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DEPARTMENT OF
ECOLOGY

Open File Technical Report

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Fish Habitat Analysis Using the Instream Flow Incremental Methodology

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SUMMARY

The Washington State Department of Ecology (Ecology) conducted an instream flow study in the Big Quilcene River using the Instream Flow Incremental Methodology. The study provides information about the relationship between streamflows and fish habitat which can be used in developing minimum instream flow requirements for fish in the Big Quilcene River. One site, composed of eight transects, was chosen. The site was located at approximately River Mile 1.1. Streamflow measurements and substrate information were recorded at high, medium and low flows. This information was entered into the IFG4 hydraulic model to simulate the distribution of water depths and velocities with respect to substrate and cover under a variety of flows. Using the HABTAT model, the simulated information was then used to generate an index of change in available habitat relative to changes in flow; this index is referred to as "weighted usable area" (WUA).

Determination of a minimum instream flow for the Big Quilcene River will require setting priorities for river reaches, fish species and lifestages. Different fish species and lifestages exist simultaneously in the river and each has a different flow requirement. There is no single flow that will simultaneously provide optimum habitat for all fish species and lifestages.

In addition, minimum instream flows must include flows necessary for incubation of fish eggs, smolt out-migration, fish passage to spawning grounds, and prevention of stranding fry and juveniles. Other variables to be considered include water temperature, water quality, and sediment load. These variables were not addressed in this study.

No instream flow recommendations are made in this report. This would require an evaluation of the environmental variables listed above on the river and the long-range fishery management objectives of the state and federal natural resource agencies and affected Tribes. Key results of the IFIM study are portrayed in the table below:

Flow and Habitat Relationships for the Big Quilcene River

Species	Instream Flow Which Provides Maximum Spawning Habitat	Instream Flow Which Provides Maximum Juvenile Habitat
Chinook	120 cfs	60 cfs
Coho	90 cfs	
Chum	180 cfs	
Steelhead	190 cfs	

ACKNOWLEDGEMENTS

I want to thank Stephen Hirschey (Ecology) for having provided valuable assistance in gathering field data and Jim Shedd (Ecology) for his valuable assistance in writing and providing graphics for this report.

TABLE OF CONTENTS

Introduction

The Washington State Department of Ecology (Ecology) is mandated by the 1971 Water Resources Act (Chapter 90.54 RCW) to maintain base flows necessary to provide for preservation of wildlife, fish, scenic, aesthetic and other environmental values. To determine appropriate base flows for fish habitat, one tool Ecology often uses is the Instream Flow Incremental Methodology (IFIM) to generate some of the necessary information. The base or minimum flows determined by Ecology cannot take away any existing water rights and serve to protect existing water right users by restricting new upstream diversions if the river is already experiencing low flows. This information may be used by Ecology to determine the impact of future water appropriations on fish habitat or to condition new water rights to protect instream flows for fish habitat.

Study participants included staff from Ecology, Point No Point Treaty Council, Washington State Departments of Fisheries and Game (now Department of Fish and Wildlife), National Marine Fisheries Service, and U.S. Fish and Wildlife Service (USFWS).

Project Background: Location and Description

The Big Quilcene River is located in Jefferson County and is one of the largest rivers flowing into northern Hood Canal with a mainstem length of 18.9 miles. The Big Quilcene River enters Hood Canal at the head of Quilcene bay near the city of Quilcene. The headwaters, comprised of three major branches, originate between the 5,000 and 6,000 foot level of the Olympic Mountain range mostly within the Olympic National Forest. The terrain is steep and rugged with narrow valleys and deep canyons. Below river mile (RM) 3.5 the gradient moderates and opens into a broad valley below RM 2.5. (See Figure 1).

Past logging throughout the upper portion of the watershed has left a mixture of old growth coniferous timber, some relatively recently logged areas and some second growth areas in various stages of reforestation. The lower portion of the watershed is characterized by second growth timber inner-mixed with deciduous type vegetation. The community of Quilcene, just north of the river mouth is the major settlement of the watershed. A few small farms and some rural residences are located along the river below the Olympic National Forest boundary (Williams et al., 1975).

Streamflows and habitat degradation are major concerns regarding fish habitat in the lower three miles of the Big Quilcene. Excessive streamflows have resulted in scouring of spawning beds and deposition in the lower reaches of the river. Diking and channelization between RM 2.0 and 2.5 may aggravate these problems. Low flows in the summer months severely restrict spawning and rearing areas in all accessible reaches of the river and may result in higher water temperatures. Sketchy streamflow records show a mean annual flow of approximately 200 cfs and low flows of 20 cfs or lower during the dry season near the river mouth. This low flow problem is intensified by water withdrawals of around 26 cfs by the City of Port Townsend for municipal water supply at RM 9.4 (Williams et al, 1975).

