Watercress Stream Salmonid Habitat Assessment

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For:
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Abstract

Small tributaries are found throughout the Cowichan Valley and are essential components to a healthy watershed. With development and urban encroachment, it has become increasingly necessary to map and collect baseline data on these areas in order to identify sensitive habitats and make knowledgeable land use decisions. A Sensitive Habitat Inventory Mapping (SHIM) project was undertaken in the spring of 2002, by a group of Camosun College students that focused on an unmapped tributary to the Cowichan River. This tributary, known as Watercress Stream, had been identified in earlier reports as potential suitable salmonid rearing habitat. The objectives of the project were to utilize SHIM in the collection of data to be used to create digital maps, assess the salmonid rearing potential, and conduct a presence/absence study of salmonids within the study area. Using the procedures as outlined in SHIM, data was collected on three separate occasions for a total of five days. Upon analysis of the data, it was revealed that most of the habitat parameters associated with rearing were acceptable and in many cases in the optimal range for salmonid rearing success. Coho fry were also found throughout the study area, which suggested a healthy distribution of rearing juveniles. GPS was used to create a spatially accurate map of the stream centerline and surrounding wetland. The report along with the associated data deliverables was sent to Fisheries and Oceans Canada to be incorporated in their database. Although the habitat requirements for rearing were acceptable for most salmonids, it should be noted that Coho were the only rearing species trapped and there may be other limiting factors to certain species, which the data did not capture. It is recommended that the baseline data collected be used in conjunction with further studies to assess the potential of habitat enhancement and/or protection of Watercress Stream.

Table of Contents

List of Appendices

1.0 Introduction

1.1 Project Overview

This report details a salmonid rearing habitat assessment on a tributary to the Cowichan River, utilizing Sensitive Habitat Inventory Mapping (SHIM) methodology. This project was undertaken by Camosun College students Pamela Dinn, Steve Gillanders, Adam Hliva and Michelle Kehler in partnership with the Browat Stewardship Group, Urban Salmon Habitat Program (USHP), Ministry of Water, Land and Air Protection, Fisheries and Oceans Canada and the Camosun College, Environmental Technology Program. Funding for the project was provided by USHP and Camosun College. The project was completed during the spring of 2002 and was the final component for completion of the Environmental Technology Program. Copies of the report were delivered to TimberWest, USHP, the Browat Stewardship Group, the Ministry of Water, Land and Air Protection, and Fisheries and Oceans Canada.

Watercress Stream is one of the estimated 30% of watercourses in the Georgia Basin of British Columbia that are not delineated on provincial or federal topographic maps or represented in databases. Accurately inventoried and mapped watercourses and riparian areas will help improve land use planning processes, and promote knowledgeable decisions regarding fish and wildlife habitat restoration and enhancement. Mapping watercourses and riparian habitat is critical for the protection and management of sensitive freshwater habitats (Mason and Knight, 2002).

SHIM methods were used to map Watercress Stream, as SHIM provides a standardized procedure, ensuring the data collected will be reliable for use by local municipalities. The report and associated GIS data deliverables were sent to Fisheries and Oceans Canada to be incorporated into the SHIM database for use in future land use planning.

1.2 Study Limitations

Time and experience were the primary limitations of this project. As a result only the first kilometer of the stream was mapped and surveyed. The stream extends an undetermined distance beyond the end point of this study.

To maximize the learning opportunities of this project, each of the four-team members used the GPS unit at different times. This led to some inconsistent data entry that was corrected at a later date.

Plant identification took place on May 4^{th}, 5^{th} and 11^{th}, 12^{th}. Difficulties were encountered identifying some plant species, as they were not in flower at this time. For the complete inventory of the study area see Appendix V.

1.3 Study Area Description

The general study area is located in the Cowichan watershed (see Appendix I), approximately 15 kilometres southeast of the town of Lake Cowichan (Figure 1). The Cowichan supports 9 salmonid species including Rainbow Trout *(Oncorhynchus mykiss)*, Cutthroat Trout (*Salmo clarki clarki)*, Brown Trout (*Salmo trutta)*, Steelhead (*Salmo gairdneri)*, Coho Salmon (*Oncorhynchus kisutch)*, Chum Salmon *(Oncorhynchus keta),* Chinook Salmon *(Oncorhynchus tchawytscha)*, Dolly Varden *(Salvelinus malma)* and Kokanee *(Oncorhynchus nerka kennerlyi)*.

The project site straddles properties managed by TimberWest and Skutz Falls Provincial Park, adjacent to the Cowichan River. Access to the project site is by a logging road gate located at Fairservice Mainline and Skutz Falls Road.

Watercress Stream originates in the Cowichan Valley and flows in a southern direction where it meets a side channel of the Cowichan River, known as Alder Channel. The study area includes a portion of the stream from its outlet point where it meets

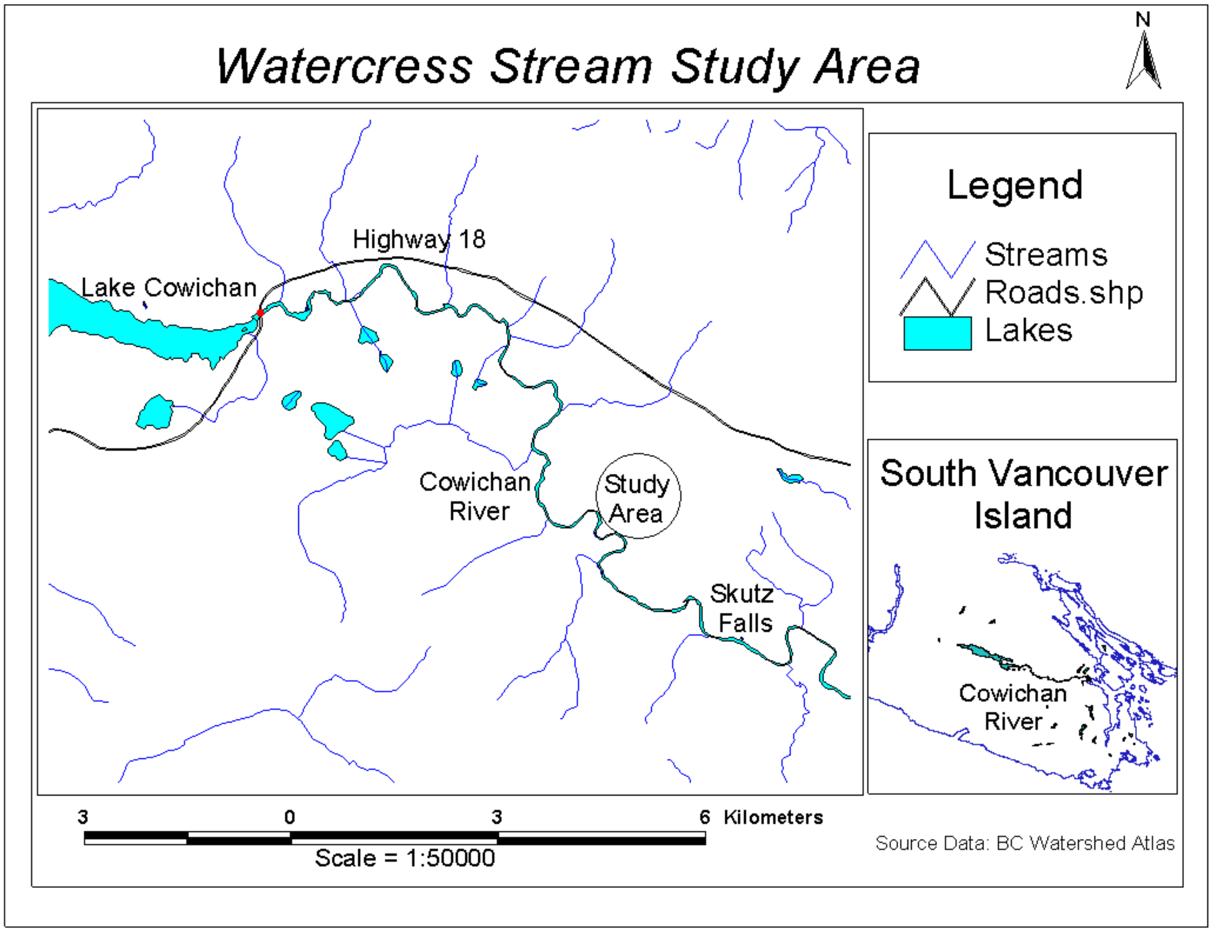


Figure 1. Watercress Stream Study Area

Alder Channel to the upstream end of the wetland known as Upper Watercress Stream (Figure 2). Approximately 400 meters west of Upper Watercress Stream is the abandoned 70.2-mile Canadian National Railway Trestle Bridge. Watercress Stream can be located on TRIM mapsheet numbers 92B.071 and 92B.081 (see Appendix II and III), with its outlet identified from GPS data at UTM Zone 10 - Easting 427,315, Northing 5,405,250.

