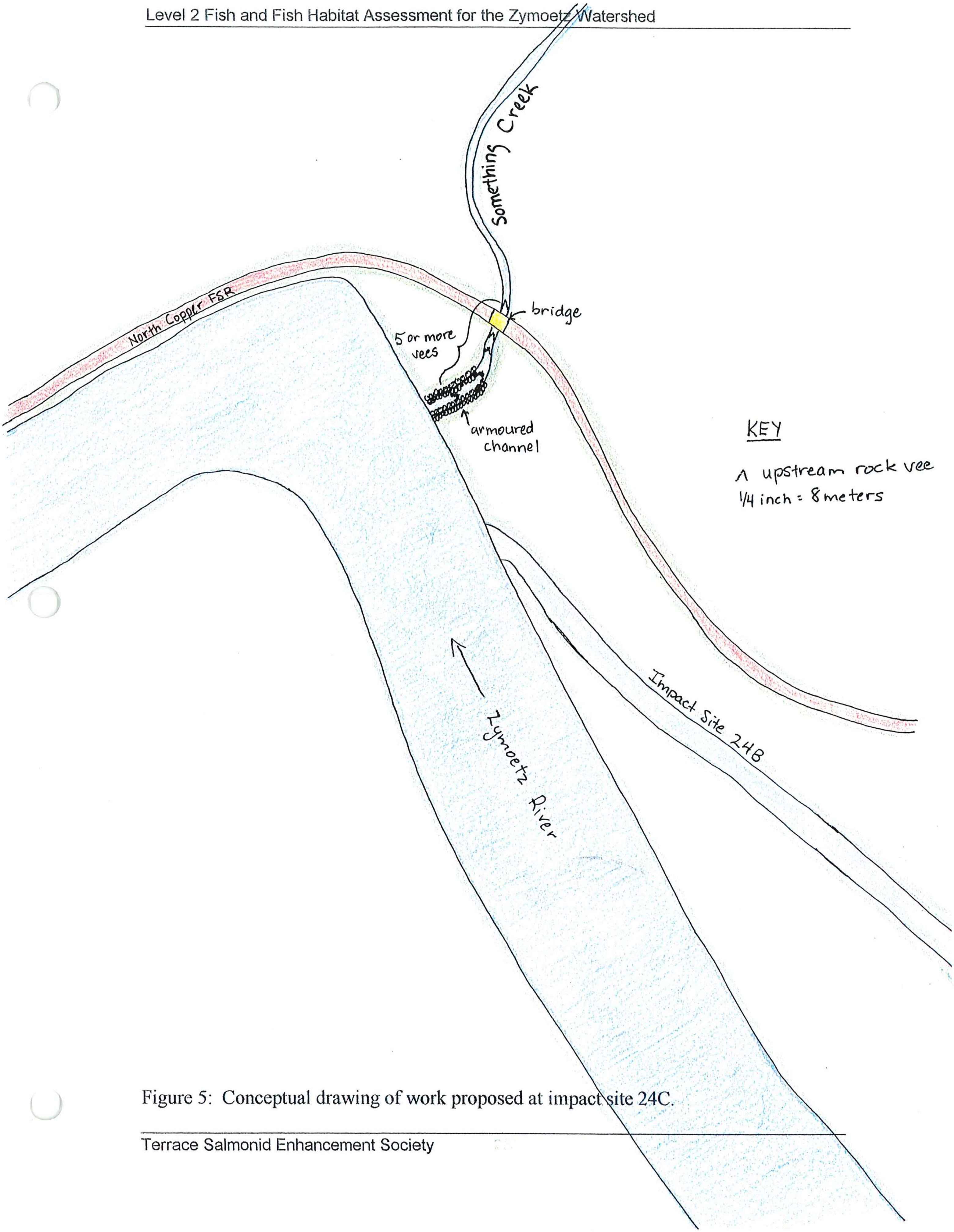


Figure 5: Conceptual drawing of work proposed at impact site 24C.

Impact Site 24B (UTM 9.5380.60425)

Location:
This side channel is found within reach 1 on the north side of Copper River at 3 km on the North Copper FSR. Access via North Copper FSR (bottom of site 24C)

Description of Site & Impact:
This side channel is 278 m in length with an average gradient of 2% (photo 13 and 14). The water flow to this channel is limited to a small, spring fed stream. The water is forced to distribute itself over a wide area leaving nearly no flow during low water. At the east end of this site the bank elevation of the channel is considerably higher than the flow of the river. This makes flooding of the channel likely only during very high water.

Data & Observations:
There was 1 coho redd found in this site close to the top of the channel. Two minnow traps revealed no fish on November 12, 1997.

Photo 13: Top side of the channel.

Photo 14: Mid-channel.

Prescription

Objective:
The intent of work is to provide a partially controlled flow of surface water into the channel. Surface water now flows into the channel supplementing a small flow of ground water, however, the problem is that the surface flow is subject to the rise and fall of the Zymoetz River flow. With a constant flow of surface water there is a strong possibility that a larger number of chinook, pink, steelhead and coho will use the channel for spawning.

Method & Materials:
The channel is a natural spawning area with good quality substrate suited for all species of salmonids that spawn in the lower Zymoetz. There is a need for some shaping and scalping of the riffle areas and the grading out of some oversize rocks not suitable for spawning. In concert with the riffle upgrading, some complexing or damming with large boulders (20 to 50 cm), at approximately five locations, must be carried out to enhance the pool riffle ratio in the channel (Figure 6). The intent is to take advantage of the natural breaks in the channel to create the riffles and pools utilizing the four channel widths more or less between the clusters. The boulder clusters are intended to be located behind the spawning pads and shaped in an upstream vee configuration which will result in some natural pool scouring below them.

Complexing with LWD to provide shelter and protection for juveniles is necessary in the pool areas. Aside from the placement of boulders in key scattered locations, LWD (20 to 50 cm) should be assembled in clusters at each pool location. To anchor key logs, trenches should be excavated in the gravel bars to bury root wads and logs. The intent is that no extensive cabling of logs should take place. After key logs are dug into the gravel, loose or floating logs can be cabled to the key logs in a way that the cable is hidden as much as possible and used only where necessary.

For the surface water intake the prescription is not proposing an intake that has a valve or any type of adjustable mechanism. A design using a shot rock dike about 3 m wide, 30 m long and 2 m high allowing percolation of water through the rocks, in turn, providing a percentage of flow into the channel. The bulk of flow would be through a culvert or set of culverts that would provide a uniform flow varying, to some extent, with the head of the river. The diameter of the culvert(s), flow rate through the channel, and engineering prerequisites are determinations that can best be made by the DFO Habitat and Enhancement Branch who should be retained in a consultative role.

There is a narrow section of the forestry access road about 0.25 km west of site 24C bridge that provides access to this site and impact site 24C that could provide shot rock for the two sites while at the same time widening the access road. PNG, MOF and SCI would have to make a decision on the feasibility of this being possible.

Expected Benefits:
Pink, coho and chinook salmon are known to have spawned in this channel over the past 40 years. The fluctuating flow of water through it has been the limiting factor. Once a more stable flow of water and improved habitat are in place, the numbers of each species will grow over time. This will help to mitigate for the loss of stable spawning habitat in this general location of the Zymoetz River as the result of fluctuating water flows that have been influenced by forest industry development in the watershed.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	5	320	1600
Jr. Biologist	1 person	4	200	800
Sr. Field Tech.	1 person	12	220	2640
Jr. Field Tech.	persons	20	180	3600
Bookkeeper	1 person	0.5	180	90
Equipment: Moxy dump truck 490E John Deere excavator low bed hand tools chain saw power winch	 hours hours hours days days days	 4 40 2 10 10 5	 125 101 95 10 25 50	 500 4040 190 100 250 250
Transportation: 4x4 crew cab	 lump sum			 780
Travel Cost (DFO Fisheries Biologist and Engineer	at cost	4		3000
Materials: cables, steel pins 2 culverts	 at cost at cost			 200
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 12	 25	 125 100 300 500
			Total cost	19065
			GST	373
			Overhead and Administration (3%)	572
			Total Contract Value	20010

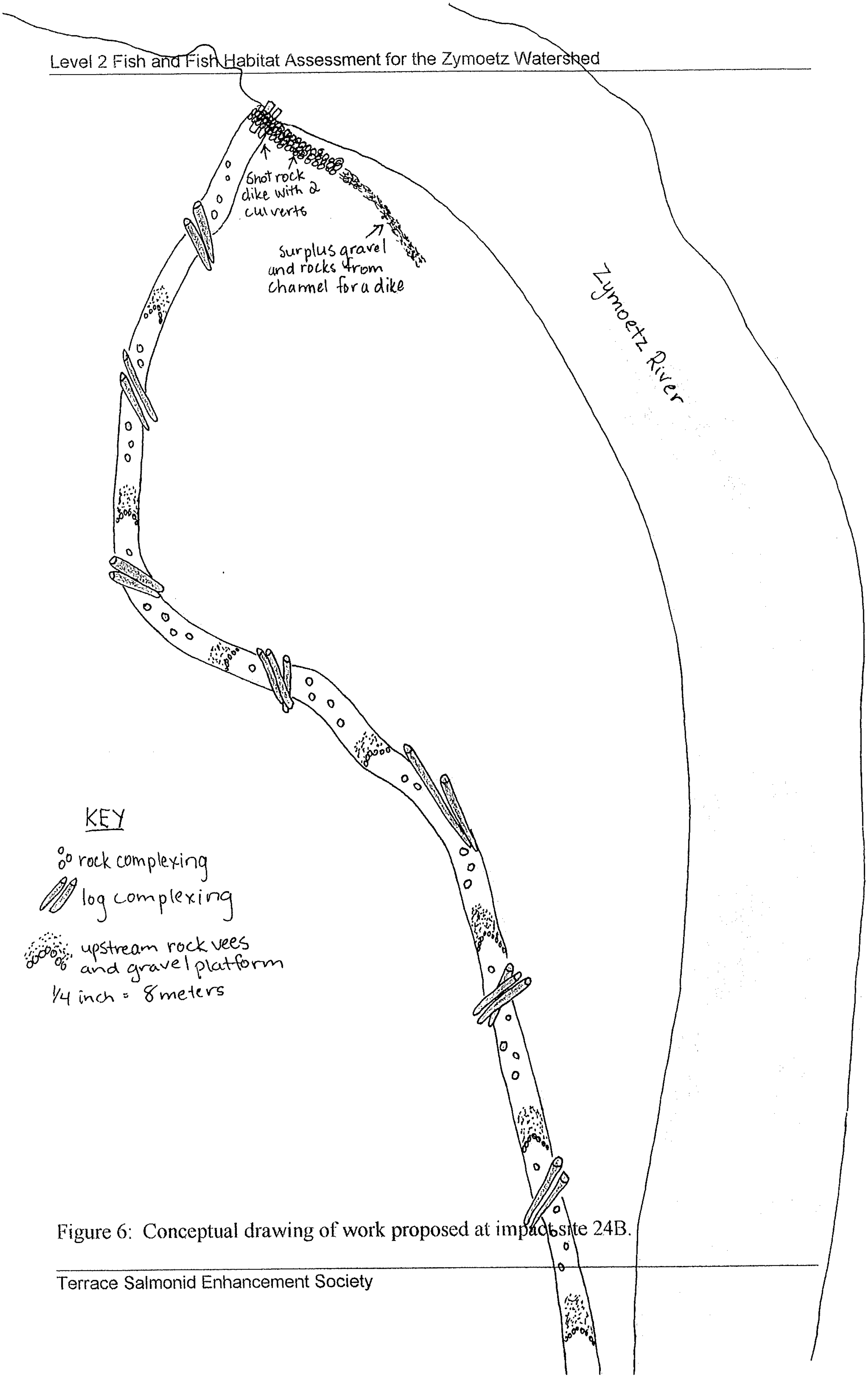


Figure 6: Conceptual drawing of work proposed at impact site 24B.

Impact Site 30 (UTM 9.5390.60408)

Location:
This culvert is located in reach 2 on the south side of the Zymoetz River at 7 km on the Copper FSR. Access is by road.

Description of Site & Impact:
According to Pollard et al. (1996), this site contains an inadequate drainage structure. Eighty percent of the corrugated metal pipe culvert is blocked with materials from road grading.

Data & Observations:
Upon its inspection December 12, 1997, this culvert was found to be of adequate size and placement.

4.1.2 Sub-Unit Two-West Copper

Impact Site 36 (UTM 9.5399.60402)

Location:
This failing bank is located in reach 3 on the south side of the Zymoetz River at 8 km on the Copper FSR. Access is by road.

Description of Site & Impact:
This slope destabilization is due to riparian harvesting and road construction.

Data & Observations:
Upon its examination, the failure was found to be of no significant impact on the stream below. Therefore, no action is required.

Impact Site 37 (UTM 9.5412.60399)

Location:
This creek (Simila Creek*) is in reach 3 on the north side of the Zymoetz River opposite 9 km on the Copper FSR. Access is by boat.

Description of Site & Impact:
The old bridge is located 100 m above the Zymoetz River on a small stream with an estimated average gradient of 50% from the bridge up, 12% from the bridge down and an average channel width of 5.5 m. The bridge has missing upright posts and the cribbing and cross braces are sagging. Midway between the Zymoetz River and the bridge lies a log jam that is a probable barrier to anadromous fish migration (photo 15). The stream has high over-wintering and rearing habitat value. Collapse of the bridge material could alter the habitat and possibly deposit a large amount of fines into the Zymoetz River.

Data & Observations:
A minnow trap set for 1 hour on December 2, 1997 revealed no fish. No adult redds were observed at this site.

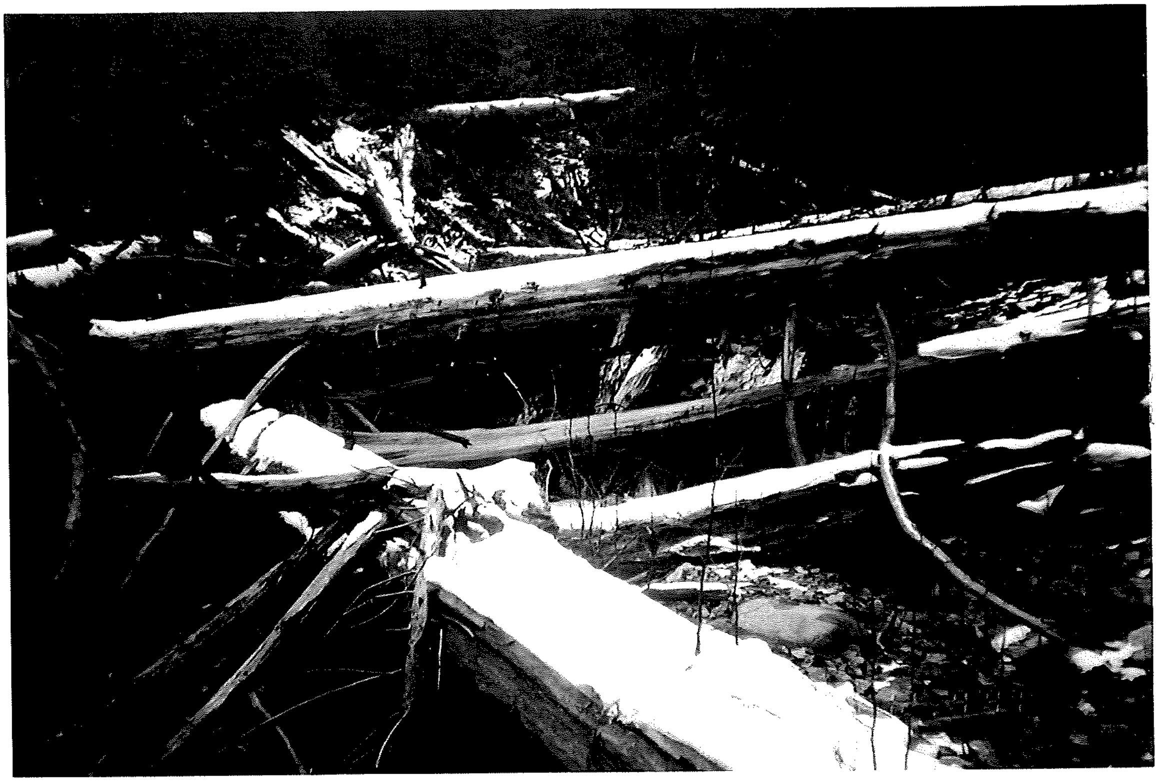


Photo 15: This log jam is a probable barrier to anadromous fish migration.

Prescription

Objective:
The purpose for rehabilitation at this site is to improve the rearing and spawning habitat for steelhead and coho salmon. This will require the removal of a bridge, that if subject to collapse will could cause the mass of timbers and fines to create a temporary dam. If the dam broke apart in a large flow of water it could cause habitat damage for about 100 m. This affected section contains the only habitat accessible to anadromous fish. As well, the downstream habitat appears to have suffered from west side logging that took place to the water's edge during the late 1960's and early 1970's. The partial log jam and dam about 65 m upstream from the confluence with the Zymoetz River, when assessed in November 1997 during normal, late fall flows was a probable barrier to upstream adult migration and requires modification to confine the flow to one or two channels. The habitat downstream from this barrier is marginal for both spawning and rearing with a rough, steep section to the river. This area requires improvement through stepping and the addition of LWD for shade and shelter.

Method & Materials:
The old bridge needs to be removed. However, this is an up slope responsibility that should be handled by the Ministry of Forests, the lead proponent for the Zymoetz up slope restoration work. We recommend this be done using a large track type excavator to scrape off as much gravel and debris from the surface as possible. Then, the rotten decking needs to be removed followed by the stringers being pulled apart by the excavator over to the west side. It is possible that the stringers may break apart and fall into the creek along with other debris. This would only cause a temporary disturbance until the pieces are removed. All the materials should be burned or spread over the bank of the road in a number of locations to blend in with the natural surroundings.

Rehabilitation and enhancement of the habitat would follow the bridge removal, with the first work being the stepping of the creek to the log jam to allow passage of adult and juvenile salmonids to the habitat above the jam. The steps can be created by the construction of a series of upstream rock vees beginning just upstream of where the creek meets the Zymoetz River (Figure 7). The vees would be located approximately four channel widths apart, in a stepped manner to slow down the water flow and create a minimal jump to pools and spawning riffles as far as the log jam and around it. The vees need to be built to a height which will allow both juveniles and adults to ascend this rehabilitated section of the creek with a minimum of difficulty. The stepping of the pool-riffle sections need to be spaced in such a way that the jumps accommodate juveniles while, at the same time, allow fish to migrate past the log jam. The jam is about 4 m higher than the river and approximately 65 m upstream on Simila creek. An estimated calculation is that about six upstream vees need to be constructed using local rocks because it is impossible to get a machine of any type to the site. All the work would have to be done using hand tools, a portable winch or other kind of appropriate small equipment that can be hauled to the site. Gravel behind the vees must be partially graded with long toothed rakes to separate out large rocks and move the gravel into locations where fish can use it for spawning. As with the other sites where upstream vees have been constructed, the rocks need to be placed in excavations so that about one half of the rock is imbedded in the substrate (see Appendix IV for rock vee construction).

Access to the site needs to be via the old logging road (which is partially grown over) for the excavator to remove the bridge. The road would have to be slashed by a crew or with a brusher. Before the in stream work can proceed, it will be necessary to construct an access route to the lower creek. It is possible to use a float boat to get to the creek but it is more difficult to get equipment across.

Expected Benefits:
Simila Creek, as described, is a steep swift flowing stream that is currently a marginal fish habitat lacking any substantial pools or riffle areas. The construction of the vees is not intended to turn this creek into a major fish producer, but rather to upgrade the habitat so that the amount of rearing area is increased and that some useable spawning habitat is available for coho, steelhead and char. This rehabilitated habitat would

provide room for up to about twelve adult salmon as well as a number of char. The Zymoetz River watershed is steep sided, most of the tributaries drop off the mountainsides, with a short section of a stream in the valley bottom that is fish friendly. Many of these habitats have been impacted by logging, road and/or utility construction and maintenance. By collectively rehabilitating the small stream micro habitats, such as, Simila Creek, we are confident that the numbers of steelhead, coho and char will increase.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	5	320	1600
Jr. Biologist	1 person	4	200	800
Sr. Field Tech.	1 person	11	220	2420
Jr. Field Tech.	persons	20	180	3600
Bookkeeper	1 person	0.5	180	90
Equipment: large track type excavator power winch 2 chain saws low bed hand tools	 hours days days hours days	 14 10 10x2=20 4 10	 137 50 25 105 10	 1918 500 500 420 100
Transportation: 4x4 crew cab	lump sum			900
Materials: cables, steel pins	at cost			50
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 11	 25	 125 100 275 200
			Total cost	13598
			GST	241
			Overhead and Administration (3%)	408
			Total Contract Value	14247

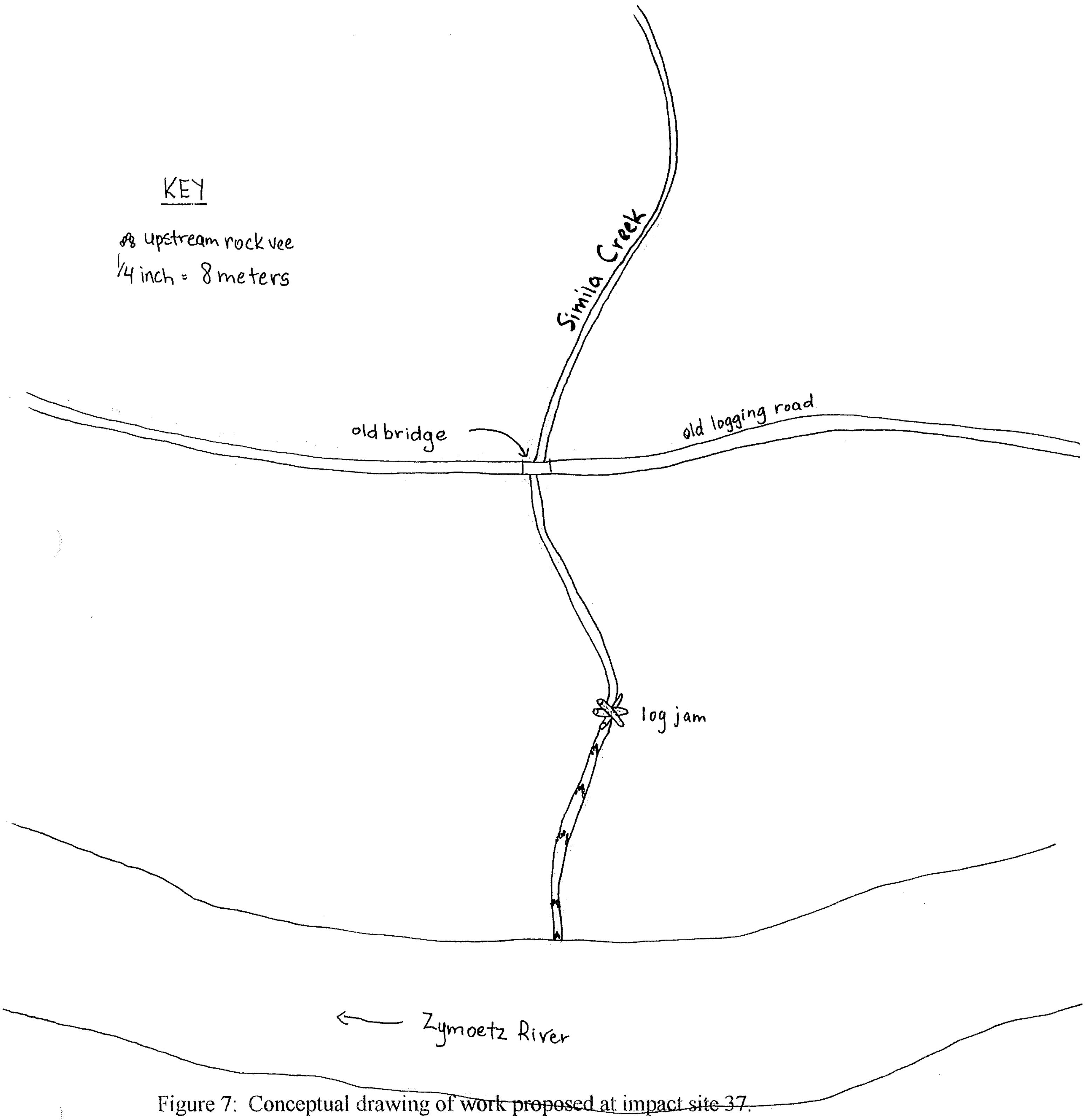


Figure 7: Conceptual drawing of work proposed at impact site 37.

Impact Site 37B (UTM 9.5410.60399)

Location:
This creek (Fiddle Creek*) is located within reach 3 on the south side of the Zymoetz River at 9 km on the Copper FSR. Access is by road.

Description of Site & Impact:
Both sides of this creek were logged to the water's edge. Road construction may have deposited material into the stream damaging rearing habitat. As well, the excavation and movement of materials required for the installation of the PNG pipeline has likely caused significant damage within the creek. It is possible that this damage is permanent. The first 75 m of this stream has a gradient of 15% (photo 16), the gradient underneath the bridge is 23% and there is an average gradient of 8% in between. The stream contains very little spawning gravel. Composed primarily of large boulders and woody debris (photo 17).

Data & Observations:
Minnow trapping on December 2, 1997 captured 2 juvenile rainbow trout with fork lengths of 115 mm and 93 mm. The relative abundance is 2.

Photo 16: Looking downstream Fiddle Creek from the PNG crossing to the Zymoetz River.

Photo 17: Looking up stream from the PNG crossing. This site consists of poor sized spawning gravel, its make up is medium to large size boulders and LWD for rearing.

Prescription

Objective:
With limited spawning gravel and lack of pools for fish to rest and find shelter in, the intent is to create a more varied and hospitable fish habitat for the lower 100 m.

Method & Materials:
The proposal is to construct three to four upstream rock vees between the Zymoetz River and the flat area immediately below the PNG pipeline crossing. An additional vee will be placed about 10 m upstream from the crossing. This crossing must be left undisturbed.

The vees would be constructed with existing rocks in the creek by a 490E John Deere excavator starting just above the fan. The second vee would be located about 12 m (four channel widths) upstream of the first, with the third and fourth another 12 m further upstream (30 m downstream of the crossing) about 20 m from the river. The first vee would be a flatter, modified structure to prevent a narrow, confined channel from developing (Figure 8).

The schedule of events should see the construction of the lower vees first (year one) and monitor their impact upon the habitat. The excavator would move as much gravel as can be found behind the vees to create spawning pads. Hand grading of larger rocks from the substrate with long toothed rakes is necessary to provide suitable spawning gravel including leveling and shaping the pads to make them as natural as possible.

Expected Benefits:
Refer to benefits for site 37 (Simila Creek).

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	4	320	1280
Jr. Biologist	1 person	4	200	800
Sr. Field Tech.	1 person	3	220	660
Jr. Field Tech.	persons	4	180	720
Bookkeeper	1 person	0.5	180	90
Equipment: 490E John Deere excavator low bed chain saw hand tools	 hours hours days days	 8 4 2 2	 102 95 25 10	 816 390 50 20
Transportation: 4x4 crew cab	lump sum			350
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 3	 25	 125 100 75 200
			Total cost	5676
			GST	89
			Overhead and Administration (3%)	170
			Total Contract Value	5935

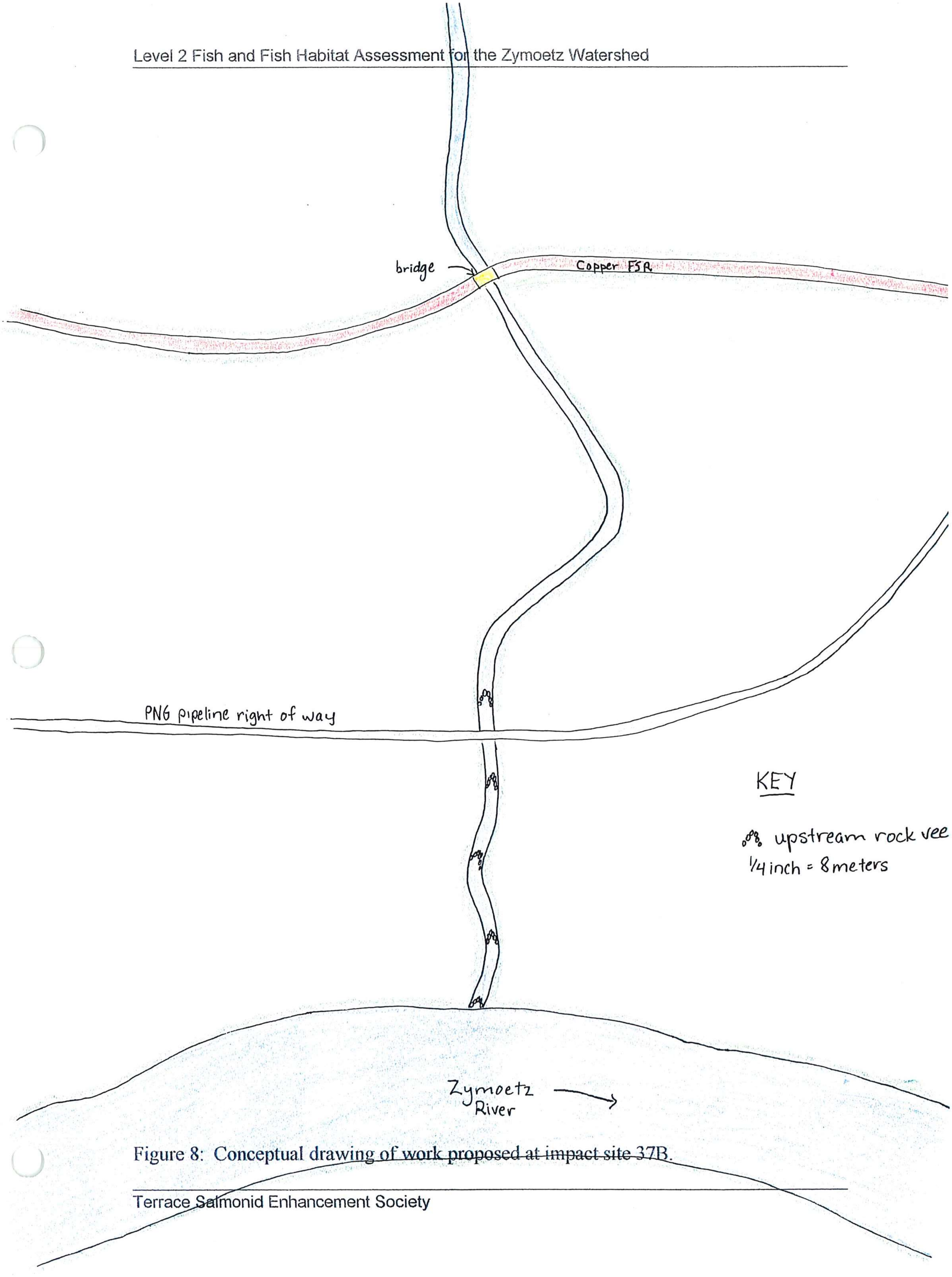


Figure 8: Conceptual drawing of work proposed at impact site 37B.

Impact Site 41 (UTM 9.5431.60390)

Location:
This slope failure is located in reach 3 on the south side of the Zymoetz River at 12.2 km on the Copper FSR. Access is by road.

Description of Site & Impact:
This road-induced slope failure is 20 m above the Zymoetz River and has a gradient of 40%. There is rip-rap secured to the lower section of this slope that is managing to secure most of the erodable material. The upper section, however, is actively failing and according to Pollard et al. (1996) appears to be a potential constant sediment input into the river (photo 18). As well, sections above the road have potential to collapse. The TSES field crew did not see any active erosion of any consequence below the road during a number of trips. Above the road, active failures were visible in a number of locations.

Data & Observations:
The erosion in a number of spots along this site has caused two small creeks flowing through to transport material. The bank needs to be stabilized as there is a high potential for a slump or serious erosion to take place above the road. There are a minimum of five separate bank locations above the road, two of which have had intermittent flow of water through them that could slump onto the road or continue to erode in a more insidious, slower manner and eventually slump or erode. Further up the slope a second eroded bank is indicating that slumping may have begun. This secondary erosion may have been caused by the construction of the PNG pipeline.

Photo 18: Slumped bank caused by road construction.

Prescription

Objective:
Both the upper and lower slopes above the road at this site require stabilization in order to eliminate current and prevent future erosion into the Zymoetz River. The slope below the road is not a major impact problem as long as grass and low shrubbery bind and stabilize it. The slope above the road is an up slope project that is the responsibility of MOF.

Method & Materials:
We recommend that both the slope above the cut bank directly below it to the road for a distance of about 50 m be partially stabilized by and flumming of water from the two small creeks flowing over the eroded sections above the road directly into the ditch line. The water needs to be picked up far enough up slope to eliminate the water flow over the area that is subject to erosion and slumping. If there is any exposed bank above or below the road, it should be grass seeded.

A soil expert or Geomorphologist should be retained to provide a more comprehensive analysis and recommendation for a long term or permanent solution, if both the erosion problem and cut bank that continues to slough after flumes have been installed. Any work undertaken would require liaison with PNG whose pipeline is located just above the slump area.

Expected Benefits:
If this bank is stabilized and the erosion is eliminated, the possible threat bank failure and the associated siltation into the Zymoetz will be greatly reduced. As well, the continued disposal of slump material from the ditch onto a land location will likely not be necessary. The retention of the natural landscape and creation of a more aesthetically pleasing cut bank is a very positive achievement.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	3	320	960
Geomorphologist	1 person	3	560	1680
Jr. Biologist	1 person	2	200	400
Sr. Field Tech.	1 person	4	220	880
Jr. Field Tech.	persons	6	180	1080
Secretarial	1 person	0.5	180	90
Equipment:				
hand tools	days	3	10	30
power winch	days	1	50	30
chain saw	days	2	25	50
Transportation:				
4x4 crew cab	lump sum			280
Materials:				
steel pins	at cost			50
flumes	meter	36	46.6	1678
grass seed	at cost			50
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	4	25	100
misc.	lump sum			200
			Total cost	7783
			GST	125
			Overhead and Administration (3%)	234
			Total Contract Value	8142

Impact Site 43 & 44 (UTM 9.5436.60390)

Location:
This creek (O.K. Creek) and collapsed bridge are located in reach 3 on the north side of the Zymoetz River opposite 12.5 km on the Copper FSR. Access is by boat.

Description of Site & Impact:
There is a 6 m waterfall impassable to fish located 114 m from the mouth of the creek. The section of creek below the falls, has an average wetted width of 2 m and an average gradient of 18% (photo 19 and 21). The section of creek above the falls has an average wetted width of 2 m and an average gradient of 60%. There is a partially collapsed bridge 200 m upstream from the mouth and 85 m upstream from reach 1 (photo 20). It is 20 m in length, 10 m above the creek.

The creek bottom is mostly large boulders making its spawning value poor. However, Pollard et al. (1996) suggests that some effort should be made to reduce the risk to downstream fish habitat.

Data & Observations:
A minnow trap captured 5 rainbow trout on November 28, 1997. The relative abundance is 0.06. The chart below represents the fork length of these fish.

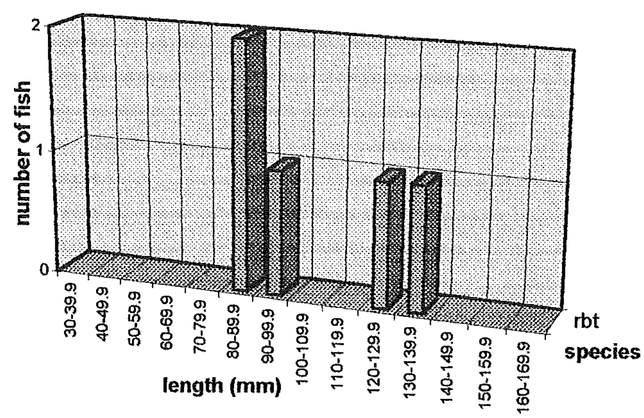


Figure 9: Fork length frequencies of fish trapped at sites 43 & 44.

Photo 19: Looking downstream to the Zymoetz River.

Photo 20: The remnants of an old bridge that risks collapse with little impact upon spawning and rearing habitat.

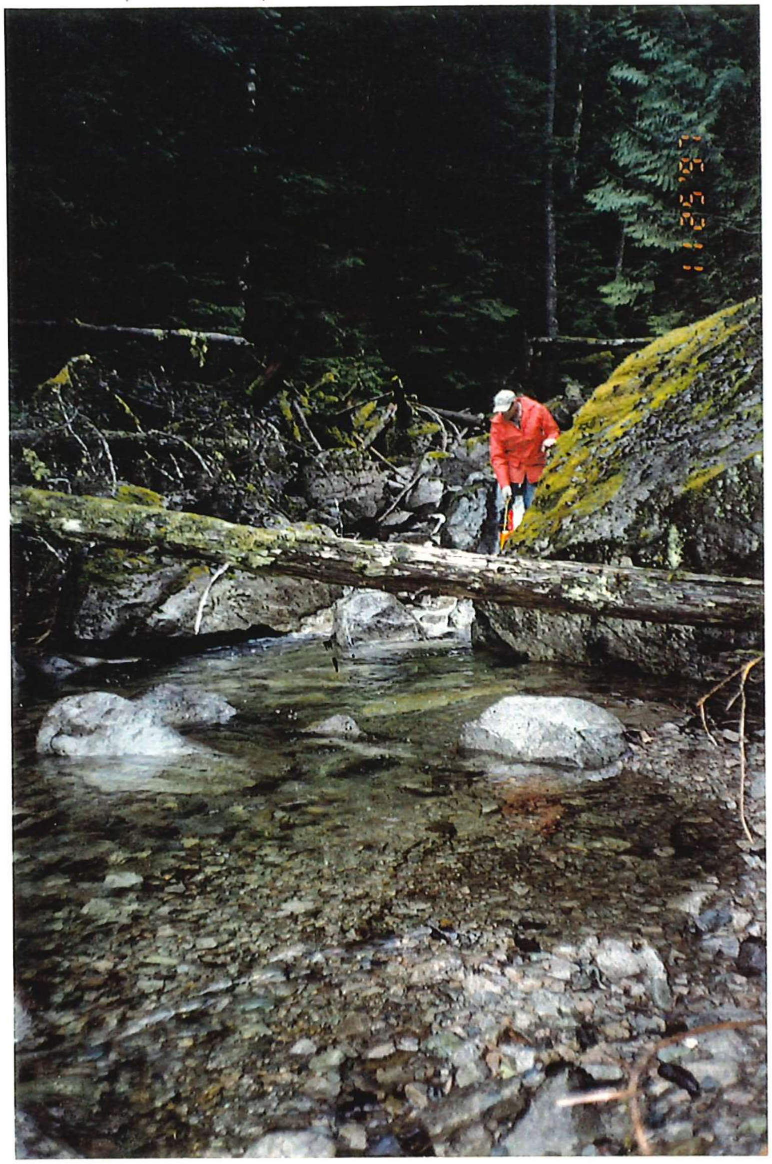


Photo 21: Looking upstream. A coho redd just below the large rock.

Prescription

Objective:
The goal is to rehabilitate the spawning habitat for summer coho, steelhead and char in the lower 50 m of the creek. The remaining bridge stringers that are still standing are not a serious threat to the stream habitat.

Method & Materials:
As with Simila Creek, the lower section of this stream lacks complexity and stability. While adult fish would not find it very difficult to migrate into the creek there is not a series of pools for juvenile and adult salmonids to hold or rear in.

It is proposed that three upstream rock vees be constructed about 4 m or four channel widths apart beginning just upstream from the mouth of the Zymoetz River (Figure 10). The vees can only be constructed by hand using native rocks and gravel because there is no road access for vehicles. Similar to using an excavator, an excavation needs to be dug by hand to a depth of approximately one half the diameter of the rocks being used. Once the main structure made of large rocks is constructed, smaller rocks need to be placed across the openings between the larger rocks with smaller spawning substrate (see Appendix V spawning gravel size requirements) back-filled behind the upstream part of the vee for a distance of about 2 m from the bank side section of the vee. Using LWD scattered along the bank, tie the logs into the vees by covering them with large rocks after trenching as much as possible. The logs should be placed diagonally across the pool with one or more logs cabled or pinned to the key logs. Logs should only be placed in the top two pools because the lower pool will occasionally be covered with Zymoetz River flood waters that could rip the logs loose. For the section of the creek from the top vee to the large, natural pool, the gravel substrate can be improved as spawning habitat by grading out some of the large rocks. Some moving of large rocks and placing of logs where none currently exist will provide shade and shelter for both juvenile and adult salmonids. The lower two vees should be modified flatter vees to prevent scouring a narrow channel.

All materials and workers need to be transported by boat across the river to the site.

Expected Benefits:
The 100 m plus of fish habitat below the waterfall is currently marginal for rearing and spawning. The water quality is high with no sediment problem. By increasing the number of spawning pads and rearing areas, the productivity of the stream will be enhanced. If spawning increases the number of juveniles beyond the rearing capability of O.K. Creek to support that production, it is felt that the Zymoetz River mainstream habitat is not rearing historic numbers of juvenile salmonids; therefore, it should be able to handle the overload of juveniles from the creek.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	4	320	1280
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	9	220	1980
Jr. Field Tech.	persons	16	180	2880
Bookkeeper	1 person	1	180	180
Equipment:				
power winch	days	5	50	250
chain saw	days	8	25	250
hand tools	days	8	10	80
float boat	days	8	50	400
Transportation: 4x4 crew cab	lump sum			584
Materials: cables, steel pins	lump sum			100
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	9	25	225
misc.	lump sum			200
			Total cost	9234
			GST	67
			Overhead and Administration (3%)	277
			Total Contract Value	9572

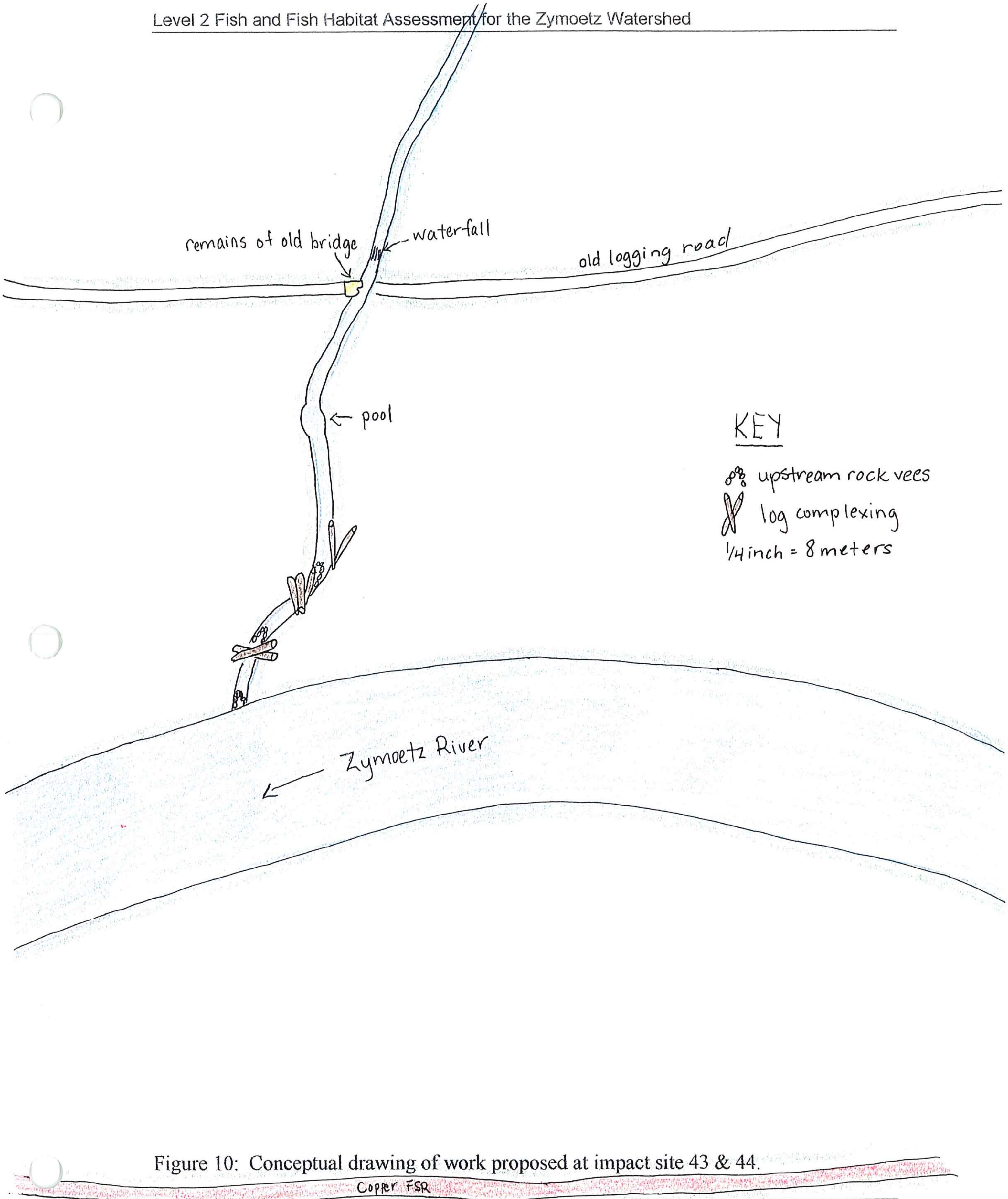


Figure 10: Conceptual drawing of work proposed at impact site 43 & 44.

Impact Site 45 (UTM 9.5441.60384)

Location:
The drainage structures at this creek (Peace Creek*) are located within reach 3 on the south side of the Zymoetz River at 13.3 km on the Copper FSR. Access is by road.

Description of Site & Impact:
According to Pollard et al. (1996), all culverts seem to be impeding the water flow of a stream with an average width of 2.2 m and the gradient is 10% (photo 22). The eastern culvert is collapsed in the middle and is filled with cobbles. The gravel built up above this structure is causing the creek water to flow sub-surface into the Zymoetz River. The western culvert is also partially filled with cobbles (photo 23). As well, the culvert at the mouth of the river is only accessible during high water events (photo 24).

Data & Observations:
Peace Creek splits into two channels about 150 m above the road resulting in the water disappearing before the road. The gravel has built up against the culverts increasing its depth. The division of flow and build up of gravel has resulted in no water at the lower end during normal and low flows. A pH reading of 8.4 was recorded January 6, 1998.

Photo 22: Peace Creek flow upstream above the gravel fan.

Photo 23: Perched culverts with no flow into the channel.

Photo 24: This culvert, just below the Copper FSR, is positioned too high.

Prescription

Objective:
The intent at this site is to consolidate the water flow into one permanent channel. Construct a box culvert or install an arch culvert to accommodate maximum flood flows while allowing juvenile and adult salmonids to migrate upstream. Consolidate the water flow above the road into one channel, reconstruct pools and riffles in the sections just above the road and downstream of the road to the river.

Method & Materials:
At the division of the creek about 150 m upstream from the Copper FSR, construct a log cribbing using cedar logs that are either fallen and are in good condition, or cut standing trees away from the riparian area. The cribbing would be about 1 m high, 2 m wide and about 4 m long. It would be a double wall structure with stringers connecting the two walls. The ballast between the walls will have to be filled by hand using large substrate from the area in front of the over flow channel using a wheel barrow and/or an all terrain vehicle and stone boat (sled).

For the section above the bridge or culvert, an upstream vee must be constructed about 2 m above the bridge so that a pool is formed above the bridge. The upstream vee configuration will, to some extent, help to flush or move gravel through the culvert by reducing or eliminating any need for removing the build up of gravel in front of the culvert. Downstream from the culvert, a second vee should be constructed about 4 m or a further appropriate distance that will assure that gravel does not build up behind the culvert. Two more upstream vees require construction for a total of three upstream vees between the road and the river. Local rocks and gravel substrate should provide the necessary materials for the vees (Figure 11). See Appendix IV for the construction of upstream vees. It should be noted that the distance between the vees should be about four channel widths, in this instance, the goal is to step the creek to slow down the water flow and contain the gravel which could mean moving the vees closer together.

Some LWD and rock complexing for shelter and shade is important downstream from the road, but it should not cross the creek in a way that could cause jamming and backing flood waters onto the road. It may be more important to anchor the upper portion of a log or logs onto the bank as key logs that smaller logs and branches can be cabled to them forming a cluster against the bank.

There has been an extensive build up of gravel against the road causing the flow of water to go under the gravel drying up the section of creek upstream and downstream of the road (where the work is to take place) during periods of low water flow. Prior to the new crossing and vees being constructed, there is a need to excavate that build up of substrate, which is likely about 1 m deep. The excavation should be sloped to the center to reduce erosion along the banks and allow vegetation to establish on the upper half.

The construction of the box culvert would to be a separate contract for a contractor who specializes in bridge maintenance and construction through MOF or SCI as an up slope responsibility. There is a necessity for the two contractors to coordinate their activities very closely. The size of the culvert being proposed is 8 m long approximately 1.5 m above the stream bottom and about 1.5 m wide (Figure 11).

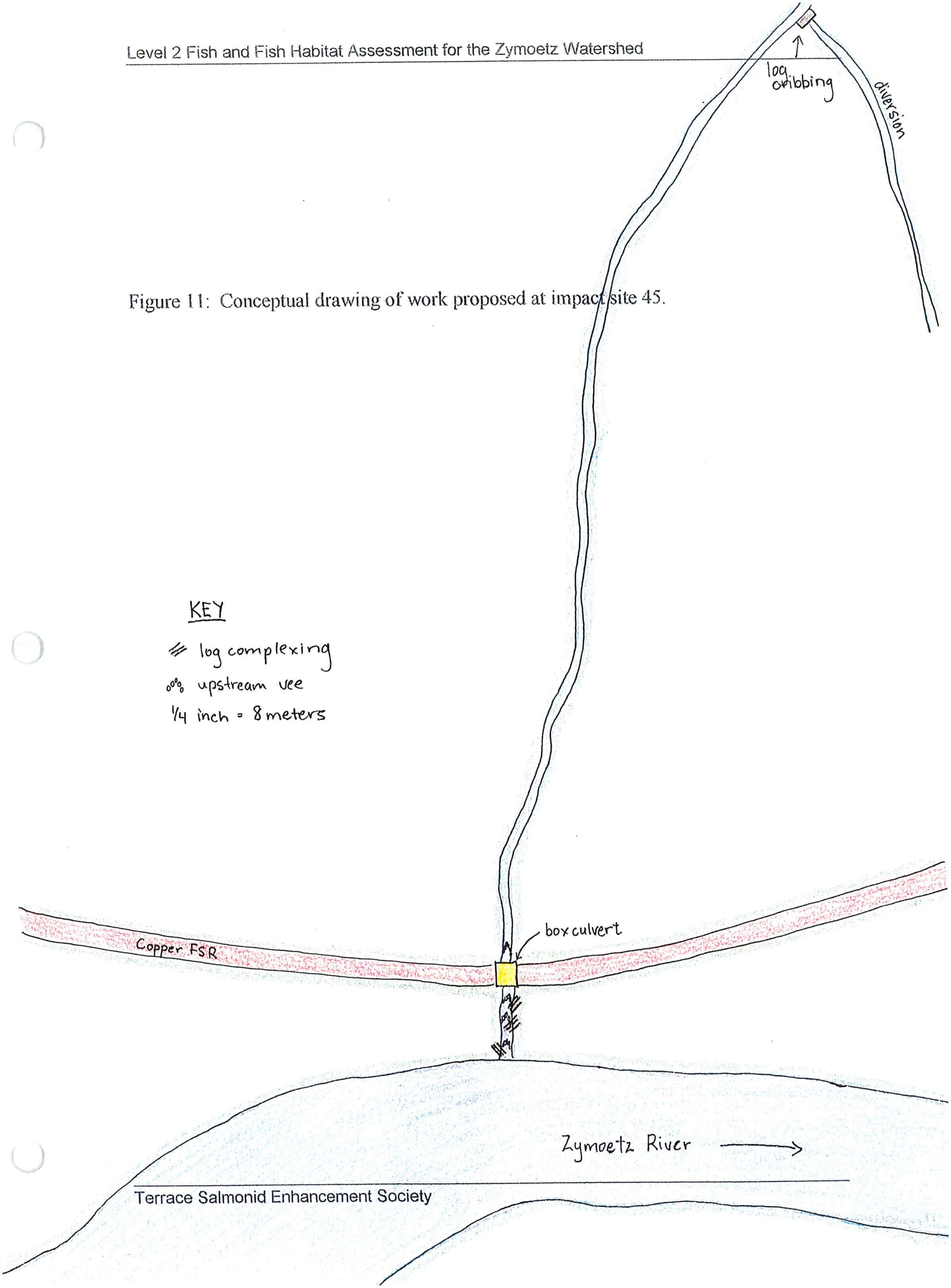
Expected Benefits:

Water only flows in the lower section of the creek during high water periods and no anadromous salmonids use this habitat. If the water flow is re-established in the lower creek, it is hoped that summer coho, steelhead and char will recolonize the new habitat.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	4	320	1280
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	11	220	2420
Jr. Field Tech.	persons	20	180	3600
Bookkeeper	1 person	1	180	180
Equipment: 490E John Deere excavator power winch chain saw ATV hand tools low bed	 hours days days days days hours	 8 2 5 4 10 4.5	 101 50 25 100 10 95	 808 100 125 400 100 428
Transportation: 4x4 crew cab	lump sum			803
Materials: cable, pins	lump sum			100
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 11	 25	 125 100 275 200
			Total cost	11644
			GST	137
			Overhead and Administration (3%)	349
			Total Contract Value	12130

Figure 11: Conceptual drawing of work proposed at impact site 45.