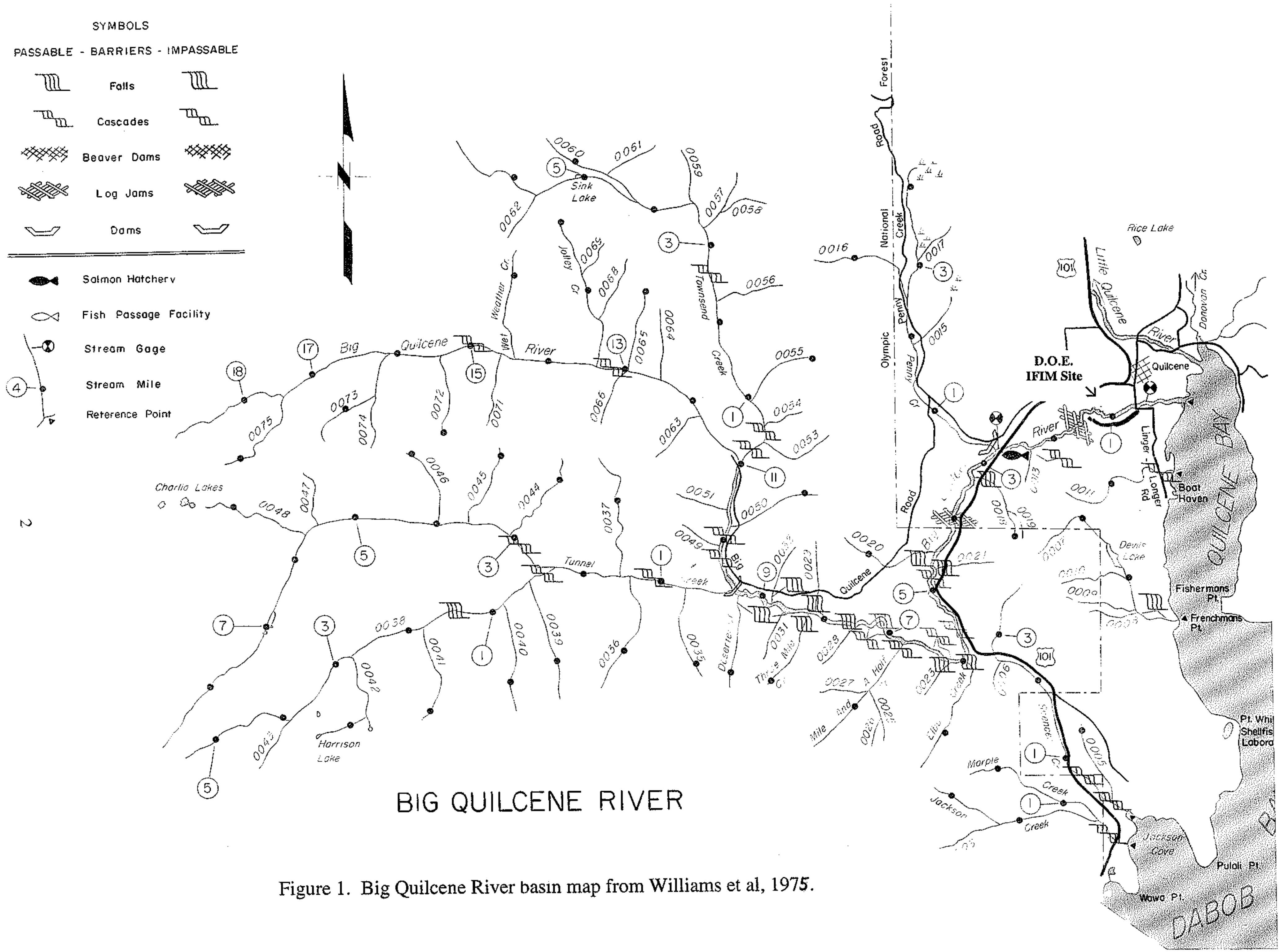


Figure 1. Big Quilcene River basin map from Williams et al, 1975.

Hydrology

Streamflow data for the Big Quilcene River is insufficient to generate a hydrograph based only on Big Quilcene River measured flows. United States Geological Survey (USGS) data exists for 1972 at RM 2.7 (just downstream of the hatchery) and for 1994-1999 at RM 9.4 (just downstream of the City's diversion). I generated a synthetic hydrograph for the Big Quilcene River at RM 2.7 with 10%, 50%, and 90% exceedence levels based on the USGS flow data for the Little Quilcene River at RM 1.0 from 1956-1977. (See Figure 2.) The exceedence values were multiplied by the ratio of the square miles of Big Quilcene River drainage divided by the square miles of Little Quilcene River drainage. Actual measured flows from the Big Quilcene River were plotted on the synthetic hydrograph to see if using a ratio of the drainage areas was valid for describing the expected flow range in the Big Quilcene River. (See Figure 3.) The measured flows fall between the 10% to 90% exceedence range and appear to be a good match.

When a single number is used to describe the flow in a stream, such as average monthly flow, it gives a very distorted idea of the normal flow in the stream. A range, such as the 10% to 90% flow exceedence values, best describes streamflow. This flow range describes the flow one would expect to see 80% of the time in the stream. The 10% exceedence value can be viewed as the quantity of flow in the stream on a specific day that reaches that flow level or higher one out of every 10 years. The 50% exceedence flow value is the median flow: over all the years of record, half of the time on that day the flow was higher and half of the time the flow was lower. The 90% exceedence level means the flow is that level or higher in 9 out of 10 years on that particular day.

Note that the 10% exceedence flow level is not an unusual flow in the stream. Streamflow in a certain year in not at the 10%, 50%, or 90% level on a consistent basis. Rather, flow normally jumps back and forth on a daily or weekly basis from the 10% to 90% exceedence level and sometimes from the 5% to 95% exceedence levels. The reason for this flow behavior is either it's raining and streamflows are very high, or it has stopped raining for a week and streamflows are now very low.