Previous site disturbances include historic logging and railway service. Little old growth exists in the project area but second growth is well established. Stream slopes and roads in the area are very stable and show no sign of erosion. Human activities presently

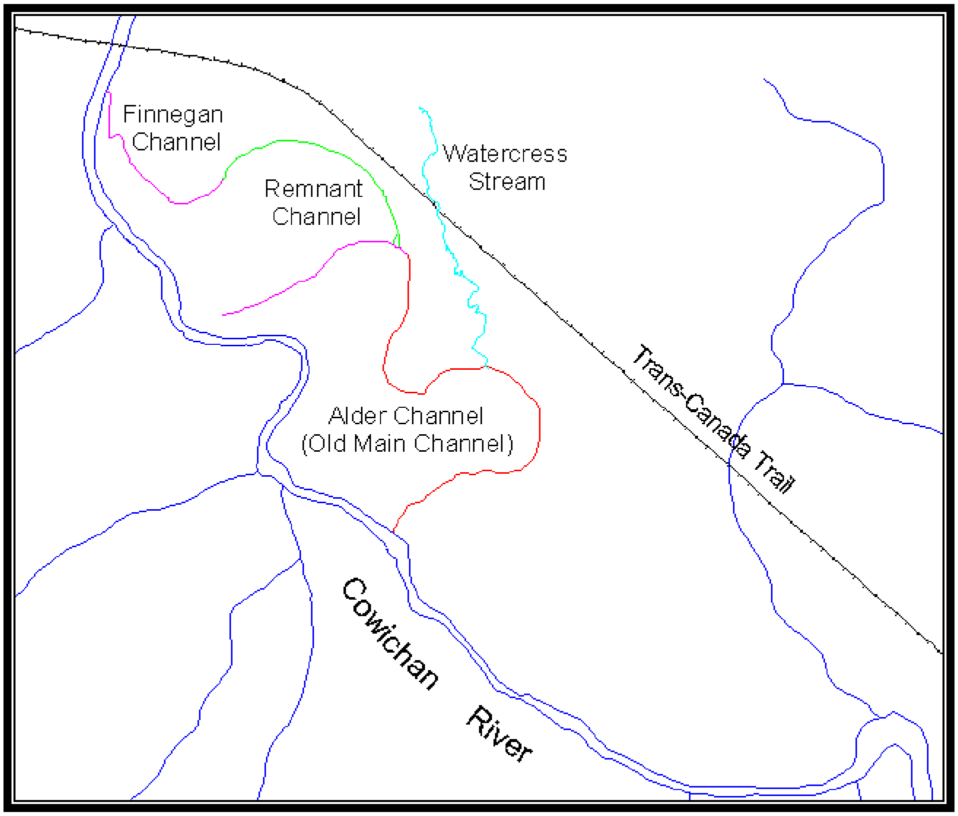


Figure 2. Alder and Finnegan Side Channels

carried out in the area include angling, hunting, camping, cycling and ATV driving. The logging road that borders the southern edge of Watercress Swamp has been proposed to become part of the Trans-Canada Trail.

In January of 1991, several severe flood events resulted in the main flow of the Cowichan River being diverted away from its original course for a distance of two kilometres. As a result of this diversion, the original course was left with extremely low water flow during dry periods. In 1993 construction efforts began to improve the habitat value of the old river channel, with the aim of providing over six kilometres of side channel habitat. An enhancement channel known as Finnegan was constructed to divert water to a remnant channel, providing water to the old main channel 400 metres below the diversion. The remaining 400 metres of the old main channel are wetted by Alder Side Channel, which was excavated within the riverbed of the old main channel to provide further back channel habitat. Alder is fed from an undefined groundwater source (Brown et al., 2000).

1.4 Need for Project

The Cowichan River has long played an important role to the first nations that lived in the area. An abundance of salmon and trout provided a reliable food source and made this an ideal place to live. Early settlers also recognized the river's recreational and economic potential and quickly began to establish communities in the surrounding area. Different industries began to take root and develop in the region, including the commercial and recreational fishing industries in the late 1800's. The Cowichan is recognized as an outstanding trout and salmon river, and has attracted anglers from around the world since the early 1900's (The Cowichan River, 2002).

Salmon populations of the different fish species remained relatively healthy and stable until the early 1950's when some of these species stock's experienced major declines, in particular Coho and Chinook salmon (Brown et al., 2000). This decline in numbers was due largely to over fishing by the commercial fishing industry and loss of suitable habitat due to logging in the area (The Cowichan River, 2002).

More recently, salmonid habitat in the Cowichan watershed has been adversely affected by a population increase of 26% (18,724 persons) in the ten years from 1986-1996. The development associated with such growth has affected and will continue to have impacts on salmonid habitat in the Cowichan River and its tributaries (Cowichan Watershed Council, 1996).

The Browat stewardship group, made up of former Camosun College Environmental Technology students, has been conducting studies on the two artificial channels since 1999. In 2000, it was determined that the Alder Side Channel was not suitable habitat for summer rearing of salmonids. This was due to high summer temperatures, algae growth and standing water created by backflow from a beaver dam. It was also determined that

Finnegan Side Channel becomes dry during low summer flows in the main channel, limiting its use as summer rearing habitat (Brown et al, 2000). It was recommended that a habitat survey be done on Watercress Stream, which appeared to be suitable salmonid rearing habitat. Watercress Stream maintains cool water temperatures during the summer months and is believed to be partly groundwater fed.

1.5 Literature Review

The literature review revealed insufficient data to indicate whether Watercress Stream provides suitable salmonid rearing habitat. Two previous Environment 208 projects have been conducted within the general area (Abrahamson et al., 1999; Brown et al., 2000). The two studies focused on the Alder and Finnegan side channels. Neither study included the specific area known as Watercress Stream. However, it was concluded by Brown et al., 2000 that due to the lack of suitable rearing habitat in the two channels adjacent to the main river, and the confirmed presence of salmon within Watercress Stream, further study was recommended.

1.6 Overview of SHIM

SHIM was initiated through the Fish Habitat Inventory and Information Program (FHIIP) in a joint effort between Fisheries and Oceans Canada and the Ministry of Water, Land and Air Protection along with many municipalities and non-government organizations. Development of SHIM is ongoing, and over 30 separate community SHIM based mapping projects have been completed throughout the Georgia Basin and Vancouver Island in the past five years (Mason and Knight, 2002).

SHIM is intended to provide standardized methods for fish and aquatic habitat mapping in urban and rural watersheds in British Columbia. The goal is to ensure the collection and mapping of high quality, current and spatially accurate information. The SHIM manual consists of a series of modules describing methods to inventory, map and compile data for BC urban and rural watercourses. The data collected is intended to supplement and enhance local land use planning maps (Mason and Knight, 2002).

As a standardized mapping method, SHIM aims to: improve information about watercourses, assist managers and communities in resource inventory and land use planning, improve the confidence of government agencies in the quality of information that non-government organizations collect, and improve the health of BC's salmonid stocks and habitats (Mason and Knight, 2002).

1.7 Salmon Rearing Habitat Requirements

Of the nine documented salmonids present in the Cowichan River, life histories vary with species. Rearing of young juveniles ranges from one month to three years in anadromous salmon and trout.

Salmonid rearing ground is defined as habitat required by newly emerged salmonid fry. This rearing habitat is comprised of many abiotic and biotic factors some of which include:

- Temperature
- Dissolved Oxygen
- Depth
- Stream Gradient
- Pool Frequency
- Substrate Size
- Riparian Vegetation
- Instream Cover

Water temperature influences the metabolism, behavior, and mortality of fish and other organisms in the environment (Bjornn and Reiser, 1991). Water temperature provides a measure of fish habitat quality and reflects riparian shading influences, the stream's response to disturbance, and spring or seep locations (Mason and Knight, 2002).

Salmonids prefer a water temperature range of 12 – 14^{o}C, and for most species water above 24^{o}C is lethal (Busch, 2000).

Most streams have sufficient dissolved oxygen to support salmonids, although concentrations in some streams may be reduced significantly as a result of large amounts of organic debris present (Bjornn and Reiser, 1991). A dissolved oxygen concentration of 6 to 10 mg/L is normally required, with less than 5 mg/L considered lethal (Busch, 2000).

Pool frequency is important and is determined by the average number of pools per specified distance. Good quality rearing habitat is defined as having a pool frequency of less than two channel widths per pool (Johnston and Slaney, 1996). For example, if a stream was five metres wide, a good pool frequency would require a pool every 10 metres.

The depth of water juvenile salmonids use depends on what is available, the amount and type of cover present, and the perceived threat from predators and competitors. It is generally accepted that newly emerged fry and juveniles prefer waters depths of 25-60 centimetres (Bjornn and Reiser, 1991).

Stream gradient can help to identify the potential extent of fish distribution, as an extremely steep gradient can be a barrier to fish movement. Stream gradient also determines the frequency of pools and their relative size. The preferred gradient of salmonids varies with species. Coho prefer a gradient of less than 1.4^{o} (3%), while Cutthroat and Chum easily tolerate much steeper gradients (Reeves et al, 1989).

Salmonids prefer streams with substrates composed of gravel (2-64 millimetre diameter) and cobble (64 – 256 millimetre diameter) (Mason and Knight, 2002). This allows for interstitial space, which creates an area for juveniles to hide out (Johnston and Slaney, 1996).

Riparian vegetation is important to juvenile salmonid survival. Its presence or absence affects the temperature and dissolved oxygen in the water, and it is the primary food source for many aquatic invertebrates, a major food source for juvenile salmonids (Bjornn and Reiser, 1991). Riparian vegetation also provides cover, protecting juvenile salmonids from predators. It is generally accepted that an abundance and diverse amount of riparian vegetation signifies a suitable rearing habitat for juvenile salmonids.

There are many different types of instream cover that are important to juvenile salmonids including instream vegetation, small and large woody debris, boulder cover and cutbanks (Johnston and Slaney, 1996). Good quality rearing habitat possesses a variety of these characteristic types. Instream cover provides refuge from predation, a velocity barrier and favourable environments for benthic invertebrates a common food for salmonids.

2.0 Project Objectives

- Conduct a detailed stream assessment following the procedures outlined in the SHIM manual
- Delineate the stream centreline and the wetland perimeter using a GPS
- Determine fish presence/absence and species type
- Photodocument the site and site features
- Use GPS coordinate data and associated attributes to create spatially accurate GIS data
- Use SHIM data to assess suitability of salmonid rearing habitat
- Provide baseline data for the SHIM database, future planning decisions and further studies

3.0 Hypothesis

Watercress Stream is suitable salmonid rearing habitat.