Impact Site 46 (UTM 9.5449.60378)

Location:
This site of erosion is found on the north side of the Zymoetz River within reach 3 opposite 14 km on the Copper FSR. Access via North Copper FSR.

Description of Site & Impact:
The eroding bank at this site is causing sediment into the Zymoetz River (photo 25).

Data & Observations:
Gravel bank erosion is not serious, but the loss of the riparian zone is.

Photo 25: This eroding bank is causing sediment into the Zymoetz River.

Prescription

Objective:
The proposal is to reduce or eliminate the erosion along the north bank of the river. There is not a serious on going weeping of sediment into the river because the materials are primarily sands and gravel. The greatest damage is the loss of riparian habitat and the potential of opening a clay seam or exposing other soils that are more damaging to fish habitat.

Methods & Materials:
The practicality of being able to armor the bank is very low because of its size and length, as well as of the site's lack of bridge or road access. The cost of armoring the bank would be very high because of the need to open up an old road or construct a temporary bridge across the river. The most sensible solution is to divert the flow away from the bank through the construction of a shot rock groyne, at the head end of the eroded bank and a second further along may be necessary to direct the water flow completely away from the bank. Access is a problem as well for construction of a groyne but not as critical because the work would have to take place during the early spring low water conditions when a large excavator could be walked across the river and reach across to pick up large shot rock. The rock would be dumped part way out in the river by a Moxy type truck.

Before any decision is made to go ahead with this prescription, a Hydraulic Engineer should be retained to provide a professional opinion on the construction of a groyne and location(s) (Figure 12).

Expected Benefits:
After the completion of this project, the riparian loss will be halted and the erosion will diminish as the river flow moves away from the bank.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	4	320	1280
Hydraulic Engineer	1 person	3	550	1650
Jr. Biologist	1 person	1	200	200
Sr. Field Tech.	1 person	3	220	660
Bookkeeper	1 person	0.5	180	90
Equipment: large excavator Moxy dump truck loader float boat low bed	 hours hours hours days hours	 8 4 4 3 4	 213 125 100 50 105	 1704 500 400 150 420
Transportation: 4x4 crew cab	 lump sum			 296
Materials: shot rock	 cubic meter	 36	 10	 360
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 3	 25	 125 100 75 200
			Total cost	7914
			GST	222
			Overhead and Administration (3%)	237
			Total Contract Value	8373

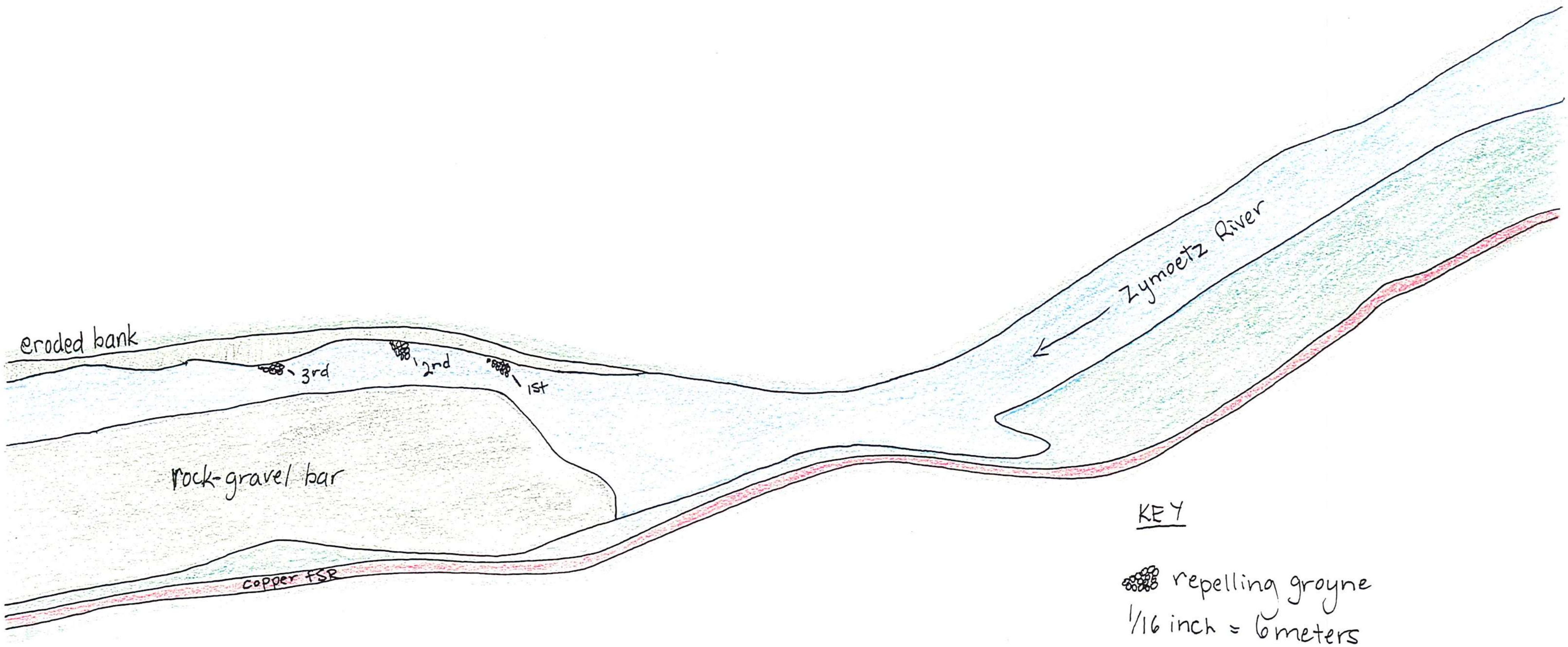


Figure 12: Conceptual drawing of work proposed at impact site 46.

Impact Sites 47 and 50 (UTM 9.5447.60375)

Location:
This side channel is located within reach 3 on the south side of the Zymoetz River at 14 km on the Copper FSR. Access is by road.

Description of Site & Impact:
The riparian zone at this site is completely gone causing the road to channelize the river. The side channel at this site is approximately 300 m long with an average width of 15 m and provides excellent rearing habitat for salmonids when there is water in it unfortunately it dries up during the winter (photo 26). Road construction through the riparian zone has constricted the channel and eliminated stream side vegetation at this site. The loss of riparian habitat to this area reduces cover, organic debris and risks a spill of oil or other pollutants ending up in the water if a vehicle were to drive into the river. Also during flood events, the channel is taken over by the mainstream Zymoetz River. During these events, the road has been eroded significantly or washed out. Pollard et al. suggests that habitat complexity be attempted in order to increase cover.

Data & Observations:
We were unable to separate sites 47 and 50 as individual impact sites as a result they have been consolidated into one site. The road is too close to the river and may have taken over a portion of the side channel when it was constructed. During major floods the road is usually partly washed away and covered with water.

Photo 26: Looking downstream from the top of the channel. Loss of stream side vegetation has resulted from adjacent road construction.

Prescription
See impact site 50B.

Impact Site 50B (UTM 9.5449.60374)

Location:
This creek (Kaluha Creek*) is located in reach 4 on the south side of the Zymoetz River at 14 km on the Copper River FSR. Access is by road.

Description of Site & Impact:
This small creek flows all year and drains off a steep slope to the road. There is almost no habitat above the road. The PNG pipeline construction and FSR construction have severally impacted the little habitat that exists about 6 m below the road. Road maintenance causes deposition of graded material and alteration of habitat above and below the culvert (photo 27 and 28).

Data & Observations:
A pH of 9.3 was recorded January 6, 1998. The drop from the culvert to the creek is too high for juveniles to migrate through. The site has good potential for rehabilitation of the micro habitat below the road.

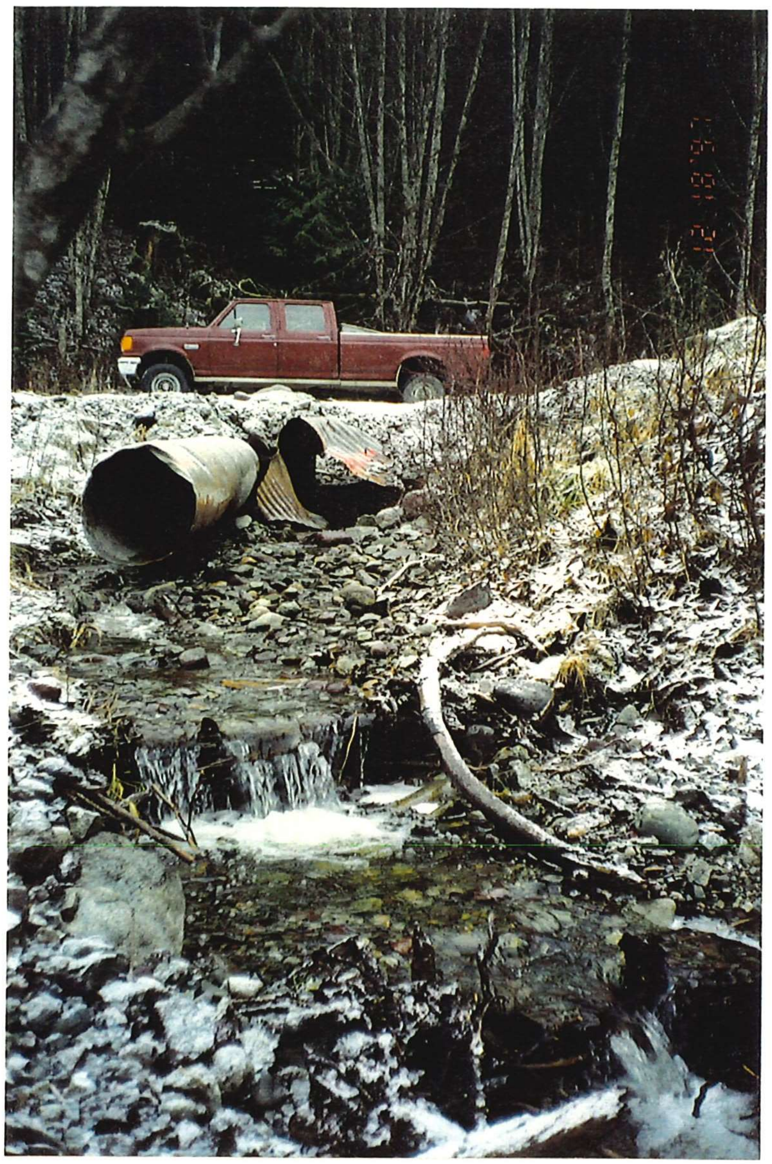


Photo 27: Kaluha Creek below the Copper FSR. These culverts are in poor condition and need to be replaced with a single box culvert.

Photo 28: Kaluha Creek above the Copper FSR.

Prescription for 47, 50 & 50B

Objective:
This side channel is filled with water during medium and high river flows but is dry during low water periods. It may be a negative factor because of the mortality of juveniles when the channel dries up.

The original thought was to install a permanent semi-controlled flow of water into the channel to maintain moving water in the channel year round. It was determined that it would be too difficult and costly to carry out this project. As a result, it was decided to drop the idea.

Build up the height of the road so that flood waters do not cover it and additional armouring along with a deflecting groyne or groynes to protect the road and eliminate the extensive scouring next to the road in the side channel and cause it to fill in by deflecting heavy, destructive flows away from the road. Where 14 Km Creek is free flowing downstream from the road it should be stepped with upstream rock vees and log dams to create a series of spawning pads and small pools.

Method & Materials:
In combination with the requirement to retain a Hydraulic Engineer for site 46, this site should be looked at the same time by the Engineer who would be tasked to recommend whether groynes would work. If they are a good idea, there should be a recommendation on their design, size, number required and location or placement.

There is an opportunity to create a spawning area in the section of this small creek downstream from the road to where it joins the river water flow in the channel. This section of the creek is partly stepped by existing logs across the creek. Where those steps exist the quality of the substrate for spawning is poor because the creek has been dug and altered by the road construction and maintenance leaving it without a normal stream definition. Grading the gravel with a long toothed rake and moving rocks by hand to reshape the pools and spawning area to be more typical of a small stream will be necessary. In addition to the existing steps more steps will have to be constructed using rocks in an upstream configuration or alternatively, if water-logged LWD is available, the same kind of configuration can be used with steel pins anchoring the logs into the substrate. Complexing of the creek is needed to provide shelter and shade using LWD.

Along with the in stream work it will be necessary to replace the culverts that 14 km Creek flows through with a single, larger metal culvert or a box culvert that will accommodate maximum flood flows. The culvert size and its placement will be the responsibility of SCI, MOF and PNG.

Expected Benefits:
The rehabilitation of the14 Km Creek habitat will in a small way, increase fish production and contribute to an overall net increase in the numbers of salmonids in the watershed. The construction of deflective groynes should, over time, move the river away from the road eliminating the annual die-off of trapped fish in the channel as it dries up.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	2	320	640
Hydraulic Engineer	1 person	5	560	2800
Jr. Biologist	1 person	2	200	400
Sr. Field Tech.	1 person	6	220	1320
Jr. Field Tech.	persons	10	180	1800
Bookkeeper	1 person	0.25	180	45
Equipment: hand tools chain saw gravel grader	 days days days	 5 5 2	 10 25 25	 50 125 50
Transportation: 4x4 crew cab	lump sum			534
Travel Expenses: (Engineer)	at cost			1500
Materials: pins				50
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 15	 25	 105 50 175 200
			Total cost	9844
			GST	16
			Overhead and Administration (3%)	295
			Total Contract Value	10181

Impact Site 54B (UTM 9.5463.60367)

Location:
This side channel is found in reach 4 on the south side of the Zymoetz River at 16 km along the Copper FSR. Access is by road.

Description of Site & Impact:
This 710 m side channel, has an average gradient of 2% and has historically provided spawning and rearing habitat for many species, in particular, chinook and coho (photo 29 and 30). A perennial flow of spring water and that from two small creeks provide a small supply to the lower half of the channel. This inadequate water supply is subject to freezing and draining away into the substrate during the winter months and low water periods. Depending on the weather, this becomes a problem at the time when adults return to spawn as they may not be able to enter the channel (as seen this year). Lack of adult migration into this site is also affected by lack of water due to low runoff and the blockage of the surface water from the Zymoetz River into the channel due to the 1991 floods. This and the accumulation of fine sediments have probably contributed to the decline of the channel's productivity and its fish count. The channel contains some good spawning gravel at its lower end, but it lacks cover from deciduous and coniferous vegetation along the channel banks. There is the availability of woody debris from a large, dry land log jam.

Data & Observations:
On November 13, 1997, three minnow traps located along the wetted portion of the lower end were found to contain 18 coho, 17 rainbow trout, and 6 char. Several inches of ice covered the pools of water at the time of trap setting and removal. A pH of 8.4 was recorded. The relative abundance of fish here is 0.6. The figure below represents the fork lengths of these fish.

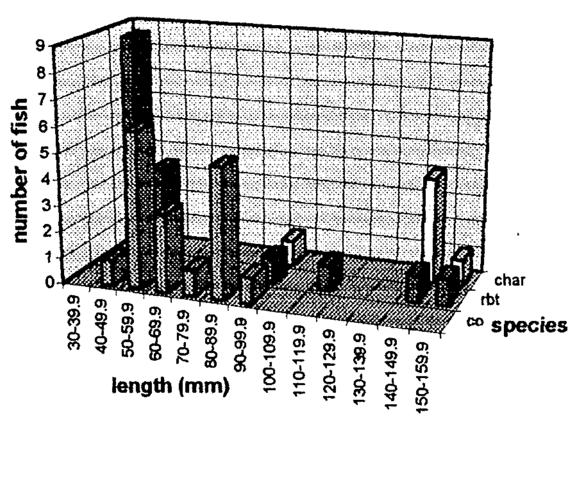


Figure 13. Fork length frequencies for fish trapped at site 54B.

Photo 29: Looking upstream on 16 Km side channel.

Photo 30: Looking down 16 Km side channel to the Zymoetz River.

Prescription

Objective:
This side channel has been subject to degradation from the Zymoetz River flooding and depositing of sediment and gravel over the original spawning gravel substrate that was extensively used in the past by chinook salmon and, to a lesser extent, by coho.

The water from the two creeks draws into the porous substrate of the channel becoming a sub-surface flow at the top of the channel and for the entire lower half during normal flows. The intent is to consolidate the surface water flow into a deeper, more uniform channel that will keep the water flow above the substrate to provide a more stable, productive fish habitat. Secondly, to determine if a sub-surface water supply can be sourced to supplement the surface supply and if a cost effective flood protection plan can be provided for the channel.

Method & Materials:
The project should be broken into two stages (Figure 14):

STAGE 1
Beginning at about the 575 m point on the channel, excavate a 3 m wide, 1 m deep new channel (the new channel would be about 1 m deeper than the existing channel) to 16 Km Creek and then downstream to the smaller creek and to the confluence with the Zymoetz River to consolidate the flow of the two creeks. The new channel excavation should not proceed until the existing wetted channel is narrowed to about 2 m by sand bags and by pushing the sand banks back with the excavator and by hand shovels.

The confined channel would carry the flow of the two creeks while the new channel is being constructed. The new channel should be constructed about 1 m north of the dike, approximately 3 m north of the Copper FSR. LWD and root wads should be installed on the inside bends of the channel to help form scour pools and gravel bars and at the same time provide shelter for juvenile and adult salmonids. The road side of the channel should be partially armoured with salvaged large rocks that have fallen from the steep rock sides above the Copper FSR, past Simpson Creek and from other locations close by.

Moderate, upstream rock vees should be constructed about every four to six channel widths apart, complementing the scour pools (see Appendix IV for rock vee construction). These structures should have enough vee to channel the flow to the center. The rocks would be dug into the substrate so that they are almost flush with the gravel substrate. They would be acting as dams below the scour pools and where new pools need to be formed.

The intent is to taper the channel banks back at about a 45 degree slope with no armouring unless a steeper slope is required at the upper part of the channel. If there is a steeper slope, it may be necessary to place rough rock (salvaged rocks) by hand at the toe of the bank. At the foot of the pools, the gravel should be graded with long toothed rakes to remove larger cobble.

Three test holes should be dug at three locations below the water table and stand pipes installed so that the sub-surface water level can be monitored for a full season.

The section of 16 Km Creek downstream from the road is a poor spawning habitat because of the road construction, maintenance and bridge placement that have altered the habitat by making it into more of a chute than a diverse natural habitat. By stepping it and changing its directions so that it swings upstream to take advantage of a flat area then swinging it back downstream to give it an oxbow effect would double the habitat. Stepping the creek using upstream vees constructed of rocks that are large enough so that half of the rock can be buried in the substrate is likely the most dependable way to step the creek while at the same time providing holding pools and spawning pads behind the vees. Similarly to impact sites 45, 37B and 37, LWD should be installed at key locations to provide shade and shelter.

STAGE 2
This involves the evaluation process to determine if sub-surface water is an option that should be considered to augment the creek water flow in the channel. The other consideration is to decide if there is a cost effective way of flood proofing the creek channel and developing a larger sub-surface water channel.

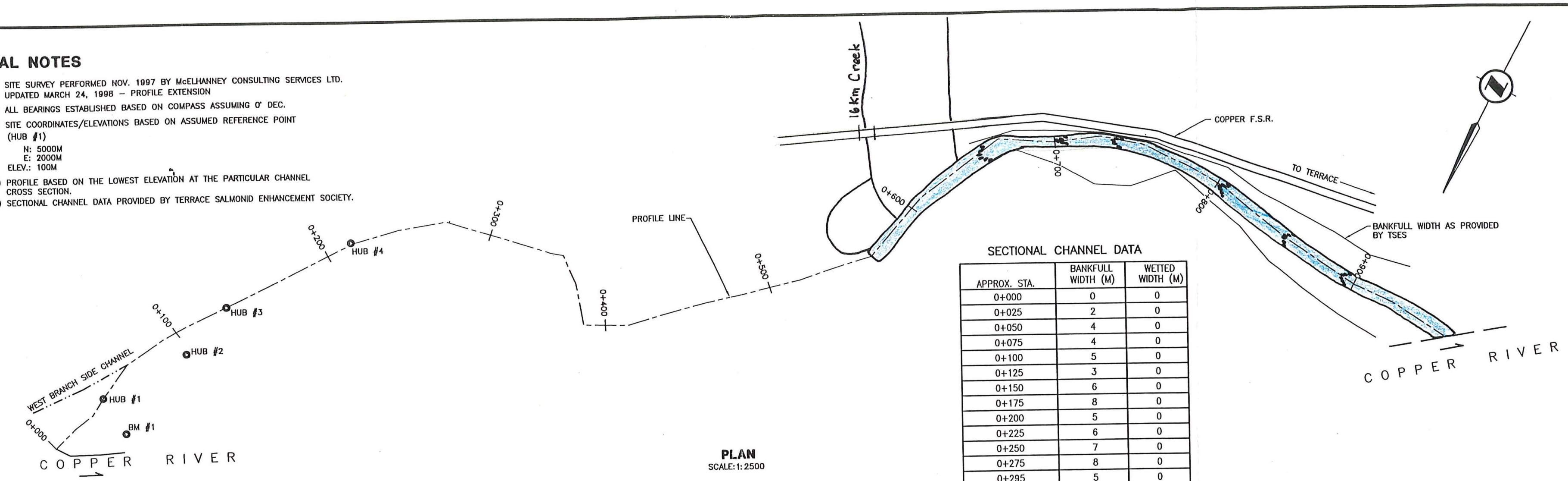
Expected Benefits:
If the rehabilitation of this former fish producing channel is realized, it is expected that coho numbers will increase from the remnant population that has been spawning at the confluence of 16 Km Creek even though a one year class may be lost. The creek flow will not attract chinooks into the channel, but a supplemented flow from sub-surface water may eventually bring these fish back into the channel, along with steelhead and char.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	5	320	1600
Sr. Biologist	1 person	1	440	440
Jr. Biologist	1 person	5	200	1000
Sr. Field Tech.	1 person	12	220	2640
Jr. Field Tech.	persons	20	180	3600
Bookkeeper	1 person	1	180	180
Equipment:				
medium size track				
type excavator	hours	48	112.75	5412
Moxy dump truck	hours	8	125	1000
966 Caterpillar	hours	8	100	800
loader	days	5	50	250
power winch	days	5	25	125
chain saw	days	10	10	100
hand tools	hours	4.5	105	473
low bed				
Transportation:				
4x4 crew cab	lump sum			888
Travel Expenses	at cost	1		840
Materials:				
steel pins, cables	at cost			100
Sundry:				
film & video	at cost			125
report production	at cost			100
communication	days	12	25	300
(radio tel)				
misc.	lump sum			500
			Total cost	20473
			GST	572
			Overhead and Administration (3%)	614
			Total Contract Value	21087

GENERAL NOTES

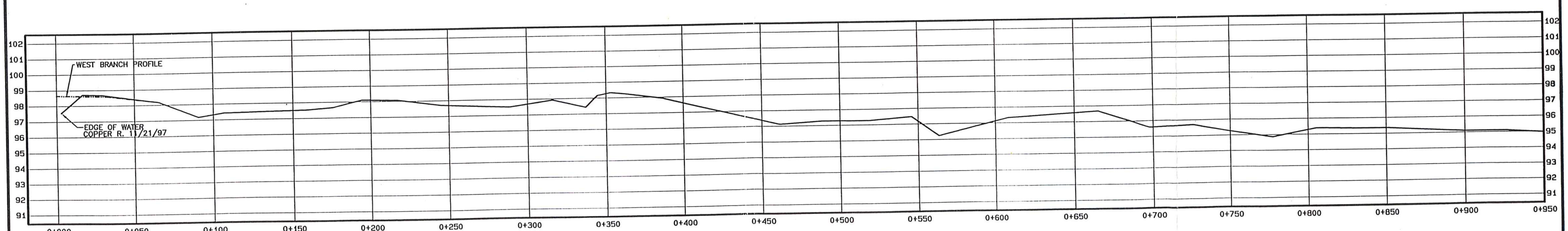
1) SITE SURVEY PERFORMED NOV. 1997 BY McELHANNEY CONSULTING SERVICES LTD. UPDATED MARCH 24, 1998 – PROFILE EXTENSION
2) ALL BEARINGS ESTABLISHED BASED ON COMPASS ASSUMING 0° DEC.
3) SITE COORDINATES/ELEVATIONS BASED ON ASSUMED REFERENCE POINT (HUB #1)
   N: 5000M
   E: 2000M
   ELEV.: 100M
4) PROFILE BASED ON THE LOWEST ELEVATION AT THE PARTICULAR CHANNEL CROSS SECTION.
5) SECTIONAL CHANNEL DATA PROVIDED BY TERRACE SALMONID ENHANCEMENT SOCIETY.



SECTIONAL CHANNEL DATA

APPROX. STA.	BANKFULL WIDTH (M)	WETTED WIDTH (M)
0+000	0	0
0+025	2	0
0+050	4	0
0+075	4	0
0+100	5	0
0+125	3	0
0+150	6	0
0+175	8	0
0+200	5	0
0+225	6	0
0+250	7	0
0+275	8	0
0+295	5	0
0+600	5	–
0+625	4	–
0+650	16	3
0+675	11	3
0+700	13	5
0+725	29	1
0+750	29	1.5
0+775	11	11
0+800	22	14
0+825	23	11
0+850	33	5
0+875	38	6
0+900	40	5
0+925	46	6

BANKFULL WIDTHS ARE NOT ALL SHOWN ON PLAN FOR CLARITY.



PROFILE
SCALE: 1:2500 HOR
1:250 VERT

NO.	DATE	REVISION LIST	BY

McElhanney

McELHANNEY CONSULTING SERVICES LTD.
Suite #1–5008 Pohle Avenue, Terrace, B.C., Canada, V8G-4S8
Tel: (250)–635–7163, Fax: (250)–635–9586

TERRACE SALMONID ENHANCEMENT SOCIETY
ZYMOETZ (COPPER) RIVER
16KM SIDE CHANNEL
SITE 54B - PLAN / PROFILE

SURVEYED:
DESIGN:
DRAWN: T.R.B.
CHECKED: T.R.B.
SCALE: AS NOTED

DATE: APRIL 1998
FILE: 2321-00391-0
TASK: 2001
DRAWING No. 16KM
REV. 1

Figure 14: Center line survey and work proposed at impact site 54B.

Impact Site 62 (UTM 9.5500.60359)

Location:
This bank failure is located within reach 4 on the south side of the Zymoetz River at 21.5 km on the Copper FSR. Access is by road.

Description of Site & Impact:
This road-induced failure is located below the road at a gradient of 120% for 120 m and above the road at a gradient of 60%. The slope failure is due to its inability to re-vegetate itself (photo 31).

Data & Observations:
The bank currently poses no impact on the Zymoetz River below, but is precarious and threatens future damage if it collapses.

Photo 31: This steep bank failure has potential to impact rearing and spawning habitat in the Zymoetz River.

Prescription

Objective:
While this site has almost no impact upon the fish habitat of the Zymoetz River, it has the potential to cause some damage if the road were to break away and the bank above were to come down with it. Determine how safe the Copper FSR is at this site and what

its chances of breaking away are. This is an up slope impact that is the responsibility of the Ministry of Forests, the up slope lead proponent.

Method & Materials:
A professional assessment by an Engineer experienced in road safety issues should be carried out to determine if the road is structurally safe. If the road is not safe and could collapse, recommend the appropriate action that should be taken to bring it up to the road safety requirements of an industrial and public road.

Impact Site 71 (UTM 9.5539.60358)

Location:
This side channel is located within reach 5 on the south side of the Zymoetz River at 25 km on the Copper FSR. Access is by road.

Description of Site & Impact:
This back channel is approximately 1.6 km long with an average gradient of 1%. It was logged extensively 30 years ago and has naturally regenerated. The problem at this channel is extensive beaver use and very low seepage water flows. Decaying organic matter from the six dams located by Pollard et al. (1996) were found to be decreasing the dissolved oxygen concentrations and disturbing water flow.

Data & Observations:
On November 21, 1997, a minnow trap revealed no fish. This site was walked from one end to the other and no inflow or outflow of water into the ponds could be found. Essentially it is seepage water that beavers have taken advantage of that does not drain away through the substrate. The water in the ponds has been examined a number of times including after heavy rains with almost no change in water quality, which is dark coloured with a swampy smell. Even after a heavy rain there was no significant difference in the inflow or outflow. There is no plan for restoration of this site.

Impact Site 74 (UTM 9.5566.60352)

Location:
This bank failure is found in reach 5 on the south side of the Zymoetz River at 28 km on the Copper FSR. Access is by road.

Description of Site & Impact:
Road construction in this area has caused a small bank slough into the Zymoetz River. The slope has an 80% gradient for 15 m. More than one half of this bank is rip-rapped; however, during high water the upper half, composed of finer material, is eroding into the river.

Data & Observations:
While some erosion has taken place and continues to take place during heavy run-off, because the road is on the edge of the river, the situation is not an active failing bank.

Prescription

Objective:
While this site is not having a serious impact upon the Zymoetz River there is the potential to do some serious damage if a major flood occurs and the Copper FSR blows out. There will be the initial release of material into the Zymoetz River and then the possibility of opening up a seam of erodable fines that could weep into the river for a number of years. This is a MOF responsibility.

Method & Materials:
The problem with this site is that any armouring that is going to be installed will be expensive because there is a need to make it durable enough to stand up to very fast flows along this bank which is on the edge of a chute. There are three options for protecting the road: the first one is to dump shot rock over the bank and build it up to a height that flood waters will not wash it away; and the second is a more expensive construction of a shot rock road-way or dike at the base of the road. To build the second option to desired height will require more material and machine time, but is unlikely to get washed away. An experienced Road Engineer should be retained to provide an expert opinion on the best choice for protecting the road. A third option would be the construction of an upstream facing shot rock groyne to deflect the water away from the bank. With this choice, a Hydraulic Engineer should be retained to provide an expert opinion. The cost of this option is likely to be less because less rocks will be required.

Expected Benefits:
The benefit of this work is very clear cut, it will either prevent any future erosion or lessen the amount. Either way, it is a net benefit to the habitat.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	3	320	960
Road Engineer	1 person	4	560	2240
Hydraulic Engineer	1 person	4	560	2240
Bookkeeper	1 person	0.5	180	90
Transportation: 4x4 crew cab	lump sum			142
Travel Expenses	at cost			1000
Sundry: report production communication (radio tel)	at cost days	1	25	100 25
			Total cost	6797
			Overhead and Administration (10%)	680
			Total Contract Value	7681

Impact Site 76 (UTM 9.5569.60353)

Location:
This side channel is found within reach 5 on the south side of the Zymoetz River at 28 km on the Copper FSR. Access is by road

Description of Site & Impact:
This is an overflow channel that has caused the loss of most of the riparian zone resulting in the channelization along the edge of the road. The lower slope has been rip-rapped and has a gradient of 70%. The upper section lacks armouring resulting in ongoing loss of the riparian area and future threat to the road.

Data & Observations:
The side channel was dry every time the site was observed. It appears, after close examination, that water velocities through the channel are extensive.

Photo 32: Eroded band and disappearing riparian zone between the Copper FSR and the Zymoetz River

Prescription

Objective:
The plan is to re-establish a riparian zone between the road and the river while preserving the integrity of the overflow channel. In concert with restoring a segment of the riparian zone the reclaimed bank will require protection or armoring from future floods.

Method & Materials:
This site extends from 28 Km Creek about 200 m upstream to the outside corner at the beginning of the channel. The primary goal is to direct the river flow away from the eroded bank and to reclaim the section where the trees are leaning over and will be lost if nothing is done.

The prescription is double faceted, the first initiative is the construction of a rock deflecting groyne 4 m long that would be located at the tip of the outside corner at the upstream end to the site. Large shot rock 1 to 2 m in diameter would have to be used for the groyne anchor rocks and in turn, buried to about 1/3 of their diameter into the substrate and partially dug into the bank. Roots from live trees will prevent much, if any excavation. It may be necessary to lay a row of shot rock for a distance of about 3 m along the bank and above the groyne (see Appendix VI for groyne construction).

The second initiative is to rip-rap the bank down stream from the groyne above the trees for a distance of about 15 m and then around and below the trees for about 5 m. The plan is to extend the shot rock out from the bank about 1 m and back fill it with over burden so that a small portion of the riparian area can be reclaimed. This would include pulling back the two leaning cedars and anchoring them with cable until their roots can establish themselves in the new material (Figure 15). For the new riparian habitat and open areas in the existing riparian habitat the contractor should transplant in a staggered manner at about 2 m spacing, cedar and hemlock 5+ years old. These trees would be removed from overstocked areas, after receiving the clearance from SCI. A close liaison is required with both MOF and SCI to insure that the in stream work does not intrude into their areas of responsibility.

Expected Benefits:
The primary benefit is to prevent further erosion of the riparian area by deflecting the river flow more to mid-channel with the secondary achievement being the partial reclamation of the riparian zone between the river and the road. This includes an improvement in the aesthetics along the stretch of river which is deteriorating as the large trees in the riparian zone fall into the river because of erosion. There will likely be a loss of fish habitat as a result of this work in the over flow of channel which was created by the erosion of the original bank. The establishment of a stable and permanent bank and riparian area, along with the spaces between the rocks, over time, will more than make up for the loss of any existing habitat.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	3	320	960
Jr. Biologist	1 person	4	200	800
Sr. Field Tech.	1 person	5	220	1100
Jr. Field Tech.	1 person	4	180	720
Bookkeeper	1 person	0.5	180	90
Equipment:				
low bed	hours	4	105	420
large track-type excavator	hours	16	133	2128
Moxy truck	hours	16	125	2000
loader	hours	16	100	1600
hand tools	days	4	10	40
power winch	days	1	50	50
Transportation:				
4x4 crew cab	lump sum			600
Materials:				
cable, steel pins	lump sum			50
shot rock/drilling	cubic meters	200 m3	10/m3	2000
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	6	25	150
misc.	lump sum			200
			Total cost	13133
			Overhead and Administration (3%)	394
			GST	437
			Total Contract Value	13964

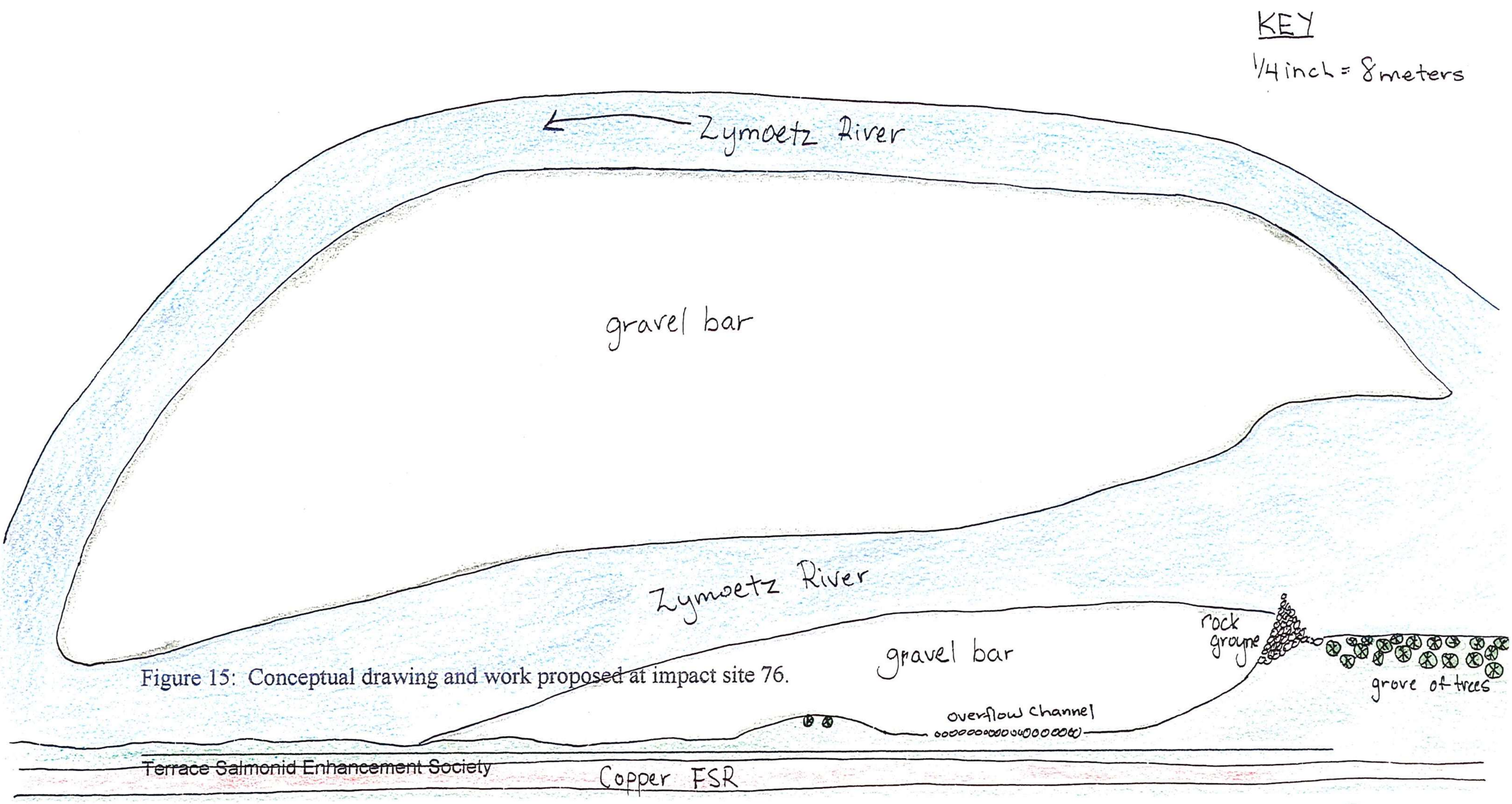


Figure 15: Conceptual drawing and work proposed at impact site 76.

Impact Site 77 (UTM 9.5568.60350)

Location:
This creek (28 Km Creek) and faulty culvert are located within reach 5 on the south side of the Zymoetz River at 28 km on the Copper FSR. Access is by road.

Description of Site & Impact:
This site is a back channel fed by ground and seepage water that was likely created by the road construction that is drained by a poorly installed culvert that was placed too high (photo 33). This area could provide excellent rearing and over-wintering habitat.

Data & Observations:
Minnow trapping above the culvert on December 2, 1997, yielded no fish. This could be, in part, due to the cold water temperatures or to the short trapping time of 4 hours. No water was observed flowing through the culvert or under it during a field trip on March 9, 1998 (photo 34).

Photo 33: This poorly installed culvert provides poor access for salmonids during all water flows (November 1997).

Photo 34: Water is no longer flowing from this channel (March 1998).

Prescription

Objective:
The objective for this site is to determine if there are fish in the back channel and if a small creek close to its head can be directed into this channel to provide a perennial water supply.

Method & Materials:
Carry out minnow trapping throughout the back channel to determine if any fish inhabit the channel and determine if the small creek close to its head end can be diverted into the channel.

Expected Benefits:
Further analysis will determine if this channel is a fish habitat and if the diversion of the small creek will either make it more productive habitat or into a fish habitat.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	4	320	1280
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	4	220	880
Bookkeeper	1 person	0.25	180	45
Equipment: oxygen/pH meter minnow traps	 days days	 1 2	 25 10	 25 20
Transportation: 4x4 crew cab	 lump sum			 213
Sundry: film & video report production communication (radio tel)	 at cost at cost days	 3	 25	 125 100 75
			Total cost	3063
			Overhead and Administration (10%)	306
			Total Contract Value	3461

Impact Site 81 (UTM 9.5574.60352)

Location:
This bank failure is located within reach 5 on the south side of the Zymoetz River at 28.5 km on the Copper FSR. Access is by road.

Description of Site & Impact:
This erosion is natural in a logged off riparian area between the Zymoetz River and the FSR (photo 35 and 36). During high water events the bank is being undercut and the remaining old growth one by one is falling into the river. Grasses have re-vegetated naturally, but Pollard et al. (1996) believes this will not be sufficient in stabilizing the bank.

Data & Observations:
This side channel that is causing all the problems and is getting larger because it is facing directly into the main flow of the river and will likely become the main flow over time unless it is trained away from the riparian area.

Photo 35: Eroded bank and disappearing riparian zone looking upstream.

Photo 36: Looking down stream along the same bank.

Prescription

Objective:
The erosion along the bank at this site is continuing to cut away the bank and cause the old growth vegetation to fall into the river. At the rate of erosion all the trees will disappear and the river will be at the edge of the road. The plan is to try and stop the erosion while maintaining as much natural aesthetics of the this popular fishing spot and the integrity of the fish habitat. Because bank erosion impacts such as this area are so common, the proposal is to treat it as a test site and try four different ways of protecting the bank and integrating them into a single unit.

Method & Materials:
Construct two deflecting groynes about 10 m apart with the first just upstream of the start of the side channel. These would be short groynes about 3 m long with about 1.5 m sunk into the bank and buried about 0.5 m into the substrate (see Appendix VI for groyne construction). Because the water velocity in the Zymoetz can be very powerful requiring the construction of any works to be built to withstand major flood conditions.

Two more groynes should be constructed from cedar logs 40 to 50 cm in diameter and about 12 m long with 9 m imbedded into the bank by being inserted into a trench then covered with another log to a height of about 1.75 m. Each log would be pinned to the other at the trench end. Between the groynes, a log crib will be constructed with the same diameter logs. A middle stringer of logs will have to be constructed to provide rigidity. They will be built the same way as the groyne logs but their diameter can be smaller. The cribbing logs facing the water will be stepped (each log, one log diameter back from the lower log) to improve the aesthetics and allow brush and grass to grow between the logs (Figure 16).

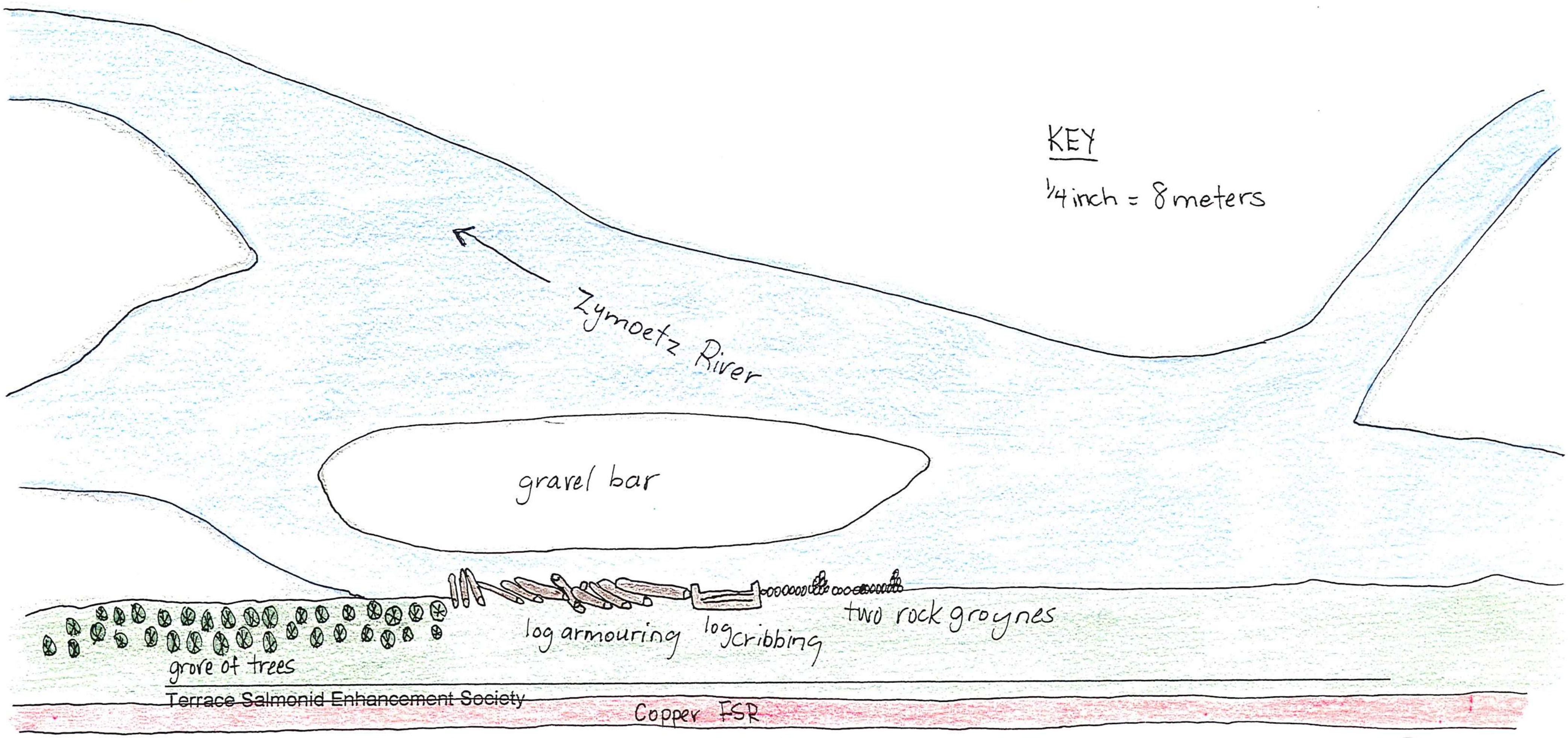
At the end of the cribbing, cable two or three clusters of logs in series to armour the lower bank. There are a number of cottonwood laying on the ground that can be used. They can be cabled to the lower log groyne, standing trees or a dead-man may be required (Figure 17).

Expected Benefits:
If this project is carried out it will reduce or stop the erosion and prevent further loss of the old growth timber, the riparian area, aesthetics and the threat to road destabilization. The spaces between the rocks below the water surface will provide habitat for juvenile salmonids.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	8	320	2560
Hydraulic Engineer	1 person	1	560	560
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	12	220	2640
Jr. Field Tech.	1 person	20	180	3600
Bookkeeper	1 person	0.5	180	90
Equipment:				
890 John Deere excavator	hour	20	133	2660
Moxy truck	hour	4	125	500
low bed	hour	4.5	105	473
front-end loader	hours	4	100	400
hand tools	days	4	10	40
chain saw	days	10	25	250
power winch	days	5	50	250
generator	days	5	50	250
drill	days	8	15	120
Materials:				
shot rock	cubic meter	60	10	600
cables, steel pins	at cost			200
Travel Expenses	at cost			1000
Transportation:				
4x4 crew cab	lump sum			1260
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	4	25	100
misc.	lump sum			500
			Total cost	17619
			GST	346
			Overhead and Administration (3%)	529
			Total Contract Value	18148

Figure 16: Conceptual drawing for proposed work at impact site 81.



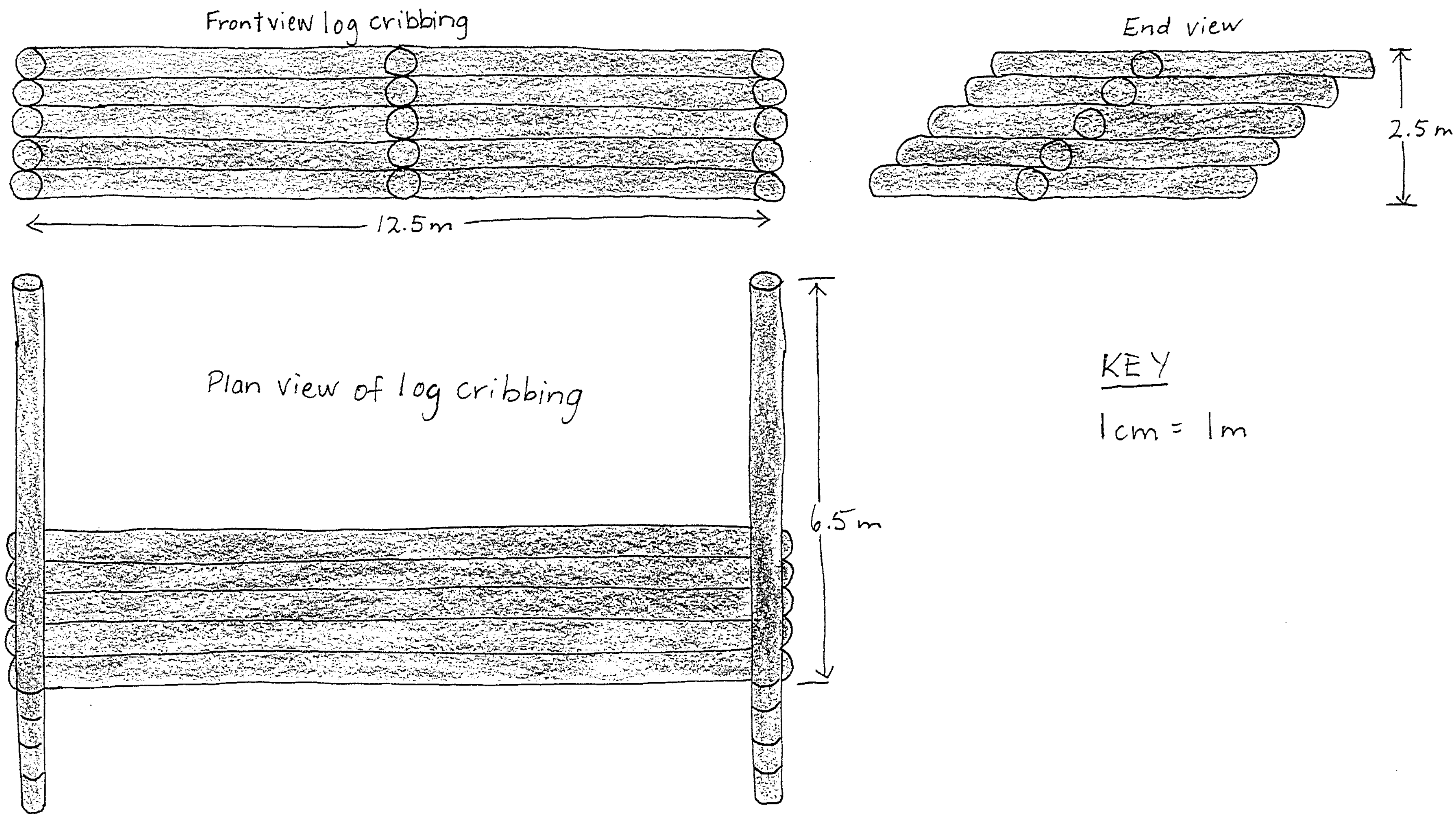


Figure 17: Conceptual drawing of log cribbing at impact site 81.