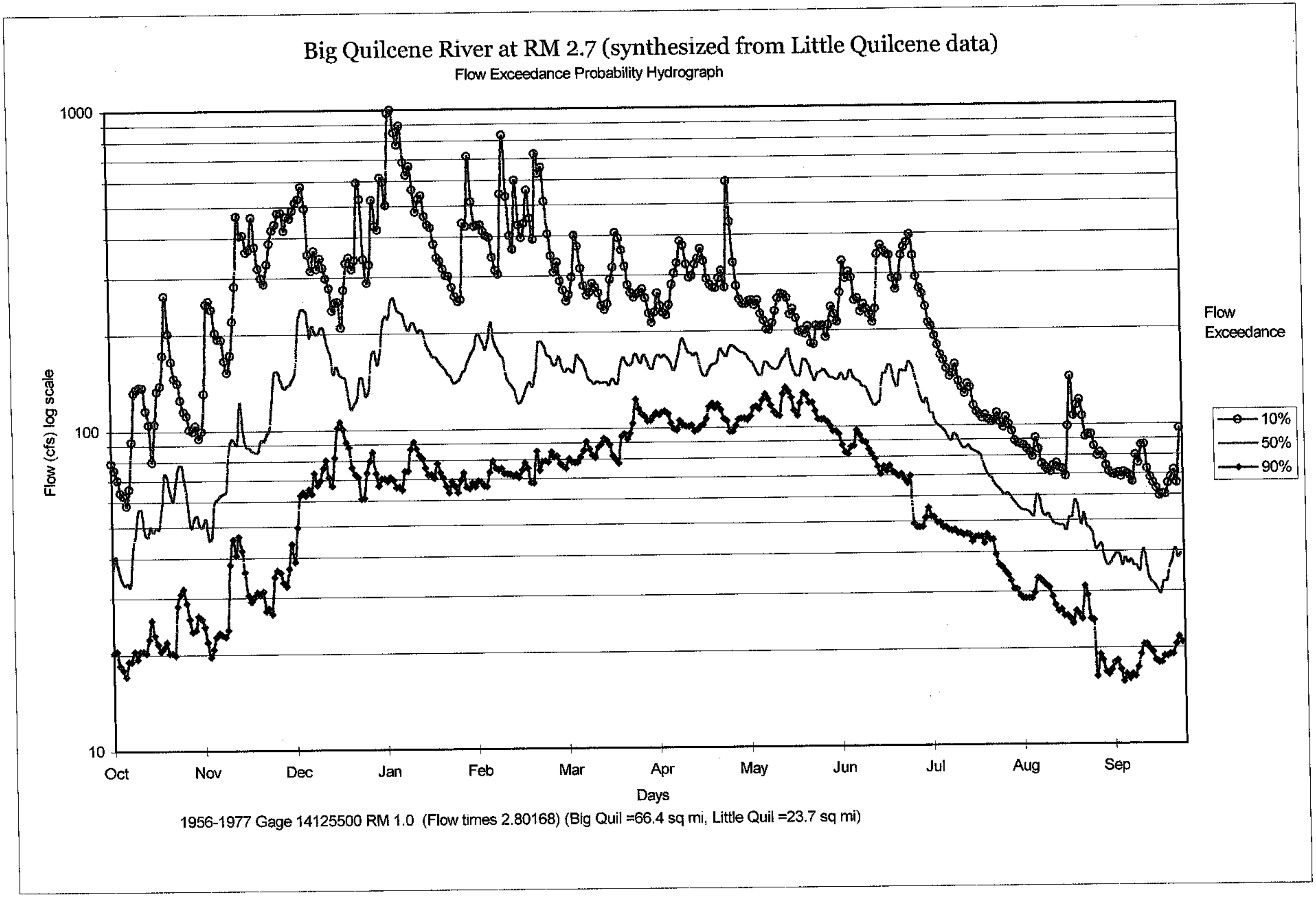
Water Quality Standards

The Big Quilcene River is listed on the Washington State Department of Ecology's 303(d) list of water bodies that fail to meet state water quality standards for instream flow and fish habitat (Ecology, 1996).

