

Copper Lower Priority Watershed
Level I Detailed Fish and Fish Habitat Assessment:
Swan Creek (30 Km Copper FSR)

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EXECUTIVE SUMMARY

Acer Resource Consulting Ltd. was retained by the Kitsumkalum Band Council to conduct a Watershed Restoration Program (WRP) fisheries assessment of Swan Creek in Subbasin CL5-UT of the Copper Lower Priority Watershed. The Copper River supports all species of anadromous pacific salmon, steelhead, cutthroat trout, Dolly Varden and bull trout. This project was funded by FRBC as a Level I Detailed Fish and Fish Habitat Assessment, however, the history of WRP assessments and the physical characteristics of the study area made the application of standard Level I protocol generally inappropriate for this assessment. Wherever possible, an attempt to follow procedures and produce deliverable products as outlined in the WRTC #8 and Schedule 'A' was made. However, a significant deviation from this protocol was required in order to attain and clearly present assessment results.

The Swan Creek study area is located between 30 and 32 km on the Copper River Forest Service Road, which initiates approximately 7 km east of Terrace, BC. Historic harvesting, road building and linear development adjacent to the mainstem Copper River have resulted in the reduction of accessible off-channel and tributary habitats for juvenile coho in the study area (Pollard et. al, 1996). Subsequent beaver colonization has further modified historic drainage and access, and the Swan Creek study area currently consists of a series of beaver dams and ponds from the mainstem Copper River to the toe of slope position.

The intent of the project was to determine fish use of the large beaver impoundment area known as Swan Creek, and to provide recommendations for restoration based on sampling results. The impetus for this project was to determine the feasibility of a detailed proposal to excavate the current channel to improve access and habitat for juvenile coho.

Results indicated that juvenile fish access is not blocked by the series of beaver dams in Swan Creek, and that coho currently use this area for overwintering. Disruption of the existing habitat was therefore not recommended. The beaver dams do however, represent a significant threat to the FSR and bridge from flooding. A low-impact solution, combining drainage control at the FSR with improved fish access (while maintaining the depth and quality of existing overwintering habitat) was therefore recommended. Several options are presented, with the final design to be determined following a more detailed assessment of the site. A diversion of the current drainage upstream of the FSR was also recommended to prevent flooding of the road and PNG right of way. In addition, a brief air and ground review of historic side channels in the low-bench floodplain area was conducted to identify other potential restoration sites. No appropriate candidate sites were located at this time. An air photo mosaic of the study area was completed to compliment this report and provide a long term management and evaluation tool.

The recommendations presented for Swan Creek are to be implemented in three phases: Phase I includes the detailed assessment and design, Phase II involves the installation and Phase III includes annual routine monitoring and maintenance. The total estimated cost of these phases is approximately \$41,000, with \$20,000, \$15,000 and \$3000 allotted to Phases I-III respectively. Any surplus from Phase I would be directed towards Phases II and III.

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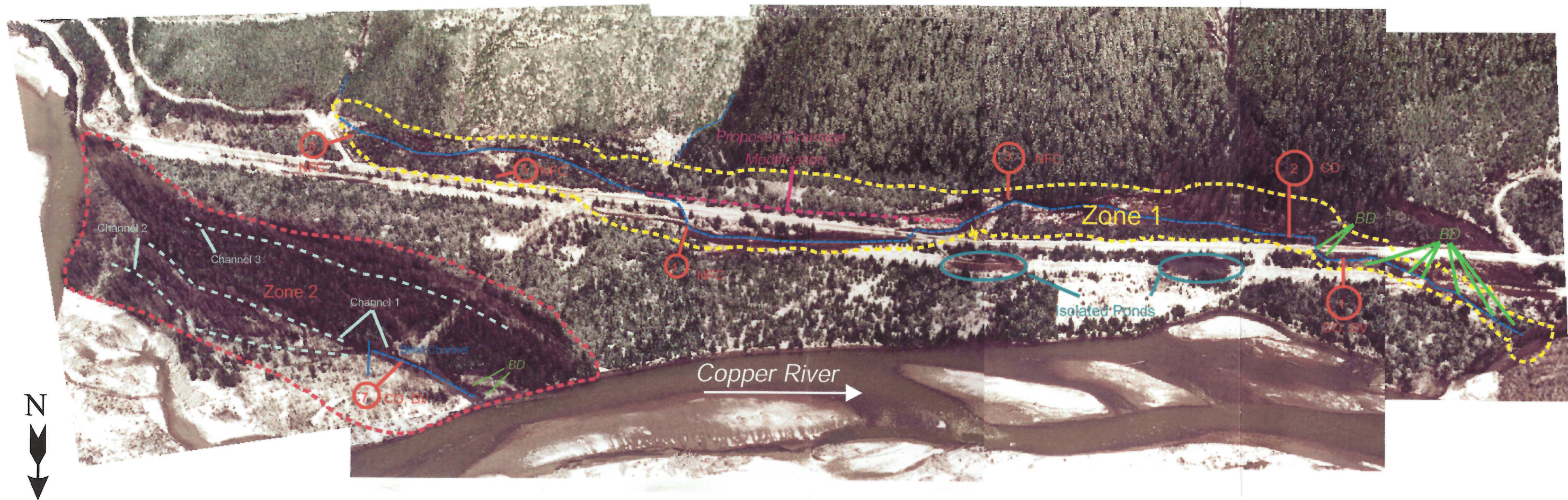


Figure 2: Oblique photo mosaic of the Swan Creek study area showing zones, current and proposed drainage patterns, fish sampling locations and results.



Copper River WRP - Swan Creek Restoration
(30-32 Km Copper FSR)
Acer Resource Consulting Ltd.
March, 2002 (Photo Date November 20, 2001)

Legend

- Drainage Pattern
- Proposed Drainage Pattern
- Discontinuous Channel
- Zone 1 Boundary
- Zone 2 Boundary
- BD Beaver Dam
- FSR Forest Service Road
- (2) CO Fish Sampling Site
- Fish Species Codes:
CO - coho, DV - Dolly Varden
NFC - No Fish Caught

INTRODUCTION

The Watershed Restoration Program (WRP) is an initiative funded by Forest Renewal British Columbia (FRBC). It was created with the intent of restoring the natural productive capacity of terrestrial and aquatic ecosystems negatively impacted by historic harvesting practices. The WRP process is implemented in several stages: the Overview Assessment, the Level I Fish, Fish Habitat and Riparian Assessment (FHAP), a more detailed Level II Site Survey and Design Assessment and, finally, ground-based restoration and rehabilitation works.

This report provides a modified Level 1 FHAP of the Swan Creek area in the CL5-UT Subbasin of the Copper Lower Priority watershed. This project does not follow the standard procedure or format of a typical Level I FHAP Assessment due to the history of WRP assessment work in the Swan Creek area and the physical attributes of the study area, which will be described below. The primary intent of this review was to define fish distribution and access in order to effectively direct ground based restoration expenditures.

Acer Resource Consulting Ltd. was retained by the Kitsumkalum Band Council to complete this assessment. The technical monitor for the project is Chris Broster of MWLAP (formerly MELP). All work for this project has been completed under the direction of Brad T. Pollard, R.P. Bio. Field work was completed by Sam Buchanan, Fisheries Technician and Murray Metcalfe, D. Tech.

BACKGROUND

The Copper River watershed contains all species of anadromous pacific salmon, steelhead, cutthroat and rainbow trout, Dolly Varden and bull trout. The watershed is well known as a steelhead fishing destination, and was once rated among the top ten steelhead rivers in BC. In recent years the quality of aquatic habitat in the watershed has been degraded and fish production has declined. Impacts to fish and fish habitat have resulted from forestry activities, road building and linear development (natural gas and hydroelectric transmission lines). Harvesting and development on the floodplain in the 1970's removed approximately 90 % of the original riparian forests in the Swan Creek area (Subbasin CL5-UT) and reduced or eliminated fish access to off channel areas (Pollard et al., 1996). The subsequent increase in beaver populations associated with regenerating forests continues to modify site drainage patterns, fish habitat and fish access. The target species for restoration efforts in the Copper Lower Priority Watershed are coho salmon and steelhead trout (Kingfisher and Acer, 2002). This assessment is specifically directed towards restoration of habitat for coho salmon.

WRP PROJECTS

The history of the WRP in the Copper Lower Priority Watershed is fairly extensive. Numerous fisheries and riparian habitat assessments have been completed since the first overview assessment was conducted in 1995 (Pollard et al., 1996). Several projects have developed into ground based restoration works, mainly focusing on the development of tributary and side or off-channel habitats. The magnitude and instability of the mainstem, combined with extreme high water events, have precluded extensive restoration work within the main channel. Further investment in main channel restoration work is therefore not

recommended, and future WRP efforts are focused on the development and restoration of off channel habitats (Kingfisher and Acer, 2002).

The Swan Creek study area was first identified in 1995 as having a high potential for restoration (Pollard et al., 1996). The site includes approximately 10 ha of deep beaver ponds and wall based channels adjacent to the mainstem, located primarily upstream of the Copper FSR. In recent years this site has been examined from the perspective of restoring fish access and productivity, specifically as a rearing/overwintering area for coho (Culp et al., 1998, Triton, 2000). A detailed (Level II) site plan for the restoration of Swan Creek downstream of the Copper FSR was developed in April 2000. The plan involved excavating the outlet channel to 1 m below the existing grade from the FSR to the Copper River (~375m), removing several of the existing beaver dams, creating permanent earth dams, excavating several pools and providing a cobble substrate over the PNG right of way. Juvenile fish ladders were proposed for the two largest beaver dams located at the FSR crossing. This plan has been postponed pending results of this assessment.

STUDY AREA

The Copper (Zymoetz) River watershed is divided into two major units by a regional boundary. The lower Copper River extends downstream from Red Canyon Creek to the mouth at the Skeena River. This portion of the watershed falls within the Kalum Forest District. This area is primarily within Skeena Cellulose Inc's (SCI) TFL 1 chart area, although minor components are managed by the MoF Small Business Forest Enterprise Program (SBFEP). The upper river and headwater lakes are within the Bulkley Forest District.

The Swan Creek study area is located between 30 and 32 km on the Copper FSR in the Copper Lower Priority Watershed, which includes 5 mainstem reaches and tributary drainages downstream from the Clore River confluence (Figure 1). The study area is divided laterally by the Copper FSR and the PNG right of way (ROW), bounded by the mainstem Copper River to the north and the toe of slope to the south (Figure 2). A 1:20K map of the study area is provided in Appendix I. The study area was divided into 2 zones based on existing drainage patterns and suspected fish distributions (Figure 2). Zone 1 (Swan Creek) includes the upslope area west of the Copper FSR and its entire drainage downstream, while Zone 2 includes a portion of floodplain habitat adjacent to the Copper River. No connection for fish movement exists between Zones 1 and 2.