Impact Site 85A (UTM 9.5582.60351)

Location:
This side channel is in reach 5 on the south side of the Zymoetz River at 28.75 km on the south side of the Copper FSR. Access is by road.

Description of Site & Impact:
Construction of the Zymoetz River mainline has cut off this side channel to adult fish. The 1000 mm culvert at the exit of this site is 90% plugged by beaver debris according to Pollard et al. (1996) which was reaffirmed during a TSES field trip. The level I assessment showed a high algal content due to the area's minimal water flow. The channel has a length of 400 m and an average width of 10 m. The culvert end closest to the river is too high to allow water in or out except during high flows.

Data & Observations:
This site was found to have two trickling water sources: a ground water source on its east side and a surface flow on its south end. The culverts on either side of the FSR are plugged preventing water flow from the Zymoetz River (photo 37 and 38). The minnow traps checked on November 14, 1997 revealed a total of 19 coho and 1 char. The water is flowing through the porous shot rock at the end of the channel likely as a result of PNG reconstructing its pipeline. The relative abundance calculated is 0.83. The chart below represents the fork lengths of these fish.

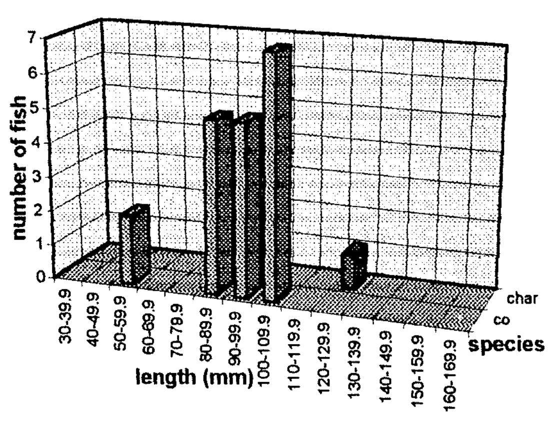


Figure 18: Fork length frequencies of the fish trapped at site 85A.

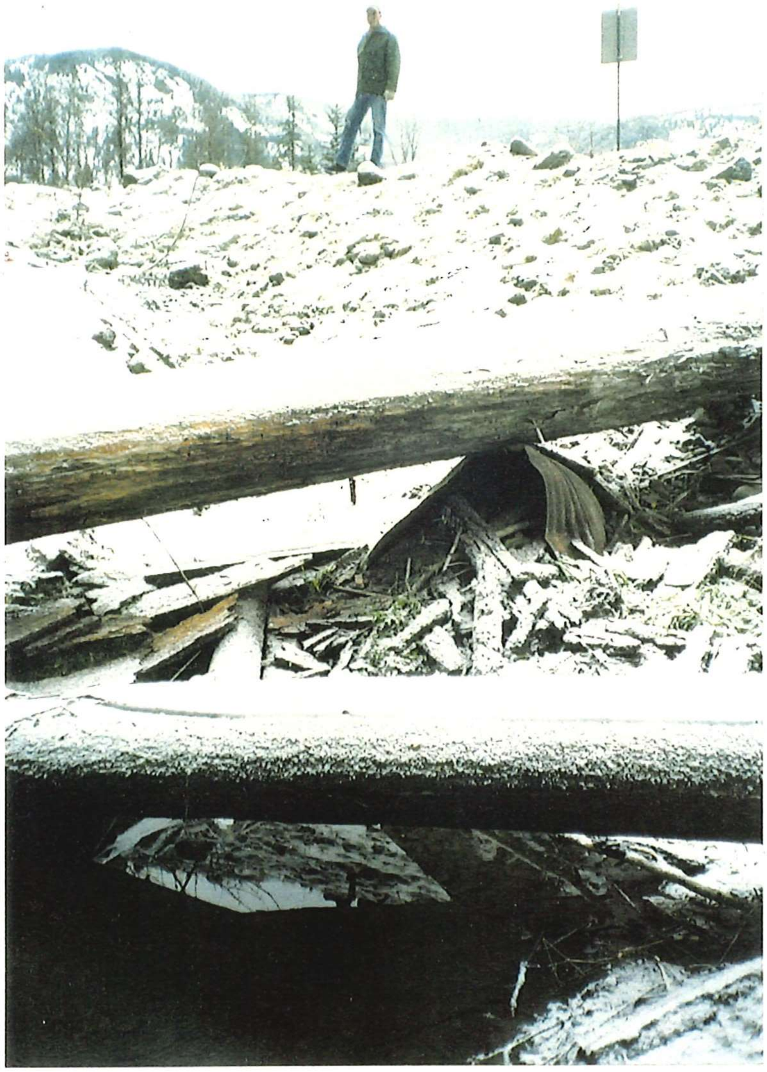


Photo 37: This plugged culvert provides no access to adult salmonids.

Photo 38: Side channel culvert in foreground provides no access for salmonids.

Prescription

Objective:
It is not possible for fish to migrate in or out of the channel because its water flow is draining from the pond through the shot rock that the road is built upon, rather than the culvert designed to handle the water flow.

The intent is to plug off the spaces between the rocks with finer materials containing clay that should prevent water flowing through the rocks.

After successfully getting the drainage water from the channel to flow through the culvert, there is the need to provide a stepped channel from the culvert to the river so that juvenile fish can migrate to and from the back channel.

Method & Materials:
Transport two or three dump truck loads of clay over burden from site 222 (clay slide on the Clore River) that is piled along the side of the road. This material needs to be spread across the rocks under water at the bottom end of the channel. An excavator is the most appropriate machine to spread the material under water. A cost saving can be made by using the excavator that is used for the work at site 81.

The inlet end of the culvert is badly bent and plugged up. The culvert needs to be bent back into its original round shape and that will require some ingenuity. A hydraulic jack and a coma-long are two tools that will be necessary. The excavator may be useful in reshaping the culvert and can be used to remove the debris that is cleaned from the culvert.

Prior to sealing the shot rock openings that will allow water to flow through the culvert draining water from the back channel there needs to be construction of a stepped channel from the river to the culvert. The rocks need to be stepped which is going to require chipping and shaping the rocks so that pockets or small pool areas are formed. For these steps to be water tight it is necessary to use concrete to seal the rocks while they are dry. Either gravel in the culvert or baffles hung from cables attached to the front of the culvert may be necessary to break the water flow so that juvenile salmonids may be able to swim back and forth through the culvert. While it is understood that concrete cannot normally be used for rehabilitation work, the unnatural road which is over 3 m above the river poses an impossible natural reclamation project. The height of the road prevents fish from entering the channel during normal flows of the Zymoetz River.

Expected Benefits:
By providing access for juvenile salmonids into this known rearing area that is fed by sub-surface water there will be a net increase in rearing habitat and over time in fish production.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	5	320	1600
Jr. Biologist	1 person	4	200	800
Sr. Field Tech.	1 person	10	220	2200
Jr. Field Tech.	persons	16	180	2880
Bookkeeper	1 person	0.5	180	90
Equipment:				
generator	days	2	50	100
490E John Deere excavator	hours	8	101	808
966 Caterpillar	hours	8	100	800
loader	hours	8.	80	640
tandem dump truck	days	2	50	100
power winch	days	2	25	50
chain saw	days	2	68	136
electric rock drill	days	8	10	80
hand tools	hours	5.5	95	523
low bed				
Transportation:				
4x4 crew cab	lump sum			850
Materials:				
redi-mix cement	at cost	10	8.29/bag	83
cable, steel pins	at cost			100
cement baffles	at cost			100
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	10	25	250
misc.	lump sum			200
			Total cost	12615
			GST	227
			Overhead and Administration (3%)	379
			Total Contract Value	13221

Impact Site 90 (UTM 9.5585.60353)

Location:
This side channel is located in reach 5 on the south side of the Zymoetz River at 29.5 km on the Copper FSR. Access via five minute walk along a trail that follows the PNG pipeline clearing.

Description of Site & Impact:
This side channel is 589 m in length (photo 39, 40 and 41). The presence of stumps in the wetted portion of the channel is evidence that this area has been affected by past logging practices. As well, beavers have negatively impacted the flow of water into the channel from a creek (Swan Creek) running across the road under a bridge located mid-channel (photo 42). Currently, the channel is mostly fed by sub-surface water that has a small flow year round. This creates more of a back water area than a functional side channel. The channel bed is composed of a mix of spawning size gravel and boulders and the channel banks provide some deciduous cover.

Data & Observations:
The presence of four 1997 coho redds were observed throughout the wetted sections of the channel. As well, 4 live and 2 dead spawning coho were visually observed. A total of 51 coho and 2 rainbow trout were trapped in the main channel on November 14, 1997. A pH reading of 8.0 was taken. The relative abundance at this site is 2.20. This provides further evidence that the potential for rehabilitation is high. The chart below represents the fork lengths of the fish caught at this site.

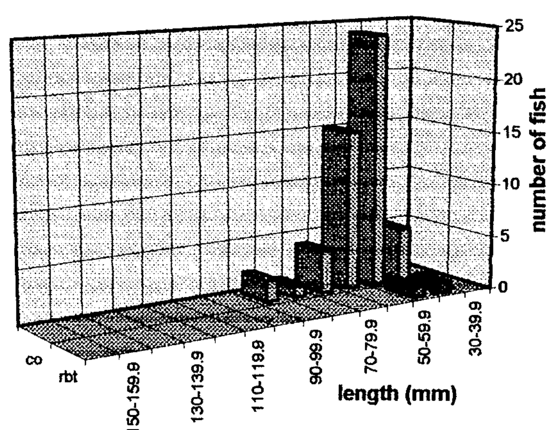


Figure 19: Fork length frequencies of the fish trapped at site 90.

Photo 39: Entrance of 29.5 Km side channel with Zymoetz River in foreground.

Photo 40: Just downstream from the entrance.

Photo 41: Just past the midway point of the side channel.

Photo 42: Mid-channel where Swan Creek joins with the side channel.

Prescription

Objective:
The goal is to establish a permanent sub-surface water flow into the channel that will allow adult salmonids to enter the channel during all seasons. Also, to improve the existing habitat and increase the amount of available habitat for both rearing and spawning salmonids. This habitat enhancement is focused on assisting the rebuilding of summer coho stocks which have been identified as one of the most depressed salmon species in the Skeena watershed. Steelhead, chinook, char and cutthroat may also benefit from this work. In addition, the intent is to stabilize this side channel by blocking off the river water flow which will protect it from major Zymoetz River flood events.

Field trips over the winter, during the period of lowest river water levels showed sub-surface water flows until the end of March 1998 when the last field trip was taken.

Method & Materials:
The work will be broken into two phases (Figure 20):

PHASE 1
The proposal is to walk an excavator, via the PNG right of way beginning at 29.5 km on the Copper FSR, to the top of the channel just upstream of where Swan Creek enters the channel. A test excavation is to be carried out in the dry channel to determine if sub-surface water is available in sufficient quantities for the channel development (a small natural flow currently exists that provides enough water for adults to migrate through to almost the top of the channel and for juveniles to rear in the top pool). If sub-surface water is available, the excavation needs to be enlarged to provide the desired flow for the channel (the flow rate will be determined by DFO and/or an experienced Fisheries Engineer).

PHASE 2
If it is decided to go ahead with the project, it will be necessary to provide permanent and easy access to the site, the field crew will need to brush out a roadway and the excavator will scrape and level out the rough spots. The road will be of sufficient quality that Moxy dump trucks hauling shot rock can negotiate.

Following excavation of the sub-surface water test channel which should be temporarily bermed off, construct a series of spawning riffles and pools using rock dams and upstream vees to hold back graded gravel that will provide a substrate suitable for spawning coho, with additional complexing of the channel using LWD and rocks to create shade and shelter (see Appendix IV for rock vee construction). If there are not enough large rocks at the site, a load will have to be trucked into the channel.

The excavator should be used to trench openings in the channel for the rocks to form the vees and, in turn, place the rocks in the openings. The vees will be placed four to six channel widths apart. The gravel will be graded by the crew at various locations along the channel and placed by the excavator in front of the vees or dams. The substrate excavated from the new channel needs to be trucked to the top of the old channel to form a protective berm. The berm needs to be built to the height of the banks and armoured with shot rock or alternatively a double wall log cribbing should be constructed using cedar logs from the log jam or trucked in from some of the other locations where LWD has built up on the gravel bars.

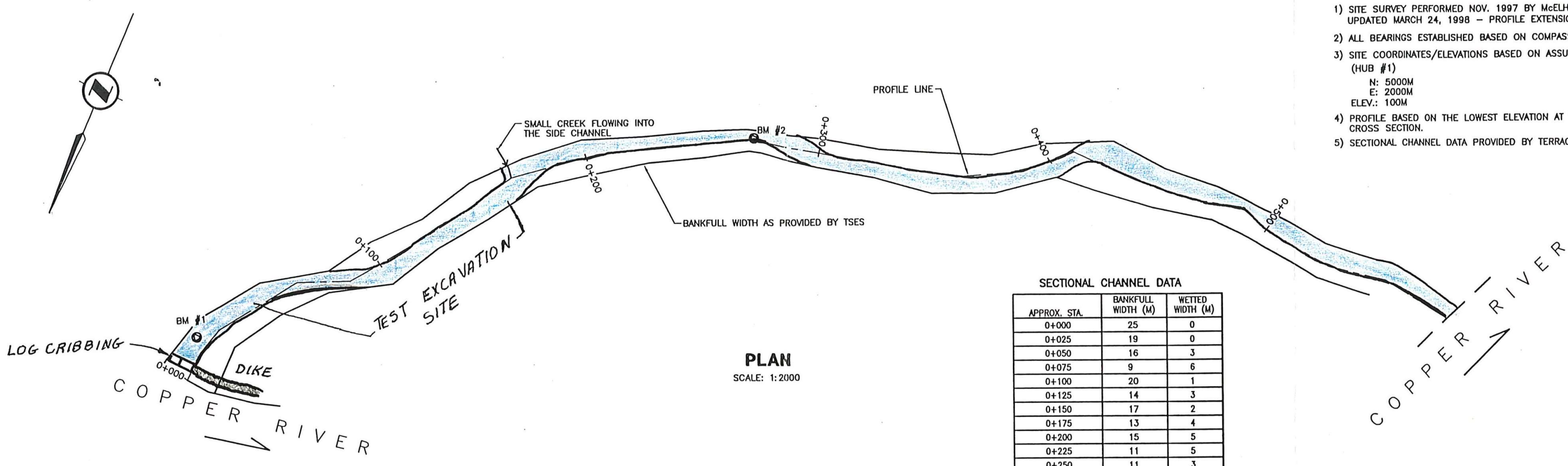
Expected Benefits:
This site has the potential to produce many coho salmon or at least significantly more than has spawned in this area over the past 30 years. If this project successfully taps a sufficient flow of sub-surface water and the spawning and rearing riffles, pools and complexing for shade and shelter are constructed according to the plan, this side channel will be a coho producer.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	7	320	2200
Sr. Biologist	1 person	2	440	880
Jr. Biologist	1 person	4	200	800
Sr. Field Tech.	1 person	17	220	3740
Jr. Field Tech.	persons	30	180	5400
Bookkeeper	1 person	1	180	180
Equipment:				
490E John Deere excavator	hours	48	101	4848
Moxy dump truck	hours	16	125	2000
loader	hours	16	95	1520
chain saw	days	15	25	375
power winch	days	5	50	250
low bed	hours	5.5	95	523
hand tools	days	15	10	150
generator	days	10	25	250
power tools	days	10	25	250
Travel Costs	at cost	2		750
Transportation: 4x4 crew cab	lump sum			1241
Materials: cables, steel pins sand bags, filter cloth, misc.	at cost			500
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	17	25	425
misc.	lump sum			500
			Total cost	27007
			GST	712
			Overhead and Administration (3%)	810
			Total Contract Value	27817

GENERAL NOTES

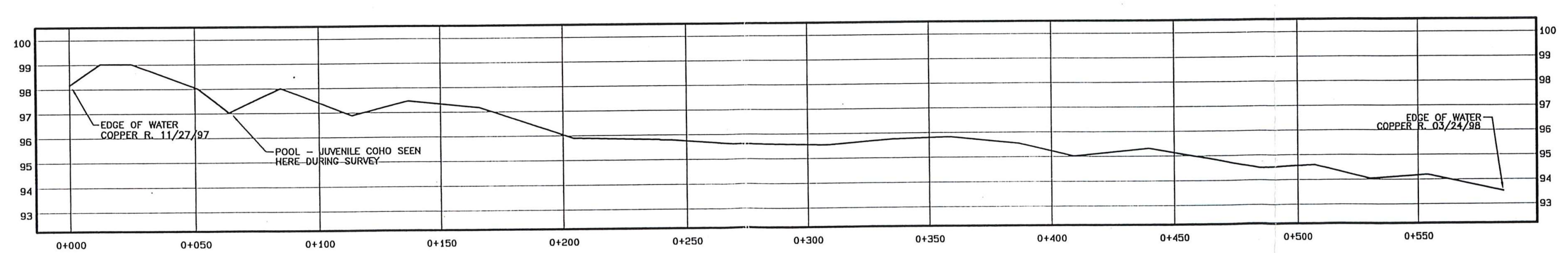
1) SITE SURVEY PERFORMED NOV. 1997 BY McELHANNEY CONSULTING SERVICES LTD. UPDATED MARCH 24, 1998 – PROFILE EXTENSION
2) ALL BEARINGS ESTABLISHED BASED ON COMPASS ASSUMING 0° DEC.
3) SITE COORDINATES/ELEVATIONS BASED ON ASSUMED REFERENCE POINT (HUB #1)
   N: 5000M
   E: 2000M
   ELEV.: 100M
4) PROFILE BASED ON THE LOWEST ELEVATION AT THE PARTICULAR CHANNEL CROSS SECTION.
5) SECTIONAL CHANNEL DATA PROVIDED BY TERRACE SALMONID ENHANCEMENT SOCIETY.



PLAN
SCALE: 1:2000

SECTIONAL CHANNEL DATA

APPROX. STA.	BANKFULL WIDTH (M)	WETTED WIDTH (M)
0+000	25	0
0+025	19	0
0+050	16	3
0+075	9	6
0+100	20	1
0+125	14	3
0+150	17	2
0+175	13	4
0+200	15	5
0+225	11	5
0+250	11	3
0+269.8	9	4
0+275	9	7
0+300	12	10
0+325	12	10
0+350	17	4
0+375	16	4
0+400	15	4
0+425	22	2
0+450	17	2
0+475	14	3
0+500	14	3
0+525	15	5
0+550	–	2



PROFILE
SCALE: 1:2000 HOR.
1:200 VER.

NO.	DATE	REVISION LIST	BY

McElhanney

McELHANNEY CONSULTING SERVICES LTD.
Suite #1–5008 Pohle Avenue, Terrace, B.C., Canada, V8G–4S8
Tel: (250)–635–7163, Fax: (250)–635–9586

TERRACE SALMONID ENHANCEMENT SOCIETY
ZYMOETZ (COPPER) RIVER
29.5KM SIDE CHANNEL
SITE 90 - PLAN / PROFILE

SURVEYED: [signature]
DESIGN: [signature]
DRAWN: [signature]
CHECKED: [signature]
SCALE: AS NOTED

DATE: APRIL 1998
FILE: 2321-00391-0
TASK: 2001
DRAWING No.: 29KM
REV.: 1

Figure 20: Center line survey and work proposed at impact site 90.

Impact Site 94 (UTM 9.5596.60355)

Location:
This channel (Warner Spring) is located in reach 5 on the south side of the Zymoetz River at 31 km on the Copper FSR. Access via short drive on secondary road just before 31 km sign on the Copper FSR.

Description of Site & Impact:
This 546 m side channel has been completely blocked to adult salmonids at least this year, by beaver activity. There are two major beaver dams in the area: one within the channel and a second at the bottom end of the main channel.

Data & Observations:
On November 14, 1997, a minnow trap located in the channel: one upstream above the in channel dam at the bottom of the channel (reach 1) revealed 51 juvenile coho. A trap found below the same dam (reach 2) contained 8 juvenile coho and 5 char (photo 43 and 44). This channel provides a substantive amount of vegetative cover for shade and shelter. The relative abundance at this site is the highest overall of all the sites sampled during this study at 2.4. A redd from an previous season was observed above this dam. The dam at the end of the channel is completely impassable to adult fish except, possibly, during very high flows. It is approximately 25 m wide and contains four small streams flowing from it directly into the Zymoetz River. A pH of 9.1 and 8.4 were recorded. The chart below displays the fork lengths of the fish captured at this site.

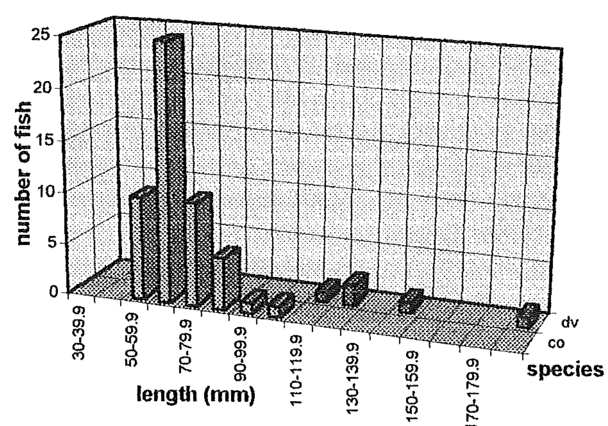


Figure 21: Fork length frequencies of the fish trapped at site 94.

Photo 43: Beginning of channel, sub-surface water flow.

Photo 44: Mid-channel below second in stream beaver dam.

Prescription

Objective:
The plan is to provide access for coho salmon, steelhead and char into the channel; increase the flow of sub-surface water into the channel to prevent the lack of water flow out of the channel during the late winter period when the Zymoetz River is very low and the channel outflow becomes sub-surface, as well, the intent is to increase the amount of useable gravel substrate for spawning and rearing habitat for juvenile salmonids.

Method & Materials:
It is anticipated that the flow can be increased by deepening the upper most step of the existing channel complex where there is free flowing water by about 1 m, widening the channel to approximately 5 m and extending the widened channel for its full length.

An excavator of the John Deere 490E class is the appropriate size because of its ability, as a relatively small machine, to maneuver between trees while, at the same time, being capable of moving a substantial amount of material and spreading it, appropriately along the east bank or creating a berm above the excavation (Figure 22).

A crew of three will be required for brushing out a road way for the excavator, cleaning branches and small woody debris from the channel, raking and smoothing out gravel, planting juvenile conifers along any new exposed bank or where the excavator has disturbed the natural landscape and final touch up where the beaver dams were removed.

A low level beaver dam at the outlet and a dam covering half the channel further upstream need to be removed. With a greater flow in the channel, the beavers may decide not to rebuild. If they do, there are three options provided to allow adult and juvenile salmonids to migrate above the dams.

OPTION 1 (Figure 23)
Create an opening on top of the dam where the water in the pond has the greatest depth. It is accepted that the beavers in the pond will quickly block off the opening unless something is constructed that will discourage them from patching it up. Previous experimentation on Hotsprings Creek, a tributary to Lakelse Lake a protective chicken wire cage was constructed around an opening in a beaver dam (Culp, 1981). The cage was a half round protective device that was reinforced with stiff wire that provided rigidity and extended out from the dam about 0.75 m. The height of the cage was about 1 m with approximately 30 cm above the water surface and the remaining 70 cm down into the water column but not touching the bottom of the pond. The cage was shaped so that it was flush with the dam underwater and the portion of the dam above the water. The cage extended over the dam at both ends and was held in place by reinforcing rod pounded into the back of the dam. The cage remained in place for more than a month, during that time the beavers made no attempt to block it off partly because the water

level in the pond dropped only a very small amount and it was impossible for the beavers to block off the cage without constructing a new dam.

For this prescription a cage could be constructed from 3/8" (1 cm) solid aluminum rod and welded together. Its size should be 1 m high, 1 m wide and 50 cm deep from the base to the outside of the half circle.

It is likely that some digging into the pond bottom will be required where the cage is located so that there is at least 25 cm between the pond bottom and the cage.

OPTION 2
The second option is a variation of the first, the difference being that rather than having an opening in the dam, a culvert or pipe is installed about 40 cm in diameter. The culvert or pipe should extend as far as the half circle cage with a slotted opening from the end of the pipe for 50 cm and about 15 cm wide. Two or more slots about 2 cm wide by 6 cm long should be cut as vertical slots that would be next to the dam which would allow juvenile salmonids to swim out of the pond if they cannot find the opening in the pipe. Some experimentation will be required as far as providing openings in the pipe so that coho or steelhead smolts can find and use the openings. Any openings within the pipe have to be just below the surface.

OPTION 3 (Figure 24)
The third option is to use the culvert technology but rather than having a half circle cage for keeping beavers out, make a rectangular cage from aluminum rod. With this option the length of the culvert can be altered so that it is flush or close to flush with the dam allowing juveniles to easily move out of the pond. The shorter culvert option could be applied to option 2.

For all three of the options to work, the water flowing out of the culverts or over the dam must be accessible for migrating juvenile and adult salmonids. The channel that the water is flowing through must be stepped, in a sense creating a fish ladder to the outlet. A variety of methods can be used to achieve this, for the bottom dam it is likely that stepping the gravel substrate with larger rocks in the shape of an upstream vee as well as lining the edges of the channel with larger rocks to increase its height as much as possible. If these channel steps are not high enough it will be necessary to construct one or more wood or concrete boxes with slotted ends for the water to flow through.

<u>Expected Benefits</u>:
There is a high probability that if juvenile and adult salmonids can move freely back and forth through the Warner Spring habitat and from the Zymoetz River to the spring water there will be a substantial increase in a fish production, particularly summer coho production in one of the potentially most desirable off channel habitats in the watershed.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/day)	Cost ($)
Project Manager	1 person	5	320	1600
Sr. Biologist	1 person	2	440	880
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	10	220	2200
Jr. Field Tech.	persons	20	180	3600
Bookkeeper	1 person	0.5	180	90
Equipment:				
chain saw	days	10	25	250
power winch	days	2	50	100
John Deere 490E excavator	hours	32	101	3232
low bed	hours	4.5	95	428
Transportation:				
4x4 crew cab	lump sum			860
Travel Costs	at cost	2		1000
Materials:				
cables, steel pins	at cost			100
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	10	25	250
misc.	lump sum			200
			Total cost	15787
			GST	281
			Overhead and Administration (3%)	474
			Total Contract Value	16542

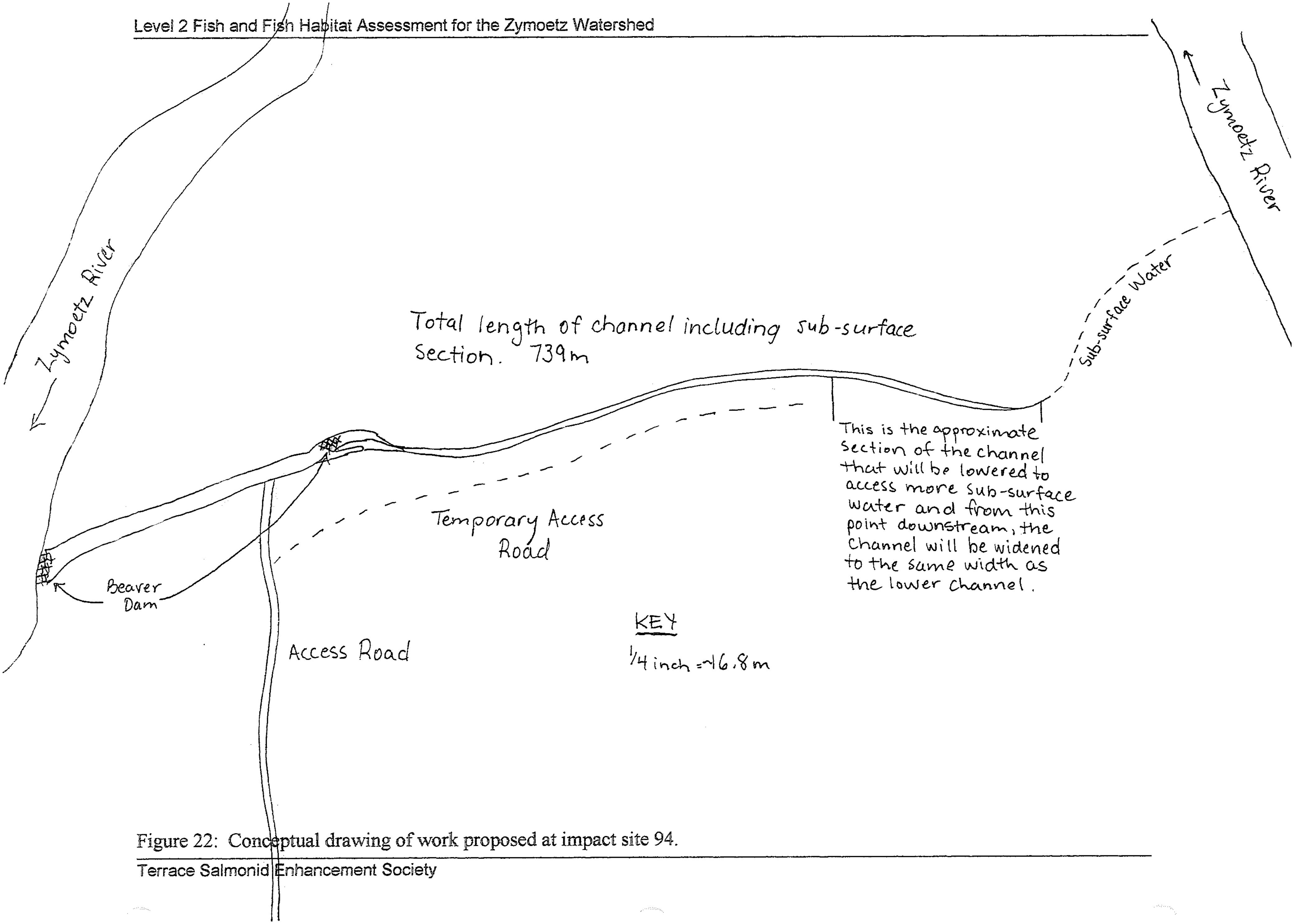
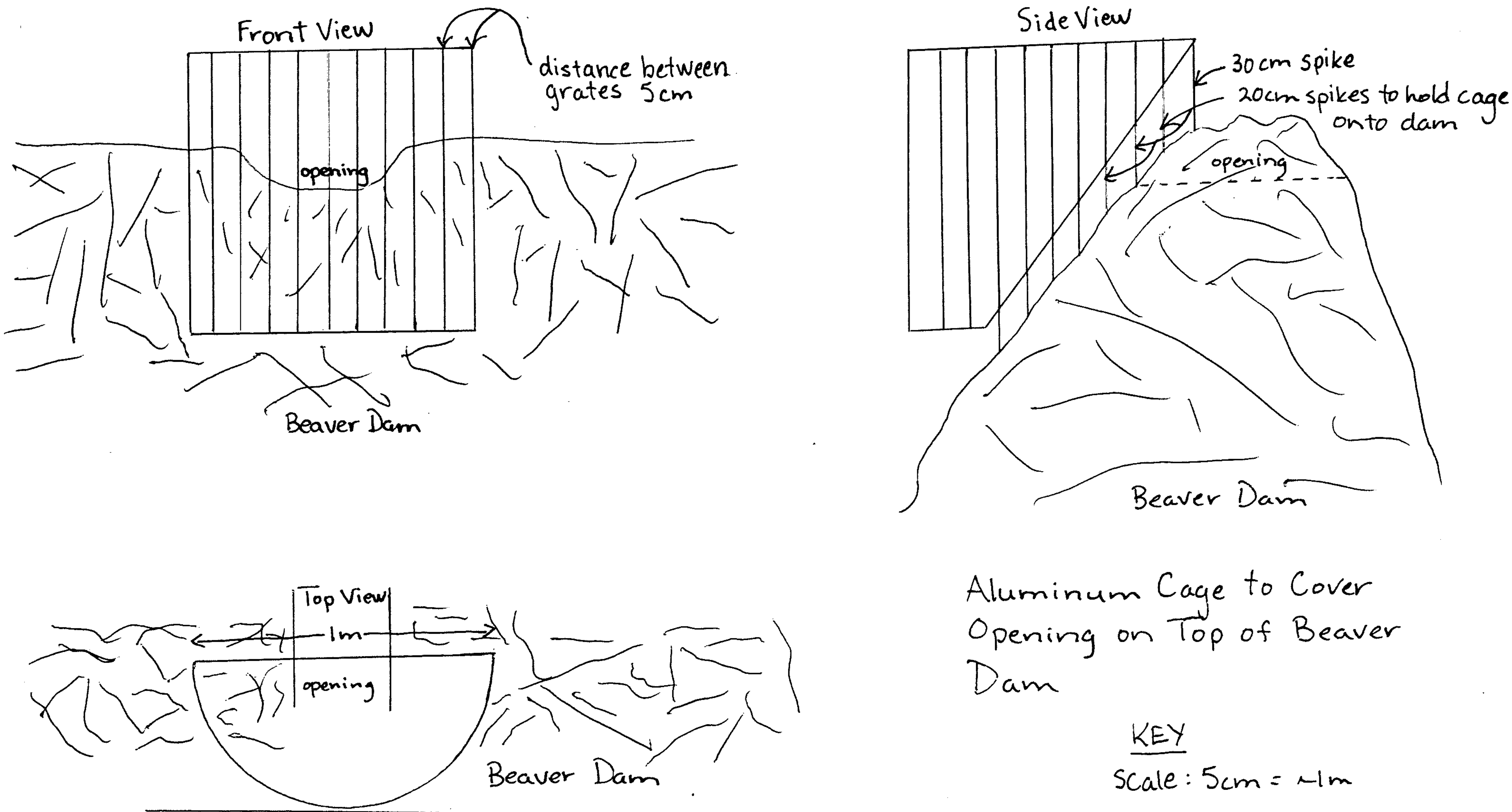


Figure 22: Conceptual drawing of work proposed at impact site 94.

Figure 23: Conceptual drawing of proposed round cage for impact site 94.



Option 3 : Culvert installation through dam with a rectangular cage covering the end of the pipe

The cage would be constructed from welded aluminum rod 1 cm diameter with an adjustable foot.

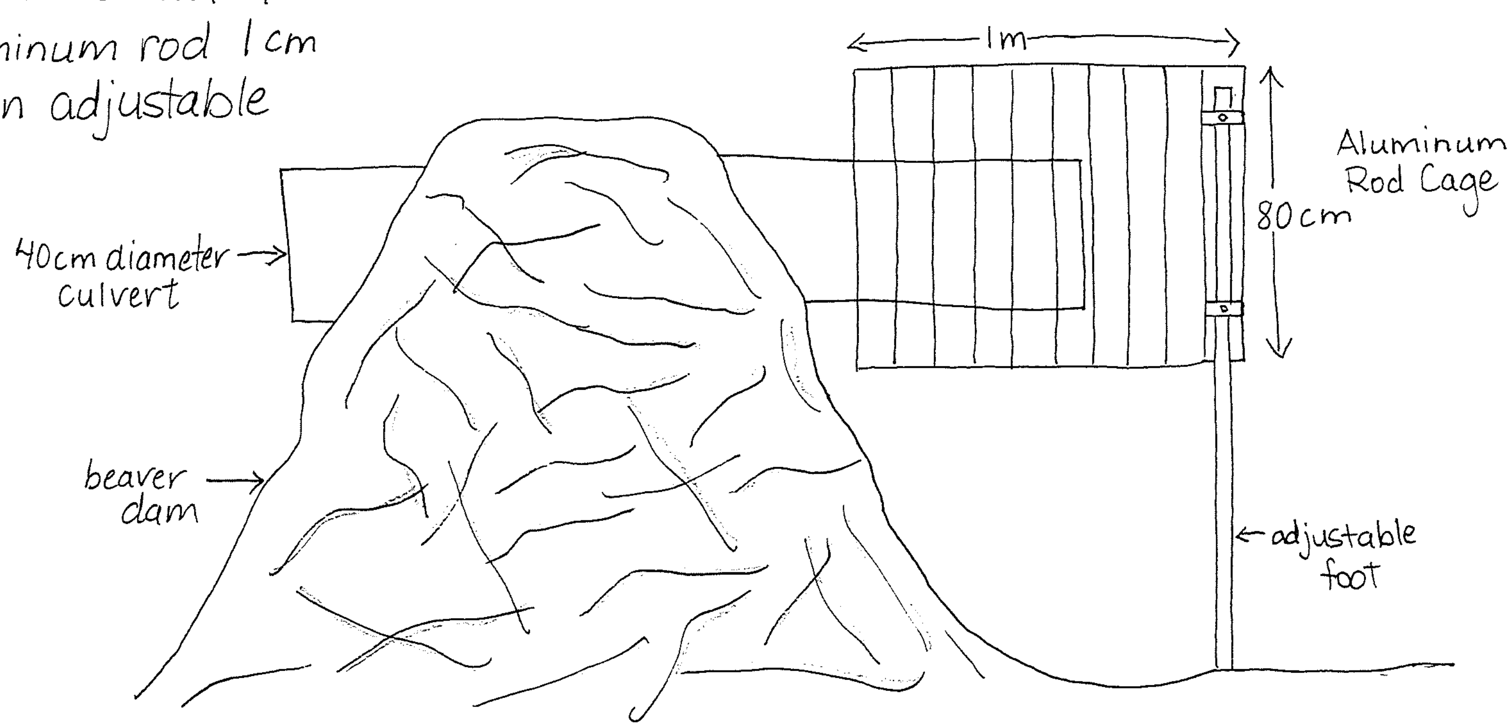


Figure 24: Conceptual drawing for proposed rectangular cage at impact site 94.

Impact Site 95 (UTM 9.5587.60352)

Location:
This creek (Swan Creek*) is located within reach 5 on the south side of the Zymoetz River between 30 km and 32 km on the Copper FSR. Access is by road.

Description of Site & Impact:
This creek has two main reaches. The first is a number of sections on either side of the FSR consisting of mostly dammed pools. The second is a steep section, upstream, where the original flow has been partially diverted into roadside ditches by the alluvial fan at the bottom of the steep gully (photo 45 and 46). There is a total of 11 beaver dams of various size throughout this creek's 2+ km length which have also contributed to its flow diversion (photo 47 and 48). The vegetation surrounding this stream consists of about 60% sitka spruce, 20% western hemlock and the remaining 20% is a mixture of young subalpine fir, cottonwood, sitka alder, willow and red osier dogwood. There is no flowing water in Swan Creek below the fluvial fan (photo 49).

Data & Observations:
One minnow trap was set on either side of the road; no fish were caught. One possible reason for lack of juveniles on the south side of the road was the presence of four large char spawning in the gravel each 30 to 40 cm long. A second factor could be that the beaver dam on the north side is impassable or a culvert could be blocked. The trap on the north side was set below the beaver dam. A trap set under the 30 km bridge revealed 1 cutthroat, with a fork length of 120 mm, on November 14, 1997. There were two spawning char observed on the north side of the FSR. The relative abundance calculated here is 0.04. There is extensive evidence of past logging throughout this stream. Examples include large stumps within the wetted portions, clear-cut areas adjacent to the stream and live trees within the creek suggesting flow diversion. Logging damage including the road construction and maintenance has been extensive. During the field trip on March 9, 1998, no water was flowing through the creek channel and most of the beaver ponds had dried up. The water flowing through the alluvial fan was flowing into a logging spur road ditch and draining away into the gravel substrate.

Photo 45: Alluvial fan caused by debris torrent, water flowing into ditch.

Photo 46: All of Swan Creek flowing into ditch.

Photo 47: Water flow into ditch stopped by small beaver dam.

Photo 48: Ditch dry below dam.

Photo 49: Swan Creek below alluvial fan, no flowing water in creek.

Prescription

Objective:
There are a number of problems with this creek, the most serious is that the lower section between the Copper FSR and the 29.5 Km side channel (site 90) dries up during the late summer, early fall and late winter even though there is water flowing in the upper creek and from a tributary creek. The primary objective is to do everything possible to maintain flow of water through the entire creek. Along with any in stream work, there is the need to determine if the loss of water is the result of the large expanse of pond area created by the beaver dams and the evaporation factor or is much of the water coming off of the mountain draining away from the creek into porous ground. After either 1991 or the 1992 flood, the upper creek blew out an enormous amount of material into a fan that the creek now flows through during, low water periods all the flow diverts away from the middle of the fan and into a side ditch with all the water lost into the porous gravel of the ditch before it joins with the creek. An excavator will trench out a new channel through the fan that will be shaped as much as possible like the original channel with tapered banks and a natural contoured shape. As well, the channel from the fan to an old spur road needs to be cleaned up and reshaped because it is a tangle of logs and other woody debris along with a massive growth of red osier dogwood in the channel. Further evaluation and monitoring of the entire creek complex is required to decide what, if anything, should be done with it.

Method & Materials:
In an effort to slow the creek velocity upstream vees need to be constructed (see Appendix IV for rock vee construction). These would be somewhat experimental to see how well they will work. The vees would be constructed from the substantial amount of large rocks in the fan using an excavator. Because of the velocity of flood flows down the chute, the rocks must be well anchored meaning more than 1/2 of the rock is buried into the substrate. As with vees proposed for the other sites these vees would have smaller rocks fitted behind the anchor rocks and gravel which can be used for spawning placed upstream of the vees for a distance of about 2 m. The distance between the vees should be about four to six times the wetted channel width. The toe of the new banks need to be armoured with large creek rocks or shot rocks that would be placed by the excavator (Figure 25). If this work can get under way before there is an increased flow of water in the channel while the beaver ponds are dry, the dams and organic material below the fan should be scraped onto a pile and stock piled onto the side of a future channel.

Additional complexing of the rehabilitated channel with rocks and LWD as per descriptions for other steep sites (site 37B) is recommended.

There is a need to reconstruct the channel in the flats as far as the spur road, 339 m downstream and beyond until the beaver ponds are reached (another 100 + m). It is overgrown with red osier dogwood and clogged with woody debris from previous logging activity. This work would have to be done with an excavator to shape and clean the channel. Some manpower is required to assist in complexing the rehabilitated channel. This first stage of rehabilitation will make a big difference but it would be wise to monitor the results of the work over one complete season before embarking upon a second phase. There is the likelihood that more work will be required in this complicated mix of channels, beaver ponds and dams, roads and the steep torrented upper section. Most of the changes to the integrity of this creek are the direct result of logging. The exposed rock and gravel banks should be covered with the organic material from the dry reclaimed beaver ponds and grass seeded and planted with conifers.

Expected Benefits:
Swan creek is currently a negative factor in anadromous fish production because of the annual loss of water flow in the lower creek and the resultant mortality of juvenile salmonids trapped in the pools that dry up.

If the prescription is successful in providing a continuous annual flow of water throughout the length of the creek, juvenile salmonids will be able to survive and eventually recolonize the rehabilitated habitat.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	5	320	1600
Jr. Biologist	1 person	5	200	1000
Sr. Field Tech.	1 person	12	220	2640
Jr. Field Tech.	persons	20	180	3600
Bookkeeper	1 person	0.5	180	90
Equipment:				
small bulldozer	hours	16	90	1440
490E John Deere excavator	hours	40	101	4040
power winch	days	8	50	400
chain saw	days	10	25	250
hand tools	days	10	10	100
low bed	days	4.5	95	428
Moxy dump truck	hours	8	125	1000
Transportation:				
4x4 crew cab	lump sum			1152
Materials:				
shot rock	cubic meter	60	10	600
cables, steel pins	at cost			100
grass seed	at cost			100
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	12	25	300
misc.	lump sum			500
			Total cost	19565
			GST	536
			Overhead and Administration (3%)	587
			Total Contract Value	20688

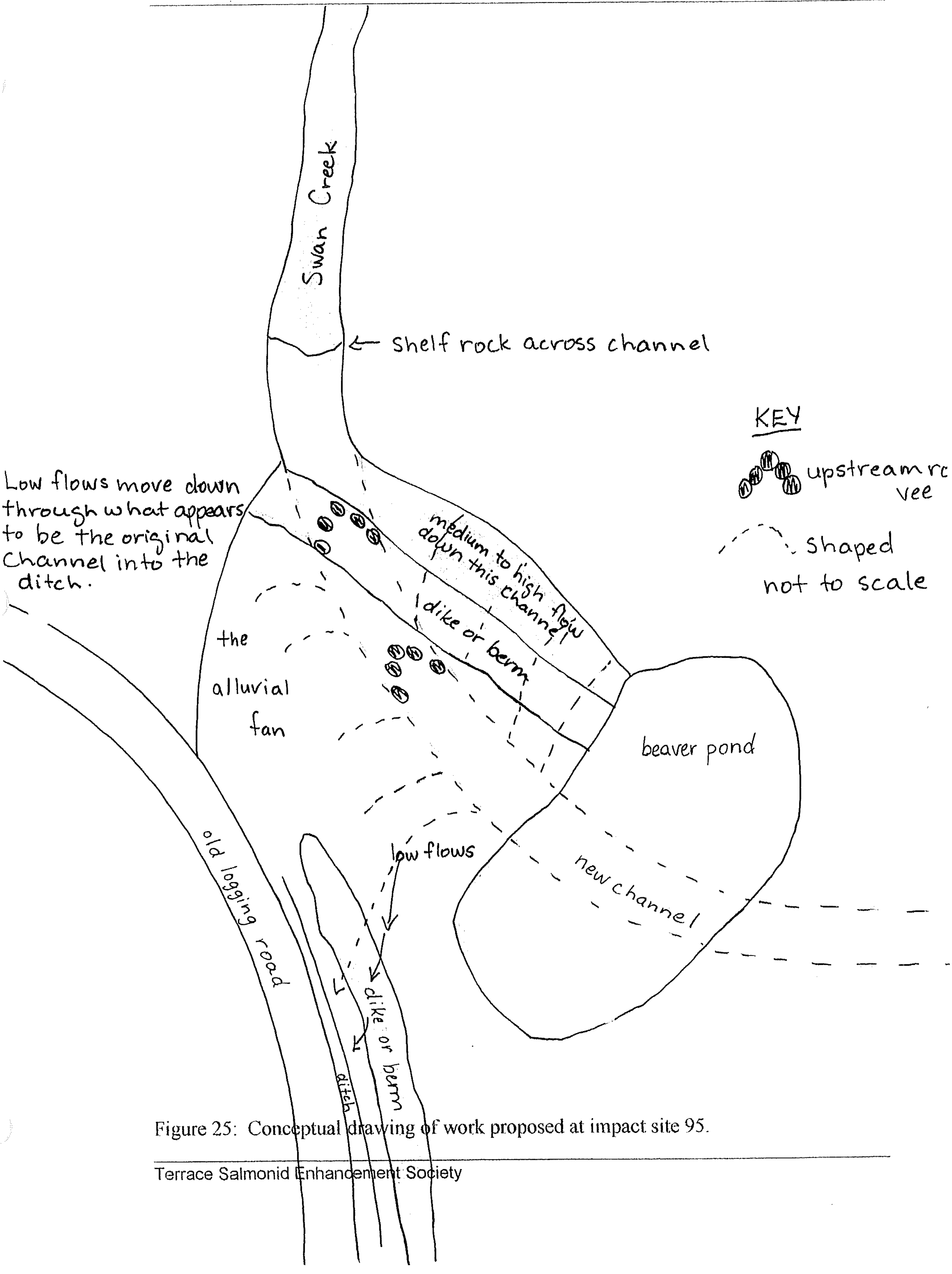


Figure 25: Conceptual drawing of work proposed at impact site 95.

Impact Site 97 (UTM 9.5607.60349)

Location:
This side channel is found in reach 5 on the north side of the Zymoetz River opposite to 32 km on the Copper FSR. Access is by boat from the west side and Copper FSR.

Description of Site & Impact:
This side channel originates from a break through from an inside bend of the Zymoetz River about 0.75 km from its outlet. There is only seepage flow in the channel that is surrounded by both coniferous deciduous vegetation for shade and shelter (photo 50).

Data & Observations:
On November 26, 1997 there was water in the channel's lower one half with only seepage water flow.

Photo 50: The vegetation surrounding this channel would provide substantial shade and shelter for rearing fish if they had access to the channel.

Prescription

Objective:
There is excellent potential to establish a controlled flow of ground or surface water into this channel site. There is only seepage water into the channel during normal Zymoetz

River water flows. Very high flood waters (1978 flood) have previously flowed through the channel.

This report is not putting forward a prescription for development but recommends that this site be analyzed in more detail to determine if habitat rehabilitation or enhancement should be carried out. This should be completed by the TSES at the same time as additional assessment is taking place with other sites, for example, the Clore River Slide.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/day)	Cost ($)
Project Manager	1 person	3	320	640
Sr. Biologist	1 person	2	440	880
Jr. Biologist	1 person	2	200	400
Sr. Field Tech.	1 person	2	220	440
Bookkeeper	1 person	0.25	180	45
Transportation: 4x4 crew cab	lump sum			210
Travel Costs	at cost	2		1000
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 2 	 25 	 100 50 50 100
			Total cost	3915
			Overhead and Administration (10%)	392
			Total Contract Value	4307

Impact Site 99A (UTM 9.5615.60346)

Location:
This channel is located in reach 5 on the south side of the Zymoetz River between 33 km to 34 km on the Copper FSR. Access via Old Copper FSR turn off just before 33 km sign on the Copper FSR.

Description of Site & Impact:
This is a large channel 660 m in length with an average of a 3% gradient. The wetted portion, within reach 1, consists of mainly cobbles and boulders along with occasional pockets of gravel (photo 51 and 52) and the dry portion is in reach 2 (photo 53). The source of flow into the wetted channel is a small stream (Doll Creek) that enters approximately 200 m upstream from the Zymoetz confluence. This entrance appears to be impassable to juvenile and adult fish. As well, Pollard et al. (1996) notes that the entire riparian zone was logged resulting in the non re-vegetation of some sections of the bank. The primary impact was from the 1992 flood that broke through at site 103 altering the habitat throughout the length of the channel, depositing sand and sediment, but also opening the outlet of the channel into the Zymoetz River and providing access for adult and juvenile salmonids.

Data & Observations:
Upon the examination of this side channel, it is apparent that a large amount of sediment (characterized by red film) exists upon the rocks and in the water. In agreement with Pollard's Level 1 assessment findings (1996), this channel was found to have good areas of habitat for over-wintering and rearing. This is confirmed by the minnow trapping results of November 14, 1997, resulting in a diversity of fish: 16 coho and 1 juvenile rainbow, and 3 large char. The relative abundance here is 0.85. A pH of 8.4 was recorded. The chart below displays the fork length frequencies for these fish.