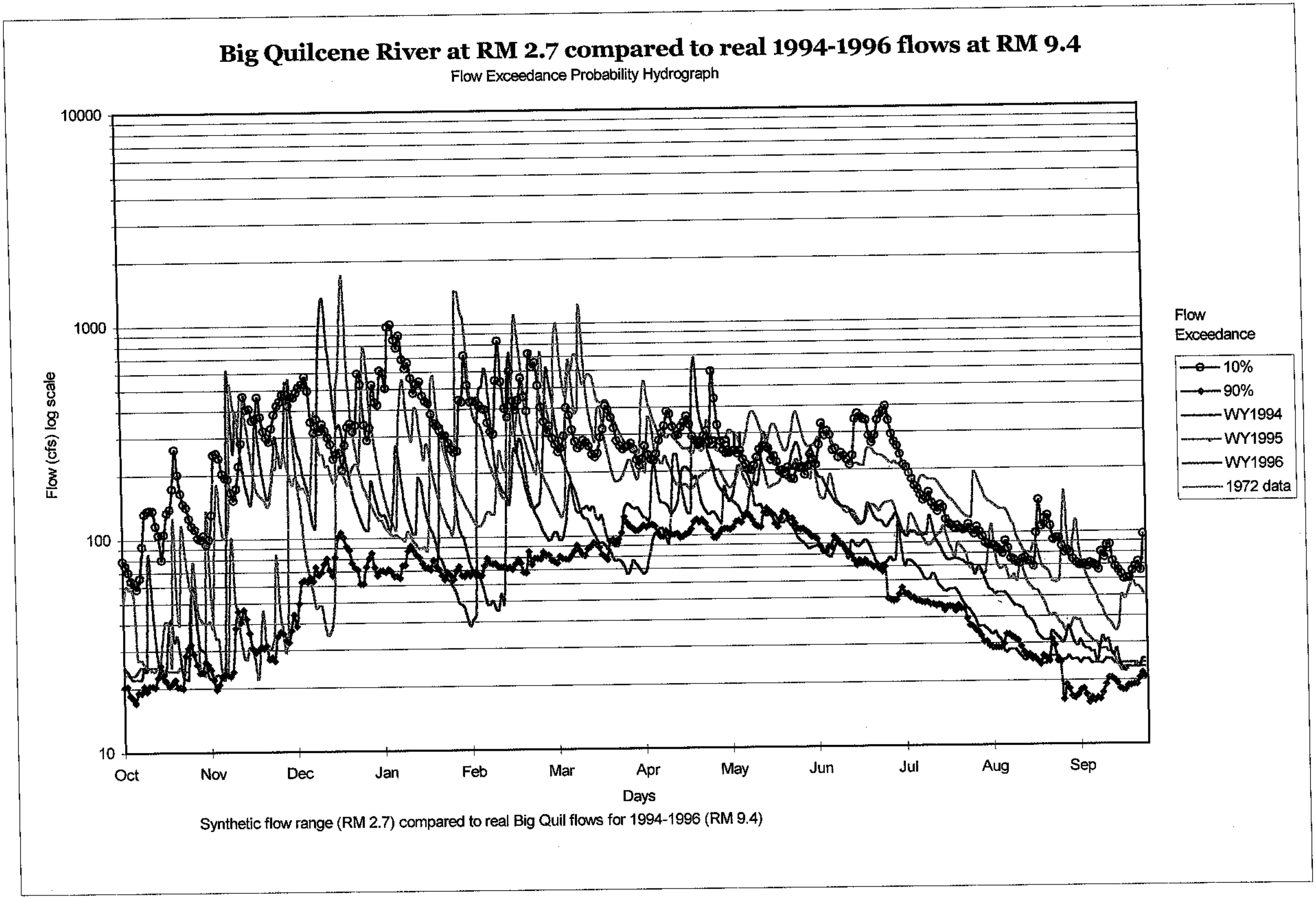
Fish Use and Status

Migration Blocks for Adult Salmonids

There is a natural fish migration barrier at RM 7.6 and one steelhead has been recorded at



Big Quilcene River at RM 2.7 (synthesized from Little Quilcene data)
Flow Exceedance Probability Hydrograph
Flow (cfs) log scale
1000
100
10
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Days
Flow Exceedance
10%
50%
90%
1956-1977 Gage 14125500 RM 1.0 (Flow times 2.80168) (Big Quil =66.4 sq mi, Little Quil =23.7 sq mi)



1972 and 1994-1996 flows are downstream of Port Townsend's 26 cfs diversion

RM 6.8. A small falls at RM 5.1 is believed to be a partial block to coho (Hosey and Associates, 1985). The Quilcene National Fish Hatchery (QNFH) is at RM 2.8 at the mouth of Penny Creek. The hatchery has an electric fish weir to block upstream migration of adult coho and chum, but allows upstream passage of adult steelhead and cutthroat (QNFH, personal communication). The only large tributary in the lower river is Penny Creek, but the hatchery's dam blocks fish access after 200 feet. Most of the coho, chinook, and chum spawn in the lower 2 miles of the Big Quilcene River (Williams et al., 1975).

Chinook Salmon

Chinook salmon were listed on March 23, 1999 as a threatened species for Puget Sound, which includes the Big Quilcene River (See Appendix A). In 1998, only 5 adult chinook returned to the hatchery. The QNFH tried raising spring chinook for over a decade, but gave up after 1992 due to low returns (QNFH, personal communication). Upstream migration is from early September through mid-October while spawning extends from mid September through early November. Chinook juvenile rearing is from January through the first of April with out-migration between April and June. The lower river section below the hatchery at Penny Creek is the primary spawning habitat as well as rearing area (Williams et al., 1975).

Coho Salmon

As part of the 1992 Washington State Salmon and Steelhead Stock Inventory (SASSI), the Washington State Departments of Fisheries and Wildlife classified coho stocks in the Big Quilcene River as "depressed" (WDF, 1993). According to the 1993 SASSI report, the coho salmon stock in the Big Quilcene River (believed to be a hybrid of native and introduced non-native stocks) is depressed due to chronically low escapement levels. The primary limiting factor for coho production is probably low summer flow. Other factors affecting production may be low pool volume because of the stream gradient and the lack of instream large woody debris, and diking and filling may cause a lack of overwinter habitat (WDF, 1993). However, recent coho returns to the hatchery have been about 28,000 in 1997 and 10,000 in 1998. About 25,000-50,000 coho fry are stocked upstream of the QNFH (RM 2.8) to utilize the habitat (QNFH, personal communication).

The hatchery has an early run of coho that enter the river beginning in July (See Appendix B). My snorkeling observations in 1987 found large numbers of adults in the lower river by early September (See Appendix C). The normal time coho enter the river beginning in early October and spawn from late October through the end of December. Fry emerge around the beginning of March and remain in the system for more than a year. Out-migration occurs between late February to mid April in the second year of freshwater existence (Williams et al., 1975).