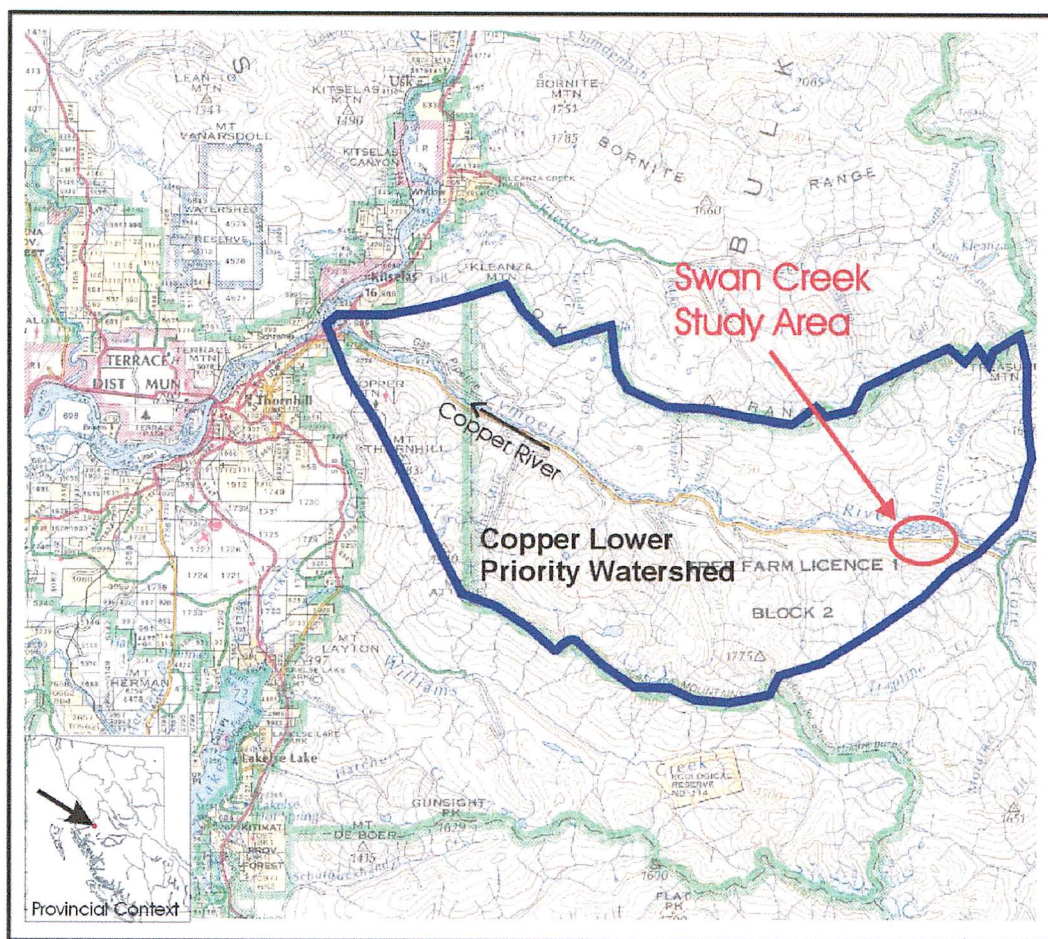


Figure 1: Location map of study area (scale approximately 1:250K).

APPROACH AND RATIONALE

Upon review of the detailed restoration plan for the site, several questions arose. First, it was unclear at what point anadromous fish access into Swan Creek was obstructed, if at all. This question led to a discussion of whether or not the channel excavation and dam removals downstream of the FSR were necessary or cost effective. Fish sampling conducted during summer months had revealed the presence of only Dolly Varden upstream of the FSR, suggesting that coho access was blocked. During a site visit to review the plan in 2001, however, it was suggested that coho may only move into the study area in order to locate overwintering habitat. This was based on findings from previous studies indicating that coho typically migrate into overwintering areas as water temperatures drop in the fall (Bustard and Narver, 1976, Swales et al., 1988, Beniston et al., 1988). This movement of fish often coincides with fall flood events, facilitating migration past beaver dams. Similarly, coho outmigration has been associated with spring freshet, allowing seasonal fish passage over obstructions. In addition, studies on trout have shown that fish not only pass over beaver dams during high water, but can move upstream and downstream through most beaver dams during all seasons (Olson and Hubert, 1994). Prior fish sampling, therefore, may not have accurately captured fish use of the area, and may have resulted in the development of a more elaborate restoration plan than necessary.

In addition, the efficacy of removing several of the existing beaver dams was questioned, as was the creation of permanent dams. According MWLAP's Beaver Management Guidelines, complete dam removal is not recommended, except in emergency situations, because dams provide environmental benefits and contribute to watershed health and biodiversity. In addition, removal is often ineffective, because the beavers will efficiently repair the breached dams unless beaver activity is managed by some other means. Dam removal is also correlated with the following negative impacts to fish and instream habitat (adapted from MWLAP):

- The rapid release water and sediment into downstream spawning and rearing habitat, causing scour, erosion and impacts associated with elevated suspended sediment.
- A rapid reduction in pond depth, resulting in stranding and mortality of fish, amphibians, birds and aquatic and terrestrial plants.
- Rapid changes in temperature in the remaining pond during summer months

Beaver dams provide a variety of ecological functions, including trapping sediment, storing water, increasing nutrient concentrations and promoting primary and secondary production (Olson and Hubert, 1994). As reservoirs, dams enhance stream flow throughout the year, providing critical habitat during low flow periods. They also moderate extreme flows during spring and storm run off, preventing displacement of fish and damage to habitat downstream (Finnegan and Marshall, 1997, Olson and Hubert, 1994). Beaver dams create particularly stable overwintering areas for juvenile coho, and habitats of this type are limited in the Copper Lower Priority Watershed. The presence of stable overwintering areas with cover contributes significantly to productivity of the species (Nickelson et al., 1992, Solazzi et al., 2000). The Pacific Fishery Management Council (PFMC) of Oregon (1999) in their description of essential habitat for coho state:

“...the survival of juvenile coho over the winter (which depends on not being swept downstream in high winter flows) is limited by finding adequate slow water habitat (Nickelson et al., 1992). Survival of juvenile coho was found to be greatest in areas of slack water.... separated from the main flow by streambanks or large obstructions....especially beaver ponds. Compared with other types of dammed pools, beaver ponds supported almost 5 times as many fish at a higher density.”

Currently, abundant deep habitat suitable for coho overwintering exists upstream and downstream of the FSR at the Swan Creek site. Fish use of this habitat was unclear prior to this assessment. The proposed excavation of the channel below the FSR (in order to improve access and rearing habitat) was not supported in the absence of accurate fish use information. If fish are currently using the existing habitat, and if access upstream of the FSR could be established, this would preclude the need to disrupt the channel downstream of the road. In addition, juvenile coho tend to aggregate in suitable deep habitats with cover and will tolerate higher interspecies densities during winter (PFMC, 1999). The amount of existing habitat was considered adequate to support and promote local overwintering populations of coho without further excavation, provided that seasonal access is maintained.

The intent of this assessment, therefore, was to clearly determine fish distribution and use of existing habitat. Secondly, based on fish sampling results, the goal was to develop

recommendations to reduce flood risk to the FSR and bridge, while maintaining habitat quality and fish access, with minimal disturbance to the existing channel and surrounding habitat. This project is consistent with the long term goal of improving fish habitat quality in the Copper Lower Priority Watershed through a combination of upslope, instream and riparian restoration efforts (Kingfisher and Acer, 2002).

DEVIATION FROM STANDARD PROTOCOL

Although this project was funded as a Level I Detailed FHAP, the nature of the study area (beaver impoundment) and assessment objectives are not entirely consistent with the standard habitat evaluation, diagnostics and outputs as outlined in WRTC #8. In addition, impacts to the site are specific and have been clearly identified in several previous assessments (Pollard et al., 1996, Culp et al., 1998, Triton, 2000). This approach is supported by Slaney and Martin (1997) in WRTC #9, who state: "Clearly, if habitat impacts are obvious, overzealous recording of habitat or channel or riparian conditions and applications of diagnostics is neither cost-effective nor wise spending". An effort was made to follow the standard WRTC #8 protocol and Schedule 'A' as closely as possible within the context of the assessment goals, budget and timeframe. The general approach was to:

- Determine fish use and access within the study area by intensive sampling.
- Determine if further investment in the area is warranted, and if so:
 - develop plans to maintain the quality and quantity of existing habitat,
 - develop plans to maintain fish access, and
 - develop cost effective restoration plans that minimize disturbance to existing habitat.

In addition to determining fish distribution throughout Zone 1 (Swan Creek proper), a survey of historic and current side channels in the Zone 2 floodplain was initiated. The purpose of the Zone 2 assessment was to determine current fish distribution and drainage patterns and to document opportunities for extending or developing habitat for the target species. The goal was to locate historic side channels which could potentially be developed or extended with minimal cost, effort or damage to existing fish and riparian habitats. Criteria for candidate sites therefore included direct road access and proximity to the mainstem.

RIPARIAN

A detailed riparian assessment was completed in conjunction with this project and is provided under separate cover as *Riparian and Off-Channel Assessments for Three Reaches in the Lower Copper River Watershed* (Pollard and Haworth, 2002). An overview of results and recommendations from the riparian assessment are provided in this report, however detailed riparian prescriptions and Table B-1, as required in Schedule 'A', Appendix 'B', are provided in Pollard and Haworth, 2002.

METHODS

HABITAT ASSESSMENT

A fisheries technician conducted field assessments in Zone 1 (reaches 1 and 2 of Swan Creek) on November 22 and 23rd, 2001. The study area was examined first from air photos and then from the ground to determine drainage patterns, fish access points, potential barriers and sites for restoration investment. Sampling within Reach 1 of Swan Creek recorded substrate, pool depths and area, riparian vegetation, instream cover, obstructions and water quality (temp, conductivity, pH). The study area does not display typical stream morphology due to the extensive beaver activity at the site. Assessment procedures were adapted to reflect this. No true riffles, glides, spawning areas, or boulder/cobble substrates exist, and therefore these habitat parameters were removed from the assessment. Discharge was not calculated as the site is generally backwatered, and no appropriate location for this measurement occurs.