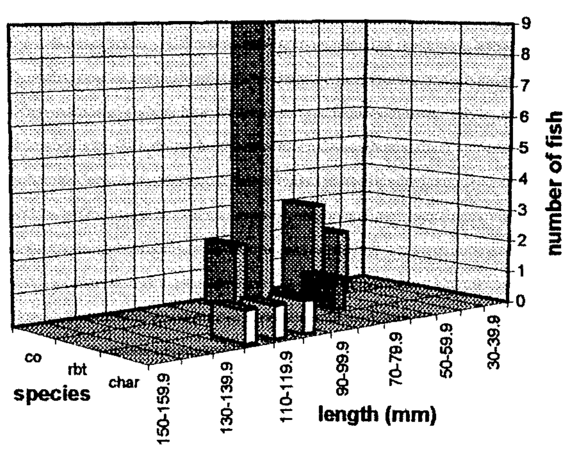


Figure 26: Fork length frequencies for fish trapped at site 99A.

Photo 51: Looking up the channel from the washed out bridge.

Photo 52: Upstream around the corner from the confluence with Doll Creek.

Photo 53: Dry section of side channel (confluence with site 103).

Prescription

Objective:
This channel, while relatively productive, will benefit from changes in its structure and make-up from the point at the old mainline FSR bridge to its confluence with Doll Creek. Excess sand needs to be removed or washed downstream to expose the gravel substrate and the many large boulders need to be regrouped to form rock dams or vees so that gravel pads and pools can be formed. Upstream of the bridge the sand problem is not an issue but the reshaping of the habitat is necessary to form a more natural pool-riffle combination rather than the flat, open expanse which lacks shelter, shade, spawning areas and only a couple of pools at the upper end.

Method & Materials:
From the confluence with the river to the old bridge one upstream vee should be constructed from the boulders in the channel, at about the center of the bridge and above the bridge, another two or three vees spaced about four to six channel widths apart. Gravel from the old road is one source of gravel substrate for spawning pads, it would have to be graded to remove oversize rocks and woody debris.

For the upstream section of the channel, the same upstream vee construction using the in stream boulders, spaced about four to six channel widths apart with spawning riffles or pads taking up about one half of the distance between the vees (Figure 27).

Shade and shelter need to be established throughout the length of the channel using LWD. Because the flow in the channel is not likely to ever be very substantial, there is no need to cable the logs. Key logs should be dug into the substrate with others tangled amongst them so that they will remain in place. If any root wads are available their trunks should be placed into a trench perpendicular to the channel flow and covered over with the excavated over burden (Figure 27).

A John Deere 490E track-type excavator and a crew of three will be required to carry out this in stream work.

On the south-east side or Clore River side of the channel, the riparian zone for much of its length lacks any mature tree species. It is primarily made up of grasses, sedges and brush species. It should be planted with cedar, hemlock and spruce at a less dense spacing than typical commercial forests (spaced about 2 m apart).

Expected Benefits:
No sign of adult coho, steelhead or char have been seen at this site. The establishment of spawning pads, the consolidation of water flow into a more confined channel and greater productivity should evolve into the recolonizing of a coho population into this channel. Either through the ability to rear more juveniles which migrate into the channel or in combination with adult spawners, this habitat rehabilitation will result in a net increase in salmonid production. Should sub-surface water be accessed at impact site 103, the increased water flow through this channel will provide considerable potential for summer coho production and likely some benefit for steelhead, char, cutthroat and possibly chinook salmon.

Cost Breakdown:
See impact site 103.

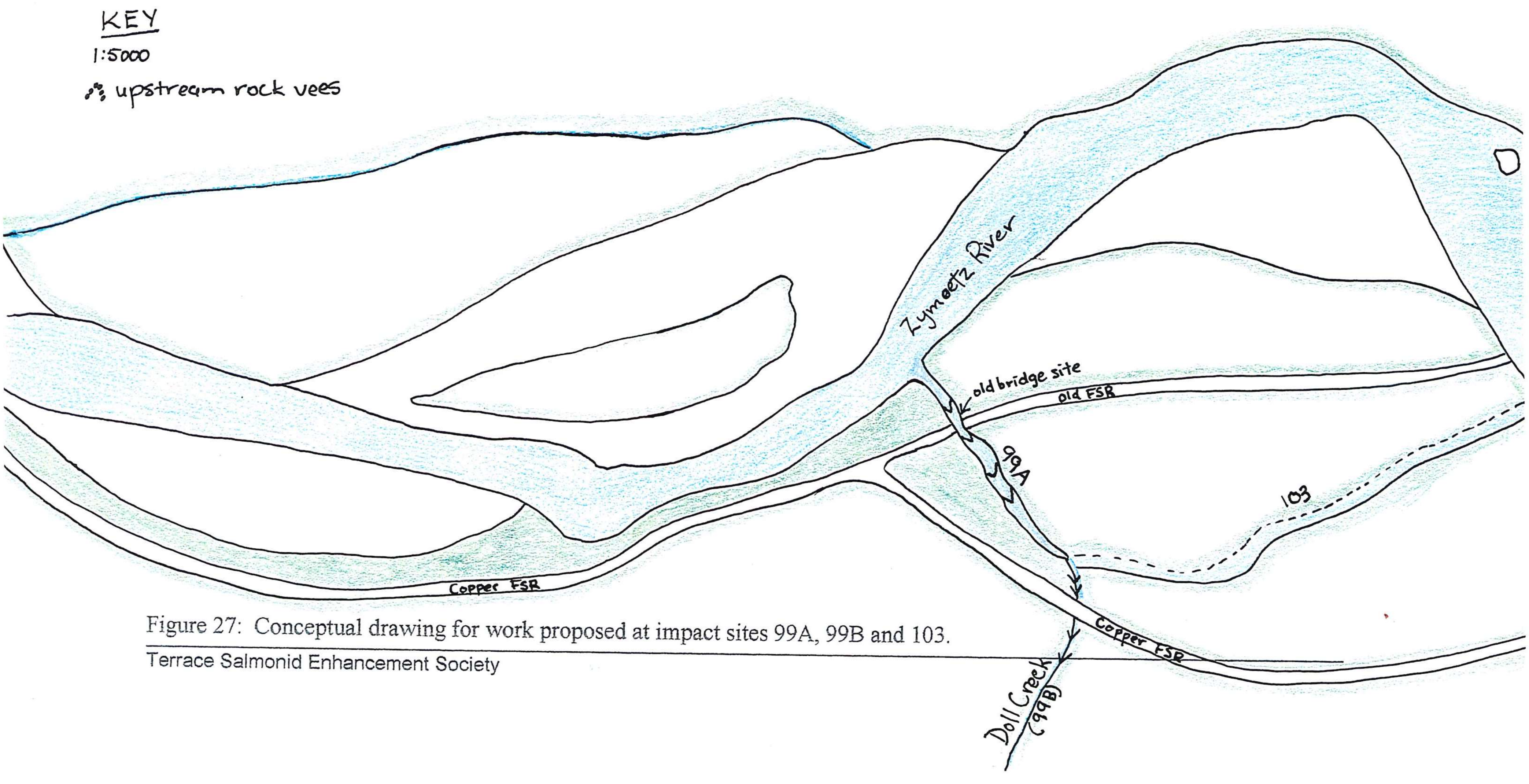


Figure 27: Conceptual drawing for work proposed at impact sites 99A, 99B and 103.

Impact Site 103 (UTM 9.5618.60346)

Location:
This site is located within reach 5 of the Zymoetz River opposite 33.5 km on the Copper FSR. Access is by road.

Description of Site & Impact:
This site is the upstream inlet of the Zymoetz River overflow channel that connects with the 99A back channel.

Data & Observations:
The channel lacked any flow or standing pools of water when examined in November 1997, January and March, 1998. The Zymoetz River was low on both these days.

Prescription

Objective:
This is an overflow channel that was created by the 1992 fall flood when the original mainline forest road was washed away and the river broke through the bush and into 99A side channel. At the time of the field trip, (November 14, 1997) the channel had no flow or water. It is proposed to take advantage of this potential new habitat by attempting to access sub-surface water to provide a constant flow of silt fee water to the site and at the same time supplement the flow of water into site 99A side channel.

Method & Materials:
Prior to the work taking place at site 99A with the excavator, the machine should carry out a series of test digs at this site to determine if sub-surface water is available. If ground water is accessed with a good flow into the channel, a temporary berm should be built until the work at site 99A is complete. Prior to resumption of the channel excavation the TSES, in consultation with the DFO Habitat and Enhancement engineering and biology staff, must sort out all the technical design questions such as flow rates, channel width and depth, compelling requirements and the size and structure of the protective berm at the head of the channel.

Expected Benefits:
If this sub-surface water channel is successful it will create an extensive amount of new habitat for primarily summer coho and to a lesser extent steelhead, char, whitefish, cutthroat trout and chinook salmon. In addition the increased water flow into site 99A will enhance its productivity.

Cost Breakdown for Impact Sites 99A, 99B and 103:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	6	320	1920
Sr. Biologist	1 person	2	440	880
Jr. Biologist	1 person	4	200	800
Sr. Field Tech.	1 person	10	220	2200
Jr. Field Tech.	persons	16	180	2880
Bookkeeper	1 person	0.5	180	90
Equipment:				
gravel grader	days	2	50	100
490E John Deere excavator	hours	24	101	2424
11/2 yard front-end loader	hours	16	75	1200
hand tools	days	8	10	80
chain saw	days	8	25	200
power winch	days	2	50	100
low bed	hours	5	95	475
Travel Costs	at cost	2		900
Transportation: 4x4 crew cab				1056
Materials: cable, steel pins	at cost			50
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	10	25	250
misc.	lump sum			500
			Total cost	16770
			GST	321
			Overhead and Administration (3%)	503
			Total Contract Value	17594

Impact Site 99B (UTM 9.5611.60348)

Location:
This stream (Doll Creek*) is located in reach 5 on the south side of the Zymoetz River at 33 km on the Copper FSR. Access by road.

Description of Site & Impact:
This site is the water source for site 99A side channel that was altered by the construction of the present Copper FSR. The 68 m creek enters the channel from the south-west and for about 30 m from the side channel to a 1.5 m cascade is a marginal fish habitat because of the lack of pools and habitat diversity (photo 54). There are three locations of this stream which are seemingly impassable to adult and juvenile fish: the 800 mm culvert at the Zymoetz River mainline crossing, the fan of the stream just before its meeting with site 99A (discussed previously) and the 1.5 m cascade 20 meters above the road. This was probably caused during road construction (the channel was lowered by the culvert).

Data & Observations:
Upon examination, the culvert was found to be partially plugged due to road grading (photo 55). The bottom section of site 99B consists of large, spaced rocks of high gradient. The suspicions of impassability were substantiated with the trapping results of November 14, 1997. The minnow trap set above both questionable sections produced no fish making either one or both likely a problem. A pH of 8.6 was recorded.

Photo 54: Above the Copper FSR, eroded bank and small water fall.

Photo 55: Degraded creek below the road.

Prescription:
Doll Creek, which supplies most of the water to 99A side channel, has been significantly altered by logging road construction and maintenance. The section of impacted creek extends from the channel to the road, and upstream of the road for about 20 m. It is proposed that the creek be stepped and that culvert have baffles installed in it so that juvenile salmonids can migrate back and forth to the habitat above the road.

Method & Materials:
The creek should be stepped with upstream vees and rock dams (refer to site 50B). It is likely that three vees or dams up to the culvert will be enough to create navigable steps for juvenile salmonids. Above the culvert, two vees or rock dams should be enough to provide access for juvenile salmonids to the 1.5 m cascade in the middle creek which prevents access. It may be possible to provide a series of steps over the cascade. The contractor who carries out the project should, with the TSES, determine if there is a cost effective way of getting fish above this barrier. LWD should be placed in key locations in the creek channel to provide shade and shelter (Figure 27).

Expected Benefits:
It is very difficult, if not impossible, for juvenile salmonids to migrate above the road as long as the creek remains the way it is. By providing access to the middle creek, a very

small, but in combination with other micro habitats a significant additional piece of fish habitat can once again make a contribution to the rebuilding of the of the endangered Zymoetz River summer coho and steelhead stocks.

Cost Breakdown:
See impact site 103.

4.1.2.1 Salmon Run Tributary

Impact Site 91 & 93 (UTM 9.5589.60356)

Location:
Salmon Run Creek side channel is found within reach 5 on the north side of the Zymoetz River opposite 28 km to 30 km on the Copper River FSR. Access is by boat from the south-west side, old logging spur road from Copper FSR.

Description of Site & Impact:
This site is a former main channel of the Zymoetz River that was diverted into its present channel after one of the 1980s floods (photo 54 and 55). This area is beginning to demonstrate high productivity as a spawning and rearing habitat for coho, chinook, summer steelhead and Dolly Varden. The stream contains adequately sized gravel and some woody debris. However, the upper sections of the channel have a low water flow and could use more complexity (photo 56). The Salmon Run Creek flood plain lacks protection from a future 50 year flood or larger by the Zymoetz River into the former main channel of the river.

Data & Observations:
On November 28, 1997, two minnow traps set for two hours each resulted in no fish caught. This could be due to the cold water temperature or short trapping duration. On December 4, 1997, some fry salvage was undertaken in pools that had been cut off from the rest of the creek due to low flows. Approximately 50 fish were salvaged 75% of those being first year rainbow trout and coho salmonids (average size 40 mm), the rest being predominately coho (average size 65 mm) with a few char mixed in (average size 70 mm). Twenty-seven coho redds, 2 live adult coho as well as 2 spawning char were observed (Culp & Culp, 1997).

Photo 56: About 1/3 of the way along the channel where the creek flows into the channel.

Photo 57: Above the confluence of the channel and creek.

Photo 58: Upper side channel, coho redd in an almost dry channel.

Prescription

Objective:
To improve the productivity of this side channel there is the need to stabilize the location of where Salmon Run Creek flows into the channel. Ideally, the bulk of the flow should be into the top end of the channel which dried up during late November 1997 when the

branch feeding it lost its flow. The loss of flow was caused by the drop in the water level in the creek drying up a number of coho redds and trapping juveniles in isolated pools.

A second objective is to increase the amount of complexity in the channel to provide more shade and shelter for both juvenile and adult salmonids.

Method & Materials:
Because of the difficulty in being able to move machinery across the Zymoetz River the timing of the contract to carry out work is a limiting factor as to what can be accomplished. With rising waters starting in May and not ending until mid September, or later depending on fall rains, the prescription is focused on using man power and small machinery.

For stabilizing the water flow in an upper branch of Salmon Run Creek the plan is to move rocks as large as 60 cm in diameter from the area about 200 m upstream (large area that was flooded where many large rocks were exposed by previous floods) using an all terrain vehicle and a flat sled or stone boat for hauling the rocks.

The rocks would be installed in excavations at the 'Y' between the main creek channel and its upper branch as a groyne directing the desired flow into the branch. The excavations would have to be dug by hand, one at a time, likely four to five rocks protruding 1 to 1.5 m into the main channel. Rocks would be piled on top to provide weight and stability. As well, some trenching from the main channel will likely be necessary to direct the flow into the branch. Two upstream rock vees should be constructed above the groyne to slow down the water flow (Figure 28). If the majority of water were diverted down this branch, it would not be a problem because it would be entering the top of the side channel.

For the complexing, on site analysis is necessary to determine where LWD and rocks should be placed. It is important to spend some time on site carefully finding the most appropriate locations for logs and rocks.

The all terrain vehicle and stone boat will be used for moving logs and rocks to the site. The machinery and equipment required for the project will have to be lifted across the river by helicopter.

A season of monitoring is required to determine if more permanent work is required using a track excavator to establish a permanent flow to the upper branch.

Expected Benefits:
The establishment of a more stable flow of water into the entire channel and improvements in complexing will add diversity to the habitat. This will increase the productivity of the channel for coho, char, chinook, steelhead and whitefish. This

channel has the potential to be one, if not the most productive side channel in the Zymoetz River watershed.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	5	320	1600
Jr. Biologist	1 person	4	200	800
Sr. Field Tech.	1 person	10	220	2200
Jr. Field Tech.	persons	20	180	3600
Bookkeeper	1 person	0.5	180	90
Equipment:				
helicopter	hours	1.5	850	1275
4x4 ATV	days	10	100	1000
chain saw	days	10	25	250
power winch	days	10	50	500
hand tools	days	10	10	100
float boat	days	10	50	500
Transportation: 4x4 crew cab	lump sum			1032
Materials: cables, steel pins	at cost			100
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	10	25	250
misc.	lump sum			200
			Total cost	13722
			GST	254
			Overhead and Administration (3%)	412
			Total Contract Value	14388

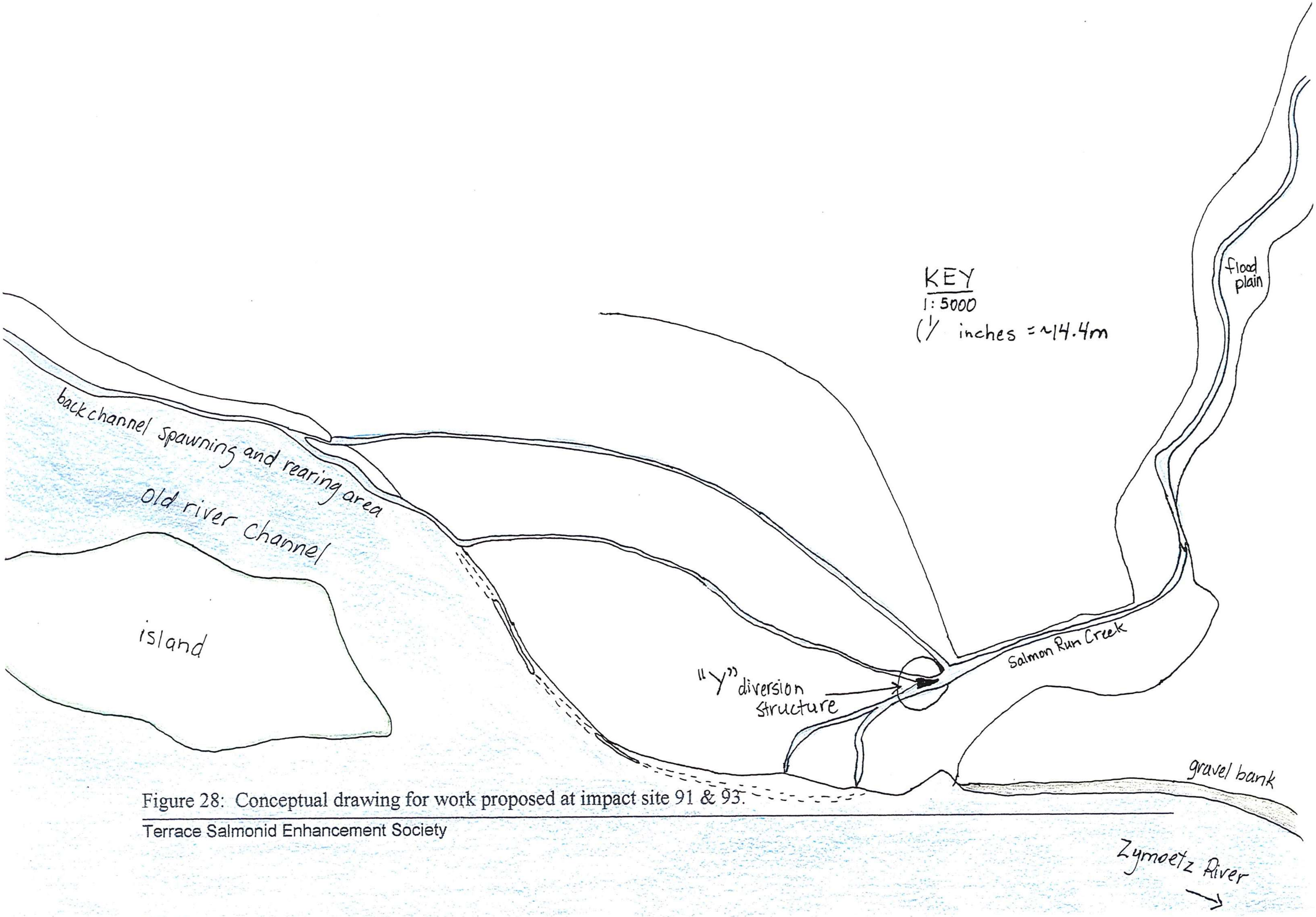


Figure 28: Conceptual drawing for work proposed at impact site 91 & 93.

4.1.2.2 Simpson Tributary

Impact Site 253 (UTM 9.5473.60367)

Location:
This creek is located within reach 4 of the Zymoetz River on the south side of the Copper River at 17.2 km on the Copper FSR. Access is by road.

Description of Site & Impact:
This site is a narrow, medium sized stream with a steep gradient and is made up of medium and large boulders with little spawning size gravel (photo 59). The exception is in front of the two upstream vees that were constructed in the creek and in the tail-out of the last pool in the creek. The fish habitat from the falls pool to the Zymoetz River has been severely degraded by the two major foods in 1991 and 1992. The high velocity of the flow has transported most of the gravel to the unstable fan at the outlet of the creek. Road and bridge construction has had an impact upon the creek. Riparian harvesting occurred adjacent to the creek at this site. Pollard et al.(1996) considered this area a chute therefore claiming no impact on the stream.

Data & Observations:
The upstream rock vees placed downstream of the bridge have provided some good spawning gravel for chinook salmon (photo 60). The creek has been monitored since the construction of the vees and while there has not been a major flood, they have stood up well to two high water events and no erosion along the banks has taken place (photo 61).

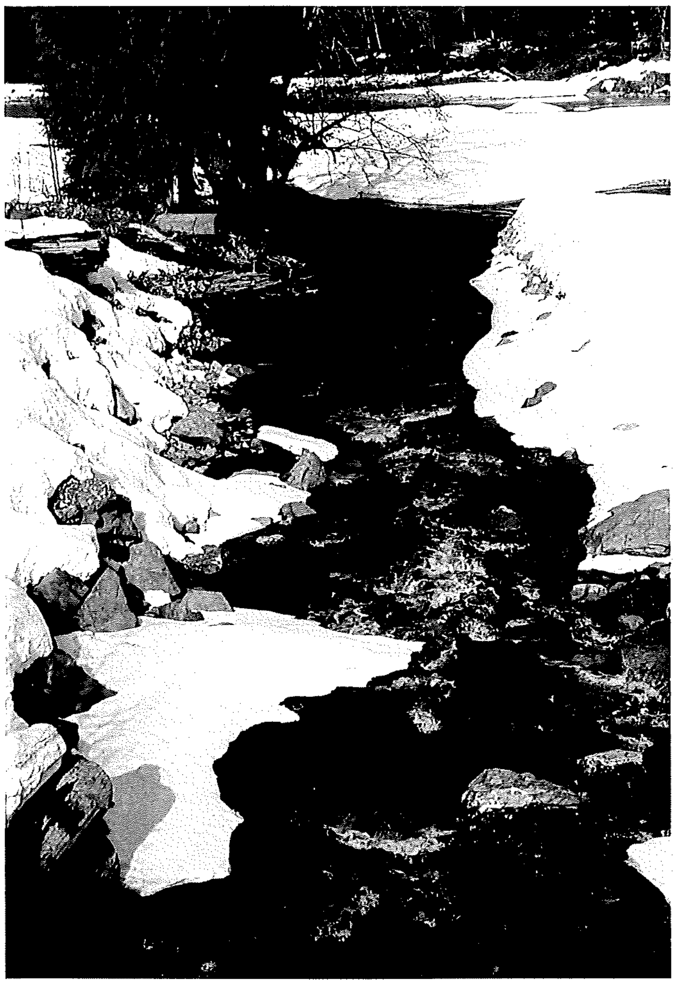


Photo 59: April 1995, before any in stream rehabilitation began.

Photo 60: After the construction of two upstream rock vees (March 1998).

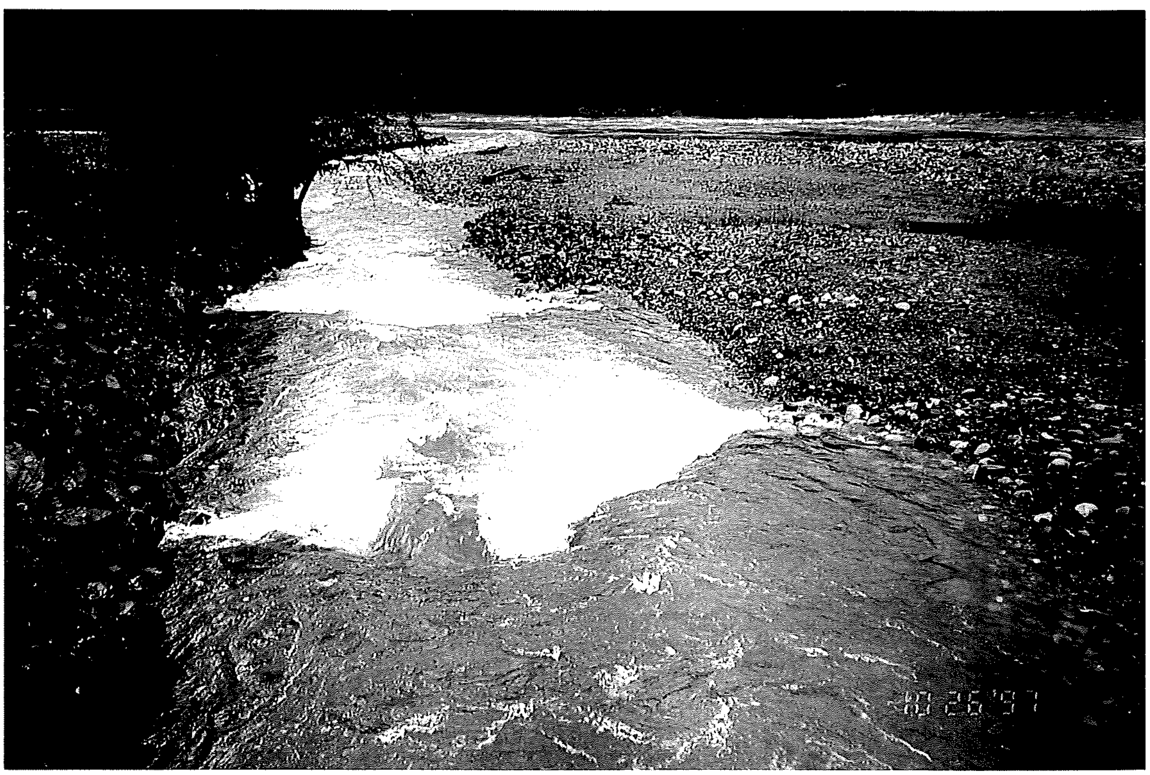


Photo 61: During a mini-flood after construction of two upstream vees (October 1997).

Prescription

Objective:
Two experimental upstream rock vees were constructed on August 14,1997 with gravel pads laid behind them. While no salmon spawned on the new gravel the vees with stood all the fall high waters and are beginning to look more natural. Along with the additional spawning area there is more rearing area, particularly for steelhead which thrive in faster more turbulent water such as the two pools above the vees and the faster water below the vees. The gravel bars next to the two vees have not eroded from the high water, also an indication that the vees are doing the job.

The proposal is to construct two more vees, one above the Copper FSR approximately 10 m above the bridge and to construct the second approximately 10 m downstream from the second one that was constructed on August 14, 1997. The purpose of constructing two more vees, is to further stabilize the creek, particularly downstream where the most valuable spawning gravel for chinook salmon is being washed into the Zymoetz River. By stabilizing the spawning habitat, the few remaining chinook salmon that find their way back to Simpson Creek are at least given some opportunity to rebuild their small numbers.

It is being proposed that a second look at establishing a semi-controlled flow channel along the left downstream bank of the Zymoetz be evaluated in conjunction with the work plan and that test holes and a short test channel be constructed.

Method & Materials:
The vees should be constructed using the same technique that was used for the first two and should be placed approximately four channel widths apart. The anchor rocks that form the main wedge should be approximately 60 cm to 90 cm in diameter. They should be fitted as much as possible into an excavation that is about one half the diameter of the rock, assuring that it cannot be easily scoured or moved by floodwaters. See Appendix IV for the construction of upstream vees.

The rocks for the vees are available from the mounds piled along the road below Simpson Creek, from the cliff upstream of the creek where the piled rock originated and from Simpson Creek itself.

Once the anchored wedge has been completed, smaller rocks need to be fitted into the openings between the larger rocks which, in turn, are followed by the deposition of the spawning size gravel which should be 30 to 60 cm deep. The diameter of the spawning gravel can vary from 2 to 8 cm in diameter (see Appendix V for the size of spawning gravel required). Sand and pebbles should be a part of the mix because they help to filter out fine sediments which impair the flow of water around salmonid eggs in the gravel. The gravel should be graded out using a portable steel grader that will separate out the different sizes. The design is not specified, but the front-end loader must be able to drop the gravel onto the grates in an effective way and be able to remove the graded gravel from under the grader. The grader must be constructed to be sturdy enough to withstand the weight of gravel and banging around by a loader with grates that can be adjusted so that different size spawning gravel can be sorted.

The distance from the top of the upper vee to that of the vee below the bridge should be about 75 m. For the second vee downstream of the lower vee constructed on August 14, 1997, the distance from the top of the vees should be about 5 m. At a location where it could become an over flow weir if water from the creek were diverted downstream along the left bank of the Zymoetz River and it should be a modified flatter vee to reduce channelization downstream. Three or four test holes should be dug in the proposed channel location to determine the depth of the water table. A 10 to 15 m section of channel should be constructed at the lower end of the gravel bar as a pilot site that can be viewed and evaluated by MELP and DFO Habitat staff.

Similarly to the construction of the first two vees, the gravel for the spawning sections should come from the large gravel bar upstream of Simpson Creek. Where ever any work disturbance of a gravel bar takes place, upon completion it should be leveled out and shaped so that it blends in with the natural contours of the bar (Figure 29).

Machinery required for the project will be a 490E John Deere excavator and a Caterpillar 966 front-end loader or equivalent size machine from other companies. Additional assessment of the proposed control flow channel should take place in 1998.

Expected Benefits:
The additional vees in Simpson Creek will slow down the flow of the creek during floods while providing some relatively stable spawning pads behind the vees along with pools for holding adults and rearing juveniles.

The focus of the work is to save the remnant population of chinook salmon in the creek, as well as attracting summer coho and steelhead by way of juvenile colonization below the falls.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	7	320	2240
Sr. Biologist	1 person	1	440	440
Jr. Biologist	1 person	5	200	1000
Sr. Field Tech.	1 person	5	220	1100
Jr. Field Tech.	persons	2	180	360
Bookkeeper	1 person	0.5	180	90
Equipment:				
low bed	hours	5	95	475
490E John Deere				
excavator	hours	16	101	1616
966 Caterpillar	hours	8	100	800
loader	days	2	10	20
hand tools	days	1	25	25
chain saw				
Transportation:				
4x4 crew cab	lump sum			506
Travel Costs	at cost	1		750
Materials: cable, steel pins	at cost			50
Sundry:				
film & video	at cost			125
report production	at cost			100
communication	days	3	25	75
(radio tel)				
misc.	lump sum			200
			Total cost	9972
			GST	206
			Overhead and Administration (3%)	299
			Total Contract Value	10477

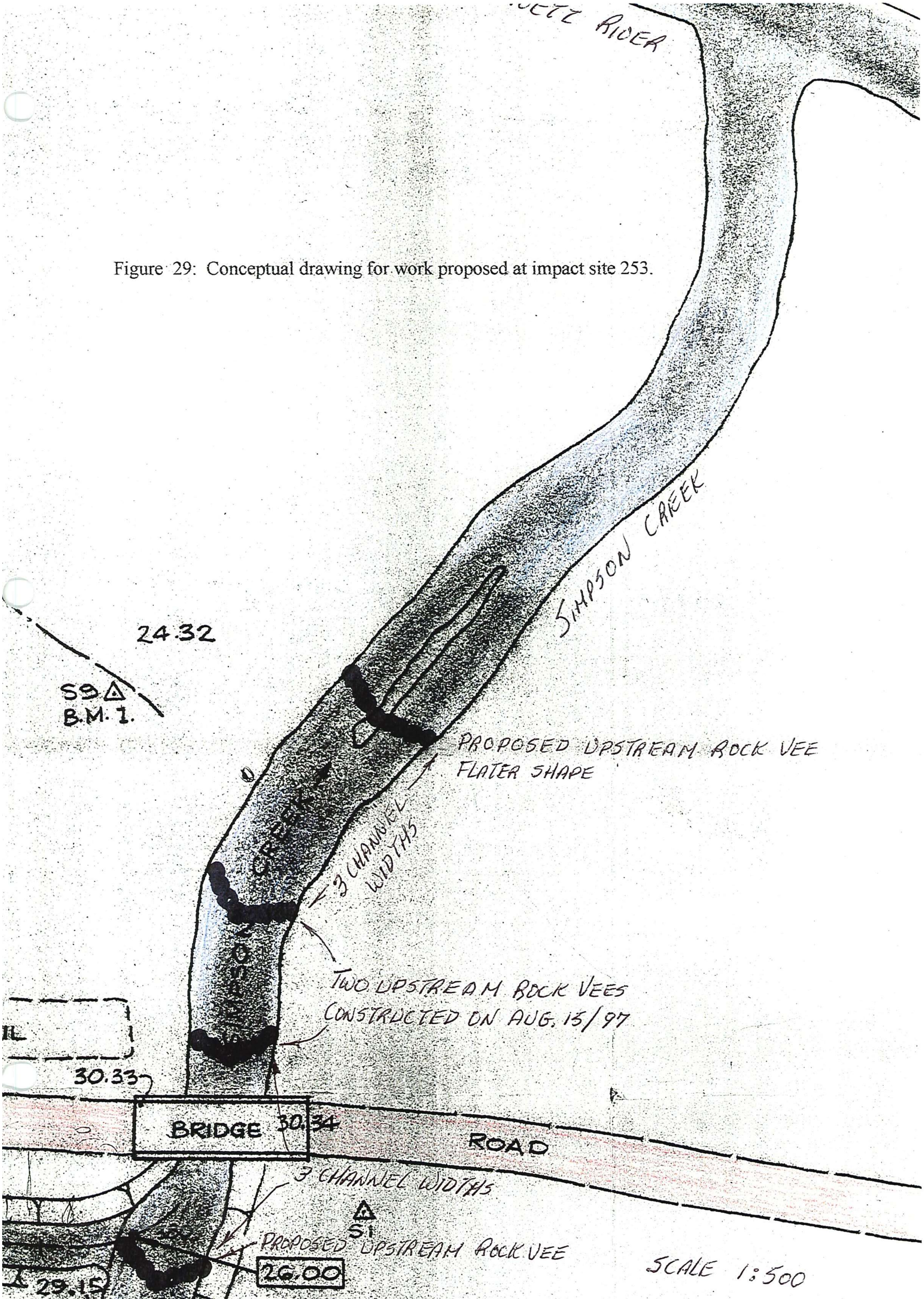


Figure 29: Conceptual drawing for work proposed at impact site 253.

4.1.3 Sub-Unit Three-Clore

Impact Site 192B (UTM 9.5685.60220)

Location:
This creek (17 Km Creek*) is found in reach 3 of the Clore River at 17 km on the Clore FSR. Access by road.

Description of Site & Impact:
This stream was blown out by the 1978 flood or one of the floods in the 1980s. It has an average gradient of approximately 14% over its 290 m length from Clore mainline bridge to the Clore River (photo 62). There are a number of spots throughout this creek that are likely not passable to adult or juvenile fish due to steep gradients, debris barriers and high velocities (photo 63 and 64). On either side, this creek is surrounded by mostly coniferous vegetation with a few deciduous shrubs. Within the creek lies large amounts of LWD and large rocks.

Data & Observations:
This area appears to have been logged to the creek's edge. This is apparent from large cables tied around stumps (photo 65) and bare, collapsed slopes adjacent to the creek. It also appears that the creek torrented during the 1978 flood event causing major riparian damage, widening of the channel and flood plain. A lot of scouring and debris transport has also taken place. The trapping results of November 17, 1997 yielded no fish from any of three traps over a 24 hour period. A pH of 8.1 was recorded.

Photo 62: Top of the torrented gully.

Photo 63: 17 Km Creek flowing into the Clore River.

Photo 64: A mid-channel section, likely impassable.

Photo 65: This cable attached to a stream side log provides further evidence that the stream was logged to its edge.

Prescription

Objective:
The proposal for this highly impacted site is to make it more fish friendly by improving its accessibility for juvenile salmonids, particularly at its lower extremity just before it empties into the Clore River. No fish were captured during the fish sampling, suggesting that 17 Km Creek may not be accessible to salmonids. The intent is to step the creek from the confluence with the Clore to the FSR bridge using upstream rock vees, rock and log dams and providing more shade and shelter.

Method & Materials:
Starting at the Clore River construct a series of upstream rock vees (see Appendix IV for rock vee construction) and take advantage of the existing log and rock dams by making some alterations so they form an upstream vee causing scour pools. Also, form gravel pads where ever possible, at the end of the pools by grading the existing gravel substrate with long toothed rakes. After the basic shape of the channel is complete, add LWD where shade and shelter is lacking. The LWD should be cabled to a dead-man or buried in the gravel with an excavator because of the potential for a large flood washing it away. Remove old logging cable from the channel.

A Registered Professional Forester (RPF) or equivalent professional or technical person who specializes in tree planting on steep and gravely slopes should be retained to recommend what trees to plant on these steep banks and what spacing should be used.

Expected Benefits:
Any improvement to the habitat of this creek, particularly providing access for fish into it will be a huge, positive change. The other plus is that construction of the upstream vees along with the log and rock dams that will slow down the water flow, reducing the bank erosion.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	4	320	1280
RPF	1 person	1	550	550
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	12	220	2640
Jr. Field Tech.	persons	20	180	3600
Bookkeeper	1 person	0.5	180	90
Equipment:				
low bed	hours	5	95	475
small track type excavator	hours	16	70	1120
hand tools	days	10	10	100
power winch	days	5	50	250
chain saw	days	10	25	250
Transportation:				
4x4 crew cab	lump sum			1248
Materials:				
cable, steel pins	at cost			200
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	12	25	300
misc.	lump sum			300
			Total cost	13228
			GST	154
			Overhead and Administration (3%)	397
			Total Contract Value	13779

Impact Site 205B (UTM 9.5666.60248)

Location:
This creek (12 Km Creek*) is located in reach 3 of the Clore River at 12 km on the Clore FSR. Access is by road.

Description of Site & Impact:
Under the Watershed Restoration Program in 1995, J&S Outdoor Ventures performed some stream rehabilitation and diverted the creek back to what appeared to be its original location. This was difficult to determine due to the large amount of logging damage. The position of this creek was shifted significantly after the construction of the Clore mainline and a logging spur road. This diversion impacted the flow of the water causing it to dissipate over an expanded area.

Data & Observations:
Upon examination, it was discovered that the creek is holding its new position in most places along its upper length (photo 66, 67, and 68). As the creek approaches the Clore River it loses its flow and disappears. A minnow trap set for three hours on November 28, 1997 resulted in no fish caught. There was visual observation and trapping of resident char by J & S Outdoor Ventures at the time of their work in 1995. The creek must be diverted into a new channel (photo 69).

Photo 66: 12 Km Creek at the division where it wants to turn to the right (this is where the creek would be diverted)

Photo 67: Full flow of 12 Km Creek below division (right channel blocked off at division).

Photo 68: Downstream on creek showing loss of flow even though full flow has passed the division.

Photo 69: Proposed new channel for 12 Km Creek.

Prescription

Objective:
The work carried out by J&S Outdoor Ventures in 1995 was successful in returning the flow back into the upper original channel but not, as it turns out, into the lower original channel. The inability of the lower channel to hold water suggests that it may not be the original channel. In addition, the creek wants to flow to the south about a third of the way between the Clore FSR and the Clore River side channel which is known rearing habitat for coho, steelhead and whitefish. This side channel was, at one time, a spawning area for coho and likely steelhead before it lost most of its flow as a result of one of the floods in the 1990's. The combination of events and circumstances makes a strong case for diverting the flow of 12 Km Creek into the top end of the side channel.

Method & Materials:
The plan is to divert the flow at the 160 m point on the creek downstream from the Clore FSR into the top section of the side channel of the Clore River. The project would require a small, track type excavator and a crew of three who would look after the lay out for the route of the creek to the side channel, the final bank grading, helping the excavator place LWD for shading and shelter, construct upstream rock vees, rock dams, plant grass's and transplant some larger cedar, spruce, hemlock and balsam in the riparian area and along the exposed creek bank (Figure 30). The side channel will

require some gravel grading and construction of upstream rock vees so that some pool areas are scoured out for holding areas and gravel pads are formed for spawning. The size and configuration of the vees, pools, and spawning pads are site specific along with the need for complexing shade and shelter. See Appendices IV and V for rock vee construction and spawning requirements of salmonids.

Expected Benefits:
The addition of more water to an almost de-watered side channel habitat will be a major boost for coho and steelhead production in the Clore River and it will allow juvenile salmonids to migrate into 12 Km Creek to take advantage of that habitat.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	4	320	1280
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	12	220	2640
Jr. Field Tech.	persons	20	180	3600
Bookkeeper	1 person	0.5	180	90
Equipment:				
low bed	hours	5	95	475
small track type excavator	hours	16	70	1120
chain saw	~~hours~~ days	10	25	250
power winch	~~hours~~ days	5	50	250
hand tools	~~hours~~ days	10	10	100
small gravel grader	days	5	25	125
Transportation: 4x4 crew cab	lump sum			1176
Materials: grass seed, fertilizer	at cost			50
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	12	25	300
misc.	lump sum			300
			Total cost	12581
			GST	162
			Overhead and Administration (3%)	377
			Total Contract Value	13120

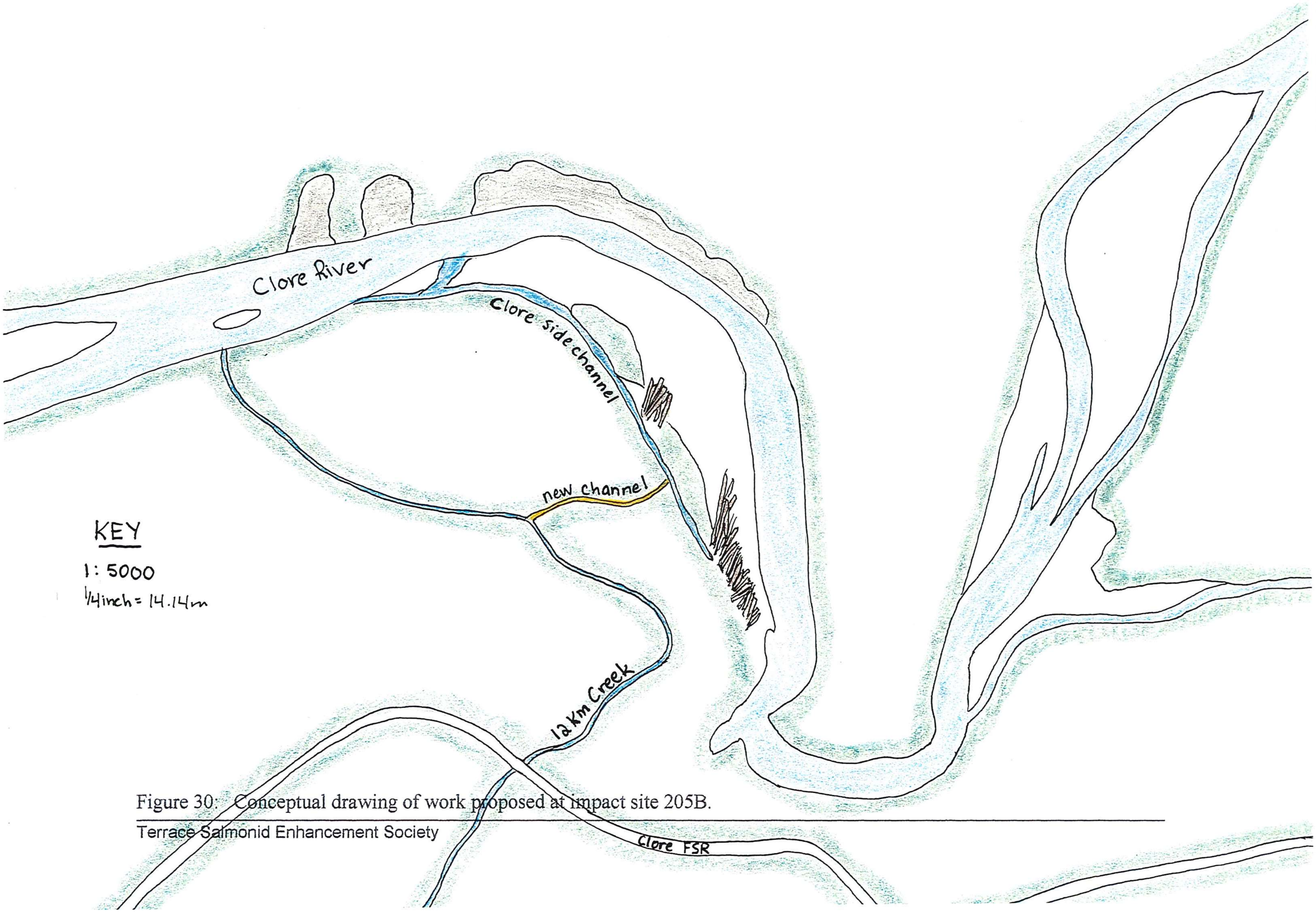


Figure 30: Conceptual drawing of work proposed at impact site 205B.

Impact Site 211 (UTM 9.5654.60279)

Location:
This creek (Elf Creek), can be found in reach 3 of the Clore River at 10 km on the Clore FSR. Access is by road.

Description of Site & Impact:
This creek above the Clore mainline bridge (reach 3), flows down a steep gully (photo 70) then reduces its gradient below the bridge to approximately 10% for 145 m where it meets with the old river main channel (reach 2) (photo 71 and 72). It flows along this channel for an additional 592 m before joining with the river. In some places, the old river channel is too wide to accommodate the relatively low volume of water from the creek. The result is an inadequate flow, or fanning effect in some areas making adult fish passage difficult if not impossible at times of low water. An additional problem suggested by Pollard in his Level 1 assessment (1996) is that the banks of the creek are actively eroding and this material is obstructing the old river main channel.

Data & Observations:
There is evidence to suggest the upper portion of this creek contains some good habitat for rearing. On November 18, 1997, 4 rainbow trout and 1 char was trapped approximately 80 m from the Clore mainline bridge. A second trap in the old river main channel contained 5 coho and 2 char. A third trap revealed 15 coho and 2 rainbow trout. As well, a tight group of 30 to 40 adult whitefish were visually observed in the old river main channel section of the creek. The relative abundance at this site is 1.27. A pH of 8.2 was recorded. Figure 9 represents the fork length frequencies of all fish trapped at this site. Despite a fair yield of fish, the lower section of the creek provides little complexity and protection for juveniles and adults.

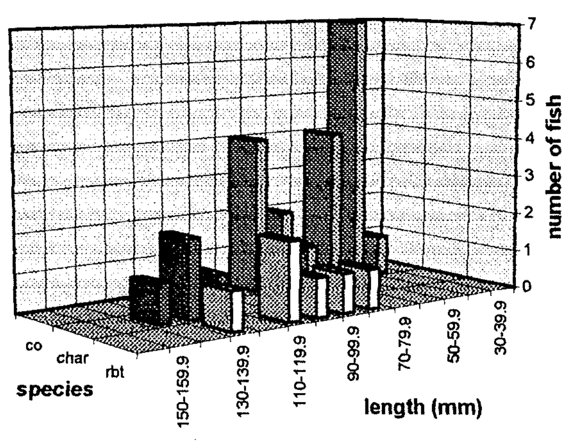


Figure 31: Fork length frequencies for fish trapped at site 211.

Photo 70: Torrented gully of Elf Creek channel.

Photo 71: Top of Elf Creek side channel below the fan.

Photo 72: Mid-creek side channel looking towards the Clore River.

Prescription

Objective:
This site is made up of two different habitats, the first Elf Creek proper which flows 144 m from the Clore FSR then to the second habitat Elf Creek side channel. For the creek habitat there is a need to improve the pool and riffle ratio, which does not exist because there are virtually no riffles and few pools as a result of the creek tumbling down a gully that was blown out by one of the floods in the 1990's. The creek requires some reshaping with upstream rock vees, altering some of the existing log and rock dams and installing LWD in key places. The side slopes in the gully need to be stabilized and planted with variety of vegetation.

For the side channel there is a need to confine the water flow in the top section of the channel and to try and divert some smaller spring water flows into the channel to increase its water flow. This would be a significant benefit for increased fish production. The channel lacks shelter and shade resulting in adult coho, steelhead and whitefish being very exposed to predators. LWD needs to be placed in key locations for shelter and shade.

Method & Materials:
The proposal is to step the creek using upstream vees constructed from the large rocks in the creek, and the existing rock and log dams (see Appendix IV for rock vee construction). It is going to be very difficult to walk a track type excavator down the channel to carry out the construction of the vees, but it is going to be equally difficult to construct the vees by hand because the rocks are very heavy and the substrate is made up of the same large rocks which will make it very hard for workers to dig these rocks out and to excavate a trench for the rocks to fit into. Some how, a small or medium size track type excavator will have to be walked down the channel even if it means constructing a temporary road. The benefit of having an excavator on site is that root wads and LWD can be moved into key locations for shelter and shade, while moving heavy logs and root wads by hand will be very difficult even with the assistance of a power winch. The primary goal of this prescription is to slow down the water flow and provide more rearing habitat, not to create spawning pads. If a patch of gravel here or there can be raked or shaped into a small spawning pad that is a bonus.

Elf Creek side channel-beginning at the Elf Creek fan, which is impassable to adult fish at most water levels needs to be confined to a narrower channel and stepped. If the excavator can be walked down to the fan it would excavate a channel about 2 m wide, armoured with the heavy rock from the creek channel. Within the channel upstream vees should be constructed using rocks salvaged from the creek channel. These vees are intended as steps to slow the water velocity down, not as spawning pads. Pools will be scoured out below the vees. The vees in the creek and fan will have to be spaced closer together than the usual four to six channel widths because of the need to slow down the high water velocity. The vees should be a more moderate or flatter shape to reduce scouring.

A very productive pool has been formed by the fan which must not be altered by the channel work. A long, shallow pool below the fan is followed by a long flat riffle area that was at one time the main channel of the Clore River. This riffle which is quite shallow during normal flows, is very difficult for adult coho and steelhead to navigate through. The plan is to provide a narrower channel to increase the water depth, which can be accomplished by constructing upstream vees using the rocks from the channel. The vees will narrow the channel, plus assist in forming pools downstream, where juvenile salmonids can rear and holding areas are provided for adult coho salmon, whitefish and steelhead. The gravel above the vees should be graded and shaped for spawning, the actual length of the vee and the gravel pad is site specific and is best decided at the site (Figure 32).

There is a need for more complexing in the channel to provide shade and shelter for spawning adults. LWD is readily available throughout the old river channel and can be moved into key areas using the excavator or by the use of a power winch. The placement location for the logs and root wads is a decision best made on site rather than trying to define it in a prescription.