Pink Salmon

Very few pink salmon have ever been observed in the Big Quilcene River basin. Efforts to stimulate pink production in the Big Quilcene through hatchery releases have not been successful (Williams et al., 1975).

Chum Salmon

Two distinct runs of chum salmon are present in the Big Quilcene River. The first (summer chum) begins migrating upstream in mid-August through September and spawns from mid-September through most of

October. The second run enters the river the first week of November and spawns from mid-November through mid December. Out-migration occurs from late February into May. Most chum spawning areas are in the lower two miles of the river (Williams et al., 1975). These two chum run-timings are still the same in 1996 (Appendix B).

The SASSI report lists the status of the late fall chum stock as healthy and the summer chum as critical (WDF, 1993). The SASSI lists the habitat factors affecting summer chum as: 1) logging in the upper watershed may have contributed to the serious gravel aggradation problem at the mouth of the river with channel shifting, 2) gravel compaction in the lower river, 3) diking in the lower river, and 4) dredging in the lower river.

Summer chum were listed as a threatened species under the Endangered Species Act on March 23, 1998 for Hood Canal summer-run chum. The Big Quilcene River was listed as a critical habitat area (See Appendix A). The notice in the Federal Register (Vol.63, No.46, Tues. March 10, 1999/ Proposed Rules) specifically mentioned a large increase in 1995-1996 for Hood Canal summer chum primarily due to the Big Quilcene River. This run size increase was attributed to the summer chum program started in 1992 at the QNFH and an improvement in overall natural survival in the wild. The Register listed the threats to summer chum as harvest, habitat degradation of spawning habitat, and low water flows. Under habitat problems, the Register quoted the same problems listed above from the 1993 SASSA report.

Summer chum counts in the Big Quilcene River have increased from the single digits in 1988 to 8,417 in 1997 and 2,788 in 1998 (QNFH, personal communication).

<u>Steelhead</u>

Winter steelhead run from December through May and spawn from mid-February through early June. The river has a relatively small steelhead rearing and spawning area, mostly limited to the lower end of the basin. In addition, suitable substrate material may limit steelhead spawning. Marine mammal predation may also be a limiting factor. Information on steelhead stocks in the Big Quilcene River is limited because escapements have not been monitored and no escapement goal has been identified. Consequently the SASSI report lists winter steelhead stock status as "unknown" although it does indicate the stock is historically small. No information was available on summer steelhead in the Big Quilcene River although run timing for other Hood Canal summer stocks is May through October and spawn timing is probably from February through April (WDF, 1993)

<u>Cutthroat</u>

I was unable to find any information on cutthroat trout in the Big Quilcene River, but in my snorkeling observations in June, July, and September I usually found 10-20 searun cutthroat 12-18 inches long with many more 6-12 inches long (See Appendix C). During 1986-1987 I snorkeled all the streams and rivers along the west side of Hood Canal from the Skokomish River to the Big Quilcene and always found the most and biggest searun cutthroat trout in the Big Quilcene River.

Study Methods

Overview of Instream Flow Incremental Methodology (IFIM)

IFIM was selected as the best available method for predicting how the quantity of available fish habitat changes in response to incremental changes in streamflow. The U.S. Fish and Wildlife Service in the late 1970s (Bovee, 1982) developed this methodology. The IFIM involves putting site-specific streamflow and habitat data into a group of models collectively called PHABSIM (physical habitat simulation). The most common model is IFG4, which uses multiple transects to predict depths and velocities in a river over a range of flows. IFG4 creates a cell for each measured point along the transect or cross-section. Each cell has an average water depth and water velocity associated with a type of substrate or cover for a particular flow. The cell's area is measured in square feet. Fish habitat is defined in the computer model by the variables of velocity, depth, substrate, and/or cover. These are important habitat variables that can be measured, quantified, and predicted.

The IFIM is used nationwide and is accepted by most resource managers as the best available tool for determining the relationship between flows and fish habitat. However, the methodology only uses four variables in hydraulic simulation. At certain flows, such as extreme low flows, other variables such as fish passage, food supply (aquatic insects), competition between fish species, and predators (birds, larger fish, etc.) may be of overriding importance. In addition to the PHABSIM models, IFIM may include reviewing water quality, sediment, channel stability, temperature, hydrology, and other variables that affect fish production. These additional variables are not analyzed in this report.

After the IFG4 model is calibrated and run, its output is entered into another model (HABTAT) with data describing fish habitat preferences in terms of depth, velocity, substrate, and cover. These preferences vary according to fish species and life-stage (adult spawning and juvenile rearing).

The output of the HABTAT model is an index of fish habitat known as Weighted Useable Area (WUA). The preference factor for each variable at a cell is multiplied by the other variables to arrive at a composite, weighted preference factor for that cell. For example: a velocity preference of 1.0 multiplied by a depth preference of 0.9, then multiplied by a substrate preference of 0.8 equals a composite factor of 0.72 for that cell. This composite-preference factor is multiplied by the number of square feet of area in that cell.

A summation of all the transect cells' areas results in the total number of square feet of preferred habitat available at a specified flow. This quantity is normalized to 1,000 feet of stream or river. The final model result is a listing of fish habitat values (WUA) in units of square feet per 1,000 feet of stream. The WUA values are listed with their corresponding flows (given in cubic feet per second).

Study Site and Transect Selection

A preliminary study site was selected for the IFIM study by reviewing topographic maps. Actual site selection was done during field visits. Eight transects were chosen around RM 1.1 (see Figure 1) to represent the lower river downstream of the QNFH; these transect sites are shown in the table below.