The selected data for Reach 1 were recorded on a standard Level I habitat survey card (Form 4). Following the assessment in Reach 1, it was determined that a similar assessment in Reach 2 would not provide a useful diagnosis of the habitat. Reach 2 was assessed more subjectively, in the specific context of coho overwintering habitat. Measurements of channel and habitat attributes followed the methodology provided in the WRTC # 8. Equipment used for sampling included a 30m Eslon tape, a 2.5 m telescoping meter stick, a clinometer, a hip-chain, and a 35 mm Pentax camera with Kodak Gold 200 ASA film. Visual estimates were used for depth and width values in situations where it was too deep to sample or cross the channel. Water quality measurements of pH and conductivity were recorded using hand-held Oakton meters. Sampling data (Form 4) for Reach 1 are in Appendix II. Reach breaks, habitat features and fish sampling locations are shown in Figure 2.

In Zone 2, the assessment did not include standard habitat evaluation and diagnostics as outlined in WRTC #8. The Zone 2 assessment involved fish sampling, as well as a ground based investigation to determine fish access points, barriers and the extent/viability of historic side channels. Zone 2 was specifically assessed to determine if further development of side channel habitat was feasible.

FISH SAMPLING

In order to determine if fish use the existing habitat adjacent to the Copper FSR between 30 and 32 km, an intensive sampling program was developed. Eight sample sites were selected in order to determine fish distribution and access points throughout the study area (see Table 2 and Figure 2). All fish sampling was done using non-boraxed roe baited Gee's minnow traps. Minnow traps were selected as the preferred sampling method due to low water temperatures at the time of sampling and predominately deep habitat types throughout the study area (both conditions preclude electroshocking). In addition, low fish densities were suspected, and minnow traps provide the best opportunity to catch fish due to their lengthy sampling window. Impacts to captured fish from minnow traps are also minimal compared with other sampling techniques. All traps were allowed to soak for at least 24 hours. Captured fish were identified, measured to fork length, and immediately released in the same location they were caught.

AIR PHOTO MOSAIC

A low level air photo mosaic was created by photographing the subject watershed from a Bell 206 helicopter with a floor based camera mount on November 20, at 1:00 PM. A Canon A1 SLR camera with a 50 mm lens and Kodak Gold 200 ASA film were used for photography. Photographs were taken from approximately 1400 m ASL, at a relatively constant speed of approximately 80 knots. Photographs were manually timed at 3 to 4 seconds between exposures. The resulting photo mosaic is at an approximate scale of 1:4,000, however the scale and the amount of overlap between photos varies according to changes in vertical distance and helicopter speed during the flight. A second flightline was taken at 450 m ASL, resulting in a larger scale of approximately 1:1000. Photo scale was determined by comparing a distance between two known points on a 1:20 000 scale TRIM map to the same distance on the photos, using the equation: $\text{TRIM distance (m)} / \text{photo distance (cm)} \times 100 = \text{scale}$. A series of 1:4000 scale photos were numbered and arranged with the best possible overlap for coverage and mounted on 3 sheets of tabloid (11 x 17) size paper. The resulting photo mosaic is presented in upstream order, showing date and time of photography, scale, and direction of mainstem flow, and is presented in Appendix II. A digital copy of each page is included with the project deliverables. The original mosaic was laminated as a final deliverable product. Oblique photos were taken following the photo mosaic flight. These photos were arranged and annotated digitally to display specific features within the study area (Figure 2). Figure 2 is oriented 180° to the Appendix II mosaic, to more clearly display drainage patterns within the study area. The air photo mosaics will provide a means of monitoring and evaluating site conditions over the long term.

HABITAT DIAGNOSTICS

Habitat quality was diagnosed from field observations, a review of recent air photos, standardized habitat diagnostics (WRTC #8) and professional judgement. No regional standards for habitat diagnoses were available, and several of the diagnostic parameters do not apply to the study area. Where applicable, habitat features were evaluated against the criteria for good, fair and poor salmonid habitat quality as provided in the WRTC #8. These were adapted to best describe the characteristics of the study area and the data collected. Habitat parameters evaluated included access, pool characteristics and cover as they relate to rearing and migration requirements of juvenile salmonids, specifically coho. Impacts to aquatic habitat were not assessed as per the WRTC #8, as restricted access due to linear development and beaver activity and water supply were previously noted as a limiting factors for optimal utilization of the area by the target species (Pollard et al., 1996, Culp et al., 1998).

RESULTS AND DISCUSSION

FISH SAMPLING

Zone 1 Results

Fish sampling in the study area revealed that juvenile fish access is not restricted by the series of beaver dams below the Copper FSR in Reach 1. Twenty-seven juvenile coho were captured in a single overnight set of 2 minnow traps above these dams in Reach 1 (Figure 2, Table 1). Fork-lengths from these fish ranged from 70 mm to 128 mm, indicating that two age classes of fish are present (Table 3). This also suggests that fish access from the mainstem was available for at least two consecutive years. These results indicate that the removal of dams downstream of the FSR is unnecessary, and that the existing habitat is functioning as an overwintering site for juvenile coho.

The single large beaver dam immediately beneath the FSR bridge and the subsequent dam approximately 20 m downstream appear to restrict fish migration most years, based on fish sampling results. However, two juvenile coho were captured upstream of these dams, which reveals that juvenile fish can move past these obstructions. The lower number of fish captured at Site 2, as compared with Site 1, however, suggests that fish have difficulty moving past these two dams. It has also been suggested that larger predatory fish such as resident Dolly Varden or cutthroat trout inhabiting the pond upstream of the FSR may have reduced the relative abundance of coho at Site 2 (Culp et al, 1998). The presence of piscivores such as Dolly Varden may also result in avoidance of the area by juvenile coho (Jackson et al. 2001). Both fish captured at Site 2 appeared to be of smolt age by size (123 and 134 mm fork length) and by appearance (silvery, indistinct parr marks). It is suspected that these fish are trapped upstream of the FSR until a high water event or breach in the dams allows downstream migration. These fish are also likely large enough to avoid predation.

No fish were captured at any sites further upstream in the system (Figure 2), although no significant barriers to further migration occur. This is likely because the best available habitat for overwintering exists immediately upstream of the FSR (Site 2), and fish would tend to be concentrated in this area.

Table 1: Fish sampling locations and results.

Zone	Site	Trap #	Location / Description (see Figure 2)	Result
1	1	1,2	30 km FSR downstream	27 coho
	2	3,4	30 km FSR upstream	2 coho
	3	5-8	~ 30.5 km FSR upstream	No fish captured
	4	9,10	~30.75 Swan Creek FSR downstream – PNG section	No fish captured
	5	11,12	~30.8 Swan Creek FSR west	No fish captured
	6	13,14	Branch Road West	No fish captured
2	7	15,16	Blind channel with BD at mouth	8 coho, 1 Dolly Varden
	8	No sampling	Isolated depression	No sampling, no potential for fish use

Zone 2 Results

Fish sampling locations in Zone 2 were initially selected from air photos, however several sites were eliminated from sampling because they were found to be completely isolated on the ground. Eight coho and one Dolly Varden were captured in a blind channel at Site 7, which is obstructed by a large beaver dam at the mouth (Figure 2). Captured coho appear to represent two age classes (Table 2), one fish captured measured 80 mm in fork-length, and the remaining ranged between 123 mm and 130 mm.

Table 2: Fork length and estimated age class of captured fish.

Trap #	Species	Total	Fork Length (mm)	Estimated Age Class
1	Coho	8	70-101	1+
1	Coho	5	110-128	2+
2	Coho	13	78 – 96	1+
2	Coho	1	121	2+
4	Coho	2	123-134	2+
15	Coho	3	123-130	2+
16	Coho	1	80	1+
16	Coho	4	124-130	2+
16	Dolly Varden	1	125	2+

HABITAT EVALUATION - ZONE 1 - REACH 1

Reach 1, located at UTM coordinates 09.557940.6036535, extends from a mainstem Copper River side channel approximately 375 m upstream to the Copper FSR (Appendix I, Figure 2). Reach 1 does not display typical stream morphology (ie: riffle-pool), due to a series of 7 beaver dams, and is best characterized as having dam-pool sequences with occasional shallow runs. Pool and 'other' habitat units were evaluated and diagnosed according to WRTC #8 standards. It should be noted that the application of the standard diagnostics to this reach is difficult, due to the atypical morphology resulting from beaver activity. A more subjective professional judgement of the habitat, specific to the rearing requirements of coho, is integrated into the following evaluation.

The average channel gradient in Reach 1 is 0.9 %, with gradients ranging from 0.5 to 2.5%. Average bankfull channel width in Reach 1 is 6.2 m with a wetted width of 3.2 m. The average depth in this reach was estimated at 0.5 m, however half of these values are derived from pools, the average non-pool depth is 0.3 m, including a short section which dries periodically (McElhanney, 2000). Culp et al., 1998, also indicate that water supply and channel drying is the main limiting factor for juvenile coho survival in Reach 1. Water quality measured in Reach 1 resulted in a conductivity of 90 microsiemens, a pH of 7.2, and water temperature of 2.5⁰ C at the time of sampling.

Beaver dams are responsible for the main habitat features of this reach: several large, deep beaver ponds that provide stable rearing and overwintering areas for the target species. Fish

access past/through the beaver dams, riparian conditions, flooding on the PNG right of way and flooding of the road are the main concerns in this reach.

Habitat Quality and Habitat Diagnostics

Overall, habitat quality in Reach 1 was diagnosed as fair according to habitat quality standards for salmonids provided in the WRTC #8. Five of the eleven habitat parameters evaluated resulted in a poor outcome, four resulted in a fair outcome, and two resulted in a good outcome. A discussion of habitat diagnostics outcomes is presented below and a summary of criteria used to evaluate Reach 1 and results are in Table 3.

Pools

Results of field surveys and habitat diagnoses indicate that pool habitat in Reach 1 is fair. Pool frequency and extent were rated as fair, with approximately 9 pools per kilometer of stream reach and one pool per 2.8 bankfull widths. Pools comprise an estimated 44% of the wetted area of the reach, and average pool area is approximately 340 m². Pool depths were also rated as fair in terms of adult holding capability. Sixty-six percent of the pools measured had maximum depths greater than 1 m, and the same number had a residual depth greater than 1 m. The average residual pool depth was calculated as 1.0 m, which is considered sufficient for adult holding and adequate for juvenile overwintering. The limiting factors in terms of pool quality and use of pool habitat are access (all pools are formed by beaver dams) lack of instream cover, and temperature. Very low water levels causing stranding and mortality of fish during the late winter and early spring have also been noted in past surveys of Reach 1 (Culp et al. 1998), however subsequent changes in drainage and beaver activity may have improved this condition. Pool habitat appeared to be sufficiently deep to support overwintering fish until spring freshet during this survey and continuous input of surface drainage from the two upslope sources should be adequate to provide continuous flow to Reach 1. Further investigation of the water supply issue in Reach 1, however, is likely required to resolve this issue.