4.0 Methodology

4.1 Research

Existing information relevant to the study area was acquired and reviewed. Sources of information investigated include published documents and interviews with fisheries professionals and agencies including FOC, MWLAP, CVRD, TimberWest, and the Browat Stewardship Group. Previous Camosun College ENVR 208 reports were reviewed to provide background information and detailed accounts of work conducted in the general area.

In addition to reports and interviews, maps, air photos and orthophotos of the study area were acquired for photo interpretation and general background information. These included TRIM Map sheet No. 92B.071 (see Appendix II), aerial photograph 30BCC98034 NO. 059 (see Appendix IV), and orthophoto No. 92B.071 and 92B.081.

4.2 GPS Data Collection

Differential GPS data were collected with a Trimble Pro XR GPS receiver. The GPS receiver was configured according to the SHIM protocols to collect data with real time correction.

Both position and attribute data were captured simultaneously via the SHIM data dictionary, which provides a structure for the data entry procedure outlining the parameters required for the survey.

During the first and second survey phases (May 4th, 5th, and 11th, 12th), position and attribute data were collected with the GPS. Upon reviewing the data following the second survey phase, it was concluded that additional data were required related to the physical characteristics of the stream. Two of the crewmembers visited the study area on

June 2 and collected and recorded additional attribute data. This data was later entered into the appropriate GIS attribute tables.

4.3 Watercourse Centerline, Stream Segment & Habitat Feature Mapping

Watercourse Centerline

The stream centerline and individual stream segments were collected as a line feature using the GPS. Specific habitat features were recorded as individual point features within these lines. The centre of the stream was defined as the thalweg at the time of the survey.

Stream Segment

Prior to data collection the study area of Watercress Stream was divided into two reaches, based on major habitat change. The stream centreline was further subdivided into individual segments based on similar habitat characteristics such as vegetative cover, hydrology, substrate and channel dimensions. Within each segment numerous observations and measurements were made to determine its unique habitat characteristics. These included: primary stream class, secondary stream class, dominant hydraulic type, crown closure, segment gradient, substrate composition, substrate compaction, channel dimensions, riparian class, riparian band width, bank slope, riparian structural stage, presence of snags, density of shrubs, bank stability, and dominant bank material.

Habitat Feature Mapping

Distinctive features found within the stream were mapped as point features, and their locations and associated attributes recorded using the GPS. Attributes included features such as culverts, bridges, fishways, and side channels. A range of required information including the type, code and dimensions were recorded for each feature.

4.4 Riparian Area Classification

The SHIM riparian classification is based on the land cover standards adopted by British Columbia Terrain Ecosystem Mapping.

Field Sampling of Land Cover

Representative sites were chosen in each reach to perform a riparian cross-section. A 50 metre transect was measured on either side of the stream beginning at the edge of the floodplain. Land cover was classified by surveying approximately 15 metres on either side of the 50 metre transect. The position of the boundaries for land cover polygons along the transect were recorded by distance and bearing, and the land cover type was recorded using the SHIM riparian classification system.

To add to the description of land cover, a list of major types of vegetation present was collected (see Appendix V), and wildlife species observed was recorded (see Appendix VI).

Delineating Land Cover Polygons

Polygons of riparian vegetation were digitized and added to the map using the digital orthophotos and data collected in the field as a base. All land cover polygons were delineated at a scale of 1:5000.

4.5 Fish Sampling

The objectives of fish sampling were to determine fish species presence, basic population characteristics such as fork length, fish distribution, and potential obstructions to movement.

A review of existing fisheries information for the project area was undertaken. Fish collection permits were obtained from the Ministry of Water, Land and Air Protection.

Minnow traps were set in six representative pool locations and baited with salmon roe. Sites were chosen based on habitat characteristics and were set above and below each of the two culverts in the study area to evaluate the potential for fish barriers and obstructions. The traps were set for between 15 and 17 hours during overnight periods. Data sheets were used to record pertinent information for each trap (see Appendix VII).

4.6 Water Quality

Water quality parameters measured were dissolved oxygen, conductivity and temperature. Representative sites chosen for sampling coincided with the sites chosen for fish sampling. These locations were recorded as point features using the GPS, allowing for future measurements and monitoring in the same location. Water quality was measured at mid-morning, in the middle of the channel at mid-depth, using a YSI 85 multimeter.

4.7 Photodocumentation

Digital photographs taken within the study area include: start and end points, wildlife features, wildlife trees, riparian vegetation, fish habitat features and representative fish sampled (see Appendix VIII).

4.8 Data Processing

Marc Porter, of Fisheries and Oceans Canada, provided a copy of Trimble Pathfinder Office 2.80 software for the duration of the project. This software was used to transfer data from the GPS receiver to a computer and to convert the GPS rover files to Shapefile format useable in ArcView GIS. Data corrections were carried out with the use of SHIM ArcView extensions.

5.0 Quality Control and Quality Assurance

The following guidelines were followed to ensure the highest level of quality control possible.

- Background research and information collected was from credible, reliable sources
- Checklists were carried to ensure all necessary equipment was taken to field studies
- Ensured equipment was calibrated and in good operating condition
- Visual estimates were determined independently by at least two individuals (i.e. percent cover estimation)
- Measurements were repeated when needed in accordance with guidelines or instructions
- Habitat characteristics were defined accurately and consistently
- Results were carefully observed for discrepancies in data
- Fieldwork was conducted in an ethical and environmentally friendly manner

6.0 Results

6.1 Watercress Stream Attribute Results

A 1066.6 metre section of Watercress Stream was measured, and eight distinct segments were classified according to physical stream characteristics, percent cover, and stream bank characteristics. For detailed data see Appendix IX.

Watercress Stream was classified as natural, with a general secondary stream classification of wetland and braided channel. The dominant hydraulic types were pool, riffle, and wetland. The substrate compaction was generally medium and bars were present throughout reach 2. Potential spawning habitat was identified within half of the total segments surveyed. Other stream characteristics are summarized in Table 1.

Table 1. Summary of Physical Stream Characteristics

Characteristic	Mean	Range	Standard Deviation
Gradient (degrees)	1	0 – 3	n/a
Crown Closure %	30	1-20 to 42-70	n/a
Substrate %			
Organic	22	5 – 30	n/a
Fines (<2mm)	46	5 – 70	n/a
Gravel (2-64mm)	24	10 – 50	n/a
Cobble (64-256mm)	6	5 – 45	n/a
Boulder (256-4,000mm)	2	0 – 15	n/a
Bedrock	0	0	n/a
Width (m)			
Wetted	4.21	1.90 – 7.30	1.92
Bankfull	8.36	3.30 – 14.50	4.39
Depth (m)			
Wetted	0.44	0.10 – 0.90	0.28
Bankfull	0.67	0.25 – 1.19	0.35

Note: n=8

The mean total percent cover for the area surveyed was 71%. The following table divides the 71% total percent cover into its individual components that total to 100%. This data is summarized in Table 2, for complete detailed information see Appendix IX.

Table 2. Summary of Percent Cover

Characteristic	Mean	Range	Standard Deviation
Total cover %	71	60 – 90	n/a
Boulder	18	0 – 15	n/a
Pool	17	3 – 50	n/a
Instream vegetation	47	10 – 75	n/a
Large woody debris	10	1 – 15	n/a
Overstream vegetation	16	5 – 40	n/a

Small woody debris	5	2 – 7	n/a
Undercut banks	4	0 – 5	n/a
Large woody debris count/segment	45	11 – 130	35.36
Deep pool count/segment	4	1 - 14	4.03

Note: n=8

Riparian characteristics of the left and right stream banks in each segment were recorded. The left bank was generally classified as mixed forest and qualified as natural with the stage being mature forest. The left bandwidths ranged from 50 to 115 metres, and bankslopes ranged from 1^{o} to 19^{o}. The percentage of shrubs varied throughout the stream, mainly being within 5-33%. Snags were recorded in segments closest to the start and end points of the surveyed area and totaled less than five near the start point and greater than five near the end point. There were no veteran trees in the surrounding area. The left bank was composed of fines for the entire length of the stream, and was generally highly stable.

The right bank was classified as natural in reach 1, with the exception of the gravel logging road that divides the two reaches, and as mixed forest throughout reach 2. The growth stage of the riparian vegetation was classified as low shrubs and tall shrubs in reach 1 and mature forest in reach 2. The right bandwidth ranged from 10 to 170 metres, and bankslopes ranged from 0^{o} to 14^{o}. The percentage of shrubs varied greatly from less than 5% to 67-100%. Snags were recorded in only two segments and tallied less than five in each segment. There were no veteran trees recorded. The right bank was generally highly stable and was composed mainly of fines.

6.2 Cross-Sections

Cross-sections were carried out in five representative sites throughout the study area measuring widths, depths and defining riparian characteristics. Characteristics of riparian vegetation on the left and right sides of the bank were collected in distinct bands that extended 50 metres from the floodplain end. Band widths ranged from 5 to 30 metres, and classifications included broadleaf forest, coniferous forest, mixed forest and shrubs, with the exception of the gravel road passing through the first segment of reach. For complete cross-section data see Appendix X.

Figure 3. Cross Section; Reach 1, Segment 2

6.3 Fish Sampling

Of the six minnow traps set, a total of 35 fish were sampled, of which 34 were released. The following table summarizes the results. For complete fish sampling data see Appendix XI.