Big Quilcene Transects

Transect #	Location
1	River Mile 1.1
2	88 feet upstream of Transect 1
3	57 feet upstream of Transect 2
4	105 feet upstream of Transect 3
5	91 feet upstream of Transect 4
6	73 feet upstream of Transect 5
7	72 feet upstream of Transect 6
8	63 feet upstream of Transect 7

Field Procedures

IFIM measurements were taken in May (high flow), June (medium flow) and July (low flow) of 1987. We measured flows on the Big Quilcene River at 231, 108 and 67 cfs respectively.

A temporary gage at each site was used to verify that streamflow at each transect remained steady during measurement. Transects were marked using survey hubs and flagging. Water velocity was measured using standard USGS methods with a calibrated Swoffer velocity meter mounted on a top-set wading rod.

Water surface elevations and stream-bank profiles were surveyed with a survey level and stadia rod. These points were referenced to an arbitrary, fixed benchmark. Substrate composition and cover were assessed by visually estimating the percent of the two main particle size classes and type of cover according to a scale recommended by the Washington Departments of Fisheries and Wildlife. This scale is included as Appendix F.

Hydraulic Model

Calibration Philosophy

Calibration of the hydraulic model involved checking the velocities and depths predicted by the model against velocities and depths measured in the field. This included examining indicators of the model's accuracy such as mean error and Velocity Adjustment Factor (VAF). The calibration philosophy was to change data or to manipulate data using a computer calibration option only when doing so would improve the model's ability to extrapolate without reducing the accuracy of predicted depths and velocities at the measured calibration flows.

Calibration of the IFG4 model was done cell by cell for each transect to decide whether the predicted cell velocities adequately represented measured velocities. Generally, if the predicted cell velocity at the calibration flow was within 0.2 feet per second (fps) of the measured cell velocity, the predicted velocity was considered adequate. Any change to a calibration velocity was limited to a change of 0.2 fps. The 0.2-fps change limit was thought to be reasonable considering the normal range of velocity measurement error. All cell velocities were reviewed at the highest and lowest extrapolated flows to ensure that extreme cell velocities were not predicted.

Indicators of Model Accuracy

Two indicators of the IFG4 model's accuracy in predicting depths and velocities are the mean error and the Velocity Adjustment Factor (VAF). See Appendix D for mean errors and VAFS for each transect at each site.

The mean error is the ratio of the calculated flow (from depths and velocities at the measured flows) to the predicted flow (from depth and velocity regressions). As a rule of thumb, the mean error for the calculated discharge should be less than 10 percent.

The Velocity Adjustment Factor (VAF) for a three-flow IFG4 hydraulic model indicates whether the flow predicted from the velocity/discharge regressions matches the flow predicted from the stage/discharge regressions. The velocities predicted from the velocity/discharge regressions for a transect are all multiplied by the same VAF to achieve the flow predicted from the stage/discharge regression. Calculating and comparing the flows predicted from two different regressions gives an indication as to whether or not some of the model's assumptions are being met.

A range in the VAF value of 0.9 to 1.1 is considered good, 0.85 to 0.9 and 1.1 to 1.15 fair, 0.8 to 0.85 and 1.15 to 1.20 marginal, and less than 0.8 and more than 1.2 poor (Milhous, 1984). The standard extrapolation range is 0.4 times the low calibration flow and 2.5 times the high calibration flow. The extrapolation range of the model is usually limited when two or more transects have VAFs which fall below 0.8 or above 1.2.

Options in IFG4 Model

Several options are available in the IFG4 hydraulic model (Milhous, 1989). Ecology's standard method is to set all the options to zero except for option 8 which is set at 2, and option 13 to 1 to get a summary of the velocity adjustment factors. The standard options were used for the models in this study.

Site Specific Calibration

A three-flow IFG4 model with eight transects was run for the Big Quilcene site. The IFG4 input file, a summary of the calibration details, data changes, and the velocity adjustment factors are included as Appendix D. The mean errors of the stage/discharge regressions range from 0.22 to 9.91. The velocity adjustment factors range from 0.81 to 1.02 allowing an extrapolation range from 25 to 575 cfs.

Transect Weighting

The table below lists the percent weighting each transect received relative to the whole site. Transect weighting is determined one of two ways: either the model automatically determines weighting for each transect by using the distance between the transects or transect weight is set to predetermined levels by specifying distances between transects and upstream weighting (referred to as composite weighting). Composite weighting is done when the transects are located far apart and the distances between the transects would create incorrect weighing, or the investigator wants to increase the weight of a particular type of fish habitat for that site. Transect weighting for the Big Quilcene River site was done using the distances between the transects.

Transect Weighting for the Big Quilcene Site

Transect #	1	2	3	4	5	6	7	8
Percent of Total Site	8.01	13.21	14.75	17.85	14.94	13.21	12.30	5.74

Agency Approval of the Hydraulic Model

Brad Caldwell of the Department of Ecology and Hal Beecher of the Department of Fish and Wildlife met March 29, 1999 and after reviewing the calibration details decided the hydraulic models were adequate for the extrapolation ranges listed above.

Habitat Use Model (HABTAT)

Options Used in HABTAT

The HABTAT program combines the depths and velocities predicted from the IFG4 hydraulic model with the depths, velocities, cover, and substrate preferences from the habitat-use curves. The HABTAT program calculates WUA for each flow modeled. The IOC options used in HABTAT were IOC 00000 00101 00000 000.