Cover

Cover was evaluated in all habitat units within Reach 1. Percent wood cover in pools was rated as poor, with no LWD cover occurring in any of the pools sampled. This is due to an early seral stage riparian area. Overhead cover was rated as fair, comprising an average of 28% of the total cover for all habitat units sampled. The amount of functional LWD within Reach 1 was rated as poor, calculated at an average 4.3 pieces per habitat unit sampled and 0.4 pieces per bankfull channel width. All LWD tallied was in the smallest size category (10-20 cm) and associated with beaver activity.

Spawning Habitat

Spawning habitat was rated as poor throughout Reach 1. The amount of suitable spawning substrate was rated as low for 33 % of the habitat units sampled, and as none for 66 % of the habitat units sampled. Suitable spawning substrate occurs in isolated pockets only, in the lower portion of the reach. Suitable spawning substrate may exist beneath the layer of fines that has developed as a result of the beaver dams, however maintaining these deep, slack areas for coho rearing takes precedence over the creation of spawning habitat in Swan Creek. In addition, coho spawning currently occurs in the mainstem side channel immediately

downstream of Swan Creek (Culp et al., 1998). The proximity of this spawning habitat to Swan Creek supports the idea of focusing further restoration towards rearing and overwintering habitat for coho.

Inorganic Nutrients

Levels of inorganic nutrients, specifically dissolved inorganic nitrogen (DIN) and soluble reactive phosphorous (SRP), were not analyzed for Swan Creek. However, it is not expected that inorganic nutrient levels are limiting fish production. This is based on the observation of abundant instream vegetation such as vascular aquatic plants, and the presence of numerous beaver dams which store nutrients and improve conditions for primary and secondary production (Olson and Hubert, 1994). Nutrient concentrations in the system are likely increased from historic levels due to the extensive beaver activity in the study area.

Table 3: Habitat condition diagnostics summary, Reach 1 (adapted from the WRTC #8).

Habitat Parameter	Habitat Quality Criteria			Reach 1 Result	Rating	Comment
	Good	Fair	Poor			
Pool Area	> 55%	40-55%	< 30%	44%	Fair	Pool area concentrated at upstream end of reach.
Pool Frequency	<2 Wb*1/pool	2-4 Wb/pool	>4 Wb/pool	2.8 wb/pool	Fair	~ 1 in 3 Wb
Pool LWD Cover	>20%	6-20%	0-5%	0	Poor	Minimal functional LWD.
Residual Pool Depth	>50% pools >1m	25-50% pools >1m	0-25% pools >1m	66% >=1m	Good	Average = 1m
LWD Density	>2 pieces/Wb	1-2 pieces/Wb	<1 pieces/Wb	0.42	Poor	Minimal functional LWD.
Overhead Cover	>30%	10-20%	<10%	28%	Fair	Total overhanging cover for all habitat units sampled.
Spawning Access	No Barriers	—	Barriers	Barriers	Poor	Adult access impeded at low water.
Spawning Substrate Quantity	Frequent areas	—	Absent or little material	Absent or little	Poor	Substrate may be present but buried beneath layer of fines.
Spawning Substrate Quality	Sand never dominant	Sand sometimes dominant	Sand often dominant	Sand often dominant	Poor	Not a suitable spawning area.
Spawning Areas Stability	Stable/low scour potential	Some scour or potential for scour	Unstable with scour evidence	Stable	Good	Stable channel, moderated by beaver dams.
Holding Pools	Adequate pools/km, good cover, cool	—	Few Pools/km w/good cover, cool.	~ 9 pools/km, limited cover, likely warm during summer	Fair	The requirement for holding areas is diminished by the lack of spawning habitat to migrate to.

1* Wb=bankfull channel width

Riparian

Riparian assessments completed by Pollard and Haworth, 2002 identified one continuous 9 ha stratum (B) adjacent to the first reach of Swan Creek. Stratum B in block 621600 was harvested in 1965 and brushed in 1988. Stands are composed primarily of spruce regeneration with smaller components of hemlock, willow, and other deciduous species. Leader weevil damage is extensive and densities range 300 stems per ha (sph) in wetter sites to 2400 in well drained areas. This stratum has an identical stand history to the adjacent stratum A but should be considered separately due to different planned treatment regimes and the inclusion of this strata within the Copper RMA. Approximately 2 ha of stratum B occurs within the PNG right-of-way and another 0.5 ha in ponds and wetlands from upstream beaver damming. Several of these wet areas have since been converted to a swamp designation on forest cover mapping.

HABITAT EVALUATION - ZONE 1 - REACH 2

Reach 2, located at UTM coordinates 09.558501.6036515, extends approximately 1.8 km from the Copper FSR to the toe of slope position, where steep gradient prevents further fish use (Appendix 1, Figure 2). Distinct habitat units of riffle, pool, glide, cascade and run, as defined in the WRTC #8, do not appear within the reach. Habitat evaluation in Reach 2, therefore, did not follow the standard protocol from WRTC #8, as channel morphology is atypical and the habitat is best characterized as wetland. The use of standardized diagnostics was considered impractical for this reach. The following discussion evaluates Reach 2 in the context of applicable habitat quality parameters (pool depths, cover, access, etc).

Reach Description

Two steep 2nd order systems drain into the upper bench floodplain area designated as Reach 2 (Appendix I). This reach has been extensively been modified by linear development and beaver activity. Original drainage from the hillslope to the mainstem has been intercepted, diverted and backwatered by the FSR, the PNG right of way, and numerous beaver dams. The drainage currently flows in both directions due to backwatering through 2 culverts under the FSR, flooding the PNG right of way (Figure 2).

Although fish sampling was conducted throughout Reach 2, the habitat assessment focused on a large ponded area immediately upstream of the 30 km bridge, and the habitats influenced by the proposed channel redirection (Figure 2). Within the large pond, coniferous LWD and instream vegetative cover is abundant, the average depth is greater than 1 m, with a maximum depth estimated at over 2 m. The toe of slope position of the pond, combined with surface drainage, abundant instream cover and generous depth and area, make it an excellent overwintering site for coho (Beniston et al., 1988 in Finnigan and Marshall, 1997).

Habitat Quality

Overall, habitat quality in Reach 2 is excellent in terms of providing rearing and overwintering habitat for the target species. Reach 2 does not provide any suitable spawning habitat, and has seasonally limited access for all life stages of fish due to the beaver dam located beneath the 30 km FSR bridge. Water quality is considered good, with stable perennial flow from two upslope sources, moderated during storm events by the series of beaver dams and ponds.

Pools

Pool habitat in Reach 2 is extensive, and covers approximately 1-1.5 ha. The best pool habitat is located immediately upstream of the Copper FSR, in a large beaver pond (Figure 2). This area provides approximately 0.9 ha of excellent quality rearing and overwintering habitat, with an estimated max depth of 2.5 m and an average depth of 1.3 m.

Cover

The largest pond in Reach 2 contains abundant coniferous LWD and instream vegetative cover, largely a result of beaver activity. Percent wood cover in pools was estimated at 30 %, and LWD comprised an average of 70 % of all cover types for pools. Overhead cover is minimal, however instream vegetative cover is excellent, comprising approximately 25% of cover types. The majority of LWD is coniferous and within the large (> 50 cm) diameter

class, providing persistent and stable cover. The LWD in the large pond above the FSR is clearly visible on the photo mosaic, Appendix II.

Riparian

One stratum of riparian vegetation was identified adjacent to Reach 2 in Zone 1 (Pollard and Haworth, 2002). Stratum A in block 621600 is approximately 10 ha and includes most of the area between the mainline and the toe of the slope from 19 km to Branch Road 623000. This area was logged in 1965 and brushed in 1988. Stands are composed primarily of spruce regeneration with smaller components of hemlock, cottonwood, and other deciduous species. Leader weevil damage is extensive. Densities range from 700 sph in wetter sites to 2400 sph in upland areas. Some of this area is continuously inundated due to beaver activity. Old growth forests have been maintained upslope near the western portion of this stratum.

HABITAT AND DEVELOPMENT ASSESSMENT - ZONE 2

A detailed ground assessment of Zone 2 was conducted to determine the location, extent and connectivity of historic side channels identified on air photos. The three channels apparent on the air photos were walked in their entirety (Figure 2).

Channel 1 (Warner Spring) is located in the low bench position on the floodplain in Zone 2 (Figure 2). This channel was first identified in 1997 for potential restoration (Site 94, Culp et al., 1998). The channel is obstructed at the Copper River by a large beaver dam (Figure 2). A large, deep backwater has formed behind the dam, which extends approximately 125 m upstream. Beyond this the channel abruptly ends due to a second large beaver dam, and no further channel or fish habitat occurs (Figure 2). Although this backwater is deep and wide, it has virtually no instream cover and has restricted access to and from the Copper mainstem. The area upstream of the blind channel was investigated to determine if a permanent connection to the Copper River could be established to provide additional habitat, access and flow. No appropriate location for this type of development was found. Channel 3 consists of a series of isolated ponds and depressions on the mid-bench floodplain which are not connected to the mainstem at either end and currently contain no potential for fish use.

Riparian

Two strata were identified within block 621600 in Zone 2 (Pollard and Haworth, 2002). Stratum C is located directly east of stratum B in Zone 1 and includes a small gravel area currently used as a campsite. Historic records indicate this area was harvested and spaced as per the other stratum in this block, however photo interpretation suggests further treatments have been completed. While no supporting records were found, it appears that many of the heavily weeviled spruce were "hydro-axed" and the site was replanted in 1993. The current stand is in the tall shrub seral stage with red-osier dogwood and willow being the most common species. Conifer regeneration is becoming established at low densities.

Stratum D is the largest of the strata in block 621600, measuring approximately 15 ha. This area is limited to the south by the PNG pipeline right-of-way and to the north by a natural riparian stand of 40-50 years old. This stratum has the same history the remainder of the block, however improved drainage has resulted in a more productive stand. Forests are composed of a cottonwood overstory approximately 19 m tall with conifers coming up

beneath. The majority of conifers are heavily weeviled spruce, however hemlock, balsam and cedar also occur. Some understory alder occurs along the stratum edges. The canopy is starting to close up slightly, with evidence that understory shrubs are beginning to die back. This stratum also includes a small band of mature timber left along the southern bank of the Copper directly adjacent to the mainline on the extreme eastern edge of the block. Much of this buffer has been lost to erosion since original maps were made in the early 1980's.