Figure 4. Fish Sampling; Reach 2, Segment 5

Table 4. Summary of Fish Collection Data

Species	**No. Fish Sampled**	**No. Fish released**	**Mean**	**Fork Length range (cm)**	**Standard Deviation**
Threespine Stickleback (*Gasterosteus aculeatus)*	6	6	5.5	5.1 - 5.9	0.24
Cutthroat Trout (*Oncorhynchus clarkii)*	4	4	7.7	6.7 - 9.9	2.20
Coho (*Oncorhynchus kisutch)*	25	24	8.89	4.0 - 12.2	2.41
Total	35	34	8.18	4.0 - 12.2	2.51

6.4 Pool Measurements

Seven representative pools were identified as potential fish habitat, measurements were taken and the results are summarized in Table 5. For complete details see Appendix XII.

Figure 5. Representative Pool, Reach 2, Segment 4

Table 5. Summary of Representative Pool Habitat

Characteristic	Mean	Range	Standard Deviation
Length (m)	9.07	4.50 – 14.10	3.72
Width (m)	8.01	3.10 – 14.90	4.60
Depth (m)	0.43	0.25 – 0.90	0.22

Note: n=7

6.5 Water Quality

Dissolved oxygen, conductivity and water temperature were measured at six representative sites, with results summarized in Table 6. For complete details see Appendix XIII.

Table 6. Summary of Water Quality Results

Characteristics	Mean	Range	Standard Deviation
Conductivity (μS)	42.6	36.0 – 60.0	7.98
D.O. (mg/L)	8.4	7.4 – 9.0	0.53
Temp (^{o}C)	7.7	7.2 – 8.1	0.41

7.0 Discussion

7.1 Salmonid Rearing Habitat

To assess salmonid rearing habitat, a number of elements of the SHIM survey were analyzed independently. These elements included water temperature, dissolved oxygen, water depth, stream gradient, pool frequency, substrate size, riparian vegetation, and instream cover.

Water temperature values range from 7.2°C to 8.2°C, with a mean temperature of 7.7°C. These values are well within the range of the upper and lower lethal temperature thresholds of salmonid species. Upper and lower lethal temperature thresholds are species dependent, but range from 0°C to 24°C (Bjornn and Reiser, 1991). The mean water temperature of 7.7°C is considered below the preferred temperature range of 12°C to 14°C for salmonids, however this cooler water temperature value approaches the maximum food conversion efficiency and corresponds to a potentially higher dissolved oxygen content (Bjornn and Reiser, 1991).

Dissolved oxygen values within the study area range from 7.4 mg/L to 9.0 mg/L with a mean concentration of 8.4 mg/L. A dissolved oxygen content of 6.0 mg/L to 10 mg/L is the optimal range for salmonids with less than 5 mg/L considered potentially lethal. Salmonids may be able to survive at less than 5 mg/L, but overall food conversion efficiency, swimming performance, and general salmonid development is adversely affected (Bjornn and Reiser, 1991). The mean value of 8.4 mg/L is situated well within the optimal range for salmonid requirements.

Wetted water depth values range from 0.10 to 0.90 metres with a mean depth of 0.44 metres. Newly emerged fry usually prefer a water depth of 0.25 to 0.60 metres, but depending on the amounts and type of cover present, the potential threat of predators and competitors, and habitat availability, fry will often be found above or below this optimum range (Bjornn and Reiser, 1991). The standard deviation of the wetted depth is 0.28, indicating that 67% of the depth values lie between 0.61 metres and 0.72 metres.

Stream gradient values within the study area range from 0^o to 3^o, with a mean of 1^o. Stream gradient determines the extent of fish distribution and the abundance of pool habitat. A low gradient such as 1^o is generally associated with a high frequency of pool habitat and a lower water velocity that will support juvenile salmonids. Where average gradient is greater than 1.4^o, habitat is usually not preferred by Coho Salmon, although other species tolerate steeper gradients (Reeves, et al., 1989).

Figure 6. Gradient 0^o, Reach 2, Segment 1

Throughout the study area, there is an average of one pool for every 35 meters of stream. Mean bankfull channel width is 8.3 metres. Pool habitat frequency within the study area is 4.2 bankfull channel widths per pool, which is considered in the poor quality range for salmon rearing habitat requirements (Johnston and Slaney, 1996).

Based on the data collected, a mean value of 24% of the study area consists of gravels and a mean value of 6% consists of cobbles. 68% of the study area is composed of fines and organics, which indicate less than optimum rearing conditions (Johnston and Slaney, 1996).

Riparian vegetation within the study area consists of an abundance of different plant species indicative of wetland, coniferous forest, and broadleaf forest habitats. Riparian vegetation is critical in that it affects water temperature and dissolved oxygen and provides a primary food source for many invertebrates that are in turn the primary food source for juvenile salmonids (Bjornn and Reiser, 1991). When present, riparian vegetation also provides ample cover for juvenile salmonids.

Figure 7. Instream Cover, Reach 2, Segment 3

The total instream cover for the study area is 71% comprised of 18% boulders, 17% pools, 5% small woody debris, 10% large woody debris, 47% instream vegetation, and 4% undercut banks. This is significant in that there is an abundance and diverse amount of cover available for juveniles during rearing. Cover provides shade, areas of rest, protection from predators, and acts as a velocity barrier. Fish abundance in streams has been associated with the abundance and quality of cover (Bjornn and Reiser, 1991).

7.2 Fish Sampling

Figure 8. Fish Sampling, Coho Juvenile

In total, 35 specimens were trapped. Of these specimens, 25 were Coho, 4 were Cutthroat, and 6 were Stickleback. According to their life histories, Cutthroat Trout and Threespine Stickleback are most likely resident species of the Cowichan freshwater drainage system. Finding Coho was important for the project in that it demonstrated that Watercress Stream did in fact support rearing salmonids. Coho fork length ranges from 4.0 to 12.2 centimetres, which suggests the possibility of two age classes. Coho were found in each of the six traps, indicating distribution throughout the study area. Possible obstructions include two culverts which may be barriers to migration during low flows.

7.3 SHIM Assessment

The SHIM assessment was useful in providing accurate GPS data for use in GIS applications and providing measurements required to assess salmonid rearing habitat suitability. Throughout the GPS data collection, the number of satellites and horizontal dilution of precision were well within the range outlined in the SHIM protocols. Five-metre accuracy is believed to have been achieved.

7.4 GIS Data Processing

The raw GPS data was converted to shapefile format useable in a GIS application by Trimble Pathfinder Office 2.8 software. Some of these shapefiles in their original format included outliers and GPS "noise" associated with data collection under canopy. These files required editing and processing to be considered useful as an accurate representation of the study area.

The SHIM data dictionary extension was used to smooth the stream centreline, merge attribute tables, associate points with the stream centreline, and to create riparian band polygons. This ArcView extension proved to be a very valuable tool for data processing.