Habitat Preference Curves

Data on fish preferences for depth, velocity, substrate, and cover was gathered by Department of Fish and Wildlife biologist Hal Beecher on summer chum in the Dosewallips and Duckabush Rivers. These observations were used in creating the chum spawning preference curve used in the computer model. Hal Beecher selected transects at regular intervals along the length of the study stream. He snorkeled across each transect to mark locations of fish and measured depth, mean water column velocity, substrate and cover at regularly spaced intervals across each transect. As he recorded the measurements of depth, velocity, substrate and cover, he also recorded the number of fish of each species in the immediate vicinity of each measurement. Fish locations were marked with weighted flags color-coded for each species.

Habitat availability was calculated and compared against actual fish use to determine fish preference. These fish preference values were then compared against fish preference curves that have been compiled by the agencies. The amount of weight given to the site specific preference curves depended upon how many observations were gathered, how well they compared to the existing body of observations, and whether the observations covered the full range of habitat that would be available from low to high flow.

Fish preference curves for the Big Quilcene River were agreed to by Brad Caldwell for the Department of Ecology and by Hal Beecher for the Department of Fish and Wildlife at a December 3, 1998 meeting. Existing agency preference curves were used for chinook, coho, and steelhead. These preference curves are listed in Appendix E.

Results and Discussion

The results are the fish habitat versus flow curves in Figures 4 and 5. Figure 6 shows how the wetted area changes with flow. The total area number can be divided by 1,000 to calculate the average wetted width for any flow from 25 to 575 cfs. Table 1 shows what percent of optimum habitat is available for each species and lifestage at a given flow.

These results can be interpreted by biologists to determine a minimum flow regime to protect and preserve instream flow for fish under Washington State law.

A Hosey and Associates IFIM study was done in 1985 at sites farther upstream: RMs 3.7, 5-5.3, 6.8, and 8.8 (See Appendix G). The lower reach at RM 3.7 would be most similar to my IFIM site at RM 1.1. The Hosey IFIM has optimum flows for coho spawning at 110 cfs, steelhead spawning at 180 cfs, and chum spawning at 190 cfs. My IFIM study has optimum flows for coho spawning at 90 cfs, steelhead spawning at 190 cfs, and chum spawning at 180 cfs. These three flows are very similar. Other flows for chinook spawning and chinook and steelhead rearing were farther apart.

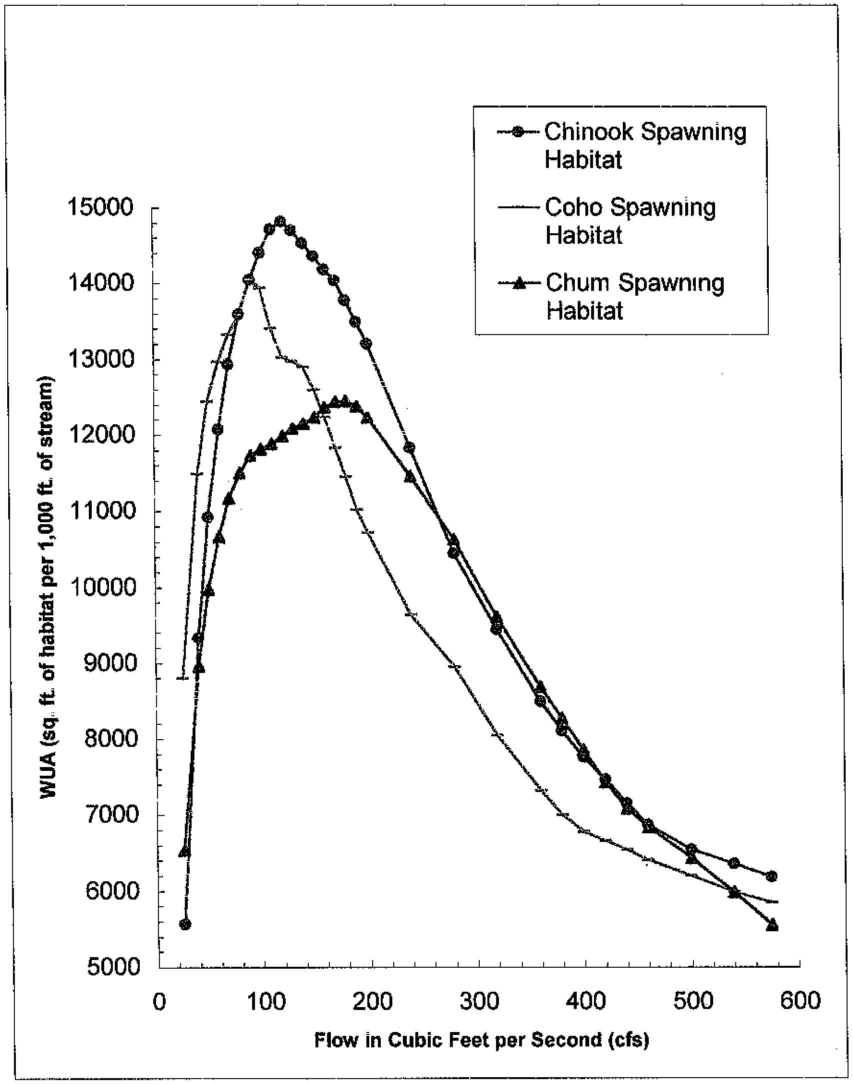
Factors To Consider When Developing A Minimum Insteam Flow

Determining a minimum instream flow for a river or stream in the Quilcene basin requires more than choosing the peak WUA flow for one lifestage of one species at one reach from the IFIM study. Because multiple lifestages existing simultaneously in a river, no specific flow will provide an optimum flow for all lifestages and species. Setting a minimum instream flow requires ranking the importance of each fish species and lifestage. This ranking requires considering long-range management plans for the fishery resources as determined by the state and federal natural resource agencies and the affected Tribes.