CONCLUSIONS AND RECOMMENDATIONS

ZONE 1- REACH 1

The series of beaver dams in Swan Creek do not appear to restrict juvenile fish access at all times and provide overwintering habitat for coho. Removal of any of these dams and/or disruption of the existing habitat is therefore not recommended. Occasional monitoring of the site is recommended however, to ensure that the juveniles can emigrate at smolt age. If spring flood events are insufficient to allow fish past the dams, simple manual adjustments would ensure juveniles the opportunity to move downstream. This would involve removing a small portion of dam material by hand to allow flow over the top of the dams during the smolting window. The timing of this monitoring should coincide with freshet for the region, which generally occurs during the smolt outmigration in May. In addition, a re-evaluation of water levels in Reach 1 during the late winter/early spring is required to determine if channel drying remains a limiting factor for successful overwintering at the site. This problem could potentially be ameliorated by the installation of a drainage and beaver control device as recommended for the beaver dam at the FSR bridge, described below.

ZONE 1- REACH 2

The beaver dam located immediately beneath the FSR bridge may alienate coho from approximately 1.5 ha of beaver pond habitat with abundant LWD cover during low flow years. This habitat is ideal for coho rearing, and particularly for overwintering, having characteristic food producing shoals and deep areas with abundant cover (Lister and Finnegan, 1997). Removal of the dam at the bridge is not recommended, as it functions to maintain the deep habitat upstream, moderate flows and trap nutrients. However, the dam represents a significant threat to the road and bridge, and may restrict critical water movement downstream during low flow periods. Therefore, the installation of fish-friendly and beaver proof drainage control is necessary. It is also of particular importance that the Ministry of Forests is made aware of the fisheries values and recommendations for the site, so that the dam is not inadvertently pulled during routine FSR maintenance.

Several options for the site are provided in Appendix III, however the ultimate solution will be determined following a detailed assessment and consultation with the Ministry of Forests. A controlled reduction in the depth of the pond of approximately 0.5 m is likely necessary to allow a margin of safety for the road and bridge, and modifications to conceptual designs may be necessary to accommodate the bridge. Installation will likely involve a reduction in the current dam height. In order to provide fish access upstream and maintain habitat quality and drainage control, a device similar to the 'beaver deceiver' is recommended (Appendix III). This would allow juvenile fish migration in both directions and prevent flooding of the road

while maintaining an appropriate water level for overwintering both upstream and downstream of the FSR. Fortunately, this dam is located such that machine access from the road is possible, and minimal disturbance is anticipated during installation.

Alternately, if no remedial action is taken at the site due to a lack of funds, this assessment has shown that coho are using the existing habitat upstream of the FSR and will be able to access this area during high water events (ie: the habitat is not entirely isolated to juvenile coho). In addition, the presence of larger predatory fish in the impoundment area is known, and despite access improvements, use of the habitat by coho and subsequent smolt output may depend on not being preyed upon by other fish (Jackson et al., 2001).

ZONE 1 - CHANNEL DIVERSION

The current and proposed drainage patterns from the toe of slope to the mouth of Swan Creek are shown in Figure 2. Water currently collects from two upslope drainage areas and flows in both directions across the FSR three (3) times before entering the Copper River side channel at the mouth of Swan Creek. To reduce the potential for road wash-out and flooding, to prevent ponding on the PNG right of way, and to improve flow to Reach 1 of Swan Creek, it is recommended that the drainage be re-directed along the south side of the road exclusively, crossing the FSR only at the 30 km bridge (Figure 2). This would reduce the flood risk to the road, and allow the existing culverts to function only as overflow outlets during extreme high water events, and provide additional volume to downstream areas during dry periods. The project would involve excavating a channel over approximately 500 m on the south side of the FSR (see Figure 2). A large berm constructed from the excavated channel material would be required adjacent to the FSR to maintain the proposed drainage pattern and protect the road. A detailed assessment of the site is required prior to the excavation.

Changes to habitat associated with the diversion of this channel are expected to result in an overall improvement in fisheries values for coho, and no net loss of habitat in terms of area. The diversion will remove approximately 500 m of poorly defined backwater over the PNG right of way, with little channel complexity and highly compacted substrate and will replace this with approximately 500 m of riffle-pool type habitat, including cover elements, gravel substrate and deep rearing and overwintering areas.

ZONE 2

Currently no recommendations for restoration have resulted from the Zone 2 assessment, although further investigation of Channel 3 may be warranted if funds are available in the future.

RIPARIAN RESTORATION

Detailed riparian restoration treatment options and priorities are provided under separate cover in *Riparian and Off-Channel Assessments for Three Reaches in the Lower Copper River Watershed* (Pollard and Haworth, 2002). A brief overview of recommendations from this report is provided below.

Zone 1

Of the four riparian strata identified in Block 621600, strata A and B have potential for riparian stand treatments. Under the direction of this document, stratum A is proposed for

heavy manipulation, including the development of a new channel (channel diversion). Once the proposed instream works are completed, final riparian prescriptions should be developed to achieve riparian restoration goals and to address any impacts resulting from construction. Riparian targets for stratum A and B include increasing summer shading, small organic debris (SOD) input and surface sediment filtering. The low site gradient, high concentrations of ambient LWD, and old forests upslope suggest that LWD production should not be a priority. Stability is also not a significant issue considering this stratum is isolated from the high water on the Copper River by a distance of some 300 m, the PNG right-of-way and the Copper FSR.

While no instream restoration work is recommended within stratum B, it would be most efficient to wait until the completion of instream works in stratum A and then to complete the riparian restoration for both strata simultaneously.

Zone 2

Strata C and D have no potential for riparian treatments at this time. Stratum C is located on the inside of a bend with evidence of active bank erosion. Colonization of deciduous pioneer species, including willow, red-osier dogwood and alder on this site are decreasing the rate of erosion. Stratum D is the most robust looking stratum in the block with adequate conifer stocking and a relatively healthy overstory of cottonwood that is reducing weevil attack rates.

CONCEPTUAL PRESCRIPTIONS

Prescriptions recommended for the Swan Creek site involve three stages:

- **Phase I (2002):** Detailed Assessment and Plans for Beaver Dam at bridge (Reach 2)
Detailed Assessment of Proposed Diversion Channel (Reach 2)
- **Phase II (2003):** Install Fish Access and Drainage/Beaver Control
Install Diversion Channel
Riparian Reevaluation
- **Phase III (2004):** Annual Monitoring and Maintenance
Routine Effectiveness Evaluations

PHASE I

Phase I will involve conducting a detailed assessment of the dam beneath the bridge, the upstream pond and diversion channel in Reach 2. A re-evaluation of water supply and water levels in Reach 1 during late winter/early spring is also recommended. The assessment should determine the appropriate water level and corresponding dimensions of drainage/beaver control devices for maintaining or enhancing fish habitat values in reaches 1 and 2 and protecting the FSR. The assessment should also determine the appropriate width, gradient, thalweg location and berm height for the proposed diversion channel. Input and/or partial funding from the Ministry of Forests will be solicited at this stage. Following the assessment, detailed drawings and an installation plan can be developed.

The Phase I assessment will likely require 5-8 field days and involve 2-3 persons, including a professional biologist and civil technicians to survey the pond and proposed diversion channel. Design drawings and installation planning will likely require an additional 7 person days. The final designs will be presented to the MWLAP WRP Specialist and Habitat

Protection Officer for approval. Applications for appropriate agency approval (Water Management Branch, Department of Fisheries and Oceans) will be submitted with the final design plans. The approximate cost of Phase I is estimated at \$20,000, with any additional funds from this phase to be redistributed to Phase II.

PHASE II

Phase II is planned for 2003. Although specific details will depend on the outcome of the Phase I assessment, preliminary habitat protection measures to be considered and implemented are as follows.

- All instream work to be conducted during the instream work window, and in compliance with DFO and Water Management requirements.
- Fish salvage to be conducted prior to work in the areas of disturbance
- An environmental monitor / professional biologist to be on site at all times
- Wherever possible, the machine will work from the road location, to minimize riparian and ground disturbance
- Silt fencing to be installed downstream prior to any reduction in dam/pond height
- Dam height reduction to be staged over several hours to control discharge of pond head and minimize downstream disturbance
- Riparian re-evaluation in context of completed restoration.

A preliminary estimate of the cost of Phase II is approximately \$15,000, with any surplus from Phase I to be included in Phase II. Expected benefits to the resource include the long term provision of excellent deep overwintering habitat with cover for coho, which has been shown to result in an increase in smolt production (Cederholm et al., 1998 and Peterson 1982, in Slaney and Zaldokas, 1997).

PHASE III

Routine Effectiveness Evaluations (REE) will be completed on all restoration works completed in the Swan Creek area. The REE will follow the guidelines outlined in Appendix 'B' of Schedule 'A' for Off Channel restoration. The main objectives of the routine evaluations will be to:

- Assess the overall condition of restoration treatments
- Assess the effectiveness of the treatments in achieving restoration objectives
- Determine if remedial work/ maintenance is required
- Implement remedial work/maintenance as required

Although minor adjustments and maintenance will occur after restoration work has been completed, the effectiveness evaluation questions anticipated for instream restoration at Swan Creek are as follows:

- Has fish access to (and from) beaver impoundment areas been established?
- Are the installed drainage devices successful at maintaining overwintering habitat above and below the FSR?
- Have the installed drainage devices installed been successful at protecting the road from flooding?
- Has the new channel successfully diverted water away from the road without flood risk?
- What is the overall condition and performance of the berm and diverted channel?

- Are the target species using the restored habitat?
- Does the relative abundance of target species in the restored habitat appear higher than in the past?

Seasonal sampling by Gee-traps at designated sampling locations will be implemented to determine access and use by target species in winter, and outmigration in spring for 2 years. Annual follow-up monitoring of drainage and beaver control devices is recommended to ensure depth and access, with specific monitoring to occur during/following extreme high water events.

All REE data, results and recommendations will be submitted in the form of an Effectiveness Evaluation Plan (EEP) report which will be updated annually and submitted to the district or regional WRP specialist and/or Habitat Protection Officer for the entire Lower Copper Priority Watershed. The EEP report will include:

- EE objectives using Ministry standards
- Expected restoration success (short or long term)
- REE scheduling, activities and cost estimates
- A summary of site specific successes/failures and required maintenance work from previous REEs
- Recommendations for further remediation, refinement or changes to prescribed works and evaluation plans based on EE results (an 'adaptive management loop' to improve the WRP program).