Expected Benefits:
Elf Creek is a very productive micro habitat that will only get better if the water flows are consolidated and increased, the creek habitat is improved, and the side channel holding and pool areas provide more shelter and security for pre-spawning and spawning salmon, char, whitefish, steelhead and protection for juveniles.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	6	320	1920
Jr. Biologist	1 person	4	200	800
Sr. Field Tech.	1 person	17	220	3740
Jr. Field Tech.	persons	30	180	5400
Bookkeeper	1 person	1	180	180
Equipment: small track type excavator power winch chain saw hand tools low bed	 hours days days days hours	 40 10 15 15 6	 70 50 25 10 95	 2800 500 375 150 570
Transportation: 4x4 crew cab	 lump sum			 1632
Materials: cable, steel pins	 at cost			 200
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 17	 25	 125 100 425 500
			Total cost	19417
			GST	308
			Overhead and Administration (3%)	583
			Total Contract Value	20308

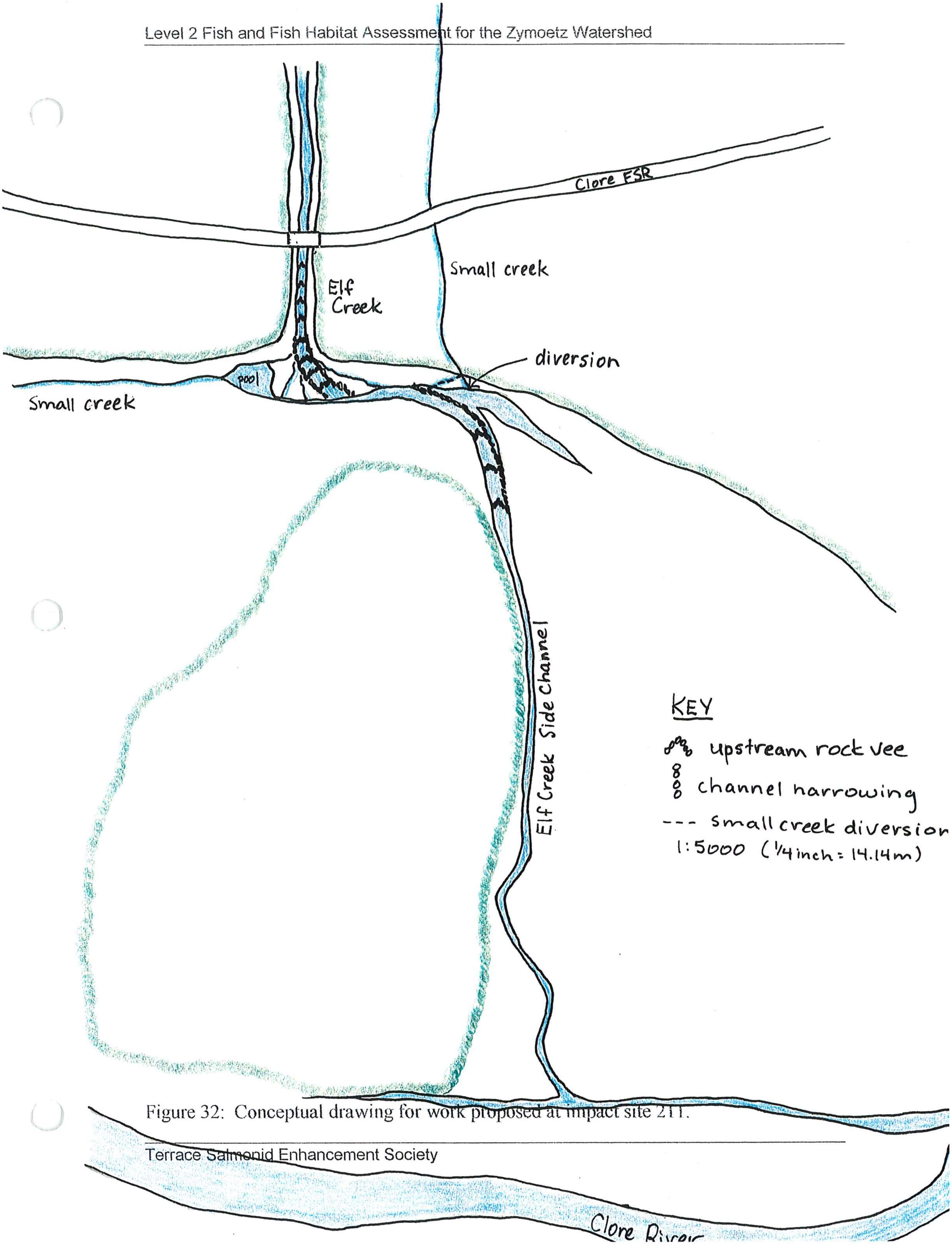


Figure 32: Conceptual drawing for work proposed at impact site 211.

Impact Site 214B (UTM 9.5653.60279)

Location:
The Clore River slide is positioned in reach 3 on the east side at approximately 9 km on the Clore FSR. Access via twenty minute walk from Clore FSR (no visible trail or start point)

Description of Site & Impact:
This slide is likely the single largest habitat impact in the Zymoetz watershed (photo 73, 74, and 75), particularly, in the opinion of anglers who fish the river and are intimately familiar with the watershed impacts. Composed of mostly clay and fines that are transported by sloughing and small creeks that run through the slide, it is estimated to span 300 m of the Clore River's edge, to be over 150 m high in most places and to be of a gradient near 90% in some places. From the location of the slide downstream, the Clore and Zymoetz Rivers have much higher deposits of red silty, fine material in the river and on the bottom substrate. The amount of material has been increasing as the slide has evolved. While no logging or logging roads have directly impacted this site, accelerated runoffs caused by logging and the 1978 fall rainstorm triggered the slide with later slides exacerbating the problem.

Data & Observations:
It was determined that this slide is, in fact, a major impact requiring rehabilitation. No data collection took place. In its place, Alan Gilchrist, Ph.D. (Geomorphologist) was flown by helicopter to the site on March 26, 1998 and will provide some opinions on how to resolve sediment flow into the Clore River and has provided some Geological history of the site and what may have precipitated the slide (see Appendix IX).

Photo 73: Looking downstream to the Clore River.

Photo 74: Clore River slide.

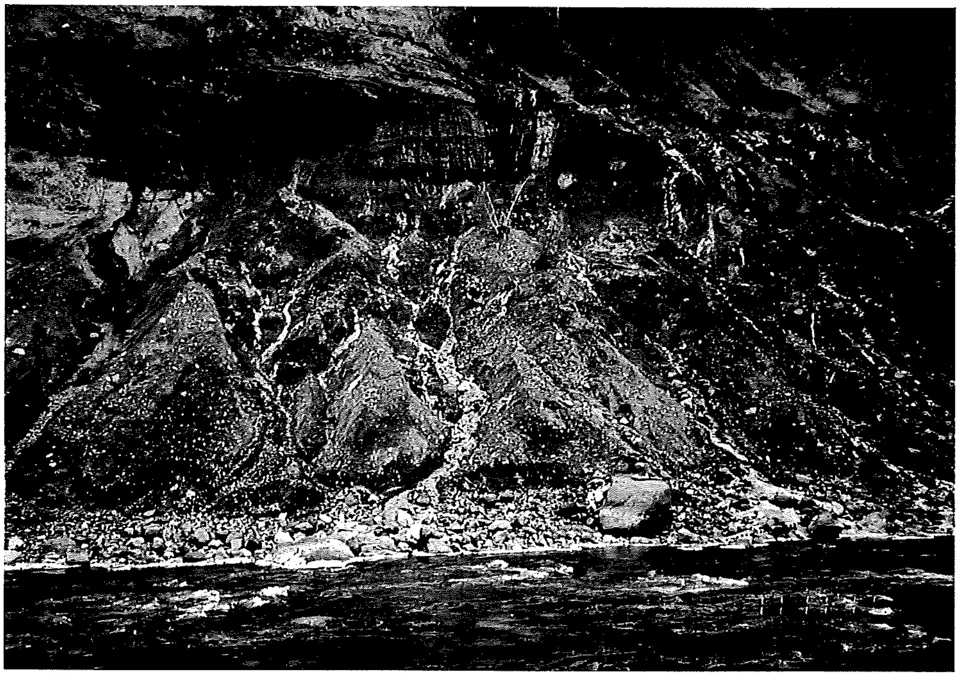


Photo 75: Clore River slide.

Prescription

Objective:
The goal for this site is to move the Clore River away from the slide so that it does not continue to erode the clay banks. This will not completely solve the problem but it will make a huge contribution to its resolution. After the river has been moved away from the slide, large shot rock needs to be anchored along the toe of the slide to stop the continued slipping of material and ultimately contributing to the stabilization of the slide.

While its tempting to try and do major things with the slide itself, experience elsewhere has shown that usually more harm than good comes out of disturbing a slide such as this. The approach that we are proposing is to try and stabilize the slide by drying out the critical areas where the small streams are eroding the clay banks and causing material to slough off and break a way, with the water flowing over the loose material washing it into the river. The proposal is to test the use of flumes to pick up the water and transport it over the unstable sections or if possible higher up the slope drain it away in another direction. While this work is taking place the planting of appropriate plants, trees and grasses will contribute to the stabilizing of the slide, particularly in the older sections where gravel and sandy soils have begun to cover the clay.

The work on the slide would be carried out by a crew of four workers who would also be responsible for the brushing out of a road way to the site. As much as possible the road would follow previous logging spur roads through the old setting.

Method & Materials:
The prescription is broken into two phases, with the DFO Habitat and Enhancement Branch being asked to take on the lead role for the technical in river work design, location. The sources of material (shot rock, tree species, appropriate grass seed, etc.) the design and supplier of the flumes for the slide will be the responsibility of the TSES (Figure 33).

PHASE 1, Year 1:

-The location of the new river channel must be determined, the berm must be designed and cost out, a source for shot rock to be used for berm construction and the toe of the slide needs to be found and the design and supplier of the flumes must be resolved.
- Lay out and construct the access road to the site.
-Install test flumes at one water location on the slide.
-Where feasible relocate the small streams that flow through the unstable areas.

PHASE 2, Year 2:

-Excavate the new river channel, construct the diversion berm and install anchors at the toe of the slide.

Expected Benefits:
The diversion of the Clore River flow away from the active slide will reduce in a substantial way the amount of sediment that flows into the river. This will result in a significant improvement to the water quality in the Clore River downstream of the slide and the Zymoetz River downstream from the Clore. While there have been no definitive studies on the Zymoetz River that have shown that the productivity of the habitat has deteriorated, the feeling of most knowledgeable fishery workers and anglers is that productivity has suffered as a consequence of the Clore River slide that took place in 1978. The productivity should increase with a major decrease in the silt load, which will mean that over time there will be more fish. The last benefit, but not the least is that the angling quality will be substantially improved with a big decrease in the silt load.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	7	320	2240
Jr. Biologist	1 person	4	200	800
Sr. Field Tech.	1 person	12	220	2640
Jr. Field Tech.	persons	20	180	3600
Bookkeeper	1 person	0.5	180	90
Equipment: helicopter power winch chain saw hand tools float boat 490E John Deere excavator low bed	 hours days days days days hours hours	 2 5 10 10 5 20 6	 850 50 25 10 50 101 95	 1700 250 250 100 250 2020 570
Transportation: 4x4 crew cab				1344
Materials: grass seed cable, steel pins flumes (500mm)	 at cost at cost meter	 50	 56	 200 500 2800
Travel Expenses	at cost	2DFO staff x 2 trips x 600		2400
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 14	 25	 125 100 350 500
			Total cost	22829
			GST	360
			Overhead and Administration (3%)	685
			Total Contract Value	23874

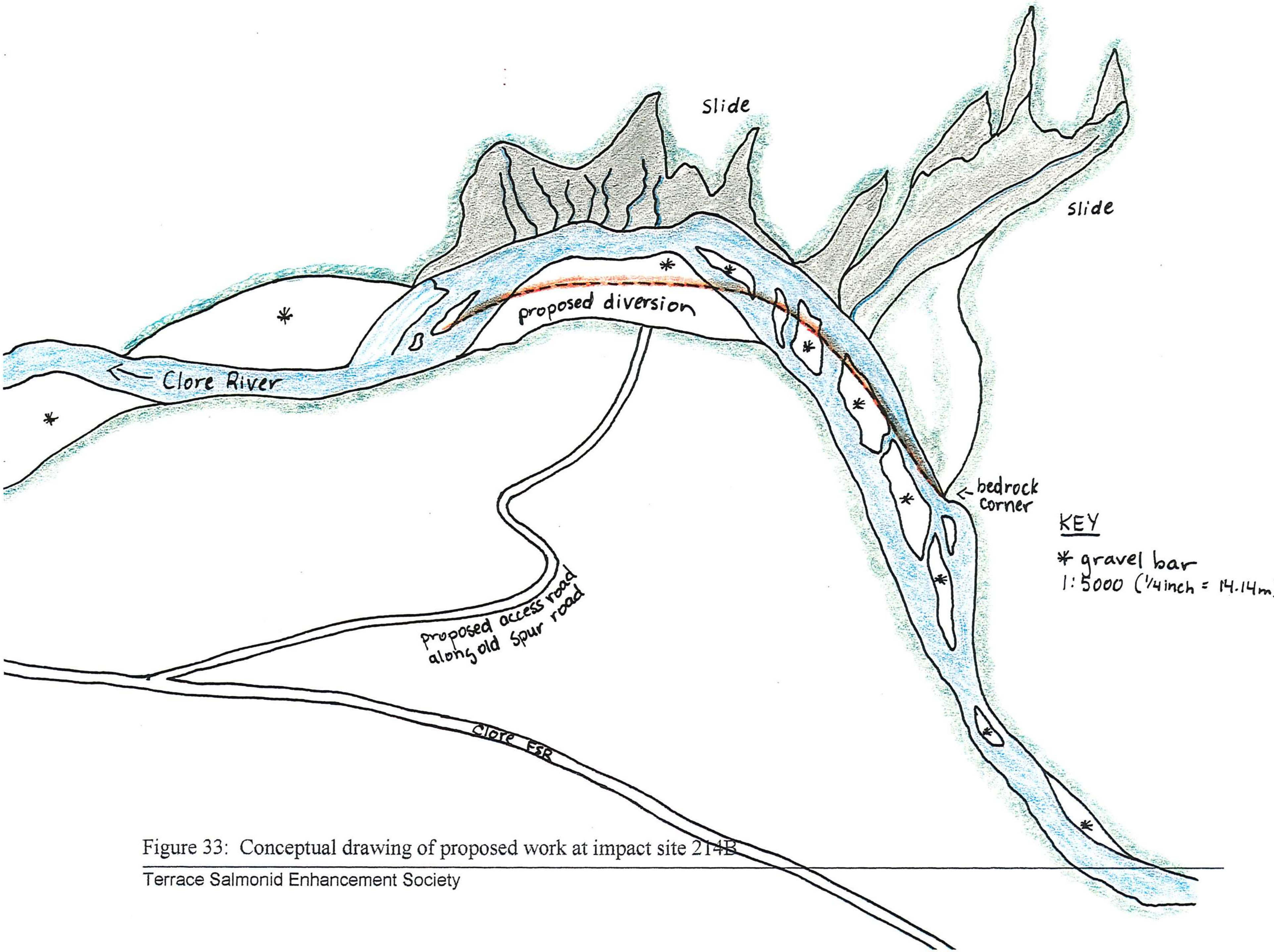


Figure 33: Conceptual drawing of proposed work at impact site 214B

Impact Site 218 (UTM 5.5638.60301)

Location:
This site is located within reach 3 of the Clore River at 4.5 km on the Clore FSR. Access is by boat.

Description of Site & Impact:
The banks at this site have eroded and the narrow riparian zone has disappeared (photo 76). This is a common impact where a one or two tree width buffer has been left after logging. In this particular situation, a number of trees blew down and the roots pulled loose weakening the bank structure. A series of floods contributed to its collapse. This has resulted in continuing erosion during high water events. Fortunately, the high content of gravel in the bank has resulted in the input of material to the river primarily being gravel and rocks. At the peak time of the impact fines would have entered the river, but not at a continuing rate during run-off from rain and snow. The exception being flood events when the same erosion will take place all over again. The boulder hole adjacent to this bank failure was one of the most popular angling pools in the Clore River before it was lost to the 1992 flood when gravel and rocks from the eroding bank partially contributed to the filling of the pool.

Data & Observations:
Restoration required.

Photo 76: Boulder hole on the Clore River. Note loss of riparian zone and eroded bank.

Prescription

Objective:
From a practical and cost effective perspective, little can be done to armour the bank. Most of the damage has been done although a future flood could scour out a clay seam causing more material to end up in the river because of the instability of the bank.

This site could become a test site for actions that can be applied on a wider basis through the participation of a selected team of about three experts: a Hydraulic Engineer, a Geomorphologist, a Fisheries Biologist, the MELP Project Monitor for the Kalum Forest District and the TSES Project Manager to provide some answers on how to rehabilitate an eroded bank where high velocities of water are the cause of the original and continuing impact.

Method & Materials:
Finance a three day field and working meeting involving the experts and the Project Manager for the TSES who will act as the coordinator. The group will determine what, if anything, can be done to rehabilitate or protect the eroded bank at site 218 and similar river bank erosion elsewhere. This will either lead to a prescription for this site or a decision will be made to let nature take its course.

Expected Benefits:
Some fairly clear answers should emerge from the meeting, the benefits for those who are charged with finding solutions to chronic bank erosion problems are obvious. If clear answers on bank strengthening and rehabilitation come out of the meeting, fish will receive benefits of improved water quality and habitat productivity.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	5	320	1600
Hydrologist or Hydraulic Engineer	1 person	3	560	1680
Geomorphologist or soil expert	1 person	3	560	1680
Fisheries Biologist	1 gov. employee	3	expenses	
Record & Report Writer	1 person	6	220	1320
Transportation: large van	day	3	100	300
Travel Costs	at cost			1800
Daily Expenses (meals, hotels)	days	3x3=9	120	1080
Meeting Room	days	2	60	120
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 1	 25	 125 250 25 200
			Total cost	10180
			Overhead and Administration (10%)	1018
			Total Contract Value	11503

Impact Site 222 (UTM 9.5622.60308)

Location:
This site is found within reach 3 of the Clore River at 3.5 km on the Clore FSR. Access via short walk from Clore FSR.

Description of Site & Impact:
This impact is the erosion of a steep gully that has accelerated since the 1978 flood when the side hill partially collapsed. With every major rainstorm since, more erosion takes place from the top of the hill to the road and on going weeping of clay sediments into the settling pool along the road.

Data & Observations:
Alan Gilchrist, Ph.D. (Geomorphologist) visited the site on March 24, 1998 with the TSES Project Manager and provided a number of opinions. The most significant opinion was to anchor the toe of the slide with large rocks, try to drain the water away from the slide, prevent any digging at the toe of the slide and try to flume flowing water over erodable material (see Appendix IX).

Prescription

Objective:
The proposal for this site is to find a way or ways to stabilize the bank area that is collapsing. Part of the solution is to drain as much water as possible away from the slide area, plant the accessible open areas with local shrubbery and grasses, and construct a log pile or concrete wall at the toe of the slide.

Method & Materials:
Luckily, this slide has not broken loose in a major way; if it had, it would have been a disaster as it is right on the edge of the Clore River. It is critical that, as much as possible, a permanent way be found to contain and stabilize the bank.

In the interim and as a partial solution, as much water as possible should be drained away from the slide-prone area by intercepting any small streams flowing into the eroded area (SCI carried out some diversion of water at the top of the slide in the 1980s and that did reduce the amount of sloughing material). If feasible, flume the remaining surface water over the slide-prone sections of the bank using half culverts about 38 mm in width constructed of galvanized metal. Sections 4 m long bolted together with overlapping flanges should pick up most, if not all, of the flow from the small streams.

Plant wattles of shrubbery in the eroded areas that are accessible and spread grass seed in the openings between the wattles and other open areas where wattles can not be planted.

SCI constructed a partial log pile wall at the toe (year unknown) which has partially held back the flow of material. The overflow has been periodically cleaned up from the ditch line and trucked down the road and dumped in an open area between the road and river. The log pile wall should have its length extended to contain more of the slide. The material that has been dumped down the road needs to be graded and contoured to blend in with the surrounding area, coniferous and deciduous trees planted and grasses planted along the edges where erosion could take place.

A Geomorphologist or slide expert should be retained to provide additional direction (over and above the advice received from Alan Gilchrist) for the work being proposed. It may be necessary to get more than one opinion such as that from an Engineer if it is decided that a more permanent containment wall should be constructed. See the concrete wall at 21.75 km on the Copper FSR. This project is an up slope responsibility of MOF.

Expected Benefits:
The work that takes place at this site is intended as a preventative measure against a major slide or to reduce its impact. It has been pointed out that a major slide could create a very serious impact upon the Clore River fish habitat, dramatically altering the ability to angle in the Clore River, the Zymoetz River downstream of the Clore, and upon the Clore FSR. Not only would there be a huge short term impact, but it is very likely that there would be a long term, on going difficult problem to deal with.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	5	320	1600
Geomorphologist/ slide expert	1 person	3	560	1680
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	12	220	2640
Jr. Field Tech.	persons	20	180	3600
Bookkeeper	1 person	0.5	180	90
Equipment: hand tools power winch 490E John Deere excavator low bed chain saw	 days days hours hours days	 10 5 16 5.5 5	 10 50 101 95 25	 100 250 1616 523 125
Transportation: 4x4 crew cab	 lump sum			 1116
Materials: cables, steel pins flume grass seed	 at cost meter at cost	 150	 46.6	 200 6990 200
Sundry: film & video report production communication (radio tel) misc.	 at cost at cost days lump sum	 12	 25	 125 100 300 1000
			Total cost	22855
			GST	686
			Overhead and Administration (3%)	686
			Total Contract Value	24227

4.1.3.1 Thomas Tributary

Impact Site 236B (UTM 9.5667.60240)

Location:
This site is located in reach 2 of Thomas Creek at 14.5 km on the Clore FSR. Access via short walk from Clore FSR

Description of Site & Impact:
A log jam (photo 77 and 78) has partially blocked off the left channel looking downstream on Thomas Creek immediately above the high falls (photo 79) and it is likely that both barriers have stopped the migration of summer coho salmon and steelhead trout into the habitat above the falls. Historically, coho have been seen upstream of the falls prior to the log jam (pers. comm. Gene Llewellyn) and it is likely that steelhead were present also.

Data & Observations:
On November 15, 1997, a char was observed just below the falls. On November 21, 1997, trapping below the falls resulted in one juvenile coho with a fork length of 71 mm. Eight live spawning coho and 6 dead adult coho, 4 char and 7 coho redds were also observed. Electrofishing, minnow trapping and visual observation above the log jam resulted in no fish of any species found (David Bustard and Associates, 1996). The relative abundance is 0.05.

Photo 77: This log jam directly behind the falls has made fish migration impossible.

Photo 78: Log jam.

Photo 79: Looking towards the log jam and falls.

Prescription

Objective:
There is a log jam above the waterfall located in the first canyon of Thomas Creek (about 750 m upstream of the Clore River) that was created primarily by logging debris which appears to have diverted more than half of the flow away from the original channel on the left bank looking down stream. It is thought that coho, steelhead, char and possibly chinook, at one time, were able to migrate into the upper watershed (pers. comm., Gord Doll, trapper in the valley and Gene Llewellyn, sport fisher have both said that Gord used spawned out coho in his traps that were captured above the falls). The goal is a very simple one and that is to remove the log jam. Then once the jam has been removed, determine if the four species will be able to migrate above the falls, if not what can be done to provide access for anadromous fish over the 3 m waterfall.

Method & Materials:
There is an old logging road that is located within about 50 m of the log jam that has been partially blocked off at the Clore FSR. The road needs to be activated so that a track type excavator can walk itself to the jam and a 4x4 truck can drive to the site. A temporary access road will have to be brushed out to the edge of the creek at the location of the jam and a flat area will also have to brushed out for the LWD that will be removed from the jam so that it can be piled in one spot and burned or later spread around the

area. If a log loader is used for the debris removal an excavator will have to be used to open the road to the site. A crew of three will be required to do the brushing and possibly helping to hook cable around the logs to be pulled out of the jam and signaling to the operator of a large track type excavator or a log loader required to remove the material from the jam. Another option is a short yarding system. This would be done with a track type log loader that is equipped with winches. The longer the reach the better for getting the LWD out of the jam. The logs and material jammed along the left bank should be removed first so that the water flows along that side away from the work. Some site specific decisions will have to be made regarding where the machine will be able to go and how it will be able to remove the material along with how to carry out the final clean up of finer woody debris and gravel and rocks after all the logs have been removed. There would be some benefit to having a logging contractor or two to view the site and provide an opinion on the most efficient way of removing the LWD.

After the entire jam is removed and if the excavator is still at the site there will be a need to measure the height of the falls and evaluate whether or not fish are able to jump over it. If it looks as though it is still a very tough jump, the excavator, if it can walk itself to the edge of the falls, may be able to move a couple of big rocks that are below the falls into a position that will create more of a step. If that is not successful the TSES Project Manager who is overseeing the work will have to make a recommendation on what, if any, further action should be taken.

Expected Benefits:
If the project is successful and fish are able to migrate past the falls, the unused habitat upstream will provide more than 3 km of new rearing and spawning habitat. It is very unusual to find a situation like this, it has the potential to be the single largest piece of new habitat that will be created within the Zymoetz River system.

Cost Breakdown:

Item	Unit	Quantity	Rate ($/unit)	Cost ($)
Project Manager	1 person	5	320	1600
Jr. Biologist	1 person	3	200	600
Sr. Field Tech.	1 person	9	220	1980
Jr. Field Tech.	persons	14	180	2520
Bookkeeper	1 person	0.25	180	45
Equipment:				
log loader	hours	40	225	9000
490E John Deere				
excavator	hours		105	1680
low bed	hours	16	95	475
hand tools	days	5	10	100
chain saw	days	10	25	250
power winch	days	10	50	250
large low bed	hours	5	150	750
		5		
Transportation: 4x4 crew cab	lump sum			1200
Sundry:				
film & video	at cost			125
report production	at cost			100
communication (radio tel)	days	12	25	300
misc.	lump sum			1000
			Total cost	21975
			GST	875
			Overhead and Administration (3%)	659
			Total Contract Value	23509

4.2 Summary

4.2.1 Relative Abundance of Juveniles

The figures below were created to compliment the calculations stated in each site description. Charts were only created for coho, rainbow and char as these were the primary species trapped. It should be noted that one cutthroat was trapped at site 94 (Warner Spring). As well, seven sculpins were captured and 30 to 40 Rocky Mountain whitefish were visually observed at sites 14B and 211 respectively.

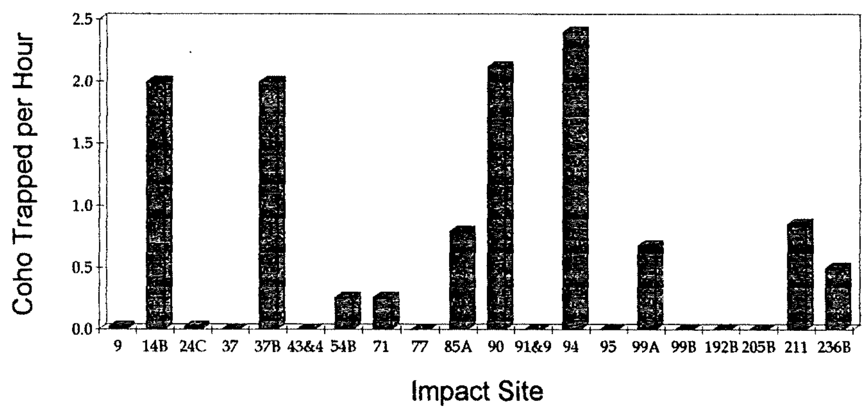


Figure 34: Relative abundance of juvenile coho between impact sites

Juvenile coho were captured at ten out of twenty sampling sites. Site 94 (Warner Spring), contained the highest abundance of coho based on the number of trapping hours.

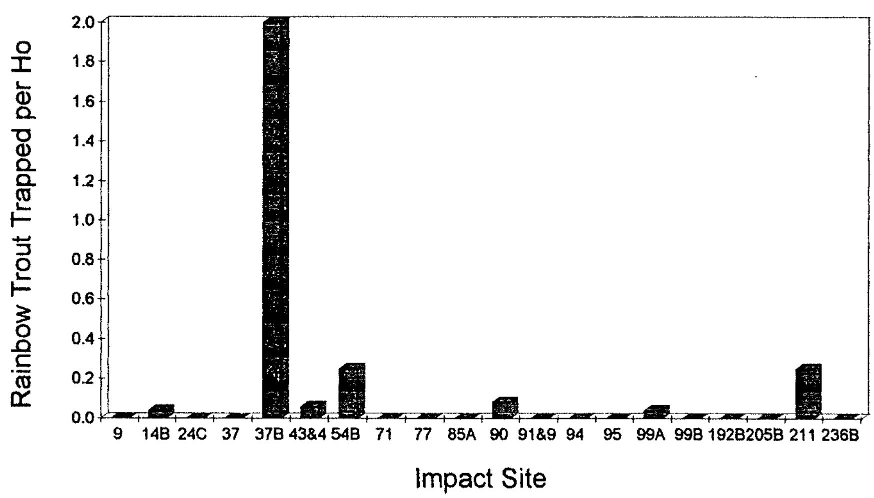


Figure 35: Relative abundance of juvenile rainbow trout between impact sites.

Juvenile rainbow trout were captured at only seven of twenty sites sampled. The majority of these were found at site 37B (Fiddle Creek) based on the number of fish trapped per hour.

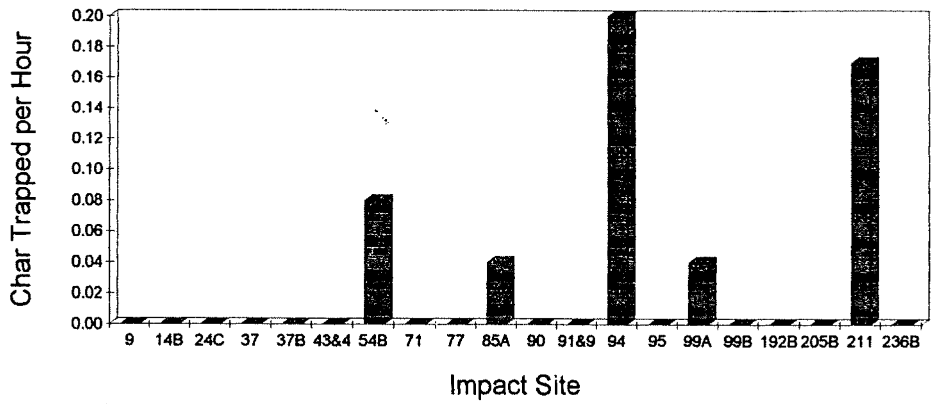


Figure 36: Relative abundance of juvenile char between impact sites.

Char were captured at only five of twenty sampling sites. Site 94 (Warner Spring) produced the highest number of char based on the number of trapping hours.

4.2.2 Location of Redds, Spawning and Holding Adults

Table 2, below, combines the information collected for this assessment with that collected by the TSES for an on going coho enumeration study (Culp & Culp, 1997). All data was collected between October 9, 1997 and December 18, 1997. Also see the colour photo mosaics in Appendix II for approximate locations of redds, spawning, and holding adults within each impact site.

Table 2. Location and abundance of redds, spawning and holding adults.

Impact Site	Redds	Spawning	adults	Holding adults
		live	dead	
9	2	0	0	
12	6	0	0	
14B	5	0	1	
24B	1	0	0	
90	4	4	2	
91&93	27	4	0	
211	11	8	1	30-40whitefish
236B	7	8	6	a pair of char spawning, 5 char redds

4.2.3 Age Class Structure

In order to estimate age class structure for coho, rainbow trout and char, the trapping results were grouped by habitat type.

4.2.3.1 Zymoetz river side channels

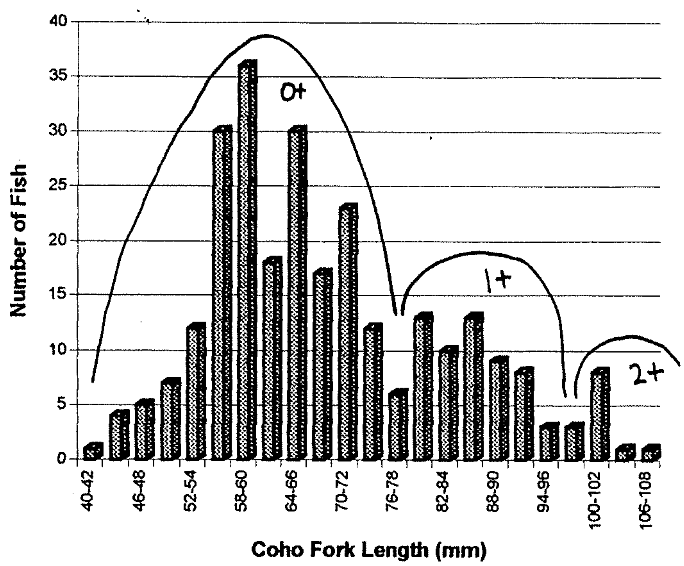


Figure 37: Coho fork length and estimated age classes for Zymoetz side channels.

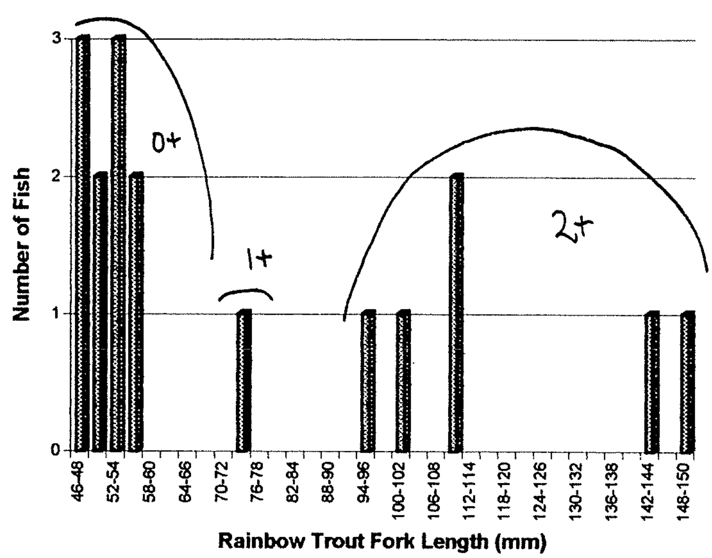


Figure 38: Rainbow trout fork length and estimated age classes for Zymoetz side channels.

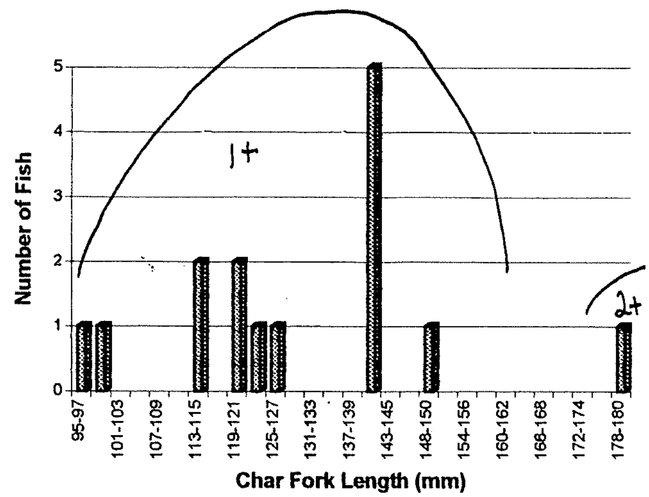


Figure 39: Char fork length and estimated age classes for Zymoetz side channels.

4.2.3.2 Elf Creek

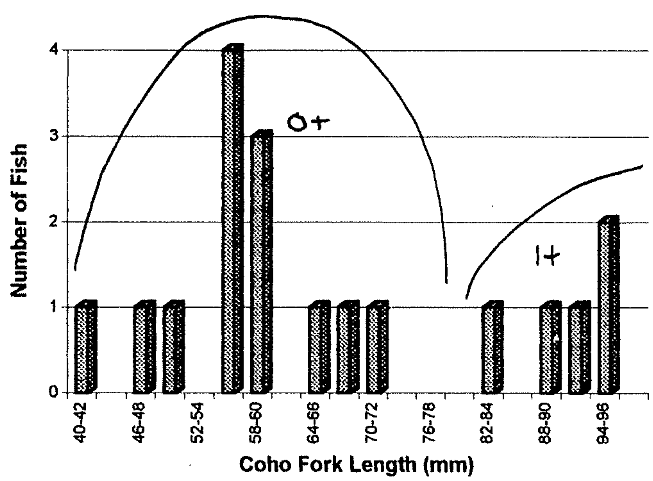


Figure 40: Coho fork length and estimated age classes for Elf Creek.

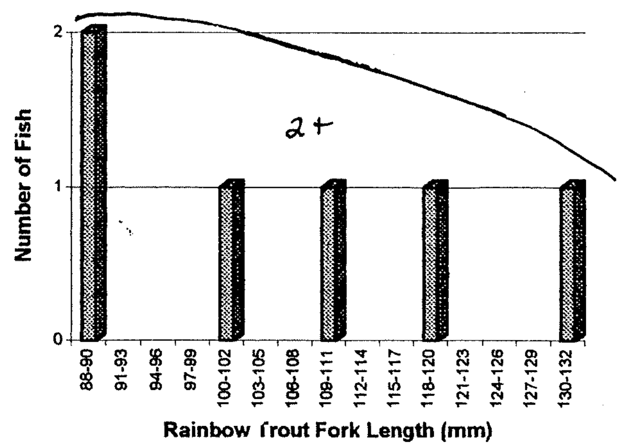


Figure 41: Rainbow trout fork length and estimated age classes for Elf Creek.

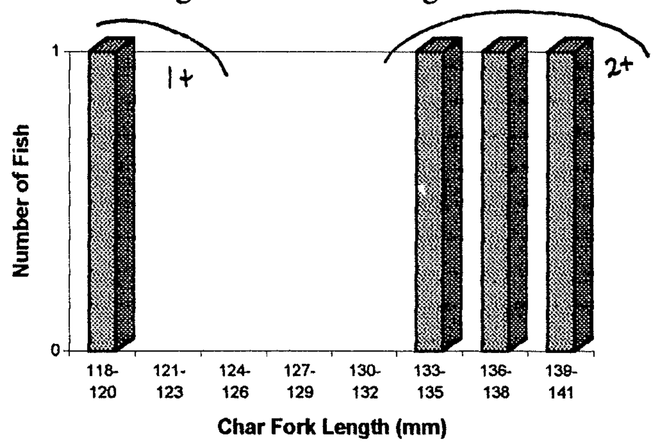


Figure 42: Char fork length and estimated age classes for Elf Creek.

4.2.3.3 O.K. Creek

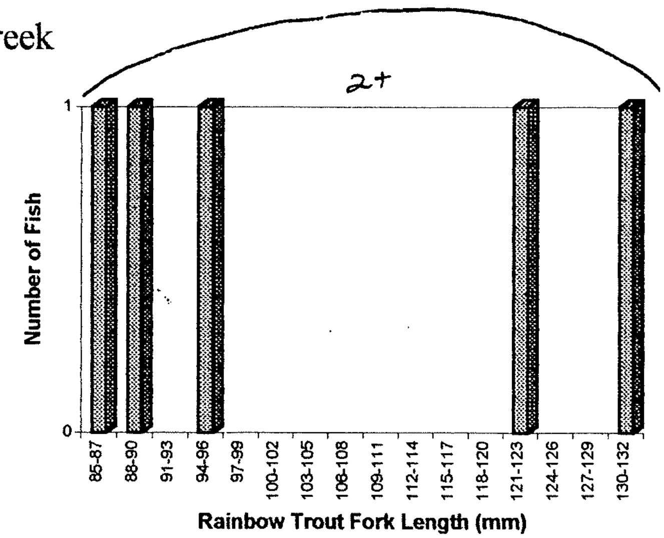


Figure 43: Rainbow trout fork length and estimated age classes for O.K. Creek.

4.2.3.4 Fiddle Creek

Both rainbow trout captured at this creek were in the 2+ age class.

4.2.3.5 Thomas Creek

The coho trapped at this creek was in the 0+ age class.

4.3 Priority of Rehabilitation and Timing Windows for 1998/99 Work

Based on the results obtained in this assessment, a prioritized list of restoration work and timing (to avoid spawning fish, incubation and rearing) has been completed and can be found in Appendix VIII along with a proposed cost for each project and total costs. These decisions were based on a number of things: the tentative budget for the fiscal year; the habitat that is in the greatest need of restoration including emergency situations; the project that is likely to produce the most fish in the shortest time; the number of man days of work that will be created; the cost effectiveness of the project; and the need to carry out additional assessment or study for the first phase of a project so that a project is not set back a year or more.

5.0 References

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Appendix I:
Maps for the Skeena/Copper (A), West Copper (B & C) and Clore (C, D & E) Sub-units

Legend

Sub-unit Boundary

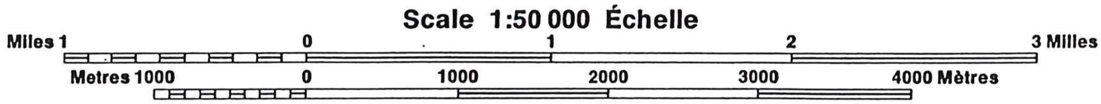
Category 1 Impact Site
(Isolated impact to the drainage that requires a non-professional prescription)

Category 2 Impact Site
(Sub-basin/reach where the impact is more cumulative in nature and requires an overall prescription or detailed survey and design)

COAST LAND DISTRICT RANGE 5

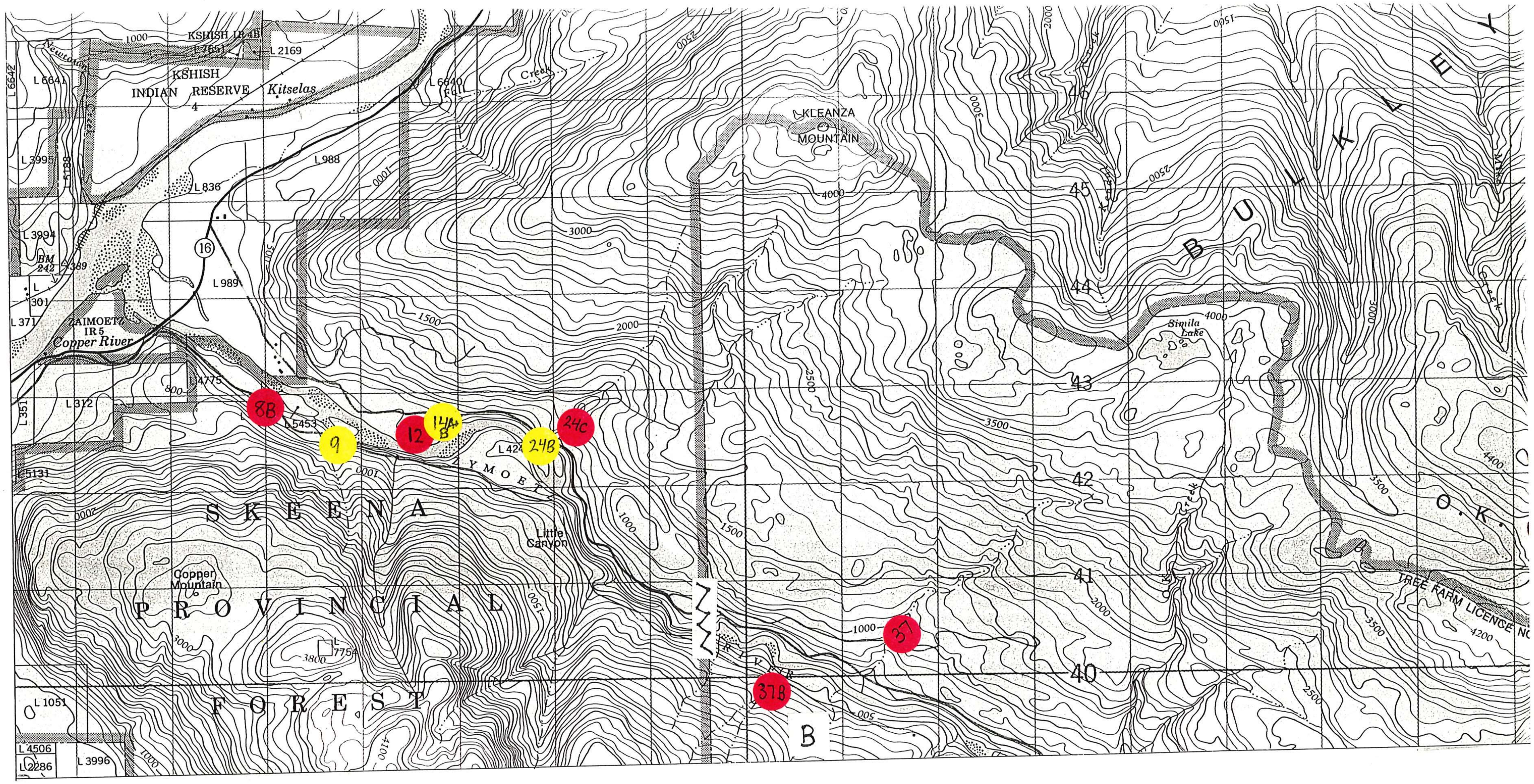
BRITISH COLUMBIA COLOMBIE-BRITANNIQUE

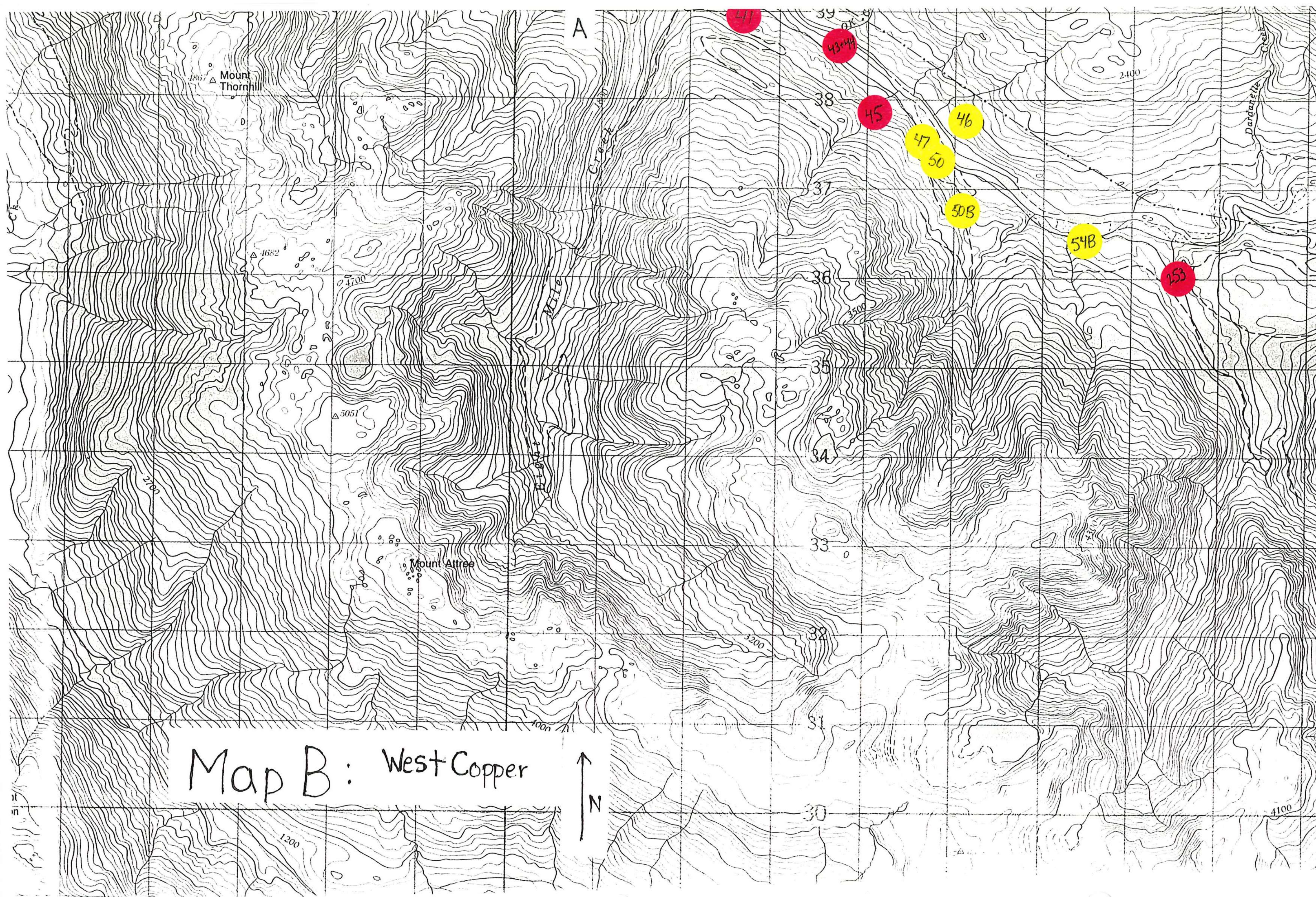
Scale 1:50 000 Échelle



All maps from Canada Center for Mapping, Department of Energy, Mines and Resources, 1992.