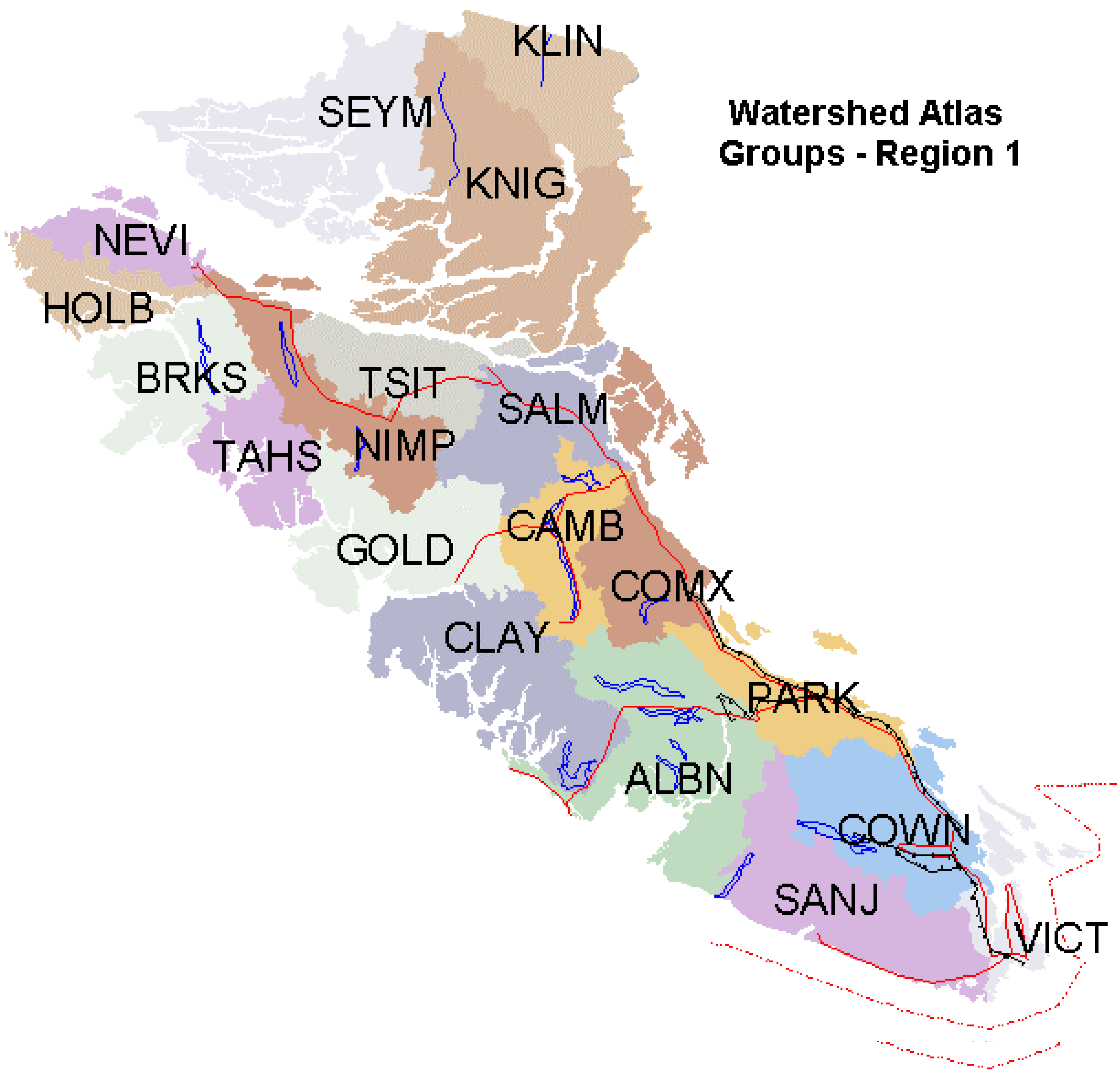
8.0 Conclusions and Recommendations

Upon analysis of the salmonid rearing habitat requirements with respect to the collected data for the study area, it was concluded that the Watercress Stream is suitable salmonid rearing habitat. Pool frequency and substrate type was found to be of substandard requirement. However parameters such as water temperature, dissolved oxygen, water depth, stream gradient, and highly diverse riparian vegetation and cover were found to be in the high quality range for salmonid rearing habitat. Good cover and cool, spring fed water compensate for the lack of pools. Coho get most of their food from overhanging vegetation, and require substrate for cover only in the winter, making the abundance of fines of less importance for this species. The suitability of the habitat was also supported by the presence of rearing juvenile Coho salmonids within the Watercress Stream.

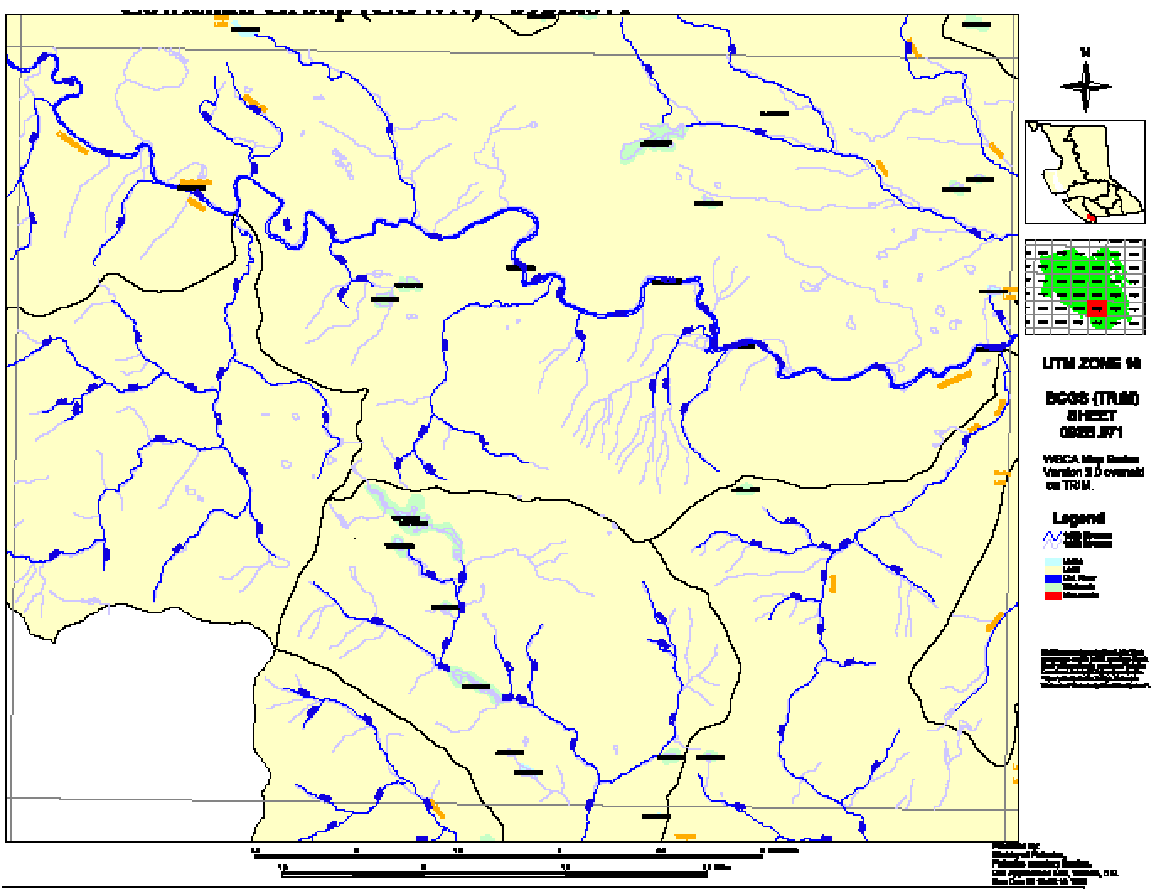
The SHIM survey provided the appropriate tools and methodology to both conduct a habitat inventory assessment and produce GIS data to be used by a variety of groups including the general public, government agencies and land use planners. SHIM and similar assessments are crucial in identifying sensitive habitats thereby providing the necessary information to assist in making informed decisions.

While conclusions have been drawn based on the data collected, it is important to note that this assessment represents a snapshot in time and provides baseline data on a previously unmapped water system. It is recommended that the data collected be used in conjunction with further studies conducted for potential habitat enhancement and/or protection of Watercress Stream.

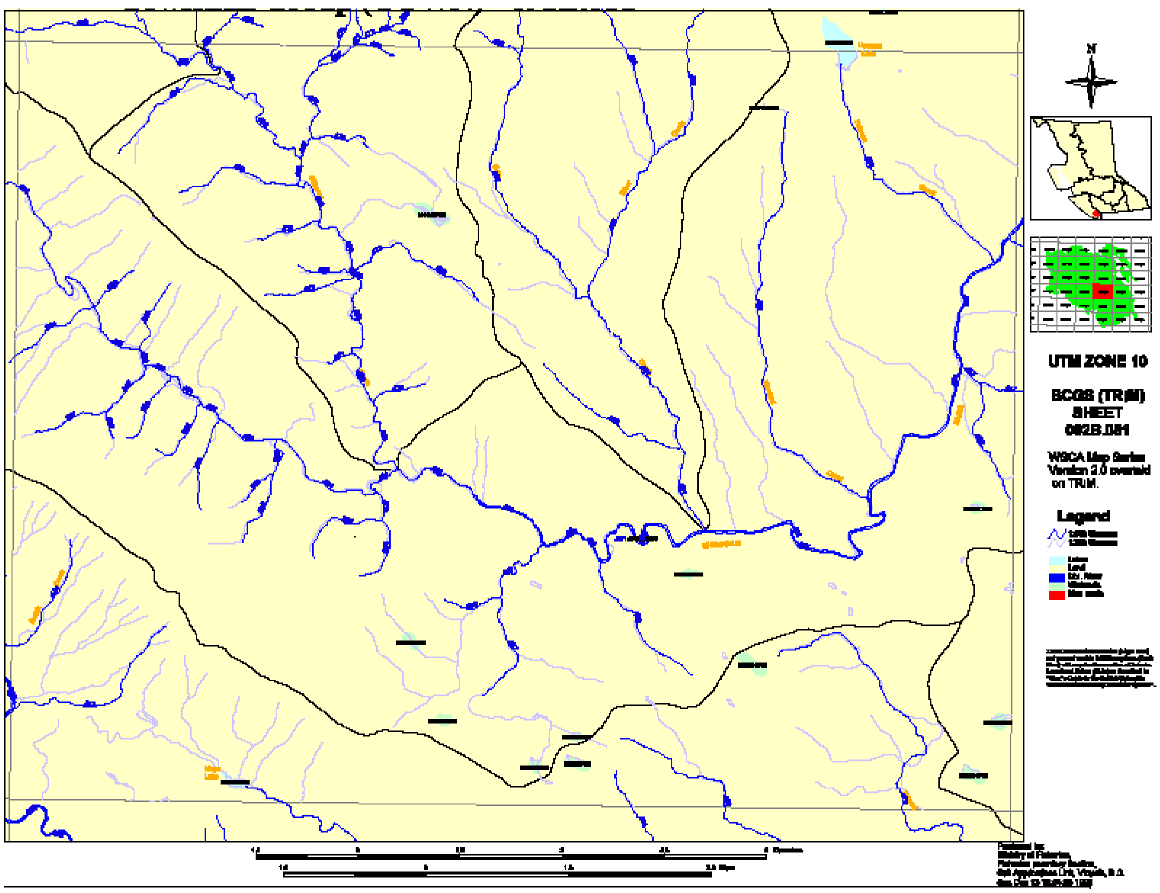
Appendix I: Region I – Vancouver Island Watersheds



Appendix II: TRIM Mapsheet Number 92B.071

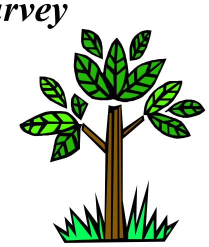


Appendix III: TRIM Mapsheet Number 92B.081



Appendix IV: Aerial Photograph 30BCC98034 No. 059

Appendix V-A: Vegetation Survey



Reach 1

Trees

Latin Name	*Common Name*
Abies Grandis	Grand Fir
Acer macrophyllum	Bigleaf Maple
Alnus rubra	Red Alder
Pseudotsuga menziesii sp.menziesii	Douglas Fir
Thuja plicata	Western Red Cedar
Tsuga heterophylla	Western Hemlock