An allocation of approximately \$3000 per year will be sufficient to conduct routine evaluations, monitoring and maintenance at the site.

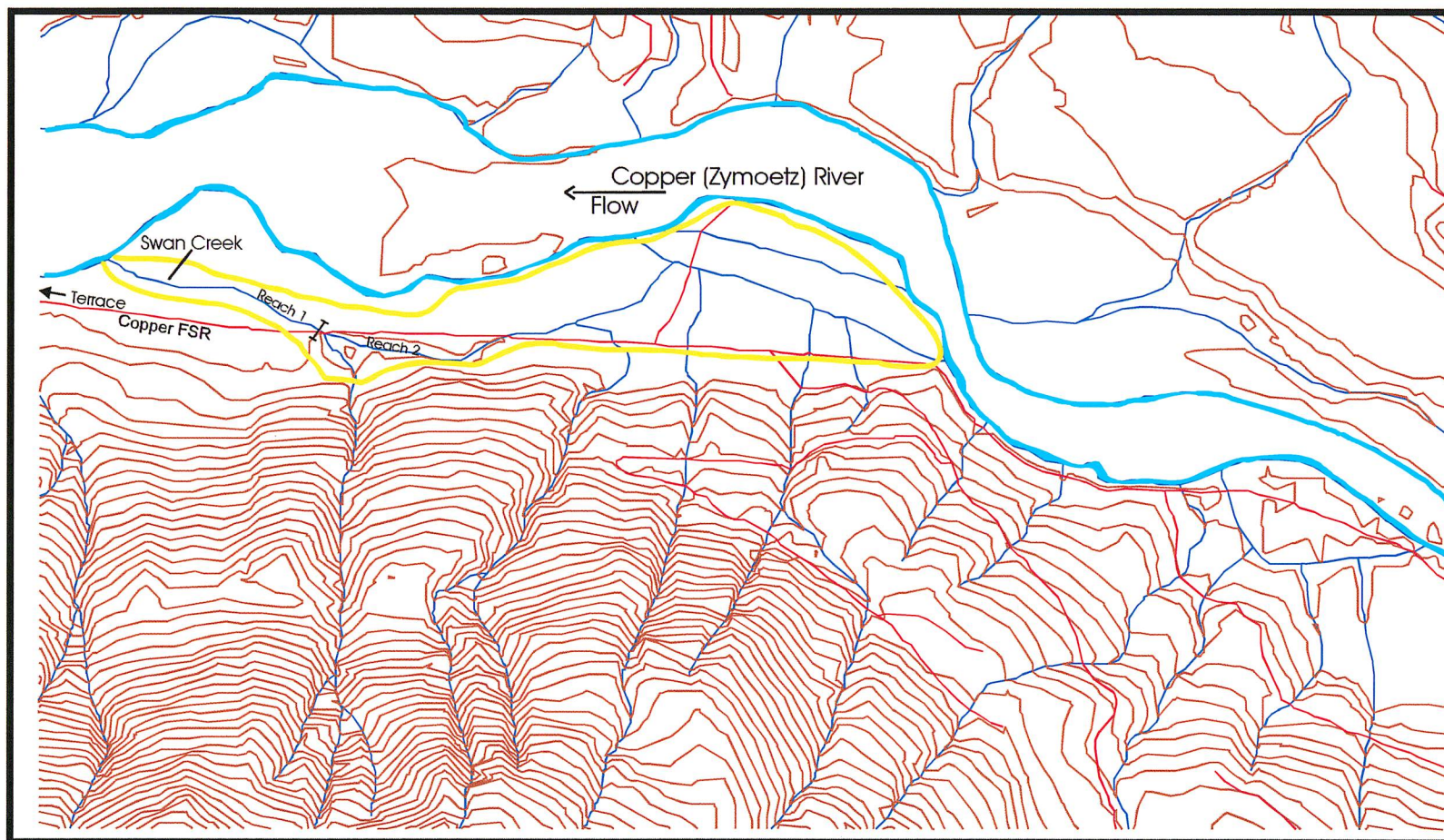
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APPENDICES

Appendix I: 1:20,000 Scale Map



Acer Resource Consulting Ltd.
March, 2002

Swan Creek WRP

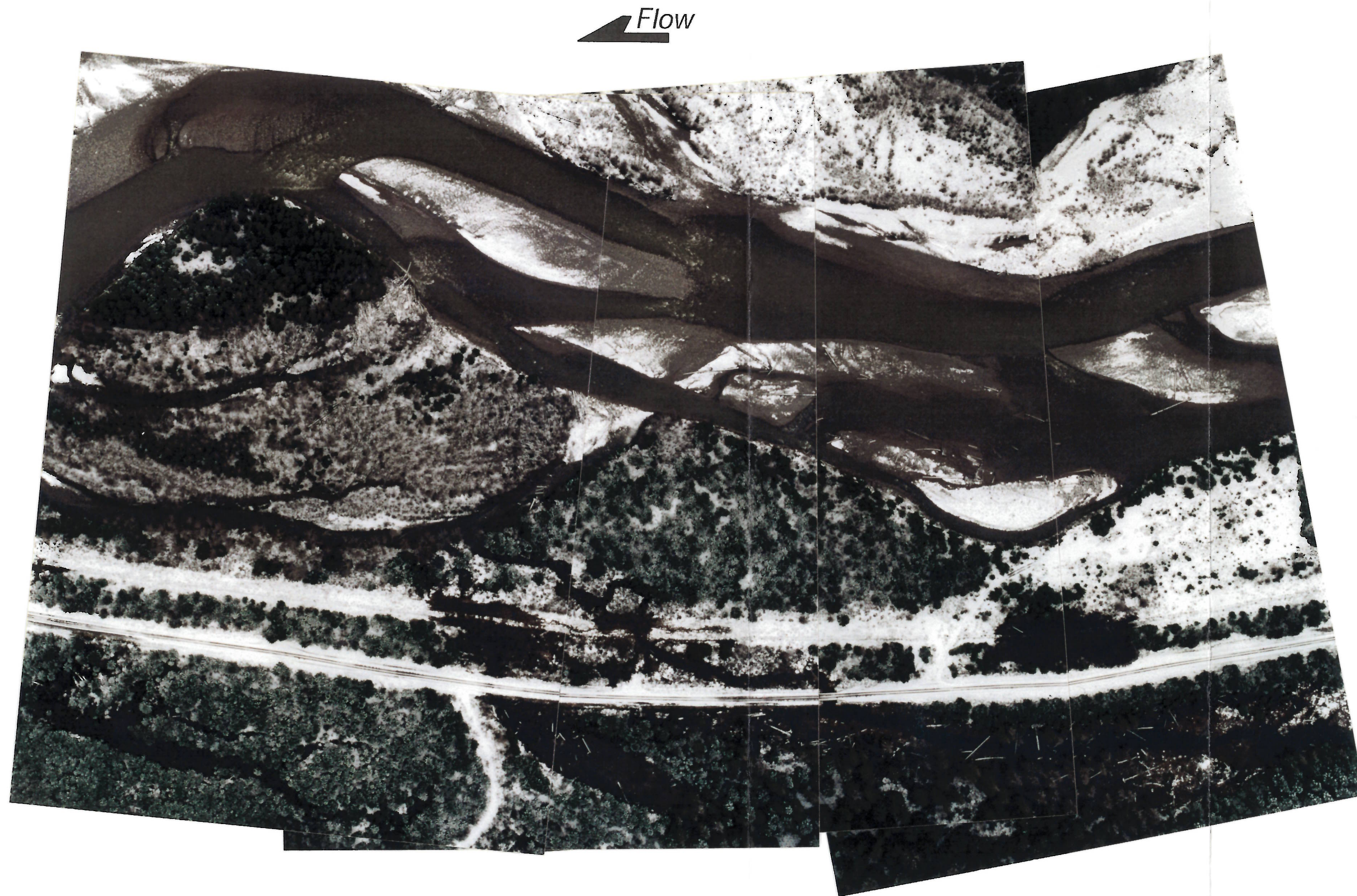
1:20,000 Scale Map
BCGS/TRIM 1031.050

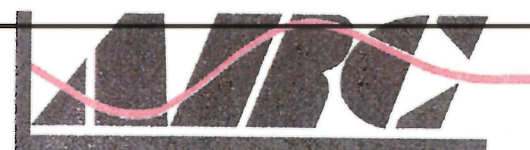
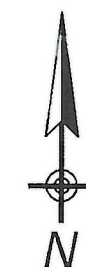
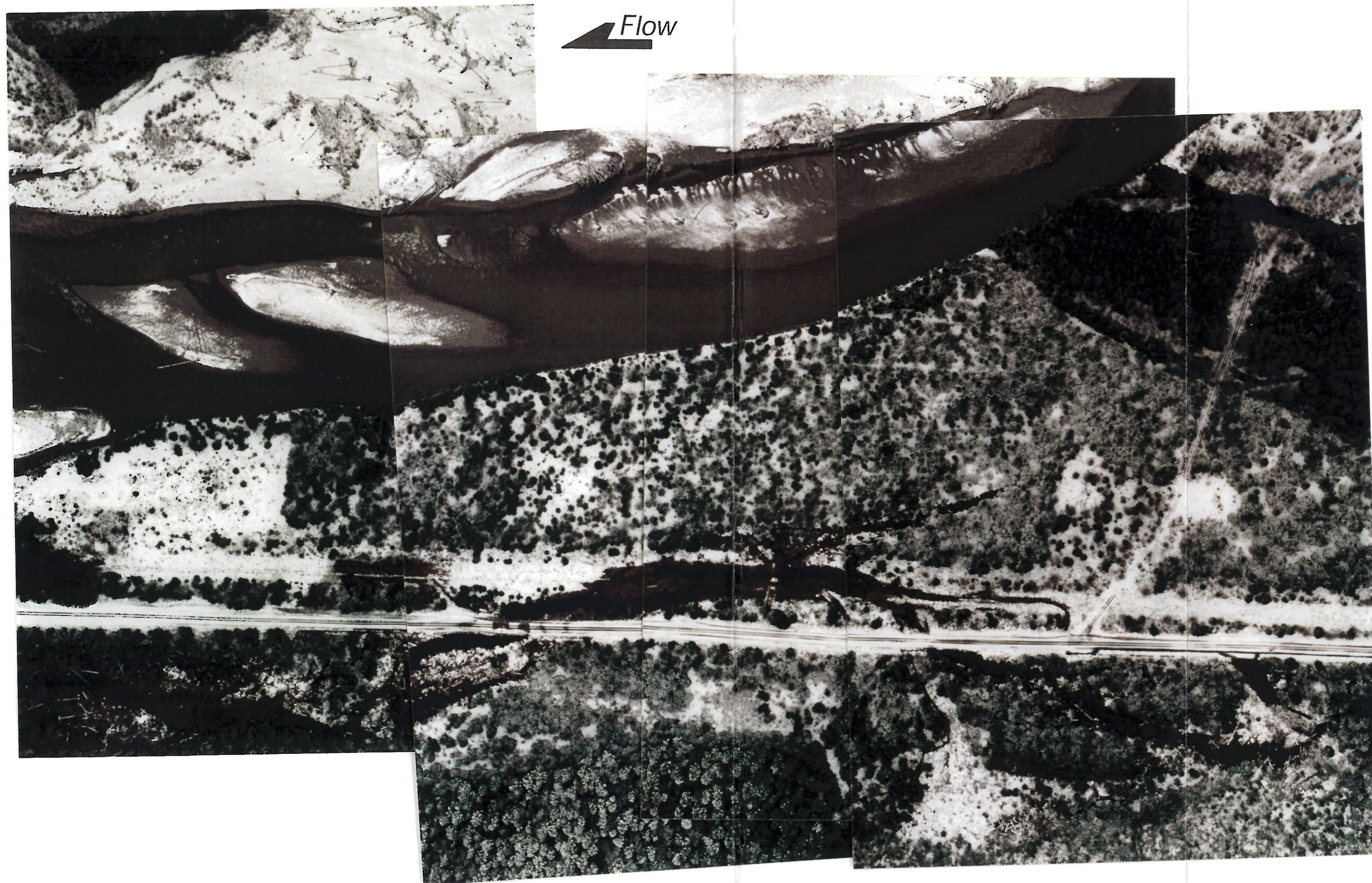
UTM at mouth:
09.557940.6036535