Map A: Skeena/Copper ↑N

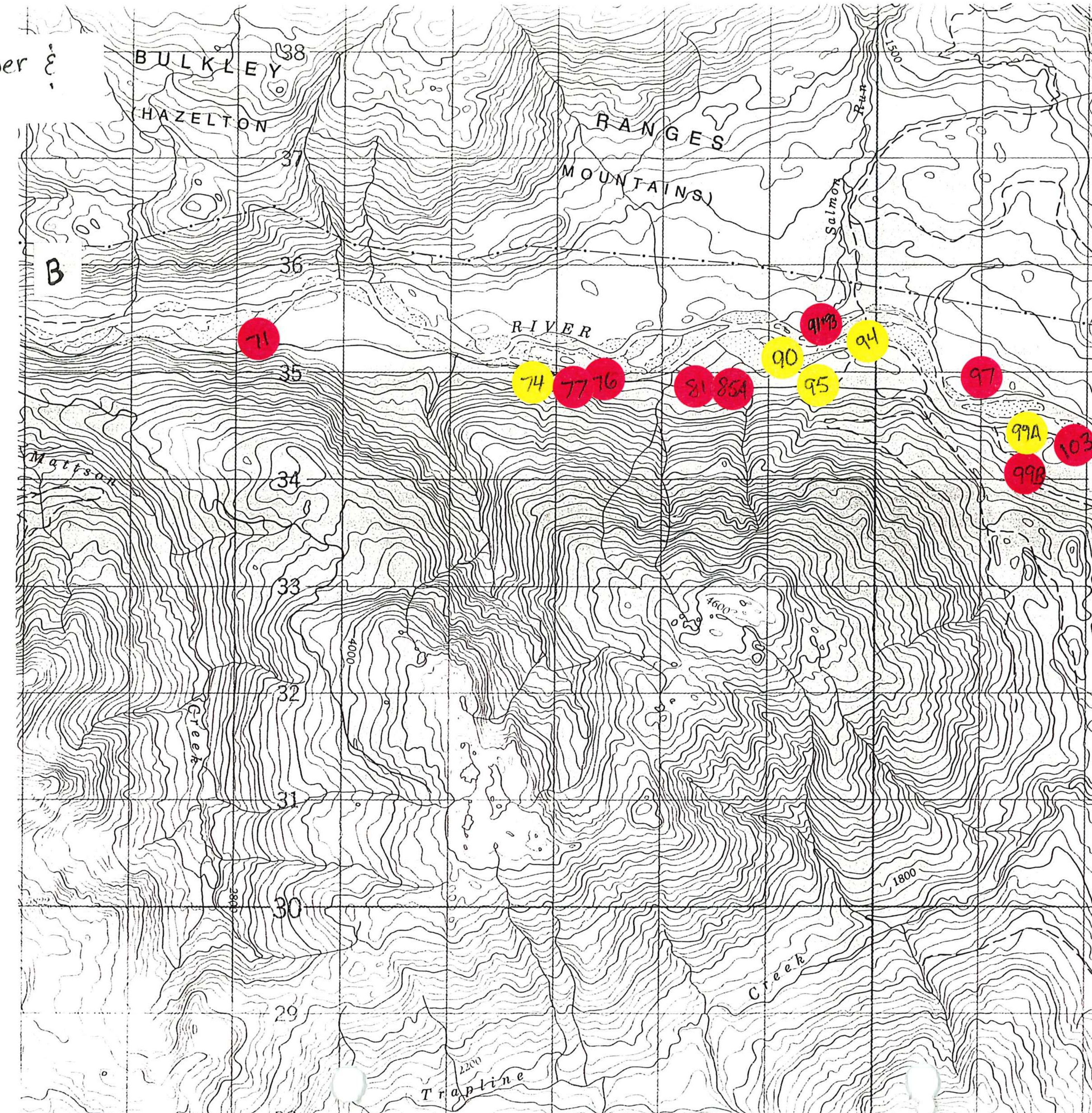




A
Mount Thornhill
4867
4682
4700
5051
Mount Attree
2700
1200
Eight Mile Creek
3500
3200
4000
2400
Dardanelle Creek
4100
39
38
37
36
35
34
33
32
31
30
41
43+44
45
46
47
50
50B
54B
253
Map B: West Copper
N

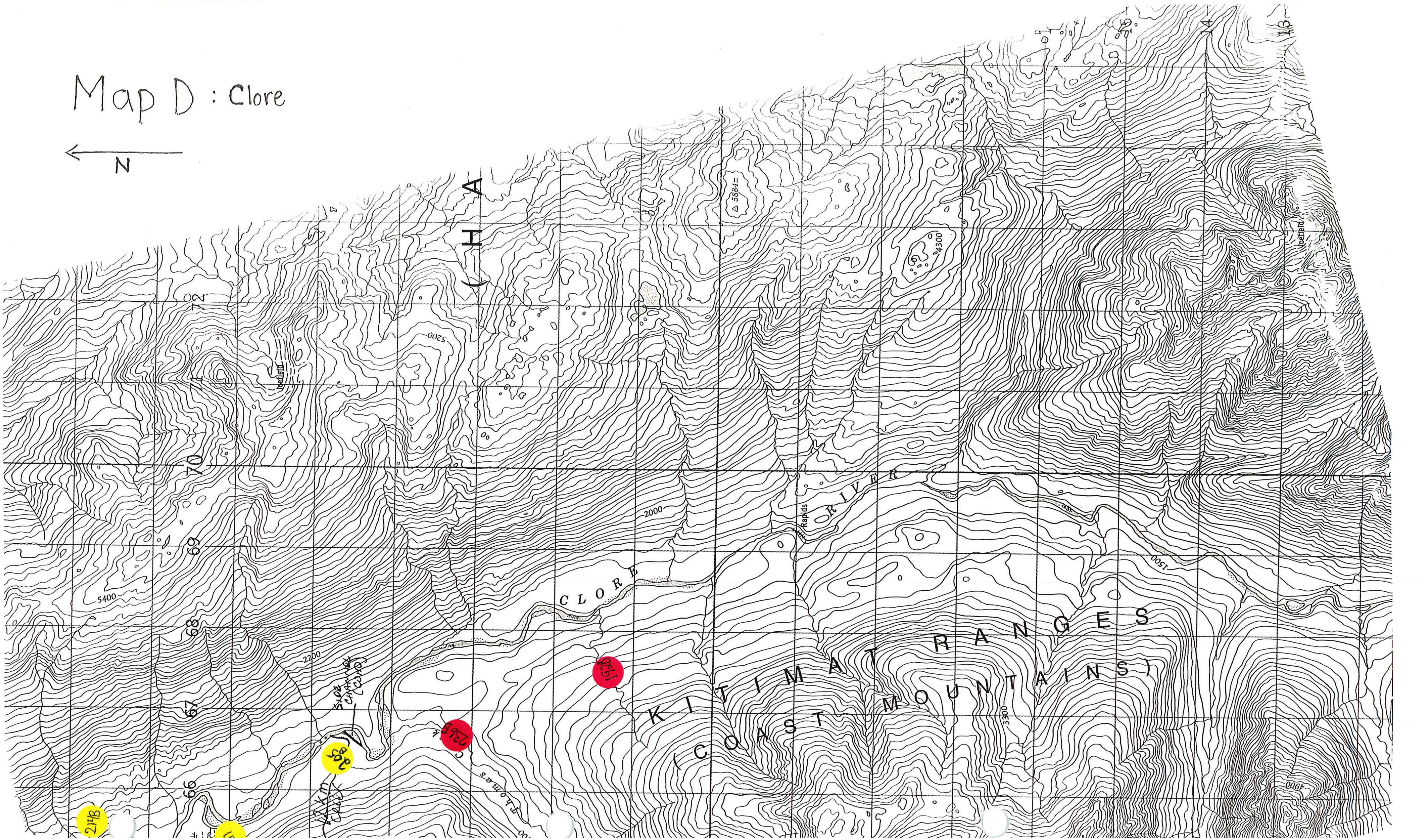
Map C: West Copper &
Clore

↑N



Map D : Clore

N


KITIMAT RANGES
(COAST MOUNTAINS)
CLORE
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5400
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14
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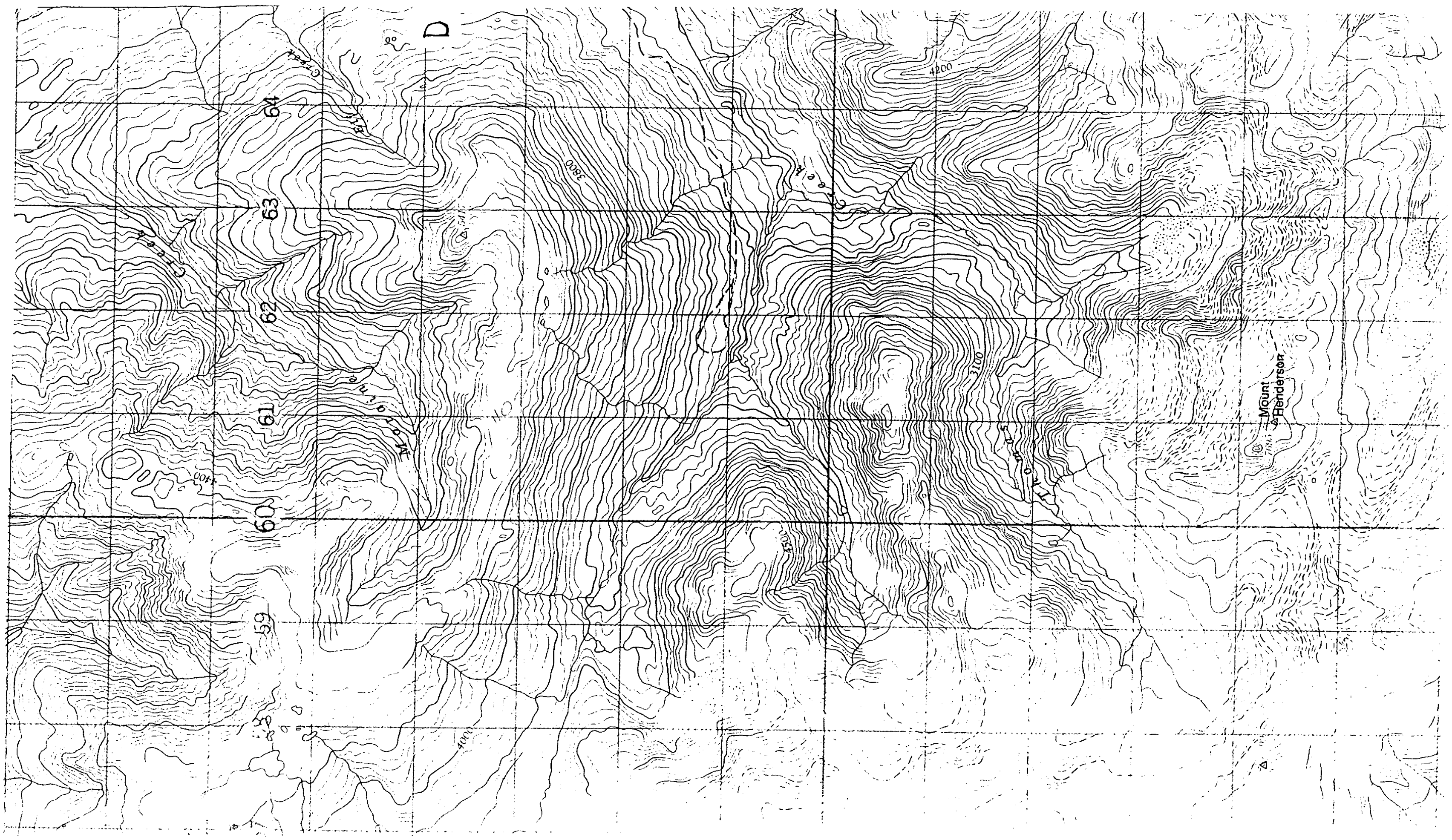
1928
2148
Side Channel (CLHO)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59
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3100
4500
4000
Mount
Henderson
Creek

Map E : Clore

N

Appendix II: Photo Mosaics

Zymoetz Watershed
LEGEND

Barriers:

beaver dam = BD
log jam = X
falls = F

BD

Sample Site &
Species Information:

co
rbt

Redd & Species
Information:

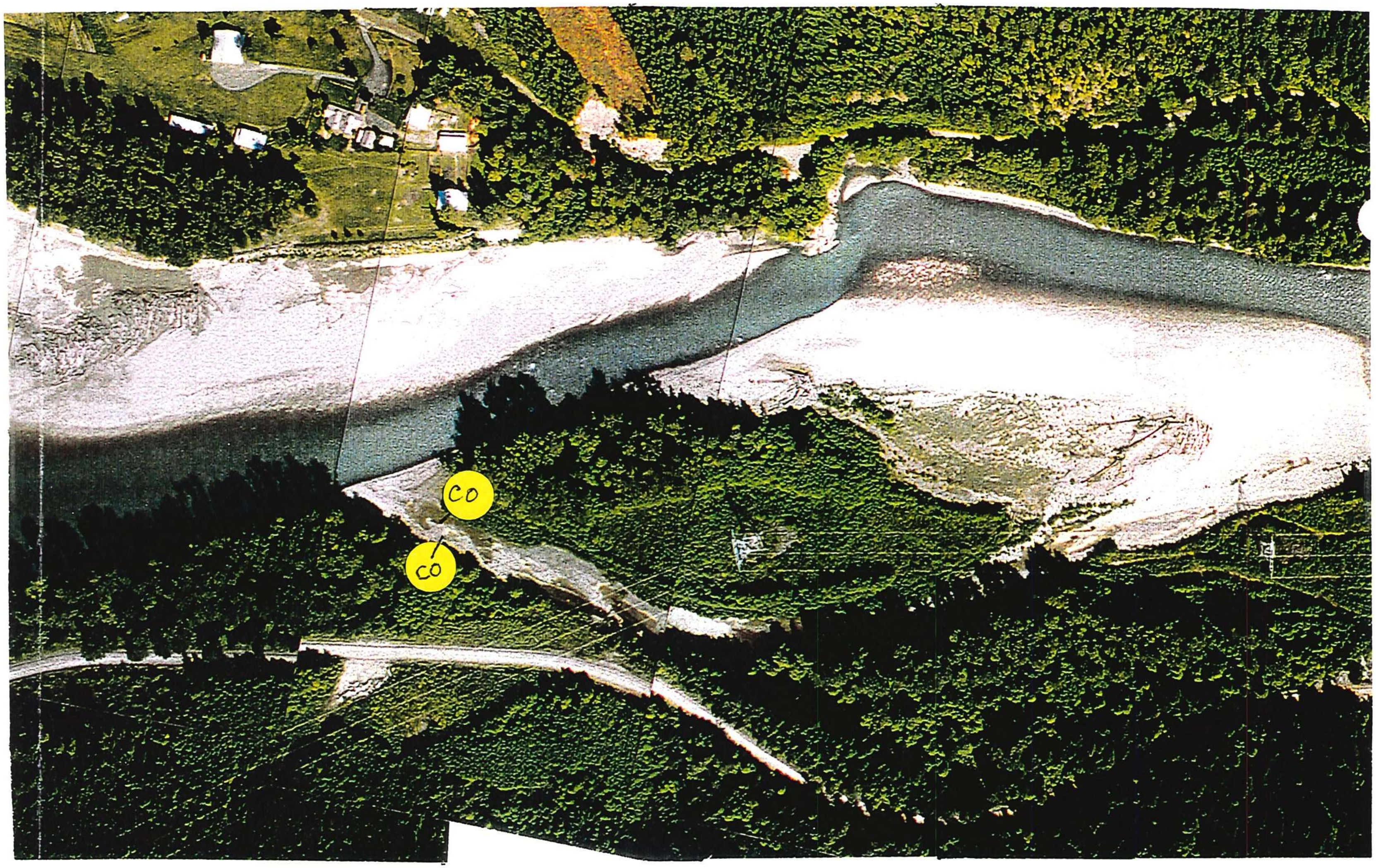
co

Spawning Adult &
Species Information:

co

Holding Adult &
Species Information:

co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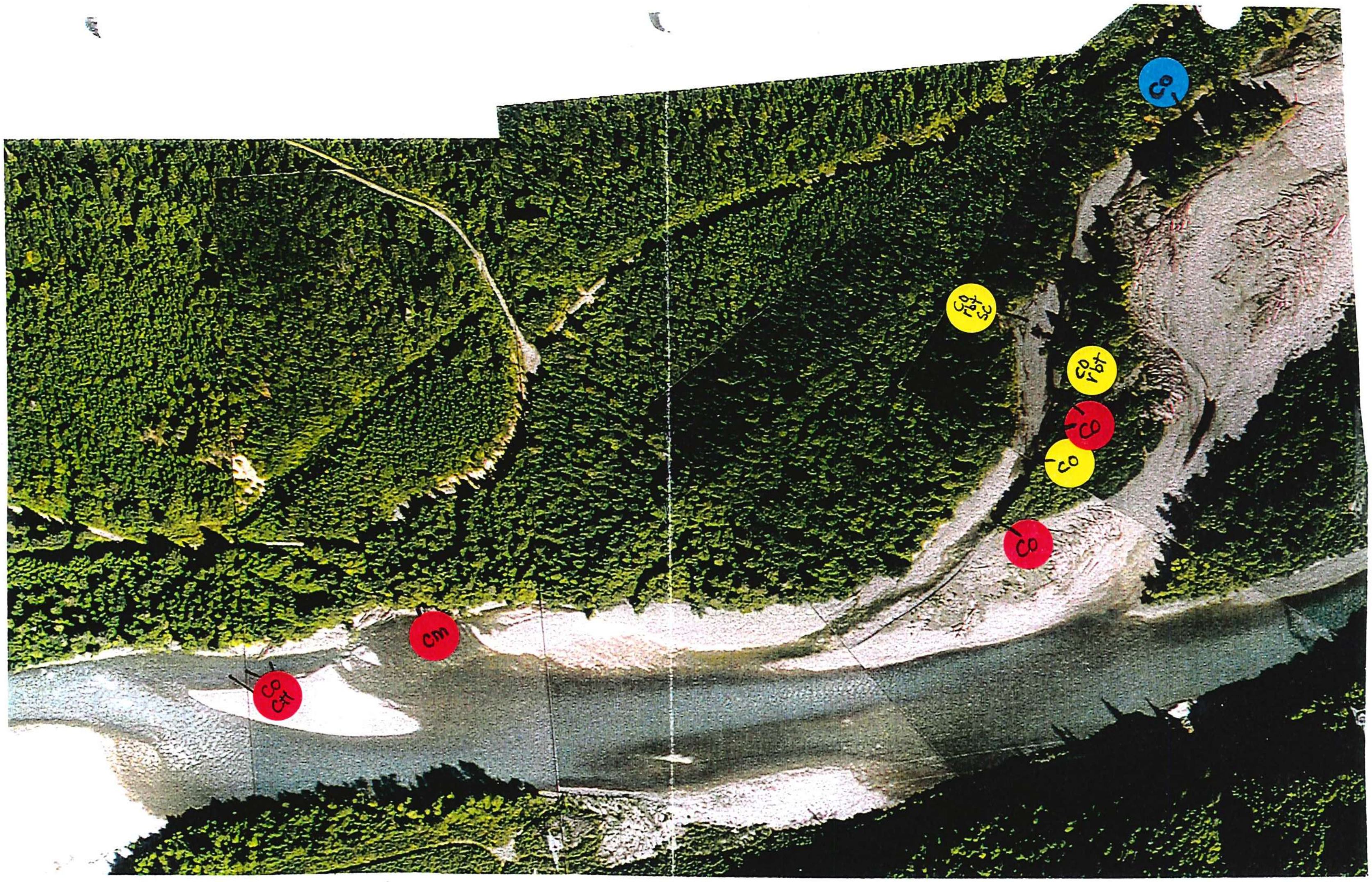
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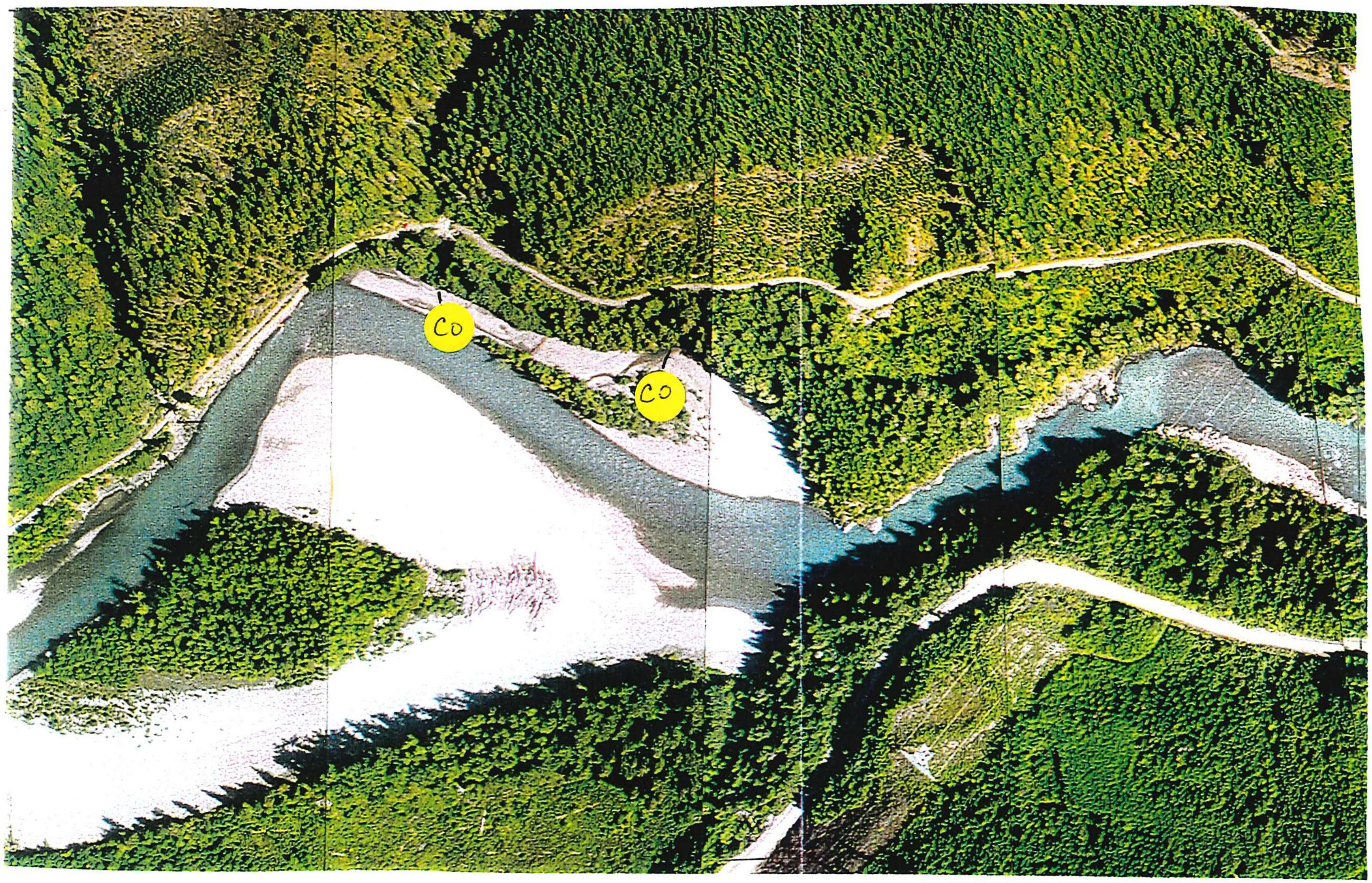
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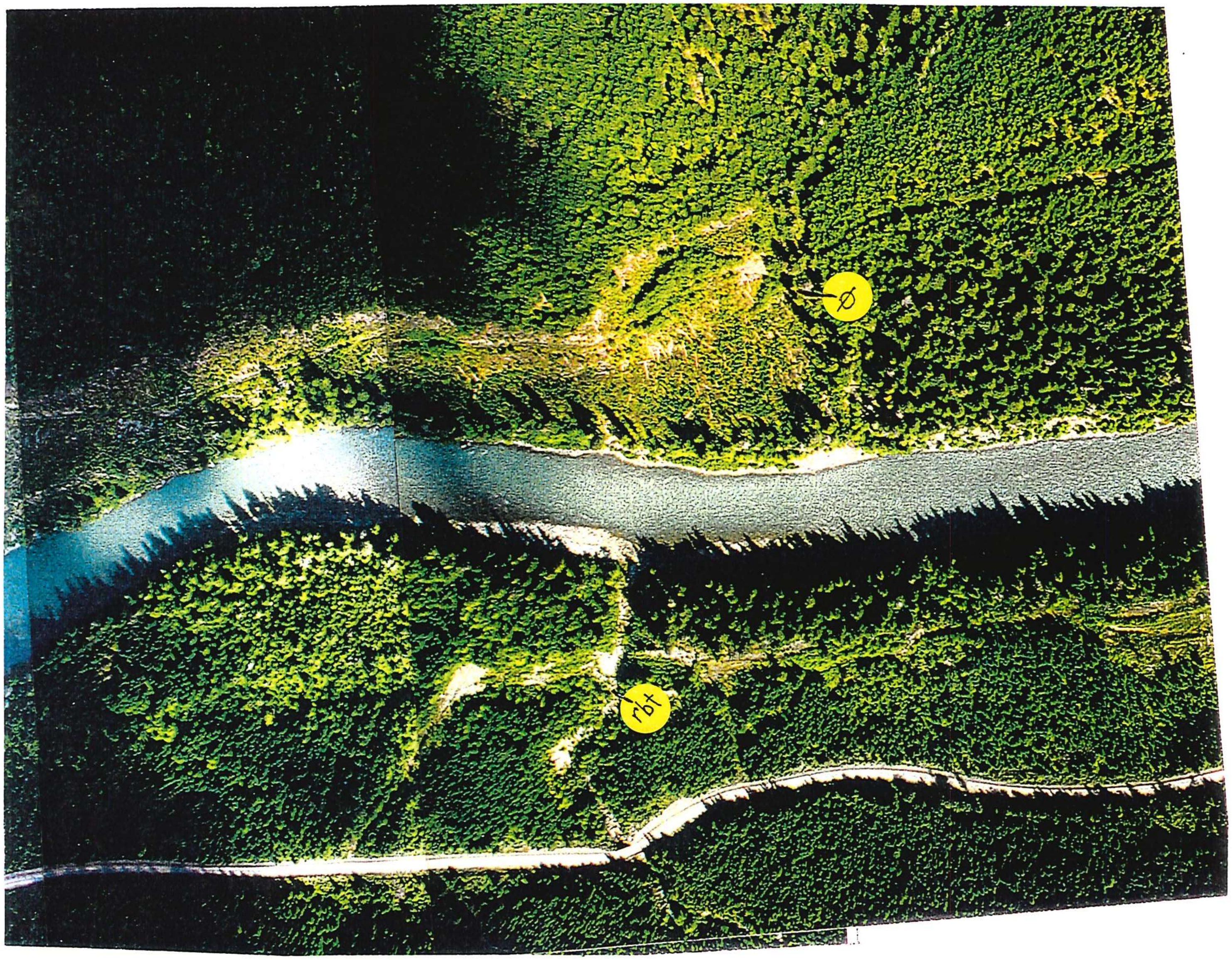
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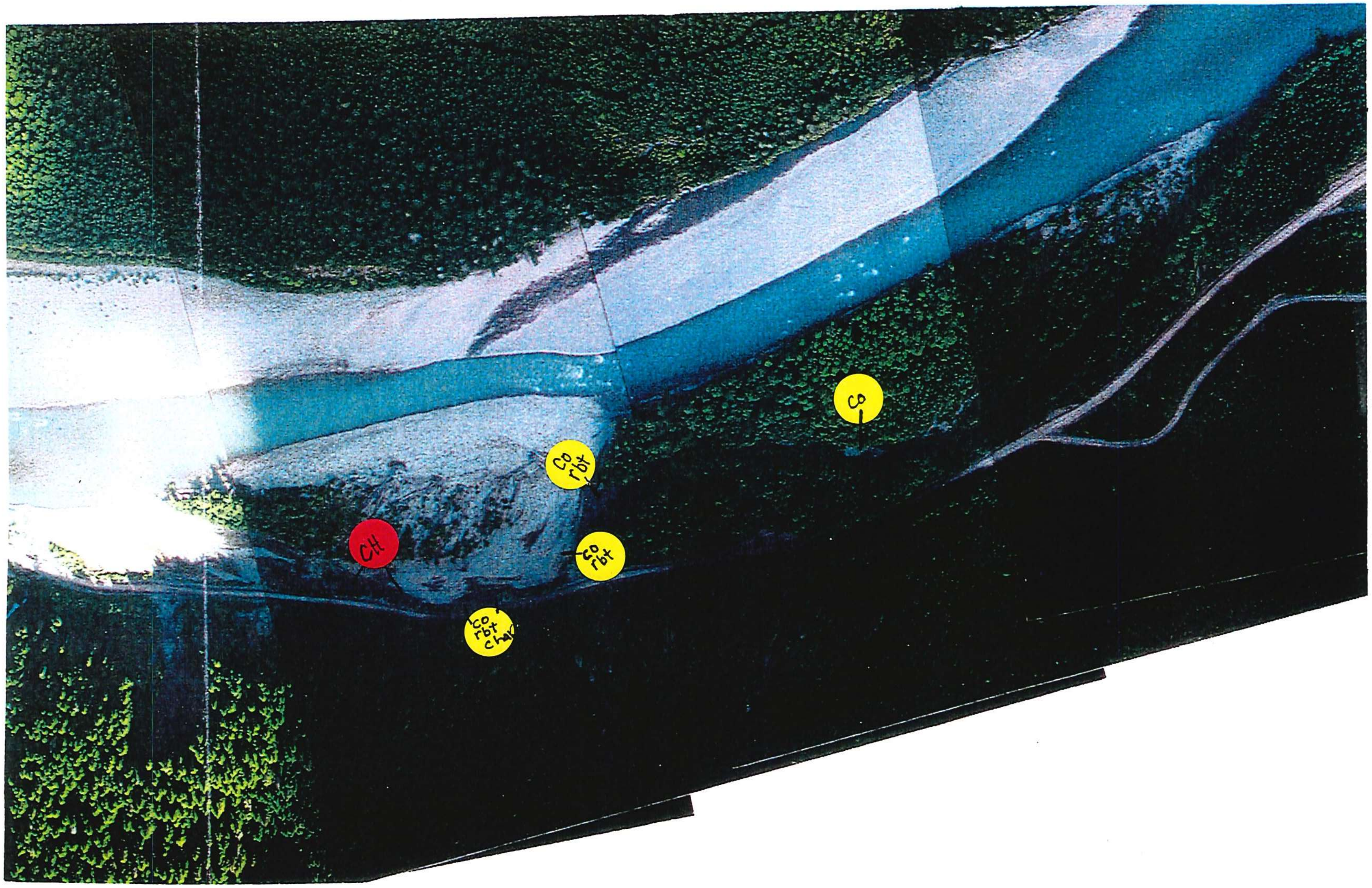
OK Creek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rbt
CH
co
rbt
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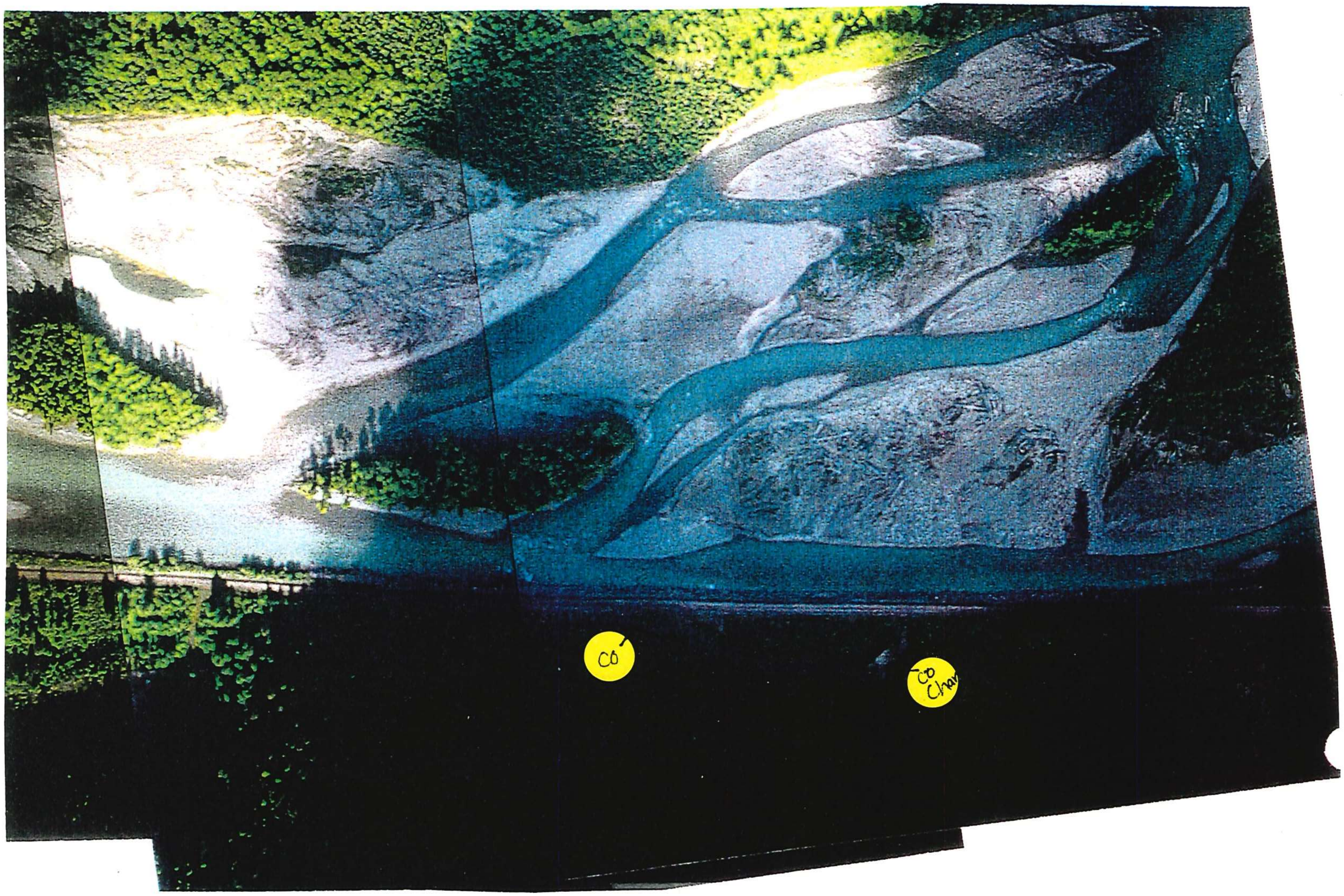
rbt
char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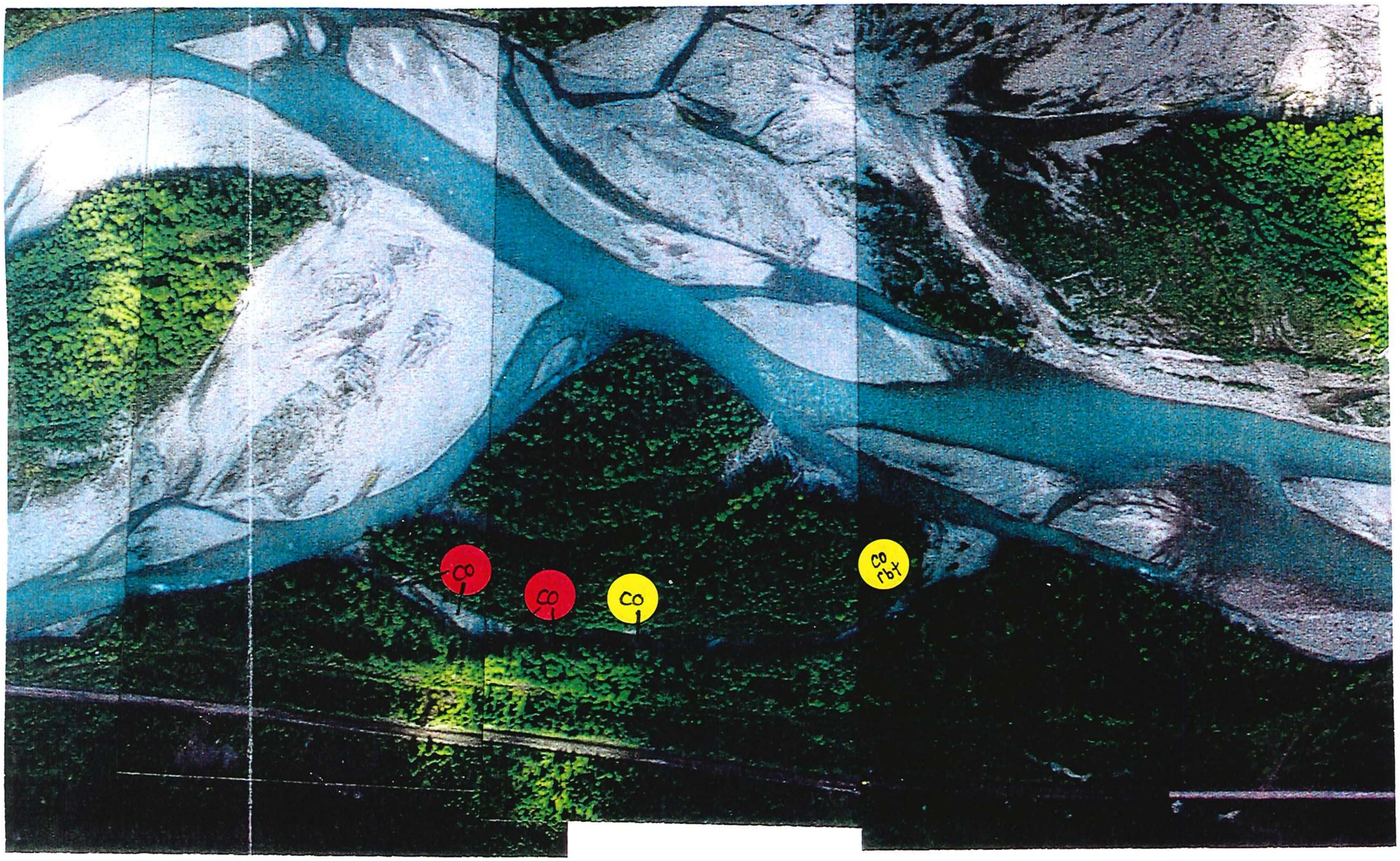
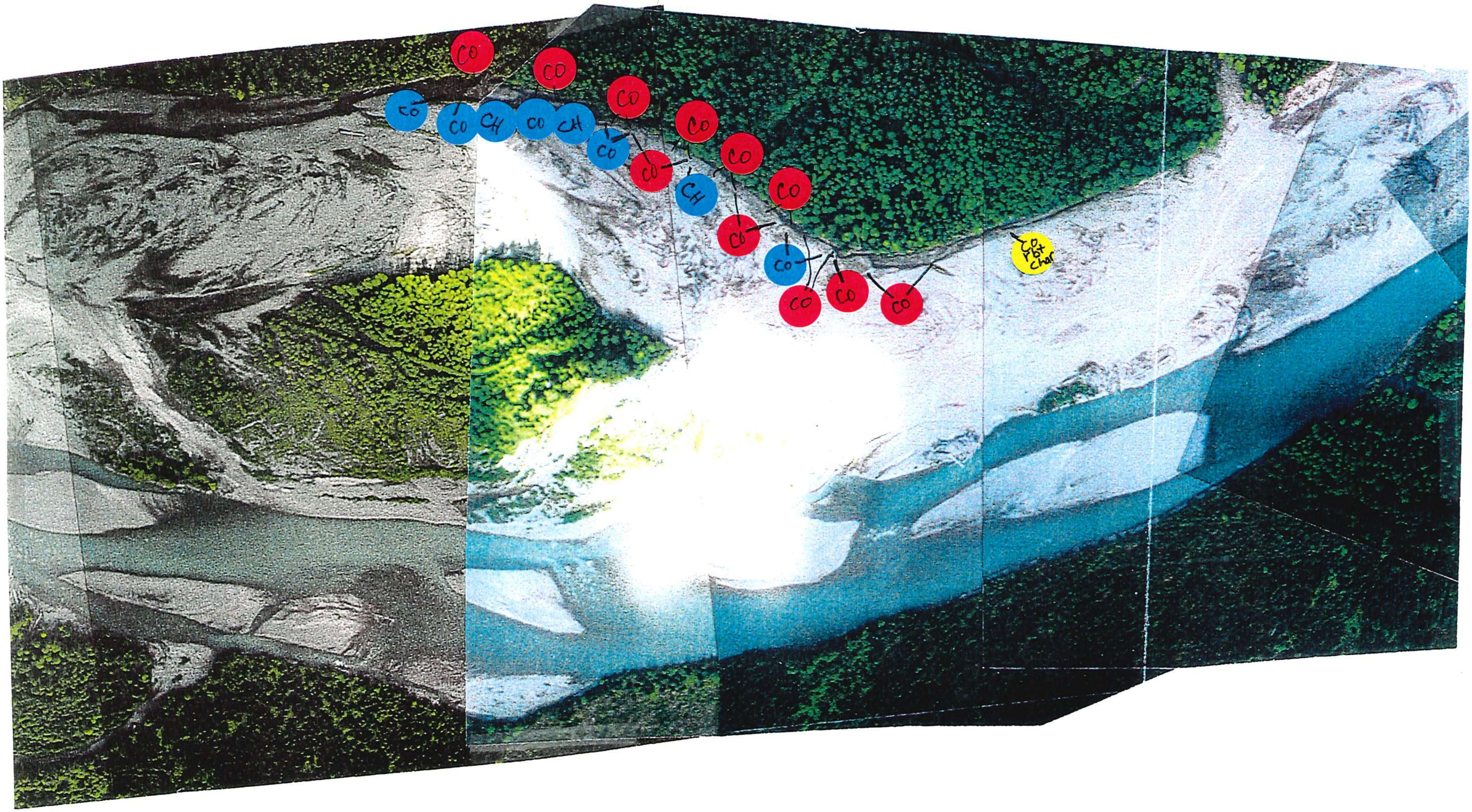
CO Char

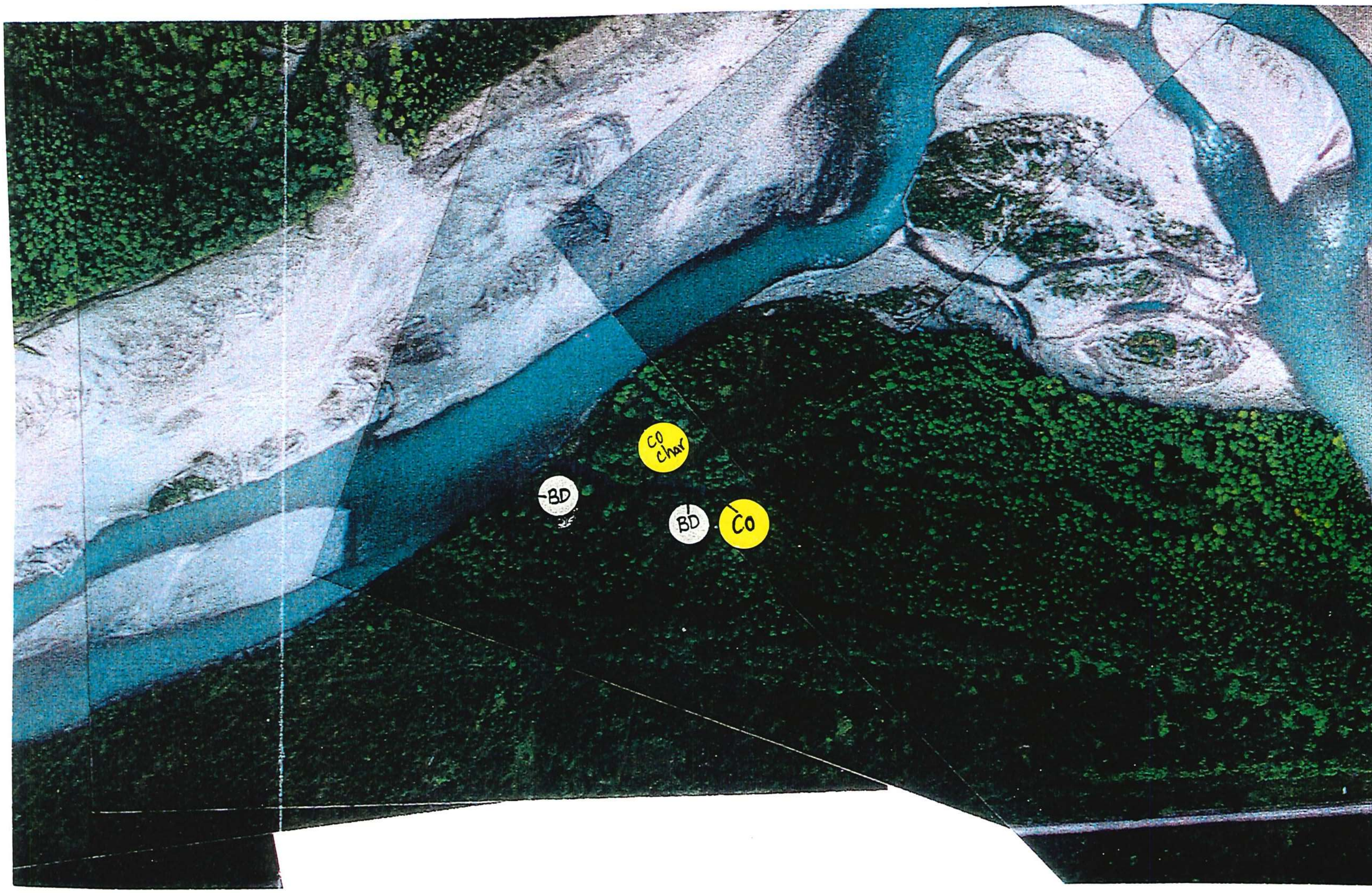


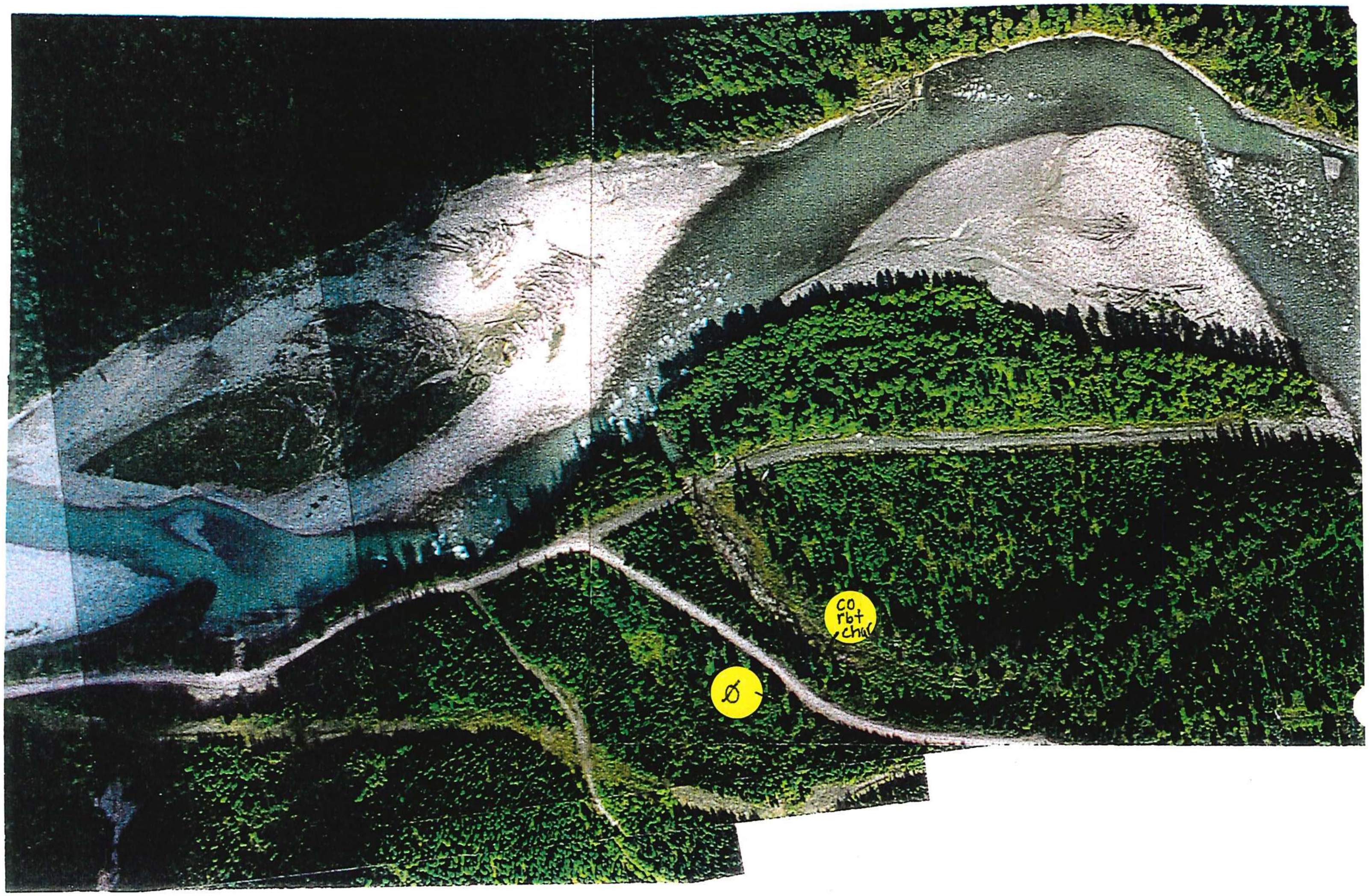
co
co
co
co
rbt

Salmon Run Creek



Warner Spring

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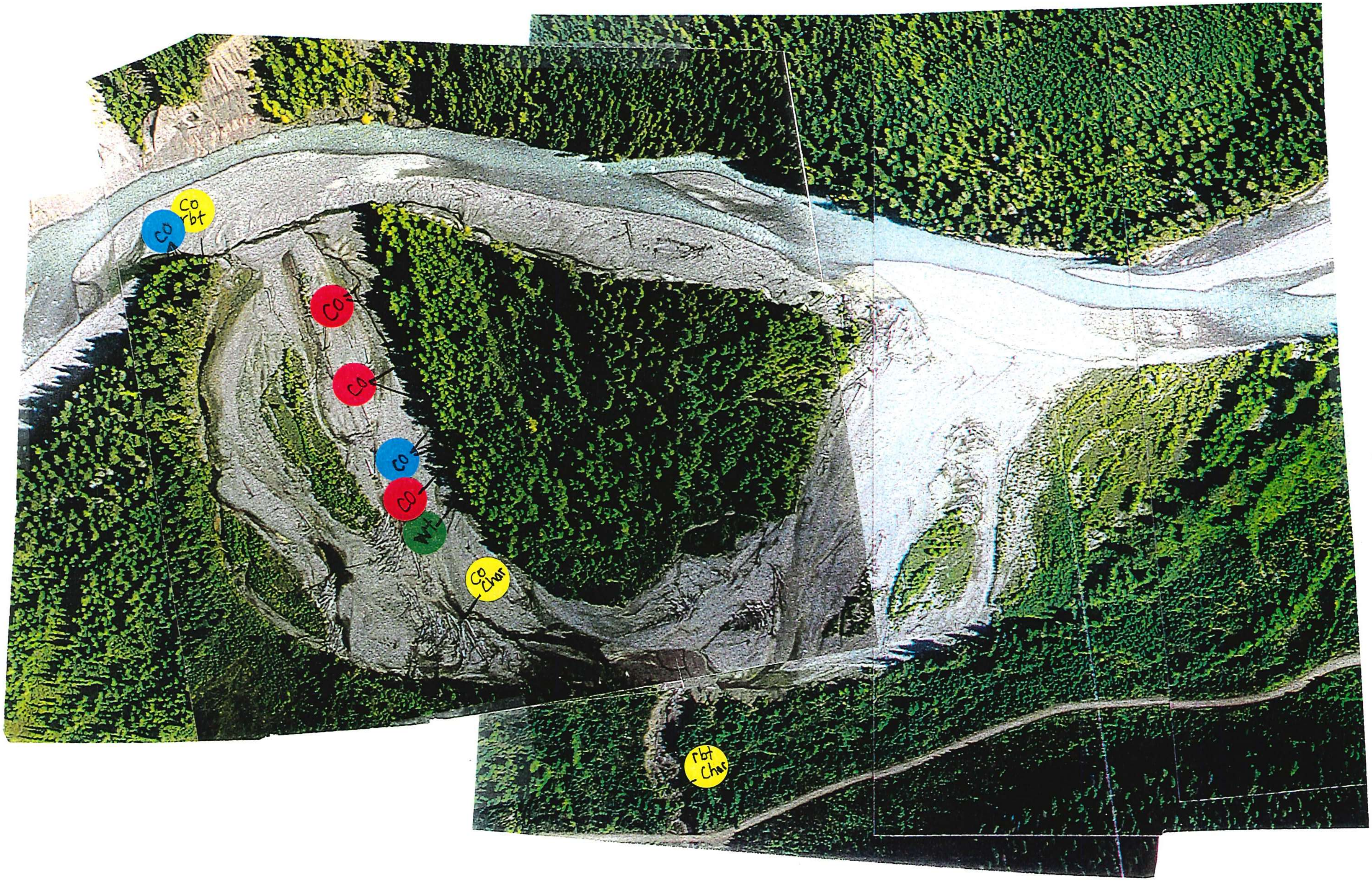
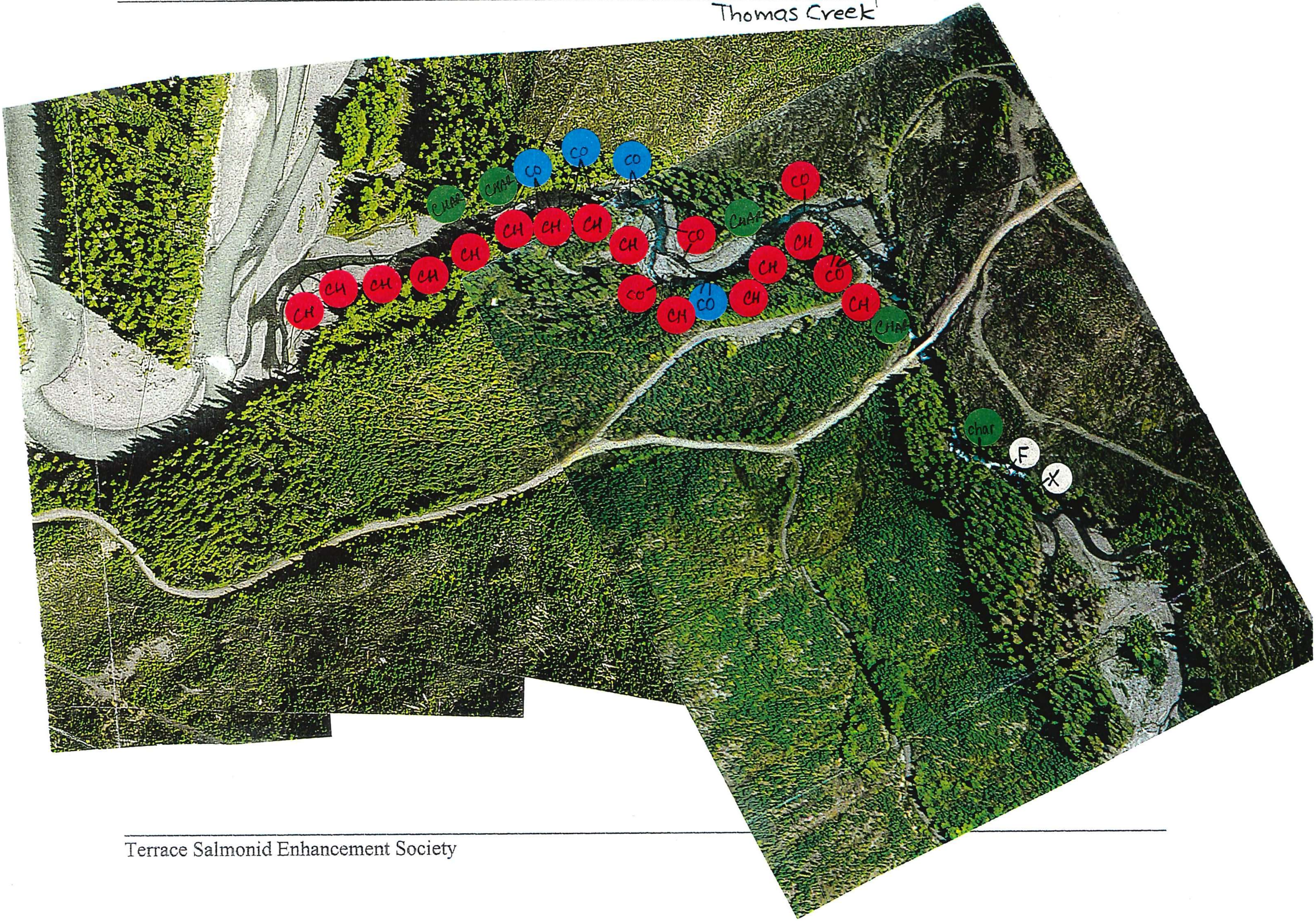
Elf Creek