Shrubs

Latin Name	*Common Name*
Cytisus scoparius	Scotch Broom
Gaultheria shallon	Salal
Holidsicus discolor	Ocean Spray (Common)
Mahonia nervosa	Oregon Grape
Ribes bracteosum	Stink Currant
Rosa nutkana	Nootka Rose
Rubus discolor	Himalayan Blackberry
Rubus spectabilis	Salmon Berry
Salix scouleriana	Scouler's Willow
Salix sitchensis	Sitka Willow

Grasses and sedges

Latin Name	*Common Name*
Carex sitchensis	Sitka Sedge

Appendix V: Vegetation Survey

Ferns

Latin Name	*Common Name*
Dryopteris expansa	Spiny Wood Fern
Polystichum munitum	Sword Fern

Mosses

Latin Name	*Common Name*
Fontinalis antipyretica	Common Water Moss

Other plants

Latin Name	*Common Name*
Achlys triphylla	Vanilla Leaf
Dicentra formosa	Pacific Bleeding Heart
Equisetum	Horsetail
Galium aparine	Cleaver
Lactus muralis	Wall Lettuce
Lysichiton americanum	Skunk Cabbage
Maianthemum dilatatum	False Lily of the Valley
Montia parvifolia	Streambank Spring Beauty (Small-leaved Montia)
Salix discolor	Pussy Willow
Sambucus racemosa ssp.pubens	Red Elderberry
Trillium ovatum	Trillium
Typha latifolia	Cattail
Urtica dioica	Stinging Nettle
Veratum viride	Indian Hellebore

Appendix V: Vegetation Survey

Reach 2

Trees

Latin Name	*Common Name*
Abies Grandis	Grand Fir
Acer macrophyllum	Bigleaf Maple
Alnus rubra	Red Alder
Picea sitchensis	Sitka Spruce
Pseudotsuga menziesii sp.menziesii	Douglas Fir
Tsuga heterophylla	Western Hemlock
Thuja plicata	Western Red Cedar

Shrubs

Latin Name	*Common Name*
Gaultheria shallon	Salal
Holidsicus discolor	Ocean Spray (Common)
Mahonia nervosa	Oregon Grape
Ribes bracteosum	Stink Currant
Rosa nutkana	Nootka Rose
Rubus spectabilis	Salmon Berry
Salix lucida spp. lasiandra	Pacific Willow
Symphoricarpos albus	Common Snowberry
Vaccinium parvifolium	Red Huckleberry
Ribes bracteosum	Stink Currant

Grasses and sedges

Latin Name	*Common Name*
Carex sitchensis	Sitka Sedge

Ferns

Latin Name	*Common Name*
Athyrium filix-femina	Lady Fern
Polystichum munitum	Sword Fern
Pteridium aquilinum	Bracken Fern

Appendix V: Vegetation Survey

Moss

Latin Name	*Common Name*
Fontinalis antipyretica	Common Water Moss

Other plants

Latin Name	*Common Name*
Achlys triphylla	Vanilla Leaf
Dicentra formosa	Pacific Bleeding Heart
Equisetum	Horsetail
Galium tifidum	Small Bedstraw
Lactus muralis	Wall Lettuce
Lysichiton americanum	Skunk Cabbage
Maianthemum dilatatum	False Lily of the Valley
Mitella pentandra	Five-stamened Mitrewort
Montia parvifolia	Streambank Spring Beauty (Small-leaved Montia)
Onenanthe sarmentosa	Pacific Water Parsley
Polygonum amphibium	Water Smartweed
Trillium ovatum	Trillium
Urtica dioica	Stinging Nettle
Veratum viride	Indian Hellebore

Appendix VI: Wildlife Survey

Reach 1

Birds

Latin Name	*Common Name*
Archilochus colubris	Ruby Throated Hummingbird
Carpodacus purpureus	Purple finches
Melospiza melodia	Song sparrow
Corvus corax	Common Raven
Turdus migratorius	American Robin
Denroica petechia	Yellow Warbler (heard)
Troglodytes troglodytes	Winter Wren (heard)
Dryocopus pileatus	Piliated Woodpecker
Sphyrapicus rubber	Red breasted sapsucker
Dendroica townsendi	Townsend Warbler
Poecile rufescens	Chestnut Backed Chickadee
Cyanocitta stelleri	Steller's Jay
Junco hyemalis	Dark-eyed Junco

Animals

Latin Name	*Common Name*
Monadenia churchi	Church's sideband snail
Ariolimax	Banana Slug
Scat: *Cervus elaphus roosevelti*	Roosevalt Elk
Ursus americanus	Black Bear

Amphibians

Latin Name	*Common Name*
Hyla regilla	Pacific Tree Frog

Appendix VI: Wildlife Survey

Fish

Latin Name	*Common Name*
Oncorhynchus clarkii	Cutthroat trout
Gasterosteus aculeatus	Threespine Stickleback
Oncorhynchus kisutch	Coho

Reach 2

Birds

Latin Name	*Common Name*
Archilochus colubris	Ruby Throated Hummingbird
Turdus migratorius	American Robin (and Robin's egg)
Dryocopus pileatus	Piliated Woodpecker

Amphibians

Latin Name	*Common Name*
Hyla regilla	Pacific Tree Frog
	Numerous unidentified frogs

Fish

Latin Name	*Common Name*
Oncorhynchus clarkii	Cutthroat trout
Oncorhynchus kisutch	Coho
Salmo trutta	Brown Trout

Appendix VII: Fish Collection Data Forms

Date May 4 2002	Reach # 1	Segment # 1	Crew Member S.G	

Site #	Site UTM	Comments
pool 1		pool at downstream end of watercress swamp
		directly upstream of culvert

Species	Length	Maturity	Comments
Coho	7.5	Juv.	Count = 12
	7.2		
	9.8		
	6.5		
	11.4		
	9.9		
	12.0		
	10.9		
	10.4		
	8.0		
	8.9		
	9.7		
	12.2		

Date in	Time in	Date out	Time out	Comments
May 4/02	18:16	May 5/02	10:12	photos 16 + 17

Reach 1, Segment 1 Fish Sampling Results

Appendix VII: Fish Collection Data Forms

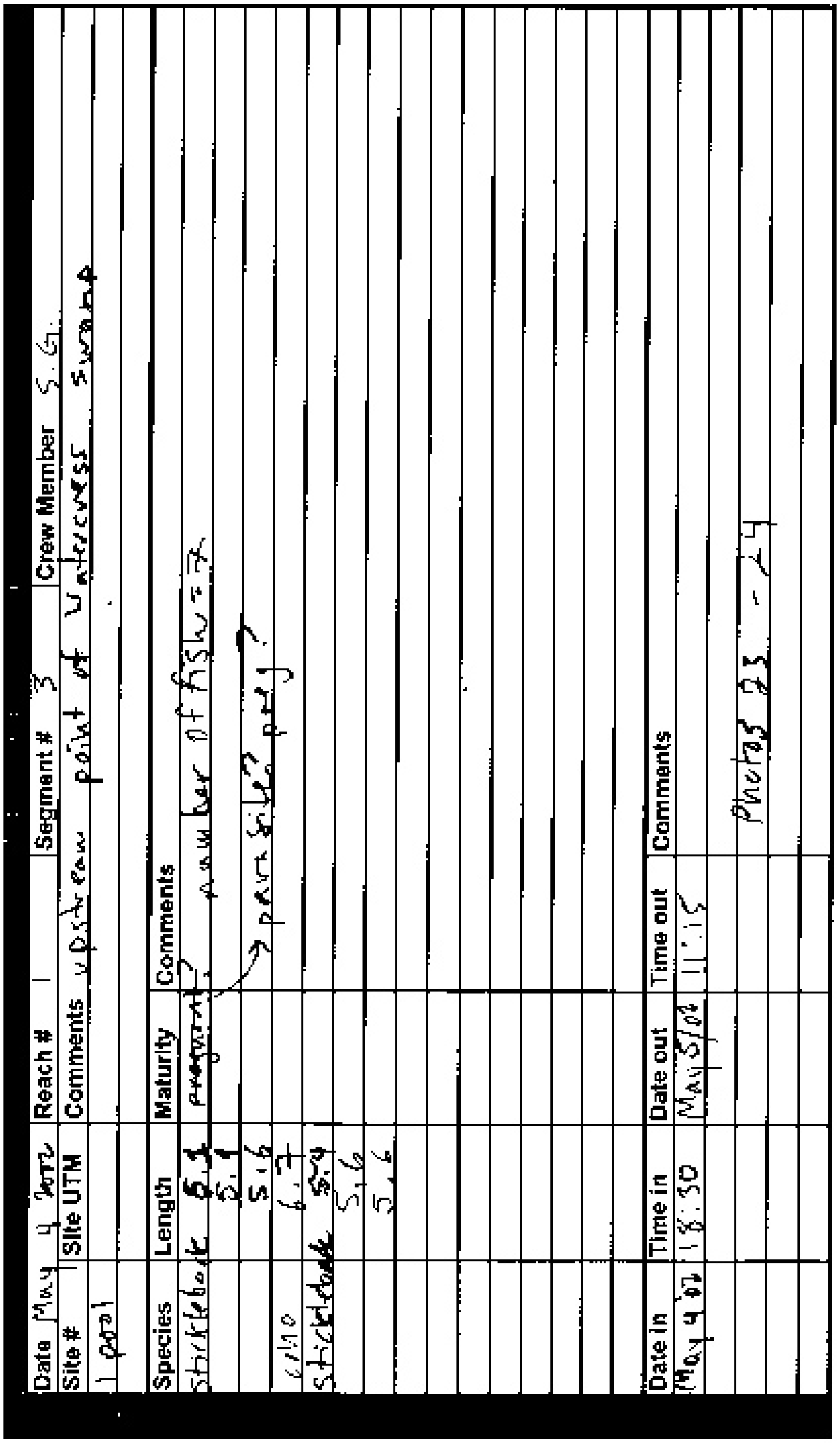
Date May 4 2002		Reach # 1	Segment # 2	Crew Member Pam & Michelle
Site #	Site UTM	Comments		
1		pool - nested feature		