Legend

Roads	
Streams	
Contours (20 m)	
Study Area	
Reach Break	

Appendix II: Air Photo Mosaic





Air Photo Mosaic: Swan Creek, Copper River Watershed (30 - 32 Km).
 Scale Approximately 1:4000
 Date: November 18, 2001

Page 2 of 3



Prepared by Acer Resource Consulting Ltd.

Air Photo Mosaic: Swan Creek, Copper River Watershed (30 - 32 Km).
 Scale Approximately 1:4000
 Date: November 18, 2001

Page 3 of 3

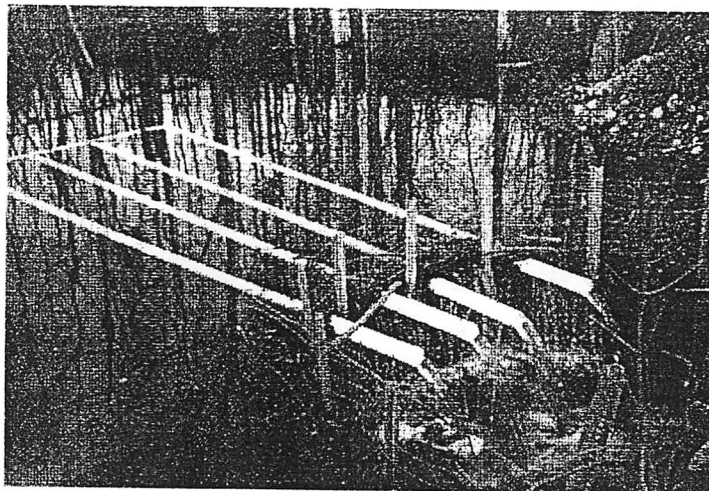
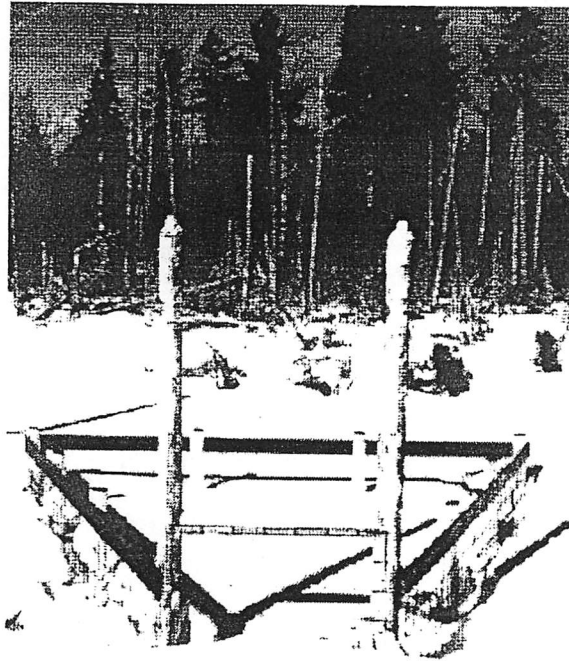
Appendix III: Examples of Conceptual Designs for Beaver Control

1. Description of the Beaver Deceiver

From: www.beaversww.org/solutions.html

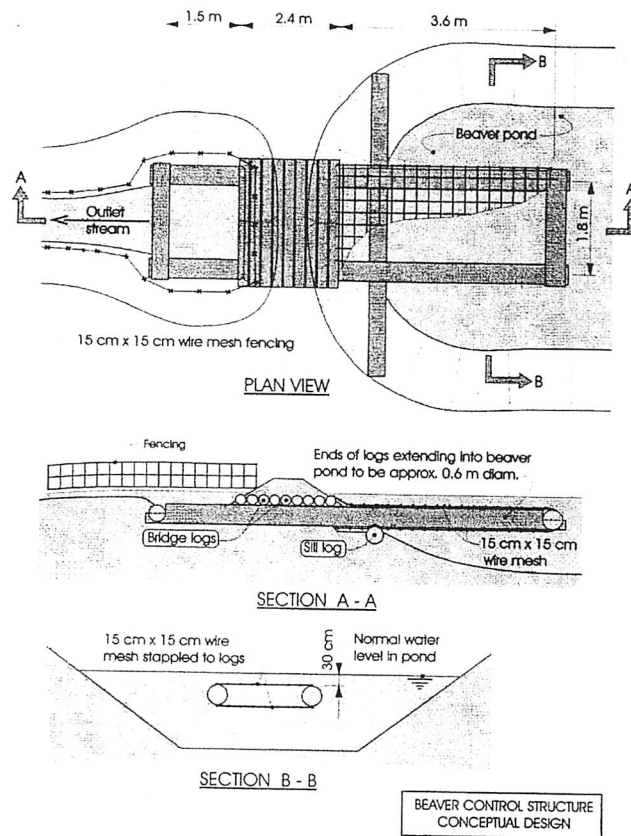
The Beaver Deceiver is a trapazoidal fence that is narrow at the culvert and widens upstream. The one shown is 15 ft x 15 ft x 15 ft. The device is made with cedar posts and 6-guage concrete reinforcing wire with 6 inch squares (this comes in rolls or sheets of 5 ft x 10 ft.).

The outlet is covered with fencing to keep beavers out. To preserve part of the wetland, a dam board is placed at the outlet for the desired water level, braced with posts. Since this also quiets the flow, it reduces the stimulus for damming. Part of the secret to the Deceiver's success is that water flows from the inside of the trapazoid's sides out, and the beaver cannot dam the fence on these sides. The shape and size of the device varies according to the site. At sites with muddy bottoms and active beavers, adding L-shaped pieces of fencing around the base, or a floor, is recommended to deter burrowing.



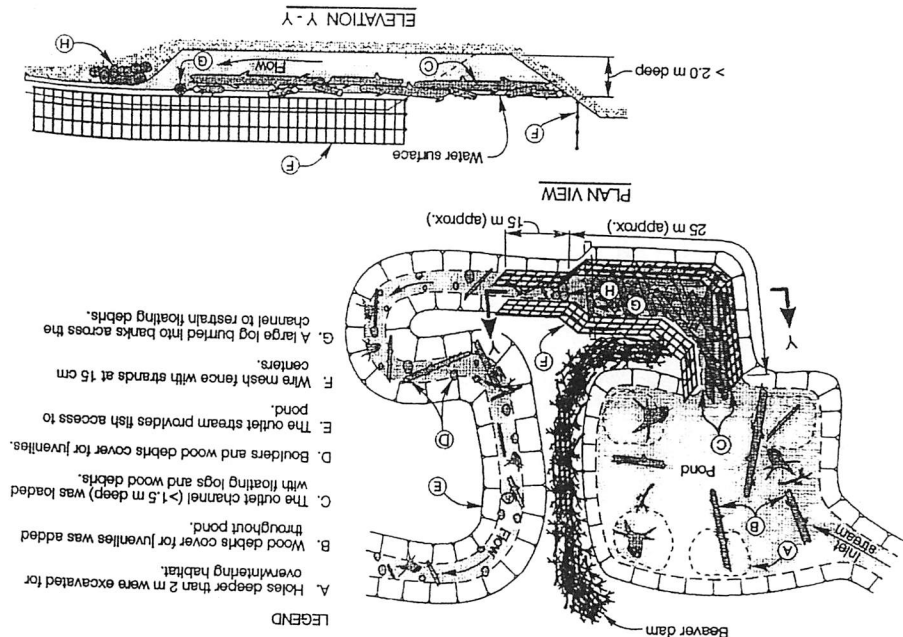
Screening Pond Outlets

From: Finnigan and Slaney, 2002. Baffling Beavers for Fish Access at Off-channel Rehabilitation Projects. Watershed Restoration Technical Bulletin: Streamline, Vol. 6. No 3:18-19.