Thomas Creek



Appendix III: Fish Distribution Data Forms 5 (Johnston and Slaney, 1996)

[illegible] 1 group of [illegible] spawners were [illegible]

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (side channel reach 1) [illegible]

UTM Code: 9.5358.60426

Watershed Code: 400-44-0000

Forest District: Kalum

Survey Crew: Chris Culp, Kezia Sinkewicz

Date: November 14, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1			V.O	MT							U	S	S	K	S	S	U	U	U		U	U	U											

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (side channel reach 1) Site 143

UTM Code: 9.5366.60427

Watershed Code: 400-44-0000

Forest District: Kalum

Survey Crew: Chris Culp, Kezia Sinkewicz

Date: November 12, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		Pl	VO	MT				U	U	U	U	H	H	K	K	K		H	H	K	U	U				U	U	U	U	U	U	U	U	U

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (side channel) Site 24B reach 1

Watershed Code: 400-44-0000

Survey Crew: Chris Culp, Kezia Sinkewicz

UTM Code: 9.5380.60425

Forest District: Kalum

Date: November 12, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		GI	VO	MT							U	U	U	N	S	S				N	U	U				N	N	N	N	N	N	N	N	N

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz ([illegible]) Site 24C

Watershed Code: 400-44

Survey Crew: Chris Culp, Kezia Sinkewicz

UTM Code: 9.5380.60425

Forest District: Kalum

Date: November 13, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		GI/PI	VO	MT						U	U	U		K						N	U	U				N	N	N	N	N	N	N	N	N
2		CI	N/A																															

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (Simila Creek) Site 37
UTM Code: 9.5412.60399
Watershed Code: 400 - 44
Forest District: Kalum
Survey Crew: Jim Culp, Chris Culp
Date: December 2, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		Cl/Gl	VO	MT										N	N	N				N	U	U				N	N	N	N	N	N	N	N	N

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz ( ) Site 37B
UTM Code: 9.5410.60399
Watershed Code: 400-44
Forest District: Kalum
Survey Crew: Jim Culp, Chris Culp
Date: December 2, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		Cl/Gl	VO	MT										U	U	U				K	U	U				U	U	U	U	U	U	U	U	U

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (O.K. Creek) Site 43&44

UTM Code: 9.5436.60390

Watershed Code: 400-44-0200

Forest District: Kalum

Survey Crew: Jim Culp, Chris Culp

Date: November 28, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		G1/C1	VO	MT										U	U	U				K	U	U				U	U	U	U	U	U	U	U	U
2		G1/K1	N/A																															

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (side channel) reach 4 Site 54B

UTM Code: 9.5463.60367

Watershed Code: 400-44-0000

Forest District: Kalum

Survey Crew: Chris Culp, Kezia Sinkewicz

Date: November 13, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		P1	VO	MT					H	H				K	H	H				K	S	S							K	S	S			

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (side channel) reach 5 Site 71

UTM Code: 9.5539.60358

Watershed Code: 400-44-0000

Forest District: Kalum

Survey Crew: Jim Culp, Chris Culp

Date: November 21, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		PI	VO	MT										N	N	N				N	N	N							N	N	N			

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (Site 77

UTM Code: 9.5568.60350

Watershed Code: 400-44-

Forest District: Kalum

Survey Crew: Jim Culp, Chris Culp

Date: December 2, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		GI/P)	VO	MT										N	N	N				N	N								N					

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (sidechannell) reach 5 Site 85A

UTM Code: 9.5582.60351

Watershed Code: 400-44-0000

Forest District: Kalum

Survey Crew: Chris Culp, Kezia Sinkewicz

Date: November 14, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		PI	VO	MT										K															K					

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (sidechannel) reach 5 Site 90

UTM Code: 9.5585.60353

Watershed Code: 400-44-0000

Forest District: Kalum

Survey Crew: Chris Culp, Kezia Sinkewicz

Date: November 14, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		PI/GI	VO	MT										K	K	K				K						K								

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (Salmon Run Creek) Site 91&93

UTM Code: 9.5589.60356

Watershed Code: 400-44-0700

Forest District: Kalum

Survey Crew: Jim Culp, Chris Culp

Date: November 28, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		Gl/Pl	VO	VO/MT				S	S	S				K	K	K				K	S	S							K	K	K			

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (Warner Spring) reach 5 Site 94

UTM Code: 9.5596.60355

Watershed Code: 400-44-0000

Forest District: Kalum

Survey Crew: Chris Culp, Kezia Sinkewicz

Date: November 14, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		Pl/Gl	VO	MT										K																				
2		Pl/Gl	VO	MT										K																K					

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (Swan Creek) Site 95
UTM Code: 9.5587.60352
Watershed Code: 400-44
Forest District: Kalum
Survey Crew: Chris Culp, Kezia Sinkewicz
Date: November 14, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		Pl	VO	MT																						K					K			K
2		Cl	N/A																															

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (backchannel) Site 99A
UTM Code: 9.5615.60346
Watershed Code: 400-44-0000
Forest District: Kalum
Survey Crew: Chris Culp, Kezia Sinkewicz
Date: November 14, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		Pl/Gl	vo	MT										K						K									K					
2		N/A	N/A																															

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (Clore - 17km Creek) Site 192B

UTM Code: 9.5685.60220

Watershed Code: 400-44-0800

Forest District: Kalum

Survey Crew: Jim Culp, Chris Culp, Kezia Sinkewicz

Date: November 17, 1997

Reach	Section	Habitat	Survey	Method	SK	SK	SK	CH	CH	CH	CM	CM	CM	CO	CO	CO	PK	PK	PK	ST	ST	ST	RB	RB	RB	CT	CT	CT	DV	DV	DV	BT	BT	BT
Number		Type	Adults	Juveniles	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp
1		CI	VO	MT										N	N	N				N	N	N				N	N	N	N	N	N	N	N	N

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (Doll Creek) Site 99B

UTM Code: 9.5611.60348

Watershed Code: 400-44

Forest District: Kalum

Survey Crew: Chris Culp, Kezia Sinkewicz

Date: November 14, 1997

Reach	Section	Habitat	Survey	Method	SK	SK	SK	CH	CH	CH	CM	CM	CM	CO	CO	CO	PK	PK	PK	ST	ST	ST	RB	RB	RB	CT	CT	CT	DV	DV	DV	BT	BT	BT
Number		Type	Adults	Juveniles	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp	juv	ad	sp
1		CI/PI	VO	MT										N	N	N				N	N	N				N	N	N	N	N	N			

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (Clore - Elf Creek) Site 211

UTM Code: 9.5654.60279

Watershed Code: 400-44-0800-030

Forest District: Kalum

Survey Crew: Jim Culp, Chris Culp, Kezia Sinkewicz

Date: November 18, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		Gl/Pl	VO	MT				U	U	U				K	K	K				K	S	S							K	K	K			
2		Cl	VO	MT				U	U	U				K						K									K	K	K			
3		Cl	N/A					U	U	U				K																				

Level 1 - Fish Distribution Data Form

Watershed Name: Zymoetz (Clore - Thomas Creek) Site 236B

UTM Code: 9.5667.60240

Watershed Code: 400-44-0800-040

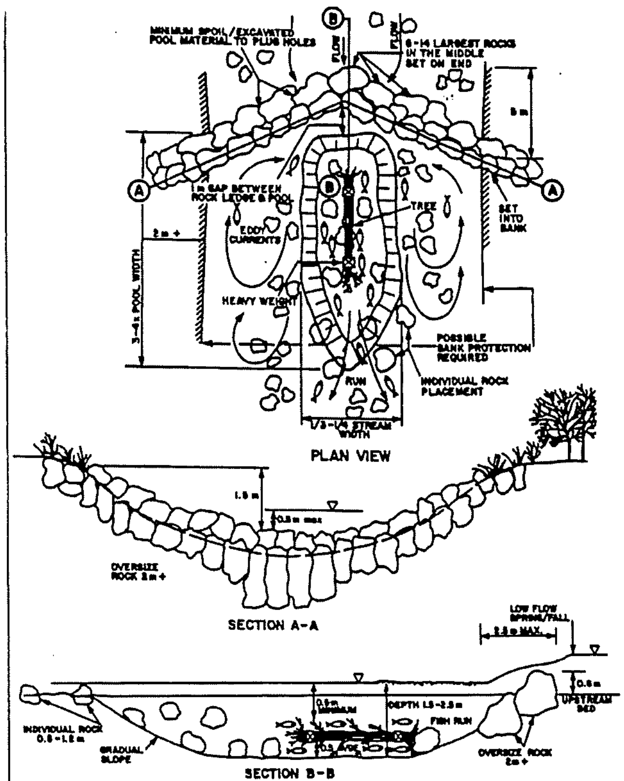
Forest District: Kalum

Survey Crew: Jim Culp, Chris Culp, Kezia Sinkewicz

Date: November 15, 1997

Reach Number	Section	Habitat Type	Survey Adults	Method Juveniles	SK juv	SK ad	SK sp	CH juv	CH ad	CH sp	CM juv	CM ad	CM sp	CO juv	CO ad	CO sp	PK juv	PK ad	PK sp	ST juv	ST ad	ST sp	RB juv	RB ad	RB sp	CT juv	CT ad	CT sp	DV juv	DV ad	DV sp	BT juv	BT ad	BT sp
1		Pl/Gl	VO	MT				S	S	S				K	K	K				H	H	H							S	K	K	S	K	K
2		Pl/Gl	N/A					S	S	S				K	K	K				H	H	H							S	K	K	S	K	K

Appendix IV: Rock Vee (Weir) Construction



CONSTRUCTION NOTES

*1 - All weir crest rocks **MUST SLOPE DOWN** from the banks **TO THE UPSTREAM POINT** of the weir to confine the main flow to the middle 1/3 of the stream.*

*2 - All rock **MUST** extend upstream from the bank where they are buried deeply to the middle point of the weir.*

3 - The largest (8-16) rocks (2 M+) must be placed at the point of the weir in a double row and set in place with the longest side pointing down (as shown) in a trench already excavated for this purpose. All rock is to be jammed together by machinery to provide tight as possible fit. Additional stabilizing rock and spoil are to be placed around these rocks, then the remainder of the weir crest may be built. The weir crest width should be 2.0 m.

4 - The upstream notch on the weir must be within the middle third of the river, but may be placed at any point within to move the current from side to side. Bank armouring may be necessary in such cases where potential bank erosion exists.

5 - The top of the rocks in the notch of the weir shall not be more than 0.6 m above the stream bed, unless an upstream pool is required. The bank tie-in location shall be 1.5 m above the stream elevation. The rocks shall taper gradually from the notch to the tie-in point on the bank.

6 - Only a minor amount of spoil material may be used to fill in the voids in the weir crest to prevent water from flowing through the weir. The spoil is only to ensure relative water tightness. All remaining spoil material must be placed 10 m beyond the stream banks, preferably 1.5 m above current water level.

7 - Excavated material from the pool to be placed as follows: 10% around the weir crest to plug holes between the rocks; 90% to be spoiled 10 m minimum outside and above current channel banks.

8 - All elevation differences shall relate to the low stream flow conditions in the fall, or at time of inspection, whichever is less.

9 - All individual placed rocks to be approximately 0.8 - 1.2 m in size.

10 - Pool depth to be 1.5 - 2.5 m maximum.

Rock vee construction. (Slaney and Zaldokas, 1997)

Nominal Diameter	CLASS 1 < 2.3 $m \cdot sec^{-1}$	CLASS 2 < 3 $m \cdot sec^{-1}$	CLASS 3 < 3.8 $m \cdot sec^{-1}$	CLASS 4 < 4.7 $m \cdot sec^{-1}$	CLASS 5 < 5.6 $m \cdot sec^{-1}$
Dmax	0.45 m (130 kg)	0.80 m (700 kg)	1.2 m (2400 kg)	1.8 m (8000 kg)	2.7 m (27000 kg)
D80	0.35 m (70 kg)	0.60 m (300 kg)	0.90 m (1000 kg)	1.5 m (4700 kg)	2.2 m (15000 kg)
D50	0.30 m (40 kg)	0.50 m (200 kg)	0.80 m (700 kg)	1.2 m (2400 kg)	1.8 m (8000 kg)
D20	0.20 m (10 kg)	0.30 m (40 Kg)	0.50 m (200 kg)	0.80 m (700 kg)	1.2 m (2400 kg)

Specifications for rock for in stream structures. Velocities are the average for the 1:50-year flood. Average rock weight in brackets. (Slaney and Zaldokas, 1997)

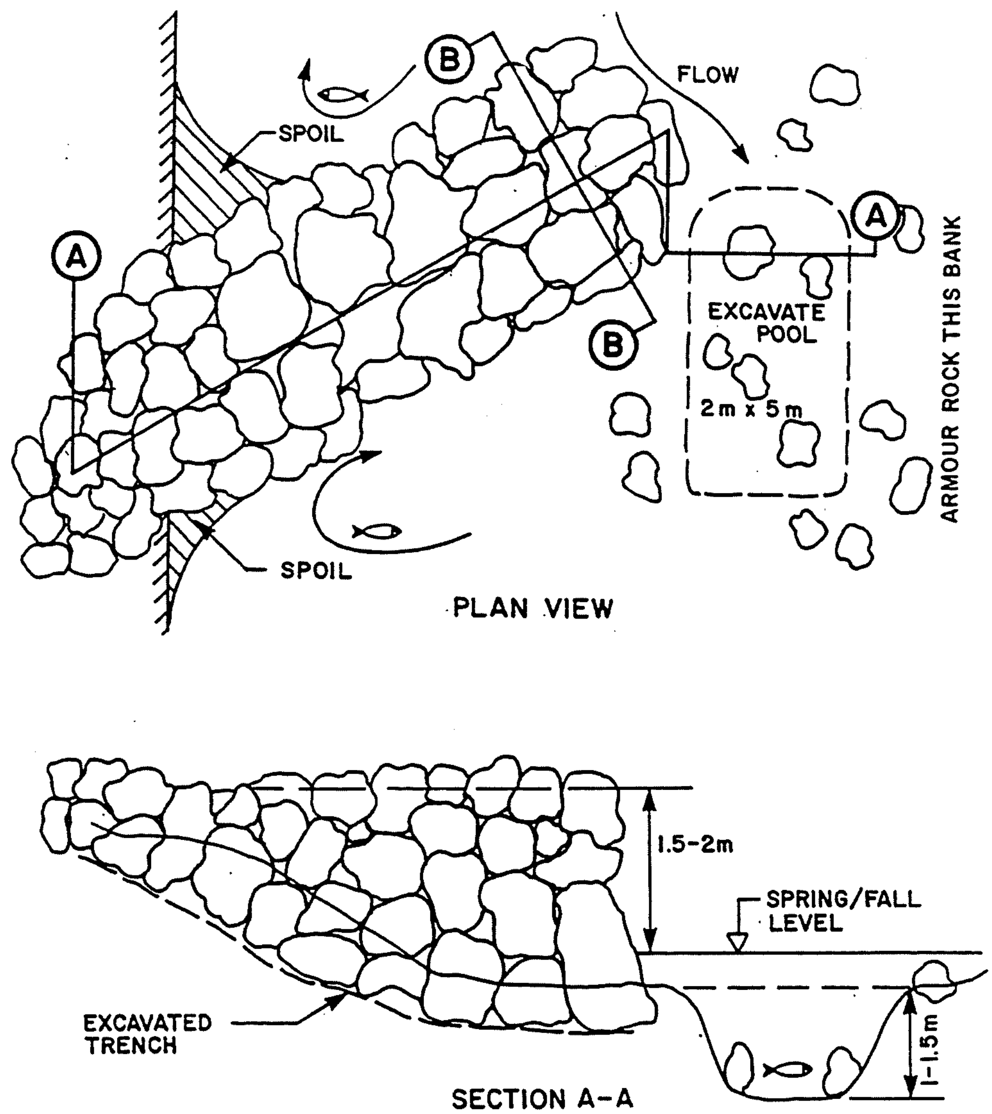
Appendix V: Spawning Requirements of Salmonids

Species	Minimum Depth (m)	Velocity ($m \cdot sec^{-1}$)	Substrate Size (mm)	Mean Redd Area (m^2)	Req'd Area per Spawning Pair (m^2)
fall chinook salmon	0.24	0.30 - 0.91	13 - 102	5.1	20.1
spring chinook salmon	0.24	0.30 - 0.91	13 - 102	3.3	13.4
summer chinook salmon	0.30	0.32 - 1.09	13 - 102	5.1	20.1
chum salmon	0.18	0.46 - 1.01	13 - 102	2.3	9.2
coho salmon	0.18	0.30 - 0.91	13 - 102	2.8	11.7
pink salmon	0.15	0.21 - 1.01	13 - 102	0.6	0.6
sockeye salmon	0.15	0.21 - 1.07	13 - 102	1.8	6.7
kokanee	0.06	0.15 - 0.91	13 - 102	0.3	0.15
steelhead	0.24	0.40 - 0.91	6 - 102	4.4 - 5.4	
rainbow trout	0.18	0.48 - 0 91	6 - 52	0.2	
cutthroat trout	0.06	0.11 - 0.72	6 - 102	0.09 - 0.9	

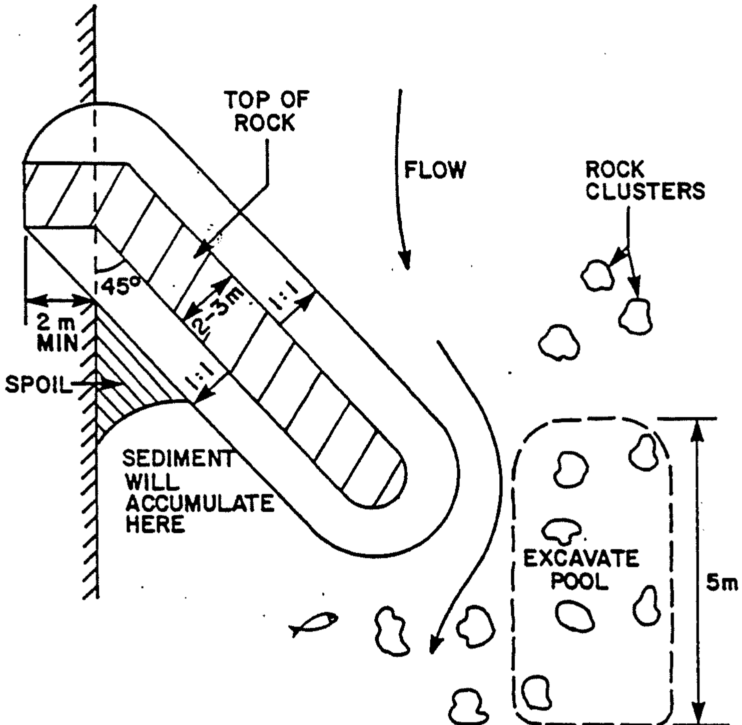
Water depth, velocity and substrate size criteria for some salmonids (Slaney and Zaldokas, 1997)

Appendix VI: Groyne Construction (Alberta Environment, 1991)

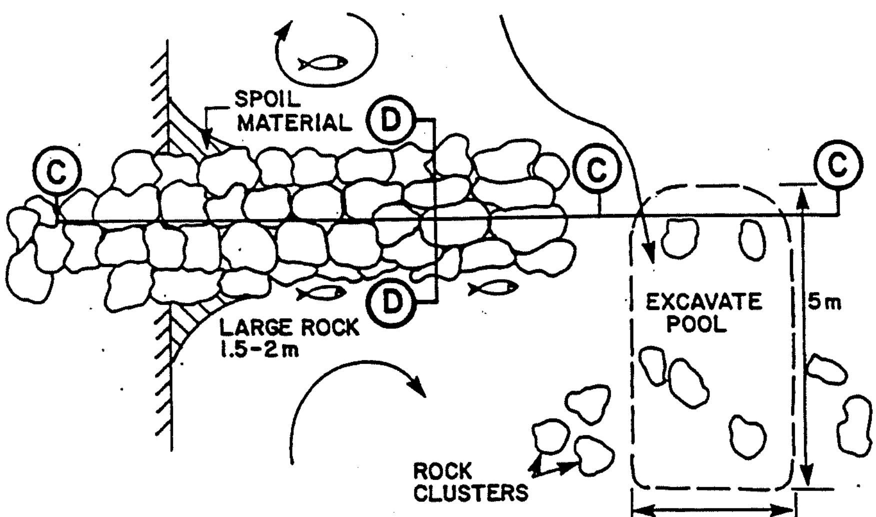
Alberta ENVIRONMENT	RIVER ENGINEERING BRANCH	TYPICAL STRUCTURE DESIGN GROYNES - FULL SIZE Smaller Rivers Small Visual Impact
DESIGNED S. LOWE, P. Eng.	SCALE SCALE 1:1000	
DRAWN N. VIZEN	DATE NOV., 1991	REVISED - JUNE, 1992
CHECKED	SHEET OF	FIGURE No. 8



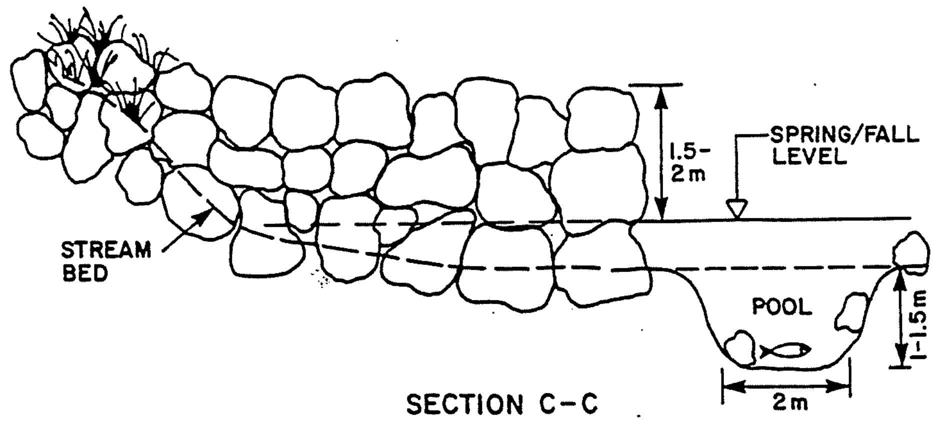
REPELLING GROYNE



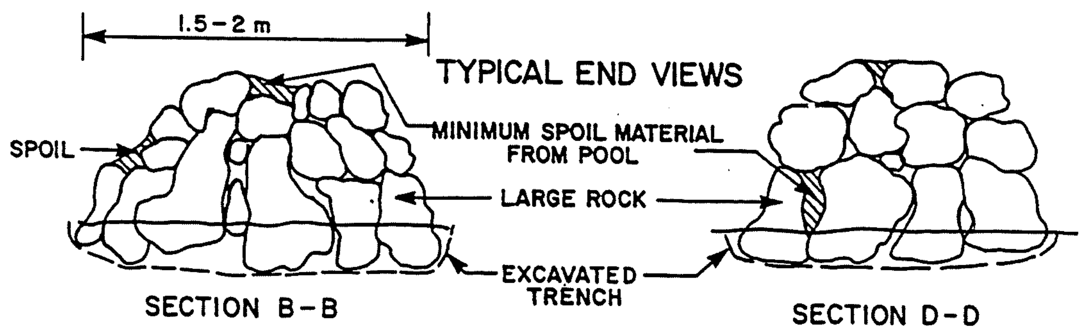
ATTRACTING GROYNE

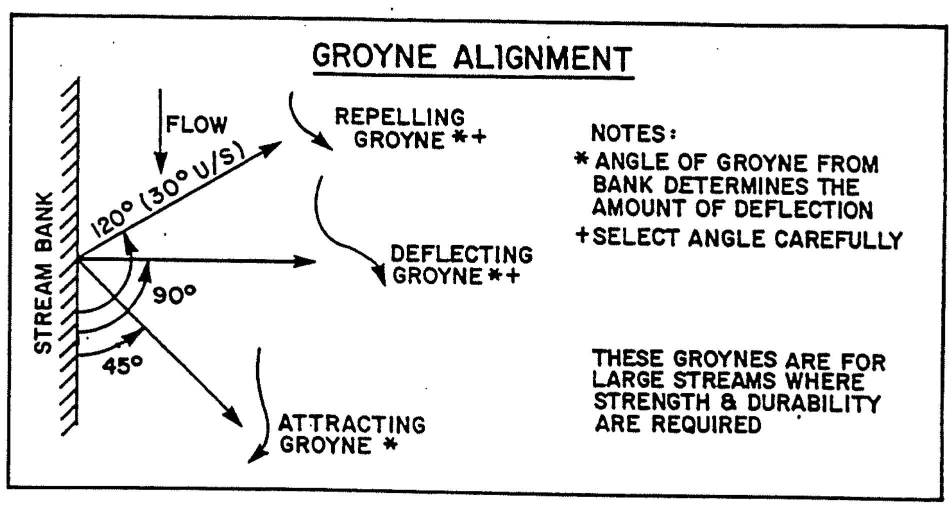


PLAN VIEW



DEFLECTING GROYNE





PURPOSE *- To deflect the main current in the stream to another location and provide economical bank protection. Feeding, resting and potential spawning areas may be located off the tips of the groynes. These groynes have a large visual impact as they are constructed full length about 1.5 m above the low water level. Groyne size does not decrease towards the stream unlike the smaller groynes. The larger size and volume will increase visibility considerably.*

CONSTRUCTION NOTES

1 - *The* ***largest rocks ALWAYS*** *to be placed at the tip of the groyne.*
2 - *Projecting length* ***MUST*** *not exceed 1/2 river width.*
3 - *Groynes* ***ALWAYS*** *to be countersunk at least 1.5 m into the bank*
4 - *Only a minimum amount of spoil material is to be placed on the groyne to fill holes and soften appearance. All remaining spoil material is to be placed 10 m outside the channel.*
5 - *Normally groynes may be combined with Rock Clusters, Fish Runs or small pools, excavated at the tip of the groyne.*

REPELLING GROYNES *- 30⁰ upstream*

1 - *Deflects the main current toward the* ***opposite*** *bank. Heavy armour bank protection* ***IS REQUIRED on the opposite bank.***
2 - *Normally installed on an outside bend to deflect the main current away from an actively eroding bank. This structure will protect a length of eroding bank up to 3.5 times the projecting length. They are normally utilized to deflect flows away from an eroding bank under severe erosion conditions, large flows or unstable banks.*

DEFLECTING GROYNES *- 90⁰ to the bank*

1 - *Deflects the current from along the bank into* ***mid-stream*** *away from the groyne. The opposite bank requires protection when the projection length approaches 1/2 the river width. These are used to provide economical channel narrowing in wide shallow reaches.*
2 - *These groynes are normally used for economical bank protection (stubby groynes) and feeding opportunities. Typical design is a series of groynes, each 3 m long at a 10 m spacing around the outside bend of a river, with a small pool at the tip of each groyne. Excavated material from fish runs must be properly spoiled or placed on the bank between groynes.*

ATTRACTING GROYNE *- 45⁰ downstream*

1 - *Deflects flow slightly, pulling it downstream,* ***behind*** *the groyne.*
2 - *These are normally used to confine rapid, shallow flow to the middle 1/2 of a river or installed on alternating banks to provide a deeper meandering channel pattern in a straight reach when combined with a large Excavated Run and Rock Clusters.*

	CLASS 2 - 3M/S-10'/S	CLASS 3 - 3.8M/S-12.5'/S	CLASS 4 - 4.7M/S-15.5"/S
Dmax	.80m - 700kg/30"-1500#	1.2m - 2400kg/48" - 5200#	1.8m-8000kg/70" - 18000#
D80	.60m - 300kg/24" -700#	.90m - 1000kg/36" - 2200#	1.5m -4700kg/60" -10500#
D50	.50m - 200kg/20" -400#	.80m - 700kg/30" - 1500#	1.2m -2400kg/48" - 5200#
D20	.30m - 40kg/12" - 80#	.50m - 200kg/20" - 400#	.80m - 700kg/30" - 1500#

Limiting River Width 20 to 60m flow depth = spring/fall levels 1.5 m
Armour Rock Classification = 1:100 mean channel velocity or greater

Appendix VII: Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 14 1997 Weather: clear (-2°) max 2° Water Conditions: clear / low
Sub-unit: Shenn / Copper Impact Site/Habitat Name: 9
Reach: 1 Survey Crew: Chris, Kezia, Wade
Location: 3km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): side channel Length (m): ~755 Gradient (%): 2 pH 8.6 (Jan. 7/98)

Mean Water Depth (m): 30/60 cm Mean Channel Width (m)- Bankfull: ____ Wetted: 11

Pool Type: scour (dammed) unknown Bed Material Type- Dominant: S-C Subdominant: ____

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char (all)

Functional LWD: (low) medium high Cover (%): ~10 Cover Type: deep pools, boulders, overhanging veg

Disturbance Indicators: excessive fines [illegible]

Riparian Vegetation- Type: N S C (D M) Structural Stage: INIT SHR (PS) (YF) MF Canopy Closure (%): 0

Fish Counts- Live Adults: ____ Dead Adults: ____ Redds: (2) coho

Juveniles- Coho (FL): (mm) 60 65 Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments: [illegible]

Total trapping hours = 91

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 12/97 Weather: clear (-2) 4 Water Conditions: clear/low
Sub-unit: Skeena / Copper Impact Site/Habitat Name: 12
Reach: 1 Survey Crew: Chris, Kezia
Location: 1km N Copper FSR

Description of Site: actually part of mainstem river

Category: 1 or 2

Habitat Type (slide, side channel etc.): side channel Length (m): ______ Gradient (%): ______ pH ______

Mean Water Depth (m): ______ Mean Channel Width (m)- Bankfull: ______ Wetted: ______

Pool Type: scour dammed unknown Bed Material Type- Dominant: ______ Subdominant: ______

Spawning Gravel- Amount: none limited extensive Type: salmon trout char all

Functional LWD: low medium high Cover (%): ______ Cover Type: ______

Disturbance Indicators: ______

Riparian Vegetation- Type: N S C D M Structural Stage: INIT SHR PS YF MF Canopy Closure (%): ______

Fish Counts- Live Adults: ______ Dead Adults: ______ Redds: (1)chum? (6)coho (1)chinook (Dec.10/97)

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:
lack of water prevented minnow trapping

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 12/97 Weather: [illegible] Water Conditions: low flow/clear
Sub-unit: Skeena / Copper Impact Site/Habitat Name: 14B
Reach: 1 Survey Crew: Chris, Kezia, Wade
Location: 1km N.Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): side channel Length (m): ~855 Gradient (%): ~2 pH 8.5

Mean Water Depth (m): 50cm Mean Channel Width (m)- Bankfull: ______ Wetted: ______

Pool Type: (scour) dammed unknown Bed Material Type- Dominant: C Subdominant: G

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char all

Functional LWD: (low) medium high Cover (%): 30% Cover Type: SWD, LWD, boulders, deep pools

Disturbance Indicators: log jam, material deposition, scour, fine debris

Riparian Vegetation- Type: N S C D (M) Structural Stage: INIT SHR PS (YF) (MF) Canopy Closure (%): 0

Fish Counts- Live Adults: ______ Dead Adults: (1) coho skin Redds: (4) coho (2) false (2) pink ?

Juveniles- Coho (FL): (mm) Rainbow (FL): ~~Char (FL):~~ ~~Cutthroat (FL):~~ Other (FL):

Trap#1
54 69 68 62 57
58 69 70 59 53 60
87 64 73 58 64
68 59 70 56 57
70 61 65 65
69 70 67 100 66
81 75 82 100 48
83 65 55 62 61
78 62 69 53 55
66
(47)

Trap#2
92 70 60
70 70 64
65 74
55 53 (26)
80 85
50 56
74 66
58 54
70 75
64 60
66 45
59 65

Trap#3
80 71
78 82
90 86
91 73
75 70
81 71
72 58
70 78
65 63
92 70
100 77 (23)

Rainbow: Trap#2 110; Trap#3 100

Other: 7 sculpin

Comments:

Total trapping hours - 48 hours

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov 12/97 Weather: Clear) max 4° Water Conditions: clear / low
Sub-unit: Skeena / Copper Impact Site/Habitat Name: 24B
Reach: 1 Survey Crew: Chris, Kezia, Wade
Location: 3km N. Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): Side channel Length (m): 278 Gradient (%): 2 pH 8.4

Mean Water Depth (m): 12 cm Mean Channel Width (m)- Bankfull: ______ Wetted: ______

Pool Type: (scour) dammed unknown Bed Material Type- Dominant: G Subdominant: C

Spawning Gravel- Amount: none limited (extensive) Type: salmon trout char (all)

Functional LWD: (low) medium high Cover (%): 20 Cover Type: ______

Disturbance Indicators: Scour, large gravel mounds

Riparian Vegetation- Type: N S C D (M) Structural Stage: INIT SHR PS YF (MF) Canopy Closure (%): 5

Fish Counts- Live Adults: ______ Dead Adults: ______ Redds: ______

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:
Two traps for 46 hours resulted in no fish caught.

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov 12/97 Weather: Clear (-2°) 4° Water Conditions: Clear/low
Sub-unit: Skeena/Copper Impact Site/Habitat Name: 24C (Something Creek)
Reach: 1 Survey Crew: Chris, Kezia, Wade
Location: 3km N. Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek Length (m): 100 falls to mouth Gradient (%): 24 bridge↑ 6 bridge↓ pH 8.2

Mean Water Depth (m): 27.5cm Mean Channel Width (m)- Bankfull: 4 Wetted: 1.5 (April 3)

Pool Type: (scour) dammed unknown Bed Material Type- Dominant: C Subdominant: G, B

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char (all)

Functional LWD: (low) medium high Cover (%): 50% Cover Type: cutbanks, boulders, SWD

Disturbance Indicators: Scour

Riparian Vegetation- Type: N S C D (M) Structural Stage: INIT SHR PS (YF) (MF) Canopy Closure (%): 50

Fish Counts- Live Adults: Dead Adults: Redds: (2) coho (1) chum.

Juveniles- Coho (FL): 45 (mm) Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments: Trap located under cut bank
Trapping Hours = 46

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Dec. 4/97 Weather: 0° / +4° snow flurries Water Conditions: clear/low
Sub-unit: West Copper Impact Site/Habitat Name: 37 (Simila Creek)
Reach: 3 Survey Crew: Jim, Chris
Location: opp. [illegible] Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): Creek Length (m): ~100 Gradient (%): [illegible] pH

Mean Water Depth (m): Mean Channel Width (m)- Bankfull: ~5.5 Wetted: ~1.5

Pool Type: **scour** **dammed** unknown Bed Material Type- Dominant: C Subdominant: G

Spawning Gravel- Amount: none **limited** extensive Type: salmon trout char **all**

Functional LWD: low **medium** high Cover (%): 20 Cover Type: LWD

Disturbance Indicators: [illegible]

Riparian Vegetation- Type: N S C **D** M Structural Stage: INIT SHR PS **YF** MF Canopy Closure (%): ~60 upper ~20 lower

Fish Counts- Live Adults: Dead Adults: Redds: 0

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:
One trap set for one hours revealed [illegible]

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Dec. 2/97 Weather: snow flurries (-1) 2 Water Conditions: low/clear
Sub-unit: West Copper Impact Site/Habitat Name: 37B (Fiddle Creek)
Reach: 3 Survey Crew: Jim, Chris, Wade, Keza
Location: 9 km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek Length (m): 250 Gradient (%): 23° [illegible] pH

Mean Water Depth (m): 35cm Mean Channel Width (m)- Bankfull: 14.8m Wetted: 2.5m (April)

Pool Type: scour (dammed) unknown Bed Material Type- Dominant: B Subdominant: C

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char all

Functional LWD: (low) medium high Cover (%): 50 Cover Type: LWD, boulders

Disturbance Indicators: scour

Riparian Vegetation- Type: N S C (D) M Structural Stage: INIT SHR PS (YF) MF Canopy Closure (%): 10

Fish Counts- Live Adults: Dead Adults: Redds:

Juveniles- Coho (FL): Rainbow (FL): (mm) Char (FL): Cutthroat (FL): Other (FL):

Rainbow: 115, 93

Comments:
Total trapping hours = 1

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 28/97 Weather: cloudy (+1) +3 Water Conditions: low/clear
Sub-unit: West Copper Impact Site/Habitat Name: 43&44 (O.K. Creek)
Reach: 3 Survey Crew: Jim, Chris
Location: opp. 12.5 km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek Length (m): ____ Gradient (%): 18-below falls, 60-above falls pH ____

Mean Water Depth (m): ____ Mean Channel Width (m)- Bankfull: 3-below falls, 6-above falls Wetted: ____

Pool Type: scour (dammed) unknown Bed Material Type- Dominant: C/B Subdominant: G/S

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char (all)

Functional LWD: (low) medium high Cover (%): 20 Cover Type: B

Disturbance Indicators: bridge, road

Riparian Vegetation- Type: N S C D (M) Structural Stage: INIT SHR PS (YF) (MF) Canopy Closure (%): 60

Fish Counts- Live Adults: ____ Dead Adults: ____ Redds: ____

Juveniles- Coho (FL): Rainbow (FL): (mm) 122 87 95 130 89 Char (FL): Cutthroat (FL): Other (FL):

Comments:
- impassable waterfall 114 m from mouth of creek

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Jan 6/98 Weather: snow flurries (-9)-4 Water Conditions: frozen
Sub-unit: West Copper Impact Site/Habitat Name: 45 (Peace Creek)
Reach: 3 Survey Crew: Jim, Chris, Wade
Location: 12.3km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek Length (m): Gradient (%): 10 pH 8.4

Mean Water Depth (m): 16cm Mean Channel Width (m)- Bankfull: 2.2 Wetted: 1 (approx)

Pool Type: scour (dammed) unknown Bed Material Type- Dominant: C Subdominant: B

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char (all)

Functional LWD: lower (low) medium upper (high) Cover (%): 20 Cover Type: LWD, cutbanks, boulders, overhanging veg.

Disturbance Indicators: creek diverted to dry channel (50%), no H_2O in lower end

Riparian Vegetation- Type: N S C D (M) Structural Stage: INIT SHR PS (YF) MF Canopy Closure (%): 80

Fish Counts- Live Adults: Dead Adults: Redds:

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Jan. 6/98 Weather: Snowflurries (-9)-4 Water Conditions: low/clear
Sub-unit: West Copper Impact Site/Habitat Name: 50B (Kaluha Creek)
Reach: 4 Survey Crew: Jim, Chris, Wade
Location: 14km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek Length (m): 13 Gradient (%): [illegible] pH 9.3

Mean Water Depth (m): 10cm Mean Channel Width (m)- Bankfull: 4.5 Wetted: 1 (April)

Pool Type: scour dammed unknown N/A Bed Material Type- Dominant: C Subdominant: G

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char (all)

Functional LWD: (low) medium high Cover (%): 5 Cover Type: LWD, boulders

Disturbance Indicators: Scour, machinery damage

Riparian Vegetation- Type: (N) S C D M Structural Stage: INIT SHR PS YF MF N/A Canopy Closure (%): [illegible]

Fish Counts- Live Adults: Dead Adults: Redds:

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:

- distance of culvert from creek is too high for fish migration.

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 13/97 Weather: clear (-2)+4 Water Conditions: frozen / low/clear
Sub-unit: West Copper Impact Site/Habitat Name: 54B
Reach: 4 Survey Crew: Chris, Kezia, Wade
Location: 16 km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): side channel Length (m): 710 (entire) 300 (lower) Gradient (%): 2 pH 8.4

Mean Water Depth (m): 66cm Mean Channel Width (m)- Bankfull: 25.9 Wetted: 5.75 (April 2)

Pool Type: (scour) (dammed) unknown Bed Material Type- Dominant: 5 Subdominant: 6

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char (all)

Functional LWD: (low) medium high Cover (%): 10 Cover Type: boulders

Disturbance Indicators: scour, road material deposition, lack of water, lost major spawning area

Riparian Vegetation- Type: N (S) C D M Structural Stage: INIT SHR PS (YF) MF Canopy Closure (%): 0

Fish Counts- Live Adults: Dead Adults: Redds:

Juveniles- Coho (FL): (mm)

Trap#1	Trap#2	Trap#3	Trap#4
81	78	0	64
51	87		
50	57		
58			
50			

Trap#5: 92, 84, 61, 60, 82, 54, 75, 58, 80

Rainbow (FL):

Trap#5	Trap#1	Trap#4
111	48	48, 50
142	48	51, 54
150	47	60, 49
95	45	58
	46	55

Char (FL):

Trap#5: 140, 145, 140, 142, 140, 150

~~Cutthroat (FL)~~:

Other (FL):

Trap 1 [illegible]
2 [illegible]
4 [illegible]
5 [illegible]

Comments:

Total trapping hours = 68

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 21 /97 Weather: low overcast (+2)+3 Water Conditions: low/clear
Sub-unit: West Copper Impact Site/Habitat Name: 71
Reach: 5 Survey Crew: Chris, Kezia
Location: 25km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): Side channel Length (m): 1.6 km Gradient (%): 1 pH____

Mean Water Depth (m): ______ Mean Channel Width (m)- Bankfull: ____ Wetted: ____

Pool Type: scour dammed unknown Bed Material Type- Dominant: S Subdominant: ____

Spawning Gravel- Amount: none limited extensive Type: salmon trout char all

Functional LWD: low medium high Cover (%): ____ Cover Type: ______

Disturbance Indicators: beaver pond complex, no water

Riparian Vegetation- Type: N S C D (M) Structural Stage: INIT SHR PS (YF) MF Canopy Closure (%): ____

Fish Counts- Live Adults: ______ Dead Adults: ______ Redds: ______

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:
A trap set for 71 hours revealed no fish

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 21/97 Weather: low overcast (+2)+3 Water Conditions: low/clear (no channel flow)
Sub-unit: West Copper Impact Site/Habitat Name: 76
Reach: 5 Survey Crew: Chris, Kezia
Location: 28 km Copper FSR

Description of Site:

Category: 1 or 2 Apply when H2O is flowing

Habitat Type (slide, side channel etc.): side channel Length (m): ____ Gradient (%): ____ pH____

Mean Water Depth (m): ____ Mean Channel Width (m)- Bankfull: ____ Wetted: ____

Pool Type: [scour] dammed unknown Bed Material Type- Dominant: C Subdominant: G

Spawning Gravel- Amount: none [limited] extensive Type: salmon trout char [all]

Functional LWD: low [medium] high Cover (%): 20 Cover Type: LWD

Disturbance Indicators: loss riparian zone, eroded banks

Riparian Vegetation- Type: N S C D [M] Structural Stage: INIT SHR PS YF [MF] Canopy Closure (%): <1%

Fish Counts- Live Adults: ____ Dead Adults: ____ Redds: ____

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:
- channel is dry
- loss of riparian zone

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Dec. 2/98
Weather: Snow flurries
Water Conditions: no flow in channel
Sub-unit: West Copper
Impact Site/Habitat Name: 77 (28 Km Creek)
Reach: 5
Survey Crew: Chris, Keira
Location: 28 Km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek (back channel) (7' no flow) Length (m): 4 creek >100 channel Gradient (%): ____ pH ____

Mean Water Depth (m): ____ Mean Channel Width (m)- Bankfull: ____ Wetted: ____

Pool Type: scour dammed unknown Bed Material Type- Dominant: C - creek, organic - channel Subdominant: G

Spawning Gravel- Amount: none **(limited)** extensive Type: salmon trout char **(all)**

Functional LWD: **(low)** creek medium **(high)** channel Cover (%): 25 creek, 30-40 channel Cover Type: creek - culvert, LWD; channel - LWD, SWD

Disturbance Indicators: logged to H_2O edge, road construction/culvert

Riparian Vegetation- Type: N **(S)** C **(D)** M Structural Stage: INIT **(SHR)** PS YF **(MF)** Canopy Closure (%): 10

Fish Counts- Live Adults: ____ Dead Adults: ____ Redds: ____

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:
No fish after 4 trapping hours.
No water flow. Mar. 9/98

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov.14/97 Weather: clear (-2) +3 Water Conditions: clear/low
Sub-unit: West Copper Impact Site/Habitat Name: 85A
Reach: 5 Survey Crew: Chris, Kezia
Location: 28.75 Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): side channel Length (m): 400 Gradient (%): ______ pH______

Mean Water Depth (m): ______ Mean Channel Width (m)- Bankfull: 10 Wetted: ______

Pool Type: scour (dammed) unknown Bed Material Type- Dominant: G Subdominant: S

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char all N/A

Functional LWD: low (medium) high Cover (%): 5-10 Cover Type: LWD, instream veg, boulders, OV

Disturbance Indicators: ______

Riparian Vegetation- Type: N S C D (M) Structural Stage: INIT SHR (PS) YF (MF) Canopy Closure (%): 5

Fish Counts- Live Adults: ______ Dead Adults: ______ Redds: ______

Juveniles- Coho (FL): (mm) ~~Rainbow~~ (FL): Char (FL): ~~Cutthroat~~ (FL): Other (FL):

Trap #1: 80 91 87 92 100 [illegible] (7)

Trap #2: 150 99 85 90 107 100 55 95 88 56 100 100 (12)

Char: Trap #2 122

Comments:

Trap #2 2   *1 Trap #1   Total trapping hours = 24

*no adult access [illegible]

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov 14/97 Weather: clear (-2°) max 3° Water Conditions: clear / low
Sub-unit: West Copper Impact Site/Habitat Name: 90
Reach: 5 Survey Crew: [illegible], Kevin, Wade
Location: 29.5km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): side channel Length (m): 589 Gradient (%): pH 8.0

Mean Water Depth (m): 27.4cm Mean Channel Width (m)- Bankfull: 14.8 Wetted: 4.6 (April [illegible])

Pool Type: scour (dammed) unknown Bed Material Type- Dominant: C Subdominant: G/B

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char (all)

Functional LWD: (low) medium high Cover (%): 10 Cover Type: cutbanks, boulder, deep [illegible]

Disturbance Indicators: scour, debris ([illegible]), lack of LWD

Riparian Vegetation- Type: N S C D (M) Structural Stage: INIT SHR PS (YF) MF Canopy Closure (%): 10

Fish Counts- Live Adults: (4) coho Dead Adults: (2) coho Redds: (4) coho

Juveniles- Coho (FL): (mm) Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Trap #1: 56, 70, 55, 69, 73, 60, 50, 65, 54, 45, 71 [illegible] (17)

Trap #2: 56 68 60, 54, 54, 70, 55, 59, 67, 62, 62, 60, 60, 52 [illegible] (32)

Rainbow Trap #2: 52, 46

Comments:

*Trap [illegible]

Total trapping hours = 24

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 14 1997
Weather: clear (-2)°
Water Conditions: clear/low
Sub-unit: West Copper
Impact Site/Habitat Name: 94 (Warner Spring)
Reach: 5
Survey Crew: Chris, Kezia, Wade
Location: 31 km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): side channel
Length (m): 546
Gradient (%): 28m from the channel: 5%; ponds to outlet 2%
pH 9.1 and 8.4 (Jan 6/98)

Mean Water Depth (m): 33.6 cm
Mean Channel Width (m)- Bankfull: 11.3
Wetted: 5.25 (0 m)

Pool Type: scour **(dammed)** unknown
Bed Material Type- Dominant: G
Subdominant: S

Spawning Gravel- Amount: none **(limited)** extensive
Type: salmon trout char **(all)**

Functional LWD: low **(medium)** high
Cover (%): 5
Cover Type: LWD, overhang veg, instream veg

Disturbance Indicators: beaver dams, stumps, riparian is deciduous

Riparian Vegetation- Type: N S C D **(M)**
Structural Stage: INIT SHR PS **(YF)** MF
Canopy Closure (%): 80

Fish Counts- Live Adults:
Dead Adults:
Redds: (1) coho from previous year

Juveniles- Coho (FL): (mm)
~~Rainbow~~ (FL):
Char (FL):
~~Cutthroat~~ (FL):
Other (FL):

Coho, Trap #1: 65 65 102 57 55 54 58 68 54 75 66; 90 60 72 87 66 60 74 62 67 80 58; 65 80 70 67 61 55 60 60 75 63 70; 60 62 58 60 59 61 60 62 55 (51)

Coho, Trap #2: 93 66 78 88 70 65 63 70 (8)

Char, Trap #: 120 180 142 115 120 (5)

Comments:

Trap #1 - above dam
2 - below dam

Total trapping hours = 24.5

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov 11/97 Weather: clear (-2)+3 Water Conditions: clear / low
Sub-unit: West Copper Impact Site/Habitat Name: 95 (Swan Creek)
Reach: 5 Survey Crew: Chris, Kezia, [illegible]
Location: 30-32 km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek Length (m): 339 (above fsr to [illegible]) Gradient (%): [illegible] pH 8.9 [illegible]

Mean Water Depth (m): 11.6 cm Mean Channel Width (m)- Bankfull: 7 Wetted: 1 [illegible]

Pool Type: (scour) dammed unknown Bed Material Type- Dominant: C-stream S-dam Subdominant: G, B-stream

Spawning Gravel- Amount: (none) limited extensive Type: salmon ~~trout~~ N/A char all

Functional LWD: low (medium) high Cover (%): 30-dam [illegible] Cover Type: LWD, instream veg

Disturbance Indicators: beaver dams (11)

Riparian Vegetation- Type: N S C D (M) Structural Stage: INIT SHR (PS) (YF) MF Canopy Closure (%): stream [illegible] dam [illegible]

Fish Counts- Live Adults: Dead Adults: Redds:

Juveniles- Coho (FL): (mm) Rainbow (FL): Char (FL): Cutthroat (FL): 120 Other (FL):

Comments:
Trapping at 4 sites revealed only one fish under the [illegible] bridge. Trapping time = 24.5

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 26/97 Weather: ______ Water Conditions: ______
Sub-unit: West Copper Impact Site/Habitat Name: 97
Reach: 5 Survey Crew: Jim, Chris, Kezia, Wade
Location: 32 km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): Side channel Length (m): ______ Gradient (%): ______ pH ______

Mean Water Depth (m): ______ Mean Channel Width (m)- Bankfull: ______ Wetted: ______

Pool Type: scour (dammed) unknown Bed Material Type- Dominant: S Subdominant: G

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char (all)

Functional LWD: low (medium) high Cover (%): 30 Cover Type: LWD

Disturbance Indicators: flood channel, sawed off stumps to H_2O edge, PNG pipeline

Riparian Vegetation- Type: N S C D (M) Structural Stage: INIT SHR PS (YF) (MF) Canopy Closure (%): 80%

Fish Counts- Live Adults: ______ Dead Adults: ______ Redds: ______

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:

- water in channel's lower half with only seepage water

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 14/97 Weather: clear (-2)+3 Water Conditions: clear/low
Sub-unit: West Copper Impact Site/Habitat Name: 99A
Reach: 5 Survey Crew: Chris, Kevin, Jim
Location: 33km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): side channel Length (m): 660 Gradient (%): 3 pH 8.4 / 9.2 (April 3)

Mean Water Depth (m): ______ Mean Channel Width (m)- Bankfull: 10 Wetted: 3.25 (April 3)

Pool Type: (scour) dammed unknown Bed Material Type- Dominant: S/B Subdominant: G

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char (all)

Functional LWD: (low) medium high Cover (%): 5 Cover Type: Boulders

Disturbance Indicators: scour, channelized habitat, bridge ripped out,

Riparian Vegetation- Type: N (S) C D M Structural Stage: INIT (SHR) PS YF MF Canopy Closure (%): ~0

Fish Counts- Live Adults: ______ Dead Adults: ______ Redds: ______

Juveniles- Coho (FL): (mm) Rainbow (FL): Char (FL): ~~Cutthroat (FL)~~: Other (FL):

Trap#1 (Coho): 87, 58, 86, 80, 86, 81, 84 ... (16)

Rainbow Trap#1: 75

Char Trap#1: [illegible] (2), 100

Comments:

Trap#1
midchannel below site 99B (... Creek) - [illegible]
Total trapping hours = 23.5

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 14 /97 Weather: clear (-2)+3 Water Conditions: clear / low
Sub-unit: West Copper Impact Site/Habitat Name: 99B (Doll Creek)
Reach: 5 Survey Crew: Jim, Chris, Kezia
Location: 33 km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek Length (m): 68 Gradient (%): 10 pH 8.6

Mean Water Depth (m): 37 cm Mean Channel Width (m)- Bankfull: 3.5 Wetted: 1.75 (april ?)