Species	Length	Maturity	Comments
cutthroat	9.7		8 - fish
coho	10.2		
	12.2		
	10.4		
	11.2		- common yellow throat warbler
	8.4		identified while stunning
	10.0		fish by its call
	11.5		

Date in	Time in	Date out	Time out	Comments
May 4 '02	18 34	May 5 '02	10:35	photos 19 - 22

Reach 1, Segment 2 Fish Sample Results

Appendix VII: Fish Collection Data Forms



Date May 4 2002		Reach # 1		Segment # 3	Crew Member S.G.
Site #	Site UTM	Comments upstream point of Watercress swamp			
1 pool					

Species	Length	Maturity	Comments
stickleback	5.1	pregnant?	number of fish = 7
	5.1		→ parasite? preg?
	5.6		
coho	6.7		
stickleback	5.4		
	5.6		
	5.6		

Date in	Time in	Date out	Time out	Comments
May 4 '02	18:30	May 5/02	11:15	
				Photos 23 - 24

Reach 1, Segment 3 Fish Sample Results

Appendix VII: Fish Collection Data Forms

Date May 11 2002		Reach # 2		Segment # 1	Crew Member S.G. / A.H
Site # 1	Site UTM	Comments	large pool downstream of segment 1/2 break		

Species	Length	Maturity	Comments
Coho	4.0 cm		many minnows sighted in pool

Date in	Time in	Date out	Time out	Comments
May 11 '02	18:45	May 12 '02	11:38	

Reach 2, Segment 1 Fish Sample Results

Appendix VII: Fish Collection Data Forms

Date May 11 /'02		Reach # 2	Segment # 2	Crew Member S.G. / A.H.
Site #	Site UTM	Comments	downstream of wood bridge culvert	

Species	Length	Maturity	Comments
coho	7.6		school of minnows sighted in pool May 11 and May 12 approximately 30-40
	4.8		Sickle-shaped anal fins for all 3
	5.1		

Date in	Time in	Date out	Time out	Comments
May 11 '02	18:15	May 12 '02	10:42	

Reach 2, Segment 2 Fish Sample Results

Appendix VII: Fish Collection Data Forms

Date May 11 2002		Reach # 2	Segment # 5	Crew Member S.G. / A.H
Site #	Site UTM	Comments		
		calvert on fairservice main line		
		downstream		

Species	Length	Maturity	Comments
Coho	10.5		
cutthroat	6.7		
"	4.6		
"	9.9		

Date In	Time in	Date out	Time out	Comments
May 11 02	18:10	May 12 '02	10:11	

Reach 2, Segment 5 Fish Sample Results

Appendix VIII-Representative Photo's of Study Area

Figure 10. Looking Upstream at Endpoint of Reach 1, Segment 3

Figure 9. Downstream at Culvert of Reach 1, Segment 1

Figure 3. Looking Downstream of Reach 2, Segment 1

Figure 4. Looking Upstream of Reach 2, Segment 4

Figure 5. Box Culvert in Reach 2, Segment 2

Figure 6. Looking Downstream of Reach 2, Segment 2

Appendix VIII-Representative Photo's of Study Area

Figure 7. Trillium in Reach 1, Segment 3

Figure 8. Large Pool in Reach 1, Segment 2

Figure 9. Cutthroat Trout Trapped in Reach 1, Segment 2

Figure 10. Stickleback Trapped in Reach 1, Segment 3

Figure 11. Tree Frog in Reach 2,

Segment 4

Figure 12. Wildlife Tree in Reach 1, Segment 2

Appendix IX: Watercress Stream Attribute Results

Table 1. Physical Stream Characteristics

Characteristic	Reach 1 Seg 1	Reach 1 Seg 2	Reach 1 Seg 3	Reach 2 Seg 1	Reach 2 Seg 2	Reach 2 Seg 3	Reach 2 Seg 4	Reach 2 Seg 5
Primary Stream Class	Natural	Natural	Natural	Natural	Natural	Natural	Natural	Natural
Secondary Stream Class	Wetland	Wetland	Wetland	Wetland	N/A	Braided	N/A	Braided
Dominant Hydraulic Type	Pool	Wetland	Wetland	Wetland	Riffle	Wetland	Other	Other
Length (m)	79.2	178.7	106.7	80.5	104.3	124.6	319.3	73.3
Gradient (degrees)	0	0	1	0	2	1	3	2
Crown Closure	1-20%	1-20%	1-20%	1-20%	21-40%	21-40%	41-70%	41-70%
Spawning Habitat	None	None	Potential	Potential	None	Potential	Potential	None
Bars	None	None	1 PT	1 PT	1 PT	9 PT	2 PT	11 PT
Substrate %								
Organic	20	30	30	30	5	20	20	20
Fines	60	60	50	30	5	70	30	60
Gravel	15	10	20	40	30	10	50	20
Cobble	5	0	0	0	45	0	0	0
Boulder	0	0	0	0	15	0	0	0
Bedrock	0	0	0	0	0	0	0	0
Compaction	Medium	Low	Low	Low	High	Medium	Medium	Medium
Width (m)								
Wetted	2.80	6.20	6.30	7.30	3.50	2.80	1.90	2.90
Bankfull	11.10	11.10	14.50	12.90	3.80	7.70	2.50	3.30
Left Floodplain	4.84	23.50	14.40	11.80	1.60	6.30	1.50	1.40
Right Floodplain	7.61	5.68	18.50	8.00	3.00	1.70	1.10	1.60
Depth (m)								
Wetted	0.51	0.50	0.10	0.81	0.15	0.23	0.90	0.32
Bankfull	1.19	0.95	0.40	1.15	0.30	0.60	0.25	0.54
Floodplain	1.65	1.30	0.89	2.00	0.64	0.82	0.41	0.60

Table 2. Percent Cover

Characteristic	Reach 1 Seg 1	Reach 1 Seg 2	Reach 1 Seg 3	Reach 2 Seg 1	Reach 2 Seg 2	Reach 2 Seg 3	Reach 2 Seg 4	Reach 2 Seg 5
Total Cover %	90	90	80	30	60	80	75	60
Boulder	0	0	0	0	15	0	0	0
Deep Pool	5	3	7	50	15	15	25	15
Instream Vegetation	75	75	70	35	20	60	10	30
Large Woody Debris	10	10	12	1	10	10	15	8

Overstream Vegetation	5	10	6	9	30	10	20	40
Small Woody Debris	5	2	5	5	5	3	5	7
Undercut Banks	0	0	0	0	5	2	25	0
Large Woody Debris Count	29	130	60	15	30	42	43	11
Deep Pool Count	1	2	4	2	3	7	14	2

Table3. Left and Right Stream Bank Characteristics

Characteristic	Reach 1 Seg 1	Reach 1 Seg 2	Reach 1 Seg 3	Reach 2 Seg 1	Reach 2 Seg 2	Reach 2 Seg 3	Reach 2 Seg 4	Reach 2 Seg 5
Left Riparian Class	Mixed forest	Mixed forest	Mixed forest	Mixed forest	Mixed forest	Mixed forest	Mixed forest	Mixed forest
Left Qualifier	Natural	Natural	Natural	Natural	Natural	Natural	Natural	Natural
Left Bandwidth	70.00	100.00	115.00	55.00	80.00	60.00	60.00	50.00
Left Bankslope	19	14	1	5	10	5	3	7
Left Stage	tall shrubs	mature forest	mature forest	mature forest	mature forest	mature forest	mature forest	mature forest
Left Shrubs	67-100%	33-66%	5-33%	5-33%	5-33%	5-33%	<5%	5-33%
Left Snag	No	>5	>5	<5	<5	No	No	No
Left Veteran	No	No	No	No	No	No	No	No
Left Bank Stability	Med	High	High	High	High	High	High	High
Left Bank Material	Fines	Fines	Fines	Fines	Fines	Fines	Fines	Fines
Left Top Bank	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Right Riparian Class	Natural Wetland	Natural Wetland	Natural Wetland	Mixed forest	Mixed forest	Mixed forest	Mixed forest	Mixed forest
Right Qualifier	Disturbed	Natural	Natural	Natural	Natural	Natural	Natural	Natural
Right Bandwidth	10.00	105.00	70.00	70.00	170.00	140.00	120.00	105.00
Right Bankslope	0	2	1	8	6	3	14	2
Right Stage	low shrubs	tall shrubs	tall shrubs	mature forest	mature forest	mature forest	mature forest	mature forest
Right Shrub	67-100%	67-100%	33-66%	5-33%	5-33%	5-33%	<5%	5-33%
Right Snag	No	>5	>5	No	No	No	No	No
Right Veteran	No	No	No	No	No	No	No	No
Right Bank Stability	High	Med	Med	High	High	High	High	High
Right Bank Material	Gravel	Fines	Fines	Cobble	Cobble	Fines	Fines	Fines
Right Top Bank	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Appendix X: Cross-section Data