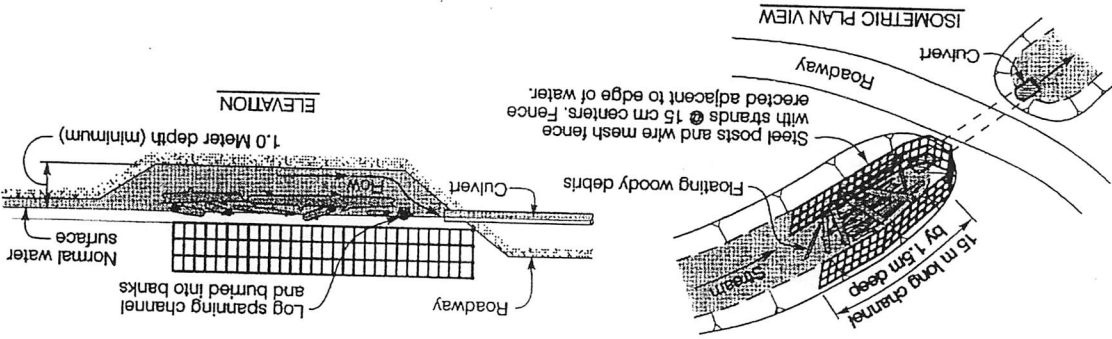


Basic design and construction features:

1. Four logs are arranged as shown on Figure 1 to create a rectangular frame. The end cuts are such that the logs are interlocked and short end logs are positioned on top of the long side logs. This arrangement ensures that the logs do not move inwards on each other and that the structure can be prefabricated and easily lifted into position with an excavator by tying lifting cables onto the long side logs.
2. Rust-resistant wire mesh (with strands 15 cm centres both ways, for adult coho access) is wrapped around and stapled to one end of the frame. A larger opening (20 cm) would be needed if large salmon and steelhead migrate through the pond, but openings as large as 30 cm are unlikely to exclude beavers.
3. A sill log is then positioned at the proper elevation as shown on Figure 1. It is important that the sill log be positioned such that when the structure is in operation, the top of the log frame will be level and approximately 30 cm below the normal operational water surface of the pond.
4. The prefabricated structure is then positioned on top of the sill log such that the end with the wire mesh is cantilevered out into the pond. All wood components need to be submerged to ensure longevity.
5. Smaller logs (or timber decking) are then used to construct a bridge spanning over the structure.
6. The rust-resistant wire mesh is then stapled to the sill log and the bridge members.
7. The entire structure is then backfilled, compacted and contoured to blend in with the surrounding dam and outlet stream.
8. The bed level of the outlet stream immediately downstream of the beaver structure is then contoured to establish the water level in the pond.
9. A rust-resistant wire mesh fence, attached to metal posts, is then erected across the bridge and a short distance downstream to eliminate beaver access to the upper reach of the outlet stream. A horizontal 30 cm mesh apron, secured with rocks, is used to ensure beavers do not excavate a route under the fence.



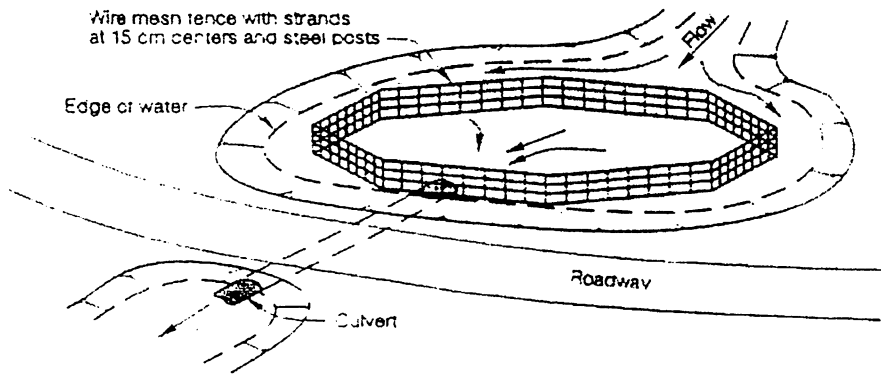
The Telkwa design - the outlet stream provides fish access into the pond
 Wire fence and floating logs restrict beaver access to the outlet
 (Finnigan and Marshall, 1997).



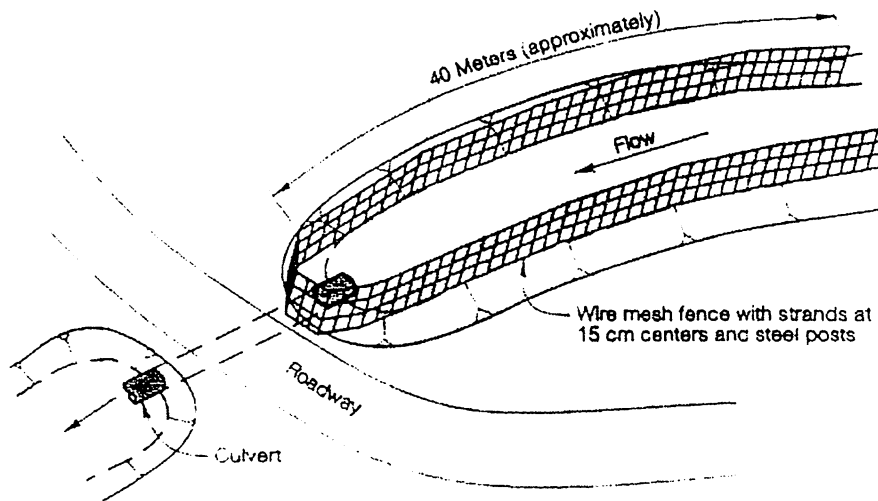
The Telkwa design adapted to a road culvert (Finnigan and Marshall, 1997).

4. Fencing

From: Finnegan, R. J. and D. Marshall, 1997. Managing Beaver Habitat for Salmonids: Working with Beavers. In: Slaney, P. A. and D. Zaldokas, eds. Fish Habitat Rehabilitation Procedures. (Watershed Restoration Technical Circular No. 9) Ministry of Environment, Lands and Parks, Victoria, BC. 1997: Chapter 13.



Example of an 'O' Shaped Fencing Layout (from Finnigan and Marshall, 1997)



Example of a 'U' Shaped Fencing Layout (from Finnigan and Marshall, 1997)

Appendix IV: WRP-FHAP Level I Habitat Assessment Data, Form 4 and Habitat Diagnosis Summary, Form 6.

Level 1 - Habitat Summary Diagnosis Report

Form Number: 16	Forest District: KALUM
	Watershed Name: ZYMOETZ RIVER
	Watershed Code: 440-000000-000000-000000-0000-0000-000-000-000-000-000
Survey Date:	Weather: Overcast, Light Snow
Discharge: (cubic meters per second)	Survey Crew: SB/MM
Subsampling Fractions:	
Riffles	Pools 1 in 1
Glides	Cascades
Other	1 in 1

Detail No	Sub Basin Name	Reach No	Section No	UTM			Distance (m)	Habitat Unit		Length (m)	Grad (%)	Mean Depth		Mean Width		Pools Only			
				Zone	Easting	Northing		Type	Cat			Bankfull (m)	Water (m)	Bankfull (m)	Wetted (m)	Max Depth	Crest (m)	Residual (m)	Pool Type
1	CL5-UT	1	1	9			0	O	1	165	2	2	0.35	6	1.5				
Comments : Dams appear passable at high water																			
2	CL5-UT	1	1	9			165	O	1	55	1.5	1	0.25	6	3.1				
Comments :																			
3	CL5-UT	1	1	9			210	P	1	45	0.5	1.5	0.55	7.5	3.4	0.9	0.25	0.65	D
Comments :																			
4	CL5-UT	1	1	9			255	P	1	55	0.5	1.8	0.75	7	3.2	1.2	0.2	1	D
Comments :																			
5	CL5-UT	1	1	9			310	O	1	20	0.5	2	0.35	8.1	3				
Comments :																			
6	CL5-UT	1	1	9			330	P	1	35	0.5	2.5	0.7	9.8	3.4	1.4	0.2	1.2	D
Comments :																			

NTS Maps (1:50,000) :	103I09	BGGS Maps (1:20,000) :	103I050

Bed Material Type						Total LWD Tally	Functional LWD			Cover				Offchannel Habitat			Disturbance Indicators			Riparian Vegetation			Barriers
Dom.	Sub-Dom.	D90 (mm)	Compaction	SG Type	SG Amt		10 - 20cm	20 - 50cm	>50c	Cover Type 1	%	Cover Type 2	%	Type	Access	Length (m)	1	2	3	Type	Structure	Canopy Closure	
S	G	35	L	AR	L	4	4			OV	65	SWD	35	PD	P					D	SHR	3	BD
S	S	10	L	AR	L	4	4			OV	60	SWD	40	PD	P					D	SHR	3	BD
S	S	5	L		N	3	3			DP	60	SWD	30							D	SHR	3	BD
S	S	5	L		N	4	4			DP	80	SWD	20							D	SHR	2	BD
S	S	10	L		N	4	4			SWD	80	OV	20							D	SHR	2	BD
S	S	5	L		N	6	6			DP	80	SWD	10							D	SHR	2	BD

Level 1 Field Assessment - Habitat Diagnosis Summary Report

Form Number:	1		Watershed Name:	ZYMOETZ RIVER																			
			Watershed Code:	440-000000-00000-00000-0000-0000-000-000-000-000																			
			Forest District:	KALUM																			
			UTM	Zone:	9	Northing:	533579		Easting:	6044243													

Detail No	Sub Basin Name	Reach No	Section No	Percent Pools		Pool Frequency		LWD Pieces		Cover				Substrate			Offchannel Habitat		Spawning Gravel			Spawning Access	
				Value	Rating	Value	Rating	Value	Rating	Wood	Boulder	Overhead	Rating	Dom	Sub	Rating	Value	Rating	Quantity	Quality	Rating	Quality	Rating
1	CL5-UT	1	1	44	F	2.8	F	0.42	P	0	0	28	F	S	S	P	H	G	L	L	P	L	P

Holding Pools per km		Scour		Nutrients		Comments
Qty	Rating	Qty	Rating	Quality	Rating	
9	F	L	G	H	G	Atypical habitat - beaver impoundment area, habitat diagnostics are N/A for spawning, and apply to rearing CO only for the purpose of this assessment

Appendix V: WRP-FHAP Level 1 Fish Distribution Data, Form 5

Level 1 - Fish Distribution Summary Report

Form Number: 1	Watershed Name: Zymoetz RIVER (Swan Creek)	NTS Maps (1:50,000) : 103I09	BGGS Maps (1:20,000) :
	Watershed Code: 440-000000-00000-00000-0000-0000-000-000-000-0		
	Forest District: KALUM		
	Survey Date (YYYY/MM/DD): 1923/01/11		
	Survey Crew: SKB/MM		
	UTM Zone: 9	Northing: 533579	Easting: 6044243

Detail No	Sub Basin	Reach No	Section No	Habitat Type	Survey Method		SK			CH			CM			CO			PK			ST			RB			CT			DV			BT			KO			EB			MW			WC		
					Adults	Juv	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	juv	ad	sp	juv	ad	sp	juv	ad	sp			
1	CL5-UT	1	1	P		MT											K												K	K	U																	
Comments: LIKELY JUVENILE ACCESS ONLY																																																