Pool Type: (scour) dammed unknown Bed Material Type- Dominant: G Subdominant: C

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char (all)

Functional LWD: (low) medium high Cover (%): 15 Cover Type: Boulders

Disturbance Indicators: road work

Riparian Vegetation- Type: N (S) C (D) M Structural Stage: INIT (SHR) PS YF MF Canopy Closure (%): 10

Fish Counts- Live Adults: Dead Adults: Redds:

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:
Minnow trap set for 23.5 hours revealed no fish

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 14/97 Weather: (-2)+3 clear Water Conditions: dry
Sub-unit: West Copper Impact Site/Habitat Name: 103
Reach: 5 Survey Crew: Jim, Chris, Kezia, Wade
Location: 33.5 km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): inlet (channel) for 99A Length (m): ______ Gradient (%): ______ pH ______

Mean Water Depth (m): ______ Mean Channel Width (m)- Bankfull: ______ Wetted: ______

Pool Type: scour dammed unknown Bed Material Type- Dominant: S Subdominant: G

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char (all)

Functional LWD: low (medium) high Cover (%): ______ Cover Type: ______

Disturbance Indicators: debris in trees, created by floods, stumps

Riparian Vegetation- Type: N S C D (M) Structural Stage: INIT SHR PS (YF) MF Canopy Closure (%): ~100

Fish Counts- Live Adults: ______ Dead Adults: ______ Redds: ______

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:
- serves as Zymoetz River inlet for 99A side channel
- no water flow

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 28/97 Weather: cloudy (+1)+3 Water Conditions: clear/low
Sub-unit: West Copper Impact Site/Habitat Name: 91&93 (Salmon Run Creek)
Reach: 5 Survey Crew: Jim, Chris
Location: 28-30 km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek Length (m): ______ Gradient (%): ______ pH ______

Mean Water Depth (m): ______ Mean Channel Width (m)- Bankfull: ______ Wetted: ______

Pool Type: (scour) dammed unknown Bed Material Type- Dominant: G Subdominant: S/C

Spawning Gravel- Amount: none limited (extensive) Type: salmon trout char (all)

Functional LWD: (low) medium high Cover (%): <5% Cover Type: LWD, overhang veg

Disturbance Indicators: old river channel created by flood (91 or 92), creek inflows to s.c. unstable

Riparian Vegetation- Type: N S C (D) (M) Structural Stage: INIT SHR (PS) YF (MF) Canopy Closure (%): ~0

Fish Counts- Live Adults: ______ Dead Adults: ______ Redds: ______

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments: Two minnow traps set for 2 hours revealed no fish.

Dec. 4/97 -> 50 fish salvaged from isol. pools
75% rbt and co (avg. 40mm) } few char (avg. 70mm)
25% co (avg. 65mm)

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov.17/97 Weather: cloud/snow (-1) +3 Water Conditions: clear/[illegible]
Sub-unit: Clore Impact Site/Habitat Name: 192B (17km Creek)
Reach: 3 Survey Crew: Jim, Chris, Kevin
Location: 17km Clore ISR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): Creek Length (m): 290 (bridge to river) Gradient (%): 14 pH 8.1

Mean Water Depth (m): ______ Mean Channel Width (m)- Bankfull: ______ Wetted: ______

Pool Type: (scour) (dammed LWD) unknown Bed Material Type- Dominant: B Subdominant: G/C

Spawning Gravel- Amount: none (limited) extensive Type: salmon trout char (all)

Functional LWD: low medium (high) Cover (%): 25 Cover Type: LWD, boulders

Disturbance Indicators: gully torrented -from debris (78 major flood)

Riparian Vegetation- Type: N S (C) D M Structural Stage: INIT SHR PS (YF) MF Canopy Closure (%): ~2%

Fish Counts- Live Adults: ______ Dead Adults: ______ Redds: ______

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:
No fish were trapped at the [illegible]
[illegible] time
- no access

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov. 28 1997 Weather: cloudy (+10°C) Water Conditions: clear/low
Sub-unit: Clore Impact Site/Habitat Name: 205E (12 km Creek)
Reach: 3 Survey Crew: Jim, Chris, Kezia
Location: 12 km Clore FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek Length (m): ____ Gradient (%): ____ pH ____

Mean Water Depth (m): ____ Mean Channel Width (m)- Bankfull: ____ Wetted: ____

Pool Type: **(scour)** **(dammed)** unknown Bed Material Type- Dominant: G Subdominant: S/C

Spawning Gravel- Amount: none limited **(extensive)** Type: salmon trout char **(all)**

Functional LWD: low **(medium)** high Cover (%): 25 Cover Type: OV, IV, CB

Disturbance Indicators: creek flowed down skid row, diverted from original channel

Riparian Vegetation- Type: N **(S)** C D **(M)** Structural Stage: INIT SHR PS **(YF)** MF Canopy Closure (%): 10

Fish Counts- Live Adults: ____ Dead Adults: ____ Redds: ____

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:
Minnow trap set for 2 hours revealed no fish
In 1995 visual observation and trapping [illegible] occurred

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov 18/97 Weather: part cloudy, snow/ 0(+3) Water Conditions: clear / low
Sub-unit: Clore Impact Site/Habitat Name: 211 (Elf Creek)
Reach: 3 (Clore River) Survey Crew: Jim, Chris, Kezia
Location: 10km Clore FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek / sidechannel Length (m): 592 (bridge to river) Gradient (%): 10 pH 8.2

Mean Water Depth (m): ______ Mean Channel Width (m)- Bankfull: ______ Wetted: ______

Pool Type: scour (dammed) (old main creek, LWD) (unknown) (old main, preformed) Bed Material Type- Dominant: G Subdominant: S/C

Spawning Gravel- Amount: none limited (extensive) Type: salmon trout char (all)

Functional LWD: (low) (channel) medium (high) (riparian area) Cover (%): 20 - creek, 5 - channel Cover Type: OV, LWD, cutbanks - channel; B, roots, LWD - creek

Disturbance Indicators: [illegible] S.C. for Clore River prior 92 flood

Riparian Vegetation- Type: N S (C) (creek) D (M) (channel) Structural Stage: INIT (SHR) (channel) PS (YF) (creek) (MF) (channel) Canopy Closure (%): ______

Fish Counts- Live Adults: (8) coho Dead Adults: (1) coho Redds: (11) coho

Juveniles- Coho (FL): (mm)	Rainbow (FL):	Char (FL):	Cutthroat (FL):	Other (FL):
Trap#2: 55, 91, 83, 90, 59 (5)	Trap#1: 88, 90	Trap#2: 126, 140, 133		
Trap#1: 65 60 57, [illegible] 41, [illegible] 95, 59 68, 70 64, 84 55, 48 50 (15)		Trap#1: 119		

Comments:
Objective [illegible] would [illegible] to provide [illegible] create one channel [illegible]

Total trapping [illegible] - 23.5

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Nov.21/97 Weather: low overcast (+2)°C Water Conditions: clear / low
Sub-unit: Clore Impact Site/Habitat Name: 236E (Thomas Creek)
Reach: [illegible] Survey Crew: Chris, Kezia, [illegible]
Location: 14.5 km Clore FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek Length (m): ____ Gradient (%): ____ pH____

Mean Water Depth (m): ____ Mean Channel Width (m)- Bankfull: ____ Wetted: ____

Pool Type: scour dammed unknown Bed Material Type- Dominant: ____ Subdominant: ____

Spawning Gravel- Amount: none limited extensive Type: salmon trout char all

Functional LWD: low medium high Cover (%): ____ Cover Type: ____

Disturbance Indicators: impassible log jam / falls -> must remove

Riparian Vegetation- Type: N S C D M Structural Stage: INIT SHR PS YF MF Canopy Closure (%): ____

Fish Counts- Live Adults: (8) coho Dead Adults: (6) coho Redds: (4) char (7) coho (all [illegible] falls)

Juveniles- Coho (FL): (mm) Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):
71 - below falls

Comments:
- impassable falls present
- [illegible] have [illegible] seen above falls
- Nov.15 char observed [illegible] falls
Total trapping hours: 19

Field Data Form for the Zymoetz Fish and Fish Habitat Level 2 Assessment

Survey Date: Jan.6 |98 Weather: Snow (-9)-4 Water Conditions: low/clear
Sub-unit: West Copper Impact Site/Habitat Name: 253B (Simpson Creek)
Reach: 4 Survey Crew: Chris, Jim
Location: 17.2 km Copper FSR

Description of Site:

Category: 1 or 2

Habitat Type (slide, side channel etc.): creek Length (m): ________ Gradient (%): ________ pH________

Mean Water Depth (m): ________ Mean Channel Width (m)- Bankfull: ______ Wetted: ______

Pool Type: scour dammed unknown Bed Material Type- Dominant: _______ Subdominant: _______

Spawning Gravel- Amount: none limited extensive Type: salmon trout char all

Functional LWD: low medium high Cover (%): ______ Cover Type: ______________

Disturbance Indicators: ______________________________

Riparian Vegetation- Type: N S C D M Structural Stage: INIT SHR PS YF MF Canopy Closure (%): ______

Fish Counts- Live Adults: ______________ Dead Adults: ______________ Redds: ______________

Juveniles- Coho (FL): Rainbow (FL): Char (FL): Cutthroat (FL): Other (FL):

Comments:
No trapping - issue is upstream vees

Appendix VIII: Priority of Rehabilitation and Timing Windows for 1998/99 Work

Instream Work

Impact Site	Prescription Cost ($)	Projected 1998/99 Cost ($)	Timing of Work
9 (old bridge channel)	29216	22338	-upper channel most of year -lower channel June, July, early August
54B (16 km side channel)	22069	13222	-May, June, July, August, September, early October
76 (28 km)	14227	6944	-May, early June, late August, September, October, November
81 (28.5 km)	20168	17427	-May, late July, early August
253 (Simpson Creek)	10677	4510	-May, July, early August
95 (Swan Creek)	16677	15114	-May, June, July, August, September, October, early Nov.
91 & 93 (Salmon Run Creek)	14662	7947	-July, early August
205B (12Km Creek, Clore River)	13372	7498	-June, July, early August
Total Cost ($)	141068	95000	

Detailed Level 2 Assessment

Impact Site	Prescription Cost ($)	Projected 1998/99 Cost ($)	Timing of Work
214B (Clore slide)	24330	9777	
77	3531	3155	
97	4847	4847	
Total Cost ($)	32332	17779	

Level 2 Assessment

Area	Projected 1998/99 Cost ($)	Timing of Work
Sub-unit 4, Eight Mile Creek, Simpson Creek, Trapline Creek, Thomas Creek	45348	
Total Cost ($)	45348	

Total Assessment Cost is $63127 for 1998/99.

Appendix IX: Geomorphologist Recommendations by Alan Gilchrist, Ph.D.

HYDROGLYPHIC
TERRAIN ANALYSTS

3504 Gordon Drive
Terrace, B:C., V8G 5P5.
Phone/Fax (250) 635-7751

Copper River Watershed Restoration Project

Level I Detailed Assessment of

Fish and Fish Habitat

Overview Hydrological Assessment of

Specific Impact Sites

Submitted by:

Alan Gilchrist, Ph.D.

March 1998

HYDROGLYPHIC
TERRAIN ANALYSTS

Copper River Watershed Restoration Program
Level I Detailed Assessment of Fish and Fish Habitat
Overview Hydrological Assessment of Specific Impact Sites

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HYDROGLYPHIC
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1.0 PROJECT OVERVIEW

1.1 Introduction

This report presents the findings of an overview hydrological assessment of several specific impact sites that are being assessed as part of the Copper River WRP Level I Detailed Assessment of Fish and Fish Habitat. This WRP contract is held by the Terrace Salmonid Enhancement Society and the Project Manager is Jim Culp. Dr. Alan Gilchrist of HydroGlyphic Terrain Analysts was subcontracted by the WRP Project Manager to visit several specific impact sites in the watershed to review and give general advice on the proposed fish habitat restoration and enhancement activities.

The findings in this report are presented in three sections. The first section contains a project overview which includes an outline of the methods used and a brief summary of the hydrology and sediment sources in the Copper watershed. It is important to review this information as fish habitat and the effectiveness of any restoring structures proposed will be affected by how water and sediment pass through the watershed. The second section gives details on each site visited. This section is divided into short summaries of the setting, proposed restoration work and analysis and recommendations. The final section gives a brief summary of the study and presents some general guidelines for restoration in the watershed.

1.2 Objectives and Methods

The primary objective of this study is to assess the rationale of the proposed restoration activities at several specific impact sites in the Copper River watershed from the perspective of a Hydrologist. An integral part of the study is to also suggest modifications to the proposed prescriptions or other options where thought necessary. It should be noted that this hydrological assessment can only be considered as a general overview for two reasons: Firstly, proposed prescriptions were only communicated verbally in the field and as such can only be considered to be of a conceptual nature; and secondly, all sites were visited only during the course of about a day in the field. Therefore, the assessment is by necessity limited in nature without the benefit of more time at each site, and several visits during the year to assess different water levels. However, the author has considerable experience in WRP assessment work and brings a wealth of local knowledge to this study, and in addition has previously assessed proposed restoration work in Simpson Creek in the Copper watershed.

This study was split into three phases. During the first phase, several documents were reviewed prior to the site visits to gain an appreciation of the physical characteristics of the Copper River and surrounding watersheds. These documents included the following:

- Quaternary Geology and Geomorphology, Smithers-Terrace-Prince Rupert Area, British Columbia, by J. J. Clague, Memoir 413, Geological Survey of Canada, 1984.
- Hydrology and Logging in the Carnation Creek Watershed - What Have We Learned?, by E. Hetherington, in Applying 15 years of Carnation Creek results, Proceedings, Pacific Biological Station, 1987.
- Hydrologic and Geomorphologic Considerations for Silviculture Investments on the Lower Skeena River Floodplain, by P.G. Beaudry, D.L. Hogan and J.W. Schwab, FRDA Report 122, B.C. Ministry of Forests, 1990.
- Cumulative Effects of Forest Harvesting on the Kitimat River, British Columbia, by E. J. Karenka, Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2218, Department of Fisheries and Oceans, 1993.

- Rainstorm and Flood Damage: Northwest British Columbia, 1981-1991, by D. Septer and J.W. Schwab, Land Management Handbook 31, B.C. Ministry of Forests, 1995.
- Floodplain Erosion Hazard Assessment, Lower Zymoetz River, British Columbia, by I. Weiland and J.W. Schwab, Forest Sciences Section, B.C. Ministry of Forests, 1996.
- Hydrological Assessment of Proposed Small-Scale Instream Structures, Simpson Creek, Copper River, British Columbia, by A. Gilchrist, HydroGlyphic Terrain Analysts, for Department of Fisheries and Oceans, 1997.

The second phase consisted of two site visits, each with a duration of about half a day, which were made on the 24 & 26 March 1998. The first five sites were visited during the earlier field visit (see sections 2.1 to 2.5) using a two wheel drive vehicle driven up the Copper River Forestry Road. The day was overcast with occasional light rain and there was minimal snow on the ground which allowed fieldwork at this early stage of the year. Jim Culp was present and explained the proposed restoration activities as we walked around each site. The last site (see section 2.6) is the Clore Slide which was visited during the later field visit. Because of the remote location up the Clore valley, a Bell Jetranger helicopter from Far West Helicopters in Terrace was used to access this site, and also perform an overview flight of the other five sites and the entire lower part of the Copper watershed. The day started overcast but ended up with sunny breaks during the majority of the flight. A video was taken during the helicopter flight to review afterwards. Jim Culp was again present together with Chris Culp from the Deep Creek Hatchery.

The third phase consisted of assimilating field data with the review of existing information on the watershed, formulating recommendations and preparation of this report.

1.3 Hydrology

Variations in discharge in the Copper River are due to snowmelt in spring and rainstorms in the fall. Spring flooding tends to be long-lived due to progressive snowmelt as temperatures rise, but of moderate quantity with comparison to fall floods which are caused by rainstorms which last a few days at most. The larger fall floods have occurred when temperatures were higher and most precipitation fell as rain rather than snow higher in the watershed. Most changes in channel morphology, for example bank erosion and the diversion of channels, have been caused by fall floods which have a great power to erode and transport large material such as logs and boulders, together with smaller material. In addition, new gravel bars are formed by sediment deposition as flood flows wane and the river can no longer move large amounts of material. During subsequent floods, gravel bars are eroded and material is moved downstream in a series of pulses, eventually reaching the mouth of the river and entering the Skeena River.

Prior to major amounts of harvesting in the watershed which began in the 1960s, air photos show that the main channel was relatively stable. Since then, however, the main channel has become less stable and a large amount of sediment has been mobilized and moved though the watershed during flood flows. This decrease in channel stability has been due to a series of major fall floods, the largest being during 1978 (100 year flood), 1991 (50 year flood) and 1992 (25 year flood). The cause of these major fall floods is unlikely to have been a consequence of harvesting activity since only a small area of the watershed (~3.5 %) has currently been logged. This conclusion comes from the comparison with experimental studies in locations such as Carnation Creek which suggest that harvesting less than 30% of a watershed does not greatly affect flood flows. Instead, the coincidence of major floods with intense rainstorms suggests that extreme weather conditions over the last twenty years or so have been responsible for flooding and the decrease in channel stability.

1.4 Sediment Sources

Sediment moved by the Copper River can be classified as fine suspended material (e.g. silt and clay) which is carried throughout the year or coarse bedload material (e.g. cobble and boulder) which is only carried during flood flows in the spring and fall. Suspended sediment may adversely affect fish but has no influence on channel stability. It is the mobilization of coarse bedload material during floods that causes channel erosion and changes in channel location.

Bedload material can also be classified according to whether the sediment is external or internal to the Copper River. External sediment is derived from tributaries, landslides or failing fluvioglacial terraces (formed by the retreat of glaciers at the end of the last ice age about 10,000 years ago). This sediment can be thought of as an input of material to a reach in the river which subsequently passes downstream to be output at the lower reach boundary into the reach below. The input of external sediment to a reach balances the output of sediment at the lower end of a reach in a stable river system. By comparison, internal sediment is derived from gravel bars within the reach and the erosion of material from the floodplain. Internal sediment can be thought of as material stored for a significant period of time within the body of the reach which is dependent upon such factors as channel gradient and floodplain width. Where sediment input and output for the reach do not balance then changes in the storage of internal sediment take place to regain a dynamic equilibrium for the river. In the case of the Copper River, a series of major floods during the last twenty years or so have caused external sources of sediment to be mobilized within some reaches which exceed the ability of the river to move or store the new material. In these cases, channel stability has been compromised as the river tries to regain its equilibrium between sediment entering and leaving each reach.

2.0 SITE DESCRIPTIONS, ANALYSIS & RECOMMENDATIONS

Each site is described below under three headings: *Setting* describes the location of the site, its morphological character and concerns that need to be addressed by the prescription. *Conceptual Prescription* describes the scope of the restoration work proposed, as described by Jim Culp, Project Manager, during the field visits. *Analysis and Recommendations* reviews the hydrological processes at each site and evaluates whether the prescription addresses the problem. Where it is thought necessary, modifications or other prescription activities are suggested.

2.1 Site 41

Setting
Site 41 is located at approximately 12.2 km on the Copper River Forestry Road at the beginning of reach 3 above the first canyon. The floodplain in reach 3 has an average width of about 250 m with the wetted channel covering about 35% of the floodplain area at low flows. At the beginning of reach 3 the road descends from above canyon to cross the floodplain next to the river. The concern at this site is the stability of the road. The slope below the road has been armored with riprap to prevent erosion by the river during floods. There is also evidence of slope movement above the road in the form of jack-strawed trees and soil creep.

Conceptual Prescription
Possibly stabilize slope.

Analysis and Recommendations
The possibility of erosion at the toe of the slope below the road is unlikely given the riprap armor that has been placed along the base of the slope. The slope above the road shows evidence of minor instability but in most areas this is inconsequential since bedrock underlies the soil which is only a fraction of a meter thick.

To the northwest of the area of riprap, the road is built into unconsolidated material which shows a higher possibility of slope failure since the loose material is more than 2 meters thick and is lying at a steep angle. However, to move the road to a more stable location would require major works which are not indicated at this time as the outside edge of the road is not failing. This site should be monitored on a continual basis for signs of slope instability and failure, in particular after major rainstorms which usually occur in the fall and elevate the soil moisture content.

2.2 Sites 46 & 50

Setting

Sites 46 & 50 are located between 13 & 14 km on the Copper River Forestry Road within reach 3 above the first canyon The floodplain in reach 3 has an average width of about 250 m with the wetted channel covering about 35% of the floodplain area at low flows. At this site the road runs along the edge of the floodplain and is not currently threatened by encroachment of the river. The concern at site 46 is that erosion on the outside of the river bend is causing bedload sediment from an internal source to be added to the river. The channel bank is being undercut and timber at the edge of the bank is falling into the river. Over the last 30 years or so lateral channel erosion has been on average about 0.5 m per year in this reach. In comparison, site 50 is a candidate for a side channel development.

Conceptual Prescription

Build a series of three groins at site 46 spaced around the outside of the river bend to deflect the river away from the bank to prevent further erosion. At site 50 build a berm to deflect water into the upper end of a side channel that is separated from the main channel by a low gravel bar to provide additional fish spawning and rearing habitat.

Analysis and Recommendations

The sideways movement of a river channel on a floodplain is a natural occurrence as the outer bank of the bend is eroded and material is deposited on a point bar around the inner edge. This is the case at site 46. A review of the historical air photos shows that although erosion of this bend has increased over the last 20 years or so, the channel is relatively stable in this reach, certainly with comparison to reach 5 upstream of the second canyon. We have to be aware that should erosion be prevented at this point then the river will naturally tend to erode material from somewhere else in the reach. Although we cannot predict exactly where this erosion will occur, a likely candidate is the bar opposite site 46 which has grown to at least twice its original size over the last 30 years. At the current time the Forestry Road is not threatened and so it is difficult to envisage any major gains in reach stability from installing a series of groins since other locations in the reach will probably be destabilized as a consequence. This proposed measure may enhance the stability of the channel bank at this site but will not significantly affect fish habitat.

Site 50 is a possible site for a side channel development since the upper portion of the gravel bar separating the side and main channels is stable and the lower portion is actively growing by deposition. However, this site is not the best choice as a side channel development since it lies next to the main channel, only separated by a low gravel bar, within the center of the floodplain. During flood conditions, water will flow through both the main and side channels and also over the top of the gravel bar. The consequence will be that any modifications made to the side channel, e.g. excavations to increase water depth, will likely be reversed during a flood as sediment is deposited in the side channel. Therefore, such an enhancement project will likely be short lived until the next major flood.

2.3 Sites 76 & 81

Setting
Sites 76 & 81 are located between 27 & 28 km on the Copper River Forestry Road in the middle of reach 5 above the second canyon. The floodplain in reach 5 has an average width of about 650 m with the wetted channel covering about 15% of the floodplain area at low flows. The road is above the floodplain in the lower half of the reach but upstream of this point crosses the floodplain and is often next to the river. The concern at these two sites is the stability of the channel bank which is being eroded by the river during floods. Over the last 30 years or so lateral channel erosion has been on average about 1.5 m per year in reach 5 which is significantly higher than in reach 3.

Conceptual Prescription
Build a groin at both sites to deflect the river away from the bank to prevent further channel bank erosion and protect a small remnant of forest between the river and the road.

Analysis and Recommendations
The conceptual prescription at this site is similar to that at site 46. Because of the similar setting of the floodplain, the comments about stream dynamics mentioned in section 2.2 also apply to this site, i.e. in most situations it is best to leave a migrating channel on a floodplain alone since preventing erosion at one point in the reach will just tend to cause erosion at another location, thus moving a potential problem elsewhere. However, in this case the narrow strip of floodplain between the river bank and the Forestry Road is being eroded quite rapidly which may eventually make the road unusable.

Several possibilities exist to rectify the situation. The most permanent solution is to relocate the road above and off the floodplain. The second alternative is to riprap the bank to prevent further erosion without any deflection of the channel. This is the solution with the least impact on the river channel. A third solution, as suggested in the prescription, is to build one or more groins out into the river to deflect the river away from the unstable bank. This is a fairly dramatic measure and will likely cause channel bank erosion on the opposite side of the river or further downstream on either bank. The channel bank around the groins should also be armored to prevent localized erosion due to increased water turbulence. The length that the groin protrudes into the main river channel will determine the degree of river deflection. If this prescription is implemented, a small structure protruding out 3 m or so from the bank should initially be used. Monitoring will determine by how much the river has been deflected and the structure can be modified to produce the optimum deflection. After deflection, a gravel bar will tend to be built downstream of the groin next to the bank. An important point worth noting when installing a groin is that the top should slope towards the center of the river and the entire structure should be below the level of the floodplain. This prevents flood waters from being directed onto the road which tends to cause major damage and can permanently change the direction of the main channel.

2.4 Site 95 (Swan Creek)

Setting
Site 95 is located on a side road just off the Copper River Forestry Road at approximately 31 km. The site is located on Swan Creek at the junction between the steep hillside and the floodplain. At this point Swan Creek has built a small debris fan onto the edge of the Copper River floodplain where the stream gradient decreases from about 25% on the hillside above to less than 5% on the floodplain below. Several other impact sites are located downstream before the creek discharges into the Copper River. Directly below the fan is a side road that accesses a cutblock to the southeast. In order to prevent possible erosion of this road, a berm has been constructed on the fan that deflects Swan Creek to the west along the edge of the floodplain rather than allowing it to extend to the north. The main concern at this site is the stability of the fan and the constructed berm, together with the potential disruption of water flowing into the lower reach of Swan Creek by the building of the berm.

Conceptual Prescription
Install large woody debris into the channel on the fan that is contained by the berm for two reasons. Firstly, to stabilize the channel and prevent the destruction of the berm during flood waters, and secondly, provide complexity to the stream and add fish habitat to Swan Creek.

Analysis and Recommendations
The steepness of the channel just above the debris fan and the natural chaotic deposits suggest that a debris flow formed the fan. Debris flows tend to occur during, or just after, very intense rainfall and are very destructive in nature. Therefore, the constructed berm will likely be breached during a major flood since it is built of loose debris. Installing log structures may make the channel marginally more stable but not significantly so due to the relatively small size of the debris in the berm. To make the channel more stable would require the channel to be armored with riprap. Because of the high gradient of this channel (20% +), it is unlikely that constructing fish habitat will be very beneficial to local fish populations.

As constructed, the berm deflects water into Swan Creek along the southern edge of the floodplain. This will help maintain water flowing in this creek throughout the year. Even if the berm was breached and the channel deflected out onto the floodplain, water would still enter Swan Creek via the ponds on the edge of the floodplain or along the ditch of the side road.

Swan Creek appears to have promise as a side channel development since it is on the edge of the floodplain away from the river and will only be affected by the highest flood levels. In addition, the Creek is low gradient, connects with the Copper River and has a lot of potential habitat over about 1.5 km of stream until the channel gradient abruptly increases. However, Jim Culp has noted that water does not consistently flow in this system throughout the year and so water levels should be monitored carefully to assess the feasibility of enhancing this site. A series of other impact sites have also been identified further downstream from site 95, for example blocked culverts where the Creek crosses the Forestry Road. These should have a high priority for restoration to maintain fish access to this valuable habitat unit.

2.5 Site 222

Setting

Site 222 is located at approximately 3 km on the Clore River Forestry Road which leaves the Copper River Forestry Road at 34 km. The slope above the road is gullied and consists of two major layers of material. The upper unit consists mainly of coarse cobbles and boulders with a matrix of sand which allows water to percolate down easily. The lower unit is glacial till which has a high percentage of clay and acts as a barrier to downward percolating water. As a consequence, a series of seepage points have formed along the edge of the slope at the junction between the two units which has allowed gullies to form as the water runs down the surface of the slope causing erosion. During heavy rainfall, the sandy layer becomes saturated with water which causes slope failure and the mass movement of material downslope towards the road. A timber retaining wall has been built to stop slides from crossing onto the road. After a minor slide has occurred, the material is apparently excavated by machinery from behind the retaining wall and endhauled away. During the overview flight it was noted that several areas in both directions, within a few hundred meters of the site, have been used as endhaul dumps to dispose of the eroded debris. These dumps are now filled close to capacity. The concern at this site is that the slope above the road is very unstable which has the potential to act as an external source of sediment to the Clore River if the retaining wall fails or the removal of landslide debris by machinery is suspended.

Conceptual Prescription

Install flumes to collect water at seepage points and direct it down to the road ditch without causing further erosion.

Analysis and Recommendations

This site is very unstable and is beyond the scope of this contract which is concerned with the restoration of fish habitat. This site should be covered under the Watershed Restoration Program, Level II Roads, Hillslopes and Gullies contract for this watershed. However, a few points can be made about the type of restoration activities that should be considered at this site which are outlined over the page.

The major problem that needs to be rectified is the poor drainage which allows water to saturate the upper sandy layer and run off down the surface of the lower unit causing erosion of the fine grained material. The diversion of water away from the slide area, perhaps with a French drain installed upslope of the failure, will allow other methods to be used, including bioengineering, to help stabilize the site. The most successful methods are likely to be the installation of live French (pole) drains in the floor of each gully, and either wattle fences or modified brush layers, depending upon conditions, on the exposed slide areas supplemented by live staking. This combination of bioengineering techniques will allow natural vegetation to become reestablished on the site and complete stabilization. In addition, the installation of a rock buttress at the toe of the unstable slope may help prevent further failures and give the vegetation a better chance to become reestablished.

These slope stabilization techniques are described in more detail in the following publications.

- A Guide for Management of Landslide-Prone Terrain in the Pacific Northwest, Second Edition, Land Management Handbook 18, Research Program Ministry of Forests, by S.C. Chatwin, D.E. Howes, J.W. Schwab & D.N. Swanston, 1994.
- Soil Bioengineering for Forest Land Reclamation, Course Material for Training Professional and Technical Staff, by Polster Environmental Services, 1997.

2.6 Clore Slide

Setting

The Clore Slide is located next to an outside river bend on the eastern margin of the Clore River floodplain between Trapline and Thomas Creeks. The Slide is a major source of fine sediment in the Copper River system. The slope above the river at this site is composed of fine grained, laminated lake sediments composed of silt and clay which were most likely deposited in a small ice dammed lake as the glaciers retreated up the Clore Valley about 10,000 years ago. The lake sediments extend about 30 m above the level of the river and are overlain by stratified sand and gravel, most likely fluvioglacial in origin. There is no logging activity on this side of the valley above the slide which is a natural feature caused by undercutting of the slope by the river as it has migrated laterally across the floodplain from west to east. The slide appears to have started downstream to the north and has enlarged by success failures upstream to the south which are steeper and have freshly exposed fine grained sediments. As an area starts to slide, the headwall area grows upslope and the angle of the slide decreases as material fails and slides downslope to be added to the river. The coarser material above collapses onto the slide surface together with mature timber which covers the fine grained sediment and actually reduces the amount of fine material that could be added to the river. At the present, the most upstream and southerly part of the slide is the most active segment where a small debris fan has impacted into the creek. However, at several points to the north water is also seeping out onto the slide surface at the base of the sandy, more permeable, upper layer which is causing erosion in a series of shallow gullies. The main concern at this site is the addition of fine sediment to the river which may be detrimental to fish.

Conceptual Prescription

Redirect the river away from the Clore Slide as follows. Excavate the old channel that is separated from the current channel by a low gravel bar. Divert the river along the newly excavated channel by building a berm starting at a bedrock outcrop a hundred meters or so upstream of the Clore Slide on the same side of the river.

Analysis and Recommendations

Moving the location of the river to avoid the slide is a major undertaking. This will not be effective at increasing the stability of the Slide unless an engineered retaining wall, which rises above the level of the surrounding floodplain, is built to separate the diverted channel from the existing channel. This is because the gravel bar that separates the two channels is below the level of the floodplain so that during high water, the gravel bar will be over-topped and water will flow back into the existing channel. Most erosion and failures on the Slide occur during high water, so the engineered retaining wall would be required to prevent the re-establishment of the existing channel.

An alternative solution is to buttress the toe of the slide with riprap to prevent slope failures and further erosion during floods. The buttress should be built high enough above the current level of the channel to be at or above the level of the 100 year flood in this watershed. After the toe has been stabilized, a variety of bioengineering techniques could be used (see section 2.5) to help stabilize the slopes above by the re-establishment of vegetation. Careful attention should be paid to stabilizing gullies fed by seepage and overland flow that tend to erode faster than the surrounding slopes. The installation of live pole drains and gully breaks is a very effective method of increasing gully stability. The construction of a buttress to stabilize the toe of the slide and separate it from the river will not prevent fine grained material from entering the river. Therefore, some form of partial barrier, such as silt fencing, should be installed between the slide surface and the rock buttress to prevent the passage of fine sediment but allows water to pass through. It is important to allow the free passage of water so that the silt and clay does not become saturated with water and turn into a slurry. Careful attention should be paid to maintain the unimpeded drainage of existing gullies across the Slide into the Clore River. The installation of sediment traps will probably be required at the mouth of each gully for a period of time after restoration activities have been completed to allow re-vegetation and binding of the fine grained slope material. These will require routine maintenance to remain effective. Once re-vegetation is complete, little sediment should be eroded down these gullies into the river.

3.0 SUMMARY

This summary is divided into two parts: The first section contains a few comments about general restoration activities that should be considered in the Copper River watershed, and the second section draws some conclusions about the specific impact sites reviewed during this study.

The Copper River is contained in a glaciated U-shaped valley that has quite a variation in the width of the valley floor which depends upon the location of resistant bedrock outcrops. Reaches 1, 3 and 5 are relatively wide, especially 5, while reaches 2 and 4 are confined within narrow bedrock canyons. Because the valley is U-shaped, tributaries are steep and often contain falls which may prevent fish migration. These steep tributaries are generally inhabited by resident fish populations that may be genetically isolated in the river system.

The most valuable habitat for salmonids is located in the Copper River, major tributaries such as the Clore River and Salmon Run Creek, and in the first few hundred meters of tributaries that cross the floodplain in reaches 1, 3 and 5 before the stream gradient increases up the steep sides of the valley. Therefore, restoration activities for salmonid species should be concentrated in these areas. The Copper River Forestry Road crosses the floodplain at many points and its construction has degraded fish habitat in some tributaries and side channels. Restoration of these sites should have the highest priority as they represent high habitat values in a system with limited resources. It has been noted earlier in this report that the Copper River is currently in an unstable phase, which is characterized by accelerated bank erosion and changes in channel location, relative to the period prior to the 1960s. This is mainly due to recent extreme weather rather than the effect of logging activity in the watershed. Restoration activity within the main channel will generally be less effective and relatively short-lived with comparison to restoring and enhancing habitat in side channels and tributaries away from the main channel. This is because the main channel is currently in a process of trying to reestablish an equilibrium between sediment supply, transport and deposition within each reach which is causing major changes in channel pattern that has reduced channel stability. As time passes, a more stable condition will be reached but in the meantime, stopping channel erosion at one location will just tend to cause erosion somewhere else. Preventing erosion of the banks of the main channel may be warranted where the Forestry Road is in danger of destruction and an alternative site outside the floodplain cannot reasonably be found.

The prescriptions that were reviewed at the specific impact sites visited during this study fall into two categories:

- Rock structures to divert the main river channel in an effort to decrease the amount of erosion at certain points, usually where the road is in danger of being washed away by the river or, in the case of the Clore Slide, to prevent fine sediment from entering the river system.
- Side channel and tributary projects with the purpose of increasing the amount of fish spawning and rearing habitat in areas off the main channel.

Given the general comments made above, it is recommended that in the case of sites on the main channel, restoration should only be attempted where a clear rationale can be defined. For example, to decrease the impact of fine grained sediment being added to the Clore River from the Clore Slide, or to stabilize the main channel bank to prevent diversion of the river down a roadbed, which is the case at sites 76 & 81.

In the case of side channel and tributary projects, these offer the greatest possibility of increasing the amount of fish habitat in the watershed. The sites with the highest potential are those with consistent water sources that are near the edge of the floodplain, away from the Copper River. Areas closer to the main channel will be impacted more by major floods which will likely modify the restoration work making it less effective. As a consequence, projects next to the main channel will tend to have a shorter working life.

Field Notes

Nov. 7/97 Jim, Chris, Kezia clear/(-2) 4°
low

Site 99A - 33km C.FSR
- lots of sediment - poor access (adult)
Site 99B
- creek flows into 99A S.C.
Site 103 - inlet to 99A (dry channel)

Site 94 (Warner Springs) 31km C.FSR
- not enough H_2O for adults
- channel w/ ladder over BD?
- take dam out? maintain?
- 4 streams from BD
- ideal coho/chinook

Site 95 (Swan Creek) 30-32km C.FSR
- steep upslope
- obviously not in original place
- worth moving back?
- flows into road side ditch - must be diverted → Beavers!

Site 90 (29.5km side channel)
- fed by (Swan Creek)
- excavate river to creek?
- high potential
- dig for g.w.

Site 85A 28.75km C.FSR
- river feeds pond channel
- can only provide access

Kelly Creek flows roadside @ 27.km C.FSR

Site 54B (16km S.C.) C.FSR
- water flows from creek to side channel (???)
- no H_2O flow in places
- ??? work done in channel
- restore H_2O flow
* transect + excavate for g.w.

Nov.10/97 Chris, Kezia clear/low (-1°) +2°
Site 12 - 1km N.C. FSR
- very little water
(1) chum redd

Site 14B - 1km N.C. FSR
- where channel meets river, may have to build on road, build dyke to keep river out
7 adult coho stir
pink? redd
- very little water

Site 14A - dry channel
- H_2O flows in 2 directions
- more potential
- fed by stream
- bring S.C. into + restore creek to one direction
- lots of cover, LWD
- joins 14B (log jam)

Site 24B - 3km N.C. FSR
(1) coho redd - pool fed by stream
- river lower than channel at start

Site 54B (16km side channel)
- traps set -
1 pond tied to tree on bank (channel dry where H_2O existed Nov.7)
2 in pool tied to WD (no H_2O flow)
3 sm pool under sm creek flowing from road
4 tied to rooted tree on bank 25m from road (bridge)
5 below 2 culverts (between)

- redd near river end (coho) - seepage H_2O from creek
trap set undercutbank

METRIC FIELD

Nov 12/97 Chris Kezia clear (-2°) 4°

Site 14B

sc 855m

2%

pH: 8.5

gravel C+G - lim

LWD - low

Inst. Cover - 30% SWD LWD, B, DP

Rip M - YF/MF 0%

Trapping: 48 hours

Trap 1 - coho

68 54 69 68
53 61 78 60
70 59 66 55
58 64 73 58
62 57 87 59
70 56 53 60
70 70 67 65
64 69 75 82
100 57 81 65
65 100 66 83
62 69 62 48

2 - coho

92 70 65 55
80 80 74 58
70 64 66 59
70 70 74 53
85 56 66 57
75 60 45 65
60 64

rbt

110

3 - coho

80 70 73 77 78
65 70 70 90 92
71 91 100 88 75
71 78 81 82 63
72 86 70

rbt

100

other

7 sculpin

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METRIC FIELD

Site 24C (Something Creek)

Trapping: 46 hours

coho - 45

falls to mouth 100m

24% ↑ bridge

6% ↓ bridge

pH: 8.3

gravel - lim C+G/B

LWD - low

Inst. Cover 50% CB, B, SWD

Rip M/YF/MF 50%

Nov. 13/97 Chris, Kerri (+2)+4 clear/low

Site 54B - 16km S.C. H_2O - frozen

SC 710m (300m - lower)
2%
pH = 8.4
gravel - lim S + G
LWD - low
Instream cover - 10% B
Rip S/YF 0%

Trapping: 68 hrs

1 - coho 81 50 51 50 58 | st (rbt) 48 45 48 46 47 | 2 - coho 78 87 57

3 - Ø | 4 - coho 64 | st (rbt) 48 50 54 60 51 49 58 55

5 - coho 92 84 61 60 82 54 75 58 80 | st (rbt) 111 142 150 95 | char 140 65 140 142 140 150

Site 85A 2* ~ *1 ← H_2O source

Set traps 1 and 2 * no adult access
SC 400m / lg pond (rearing only)
gravel - G + S
LWD - med
Inst. cover 5-10% LWD, B, IV, OV, DP
Rip M BS/MF 5%
→

Site 90 29.5km S.C.
2 traps set
1 - 11 to road in channel tied to rootwad (below BP)
2 - beside lg. stump (above BP)

Site 94 (Warner Springs)
2 traps set
1 - above BD
2 - below BD
SC. 546m
5% (213m from top (channel)
1% ponds
2% outlet
gravel - lim G + S
LWD - med
Inst. cover 5% LWD, OV, IV
Rip - M/YF 80%

Site 95 (Swan Creek)
Traps set
1 - south pond (4 char redds)
2 - north pond (below BD) - under bridge
3 - 11 to BR2000
4 - damflood 5m from BR2000
SC (above fan to spur rd) 339m
35% - gully
18% - pond/inflow
pH 8.9 - fan
8.6 - pond
gravel - none

Nov 13/97 CON'T
LWD - med
Rip - M/PS/YF
Inst. cover 30% dam
0% creek

Site 99A
2 traps set
1- pool below culverts (99B)
2- across road IN 99B
SC 660 m (include dry 103)
3%
pH = 8.4
gravel - lim S/B + G
LWD - low
Inst. cover 5% B
Rip S / SHR 0%

METRIC FIELD

Nov. 14/97 Chris, Kezia Clear/low
Site 9 - 3km C.FSR H2O - clear -2°/+3°

Side channel - 755m
22.

gravel - lim sands to cobble
LWD - low
Instream cover = 10% DP, B, OV
Rip - D/M PS/YF 0%

- Ideal for pink/chum
- steady flow of H2O → open up to river
- dig channel @ river - install control of flow

Trap - tied to fallen tree in pond beside dam (lower end)
91 hours = coho 60mm
65 "

Site 90 (29.5km) H2O clear
S.C. 589m pH = 8.4/9.1
gravel - lim C + B/G
LWD - low
Instream cover = 10% CB E DP, LWD
Rip M YF 10%
(41) live coho
(2) dead coho
(4) coho redds

METRIC FIELD

Trapped: 24 hrs

1 coho (mm)	2 coho (mm)
57 48 45 55 65	56 91 68 68 60 59 58 62
61 60 71 69 58	60 50 54 90 60 68 58 56
56 56 56 73 45	64 62 54 47 55 55 52 48
58 54 70 50	70 82 55 60 67 56 53 51
	steelhead (rbt)
	52 46

95 (Swan Creek)
3 - 30km bridge cutthroat 120mm
* Solid BD under bridge

1 - Ø 2 Ø 4 - Ø

94 (Warner Spring)

1 - coho (mm)	2 - coho (mm)
65 68 72 80 61 55 60 63	93 70 66
65 84 87 58 55 71 62 55	70 78 65
102 75 66 65 60 64 58	88 63
57 66 60 65 66 64 60	- char
58 59 74 80 75 60 59	120 180 142
54 90 62 70 63 57 61	120 115
58 60 67 67 70 55 60	

99A - coho (1)	char	st (rbt)
66 87 98 58	115	75
61 86 86 90	125	
80 86 86 58	110	
81 61 84 86		

99A pH = 8.4
99B pH = 7.6

99B - (2) - Ø

Site 85A

Nov. 14 con't

Trapping 24hrs

1 - coho			2 - coho				char
80	91	87	100	99	85	90	122
98	100	105	107	100	55	95	
80			88	66	100	100	

METRIC FIELD

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Nov. 17/97 partclouds/snow (-1) +2 Kezia, Chris, Jim

Site 192B (11km Creek) Clore FSR
Creek 290m (bridge to river)
14%
pH = 8.1
gravel - lim
LWD - high
Inst cover 25% LWD, B
Rip C/YF 20%

Trapping ; 24hrs
1 - above bridge
2 - below bridge
3 - below bridge

* no adult greens

Site 211 (Clif Creek) - 10km Clore FSR
Creek 592m (bridge to river)
10%
114m bridge to channel
pH = 8.2
gravel - extensive G + S/C
LWD - low (channel) 5% ON LWD CB
high (creek) 20% B, roots, LWD
Inst. Cover
Rip C (creek) YF
M (channel) SHR/MF

Traps Set
1 - 80m from bridge
2 - under [illegible]
3 - [illegible] Clore River

METRIC FIELD

Nov. 18/97 Chris, Kezia, Jim part clouds

Site 211 (Elk Creek) 0 (+3°)

Trapped: 23.5 hrs

1 - steelhead (rbt) char
130 100 119
110 119

2 - coho char
55 91 83 136
40 59 140
133

3 - coho steelhead (rbt)
65 55 95 59 88 90
70 84 60 48
41 95 68 64
55 50 57

* objective - to provide complexity
eg. cover (LWD)
create one channel

Nov. 21/97 - low overcast (+2) +3

Site 236 B (Thomas Creek)

1 coho trapped below falls - 71mm
(7) coho redds 19 hrs
(4) char redds
(8) live coho
(6) dead coho

METRIC FIELD

- impossible falls present
- historically, coho present above falls
- Nov 15 char observed below falls

* main issue is log jam removal
∴ field data info not needed

Site 71 [illegible] km (Cogs? FSR)

Trapping: 71 hours
∅ fish

* seepage [illegible] only ∴ no gravel
sands only

* cannot find outlet

S.C. 1.6km
1%

Site 74 [illegible] km (FSR)
80% for 15m
- erosion during heavy run off

Site 76 - [illegible] km CFSR
overflow S.C.
- lower slope 70%

Nov. 28/97 Jim, Chris, [illegible] (+1) #3
cloudy

Site 205B ([illegible] Creek)
gravel - extensive G + S/C
LWD - med
Inst cover 25% OV, IV, CB
Rip - S/M YF 10%
Trapping: 3 hours
- no fish

* 1995 char trapped + [illegible]

Site 91 & 93 (Salmon [illegible] Creek)
gravel - extensive G + S/C
LWD - low
Inst. Cover <5% OV, LWD
Rip D/M PS/MF
Trapping: 2 hours
- 2 traps = Ø fish

METRIC FIELD

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Dec [illegible]/97 Jim, Chris (+1) 2" [illegible]

SITE 37 B

FISH IN FRY TRAP
JUST BELOW MAIN LINE
BRIDGE.

2 STEELHEAD JUVENILES
115 mm
93 mm

- 1 hour

Site 77
Trapping [illegible]
[illegible] fish

Jan. 6/98 Chris, [illegible] snow (-9) -4

Main River pH = 8.5 (9 km)
8.4 ([illegible] km)

8B (Mocha Creek) - 1.75 km C. FSR
- slight gradient 5m from river
- LWD, Boulders
- passage in high waters

Site 36 - 8km C. FSR
road side banks - sharply undercut
- well veg with con
- lots firs

Site 37B (Fiddle Creek) 9 km C. FSR
creek 250m
gravel - 1m B+C
LWD - low
Inst. cover 50% LWD, B
Rip D/YF 10%

Site 25B (Simpson Creek)
- no trapping required

METRIC FIELD

Site 45 (Peare Creek) [illegible] km C.FSR
10%
[illegible] 8.4
gravel - 1m C+B
LWD - low (lower)
high (upper)
[illegible] - 0% inst. cover LWD, CE
B, DV
Rip M/YF 20%

Site 50B (Kaluna Creek) 14 km C.FSR
* almost no habitat above road
* good rehab potential below road

pH = 9.3
gravel - 1m C+G
LWD - low
Inst. cover = 5% LWD, B
Rip - N

* culvert too high for fish migration

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9

Depth 45
10
8
30
80

	WET
0+000	15
0+025	16
0+050	8
0+075	6
0+100	8
0+125	12
0+150	8
0+175	12
0+200	18
0+225	10
0+250	11
0+275	6
0+300	10
0+325	14

37B

Depth (cm) 30, 20, 60, 35, 25
WET 2, 3, 5, 2, 2
BANK - 20, 5, 8, 12 26

14B

DEPTH
200
40
10
15
30