Table 1. Cross-section Physical Characteristics

Physical Characteristics	Reach 2 Segment 2	Reach 2 Segment 4	Reach 1 Segment 1	Reach 1 Segment 2	Reach 1 Segment 3
Substrate %					
Organic	5	5	20	25	30
Fines	0	40	75	70	40
Gravel	50	25	5	5	20
Cobble	45	30	0	0	10
Compaction	High	Medium	Low	Low	Medium
Width					
Wetted	3.10	3.00	6.70	7.30	6.30
Bankfull	4.00	5.90	9.00	20.40	14.50
Left floodplain	2.70	4.60	18.50	11.30	9.60
Right floodplain	2.60	4.00	14.40	62.30	40.50
Depth					
Wetted	0.10	0.30	0.35	0.30	0.10
Bankfull	0.40	0.60	0.69	0.70	0.40
Floodplain	0.75	0.70	0.89	0.81	1.11

Table 2. Left Riparian Band

Characteristics	Reach 2 Segment 2	Reach 2 Segment 4	Reach 1 Segment 1	Reach 1 Segment 2	Reach 1 Segment 3
Left Band 1					
Riparian Class	Broadleaf forest	Coniferous forest	Shrubs	Shrubs	Shrubs
Qualifier	Natural	Natural	Natural	Natural	Natural
Bandwidth	7.70	10.40	7.13	7.10	5.25
Bankslope	10	3	19	14	1
Top Bank	No	No	No	No	No
Stage	mature forest	mature forest	low shrubs <2m	low shrubs <2m	tall shrubs 2-10m
Shrubs	5-33%	5-33%	34-66%	34-66%	67-100%
Snag	No	No	No	>5	>5
Veteran	No	No	No	No	No
Bank Stability	High	High	Medium,	Medium	Medium
Bank Material	Fines	Fines	Fines	Fines	Fines
Left Band 2					
Riparian Class	Mixed forest	Mixed forest	Mixed Forest	Mixed forest	Broadleaf forest
Qualifier	Natural	Natural	Natural	Natural	Natural
Bandwidth	6.10	18.00	10.70	13.01	4.64
Bankslope	2	1	3	-5	10
Top Bank	Yes	Yes	Yes	Yes	No
Stage	mature forest	mature forest	young forest	young forest	mature forest
Shrubs	5-33%	5-33%	5-33%	5-33%	34-66%

Snag	No	No	No	<5	<5
Veteran	No	No	No	No	No
Bank Stability	High	High	High	High	High
Left Band 3					
Riparian Class	Mixed forest	Coniferous forest	Coniferous forest	Mixed forest	Mixed forest
Qualifier	Natural	Natural	Natural	Natural	Natural
Bandwidth	5.00	21.60	15.30	29.89	7.20
Bankslope	-10	-7	12	0	41
Top Bank	No	No	No	No	Yes
Stage	mature forest	mature forest	young forest	young forest	mature forest
Shrubs	34-66%	<5%	5-33%	5-33%	34-66%
Snag	No	No	No	No	No
Veteran	No	No	No	No	No
Bank Stability	High	High	High	High	Medium
Left Band 4					
Riparian Class	Mixed forest	na	Shrubs	na	Mixed Forest
Qualifier	Natural	na	Natural	na	Natural
Bandwidth	31.00	0	16.87	0	5.90
Bankslope	2	0	2	0	16
Top Bank	No	na	No	na	No
Stage	mature forest	na	low shrubs <2m	na	young forest
Shrubs	34-66%	na	34-66%	na	5-33%
Snag	No	na	No	na	No
Veteran	No	na	No	na	No
Bank Stability	High	na	Medium	na	High

Table 3. Right Riparian Band

Characteristics	**Reach 2 Segment 2**	**Reach 2 Segment 4**	**Reach 1 Segment 1**	**Reach 1 Segment 2**	**Reach 1 Segment 3**
Right Band 1					
Qualifier	Natural	Natural	Disturbed	Natural	Natural
Riparian Class	Mixed forest	Mixed forest	Low impervious	Shrubs	Broadleaf forest
Bandwidth	10.50	6.90	6.80	11.60	19.93
Bankslope	6	14	0	2	1
Top Bank	No	Yes	Yes	Yes	No
Stage	mature forest	mature forest	low shrubs <2m	tall shrubs 2-10m	sapling >10m
Shrubs	34-66%	<5%	<5%	67-100%	34-66%
Snag	No	No	No	>5	>5
Veteran	No	No	No	No	No
Bank Stability	High	High	High	Medium	Medium
Bank Material	Fines	Fines	Gravel	Fines	Fines
Right Band 2					
Riparian Class	Mixed forest	Mixed forest	Shrubs	Mixed Forest	Mixed Forest
Qualifier	Natural	Natural	Natural	Natural	Natural

Bandwidth	10.00	15.90	14.80	31.00	30.07
Bankslope	3	-3	-2	1	1
Top Bank	Yes	No	No	No	No
Stage	young forest	mature forest	tall shrubs 2-10m	young forest	young forest
Shrubs	67-100%	5-33%	5-33%	34-66%	34-66%
Snag	No	No	No	No	<5
Veteran	No	No	No	No	No
Bank Stability	High	High	Medium	High	High
Right Band 3					
Riparian Class	Mixed forest	Mixed forest	Mixed forest	Shrubs	na
Qualifier	Natural	Natural	Natural	Natural	na
Bandwidth	29.50	27.20	28.40	7.40	na
Bankslope	-3	-1	2	-4	na
Top Bank	No	No	No	No	na
Stage	mature forest	mature forest	mature forest	tall shrubs 2-10m	na
Shrubs	34-66%	34-66%	5-33%	67-100%	na
Snag	No	<5	No	No	na
Veteran	No	No	No	No	na
Bank Stability	High	High	High	Medium	na

Appendix XI: Fish Sampling Data

Table 1. Reach 1 Individual Fish Collection Data

Reach 1: Segment 1					
Date	**Species**	**Fork Length**	**Maturity**		
4-May-02	Coho	7.5	Juvenille		
4-May-02	Coho	7.2	Juvenille		
4-May-02	Coho	9.8	Juvenille		
4-May-02	Coho	6.5	Juvenille		
4-May-02	Coho	11.4	Juvenille		
4-May-02	Coho	9.9	Juvenille		
4-May-02	Coho	12.0	Juvenille		
4-May-02	Coho	10.9	Juvenille		
4-May-02	Coho	10.4	Juvenille		
4-May-02	Coho	8.0	Juvenille		
4-May-02	Coho	8.9	Juvenille	**Total Fish**	**12**
4-May-02	Coho	9.7	Juvenille	**Ave. Fork Length (cm)**	**12.2**

Reach 1: Segement 2					
Date	**Species**	**Fork Length (cm)**	**Maturity**		
4-May-02	Cutthroat	9.7	Juvenille		
4-May-02	Coho	10.2	Juvenille		
4-May-02	Coho	12.2	Juvenille		
4-May-02	Coho	10.4	Juvenille		
4-May-02	Coho	11.2	Juvenille		
4-May-02	Coho	8.9	Juvenille		
4-May-02	Coho	10.0	Juvenille	**Total Fish**	**8**
4-May-02	Coho	11.5	Juvenille	**Ave. Fork Length (cm)**	**10.5**

Reach 1: Segment 3					
Date	**Species**	**Fork Length (cm)**	**Maturity**		
4-May-02	Stickleback	5.1	Juvenille		
4-May-02	Stickleback	5.9	Juvenille		
4-May-02	Stickleback	5.6	Juvenille		
4-May-02	Stickleback	5.4	Juvenille		
4-May-02	Stickleback	5.6	Juvenille		
4-May-02	Stickleback	5.6	Juvenille	**Total Fish**	**7**
4-May-02	Coho	6.7	Juvenille	**Ave. Fork Length (cm)**	**5.7**

Table 2. Reach 2 Individual Fish Collection Data

Reach 2: Segment 1					
Date	**Species**	**Fork Length (cm)**	**Maturity**		
11-May-02	Coho	4.0	Juvenille	**Total Fish**	**1**
				Ave. Fork Length (cm)	**4.0**
Reach 2: Segment 2					
Date	**Species**	**Fork Length (cm)**	**Maturity**		
11-May-02	Coho	4.6	Juvenille		
11-May-02	Coho	4.8	Juvenille	**Total Fish**	**3**
11-May-02	Coho	5.1	Juvenille	**Ave. Fork Length (cm)**	**4.8**
Reach 2: Segment 3					
Date	**Species**	**Fork Length (cm)**	**Maturity**		
11-May-02	Coho	10.5	Juvenille		
11-May-02	Cutthroat	6.7	Juvenille		
11-May-02	Cutthroat	4.6	Juvenille	**Total Fish**	**4**
11-May-02	Cutthroat	9.9	Juvenille	**Ave. Fork Length (cm)**	**7.9**

Appendix XII: Representative Pool Habitat

Table 1. Representative Pool Habitat Data

Physical Characteristic	Reach 2 Segment 1	Reach 2 Segment 1	Reach 2 Segment 2	Reach 2 Segment 3	Reach 1 Segment 1	Reach 1 Segment 2	Reach 1 Segment 3
Point Number	1	2	3	4	5	6	7
Length (m)	14.10	14.10	4.80	8.70	10.50	4.50	6.80
Width (m)	14.90	14.90	5.20	5.40	8.40	3.10	4.20
Depth (m)	0.25	0.25	0.27	0.38	0.57	0.90	0.39

Appendix XIII: Water Quality Data

Table 1: Water Quality Results

	Date	Cond. µs	D.O. mg/L	Temp. C°
Reach 1				
Seg 1	5-May-02	41.4	8.1	8.1
Seg 2	5-May-02	38.0	8.4	7.5
Seg 3	5-May-02	36.0	8.9	7.2
Reach 2				
Seg 1	12-May-02	40.0	7.4	7.9
Seg 2	12-May-02	60.0	9.0	8.3
Seg 5	12-May-02	40.0	8.3	7.3

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