In addition, minimum instream flows must include flows necessary for incubation of fish eggs, smolt out-migration, fish passage to spawning grounds, and prevention of stranding of fry and juveniles. Other variables, which have to be considered, include water temperature, water quality, and sediment load. None of these variables were measured in this IFIM study. Therefore, reaching a conclusion about an appropriate minimum instream flow involves integrating the results of the IFIM study with consideration of these additional variables.

It's important to know that under a minimum instream flow under Washington State's laws is not the minimum flow that must be in the stream. No one has to stop using an existing water right to meet the minimum instream flow set by rule. The minimum instream flow only applies to new water rights issued after the date the rule was adopted. The minimum instream flow is the flow at which water is unneeded for the protection and preservation of fish and therefore new water rights can be given to anyone who requests since there is surplus water available.

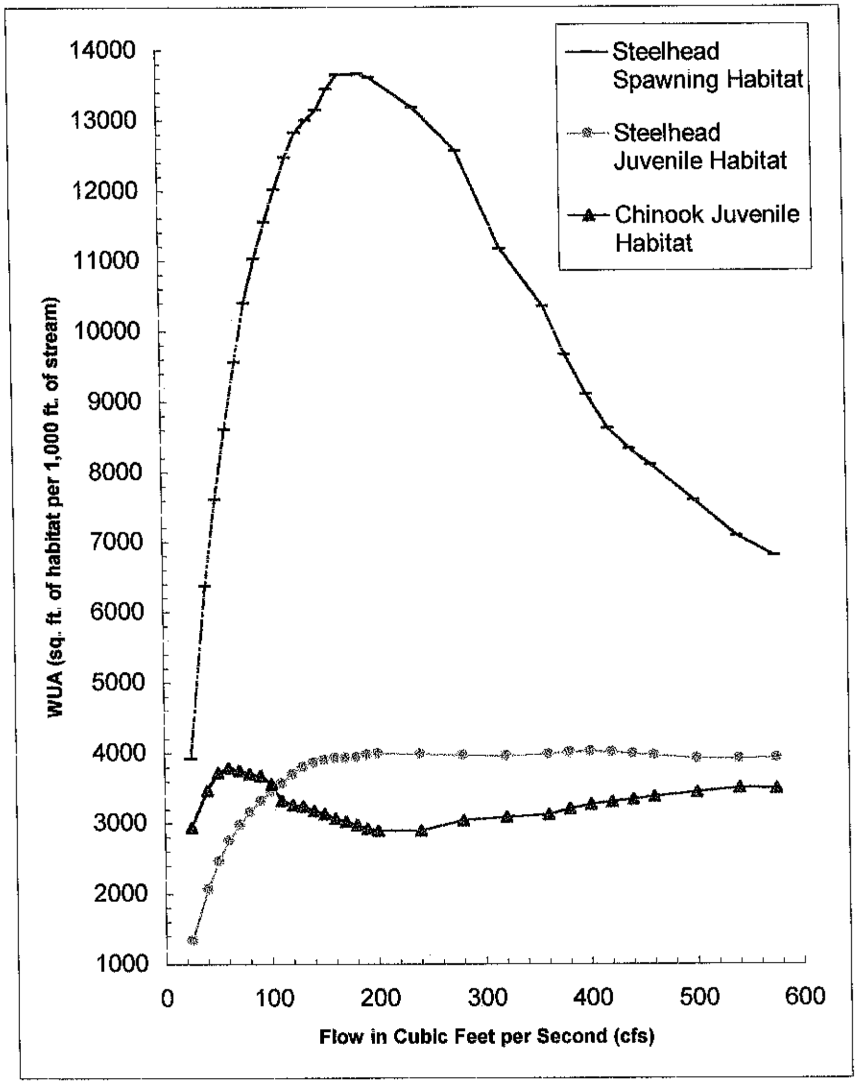
Big Quilcene River Fish Habitat: Weighted Usable Area vs. Flow (in cfs)



Flow in cfs	Coho Spawning Habitat	Chinook Spawning Habitat	Chum Spawning Habitat
575	5851	6193	5558
540	5989	6357	5986
500	6210	6544	6441
460	6415	6864	6846
440	6549	7157	7090
420	6666	7471	7432
400	6781	7767	7867
380	7000	8111	8280
360	7322	8496	8691
320	8054	9443	9615
280	8960	10456	10636
240	9644	11834	11467
200	10719	13206	12236
190	11023	13494	12392
180	11455	13781	12457
170	11842	14042	12451
160	12244	14191	12370
150	12599	14370	12234
140	12902	14535	12155
130	12979	14700	12095
120	13027	14821	11989
110	13409	14723	11886
100	13947	14407	11825
90	14056	14057	11738
80	13589	13599	11507
70	13325	12936	11180
60	12968	12074	10670
50	12450	10925	9977
40	11489	9333	8965
25	8804	5563	6538

Figure 4. WUA vs Flow for spawning chinook, coho, and chum.

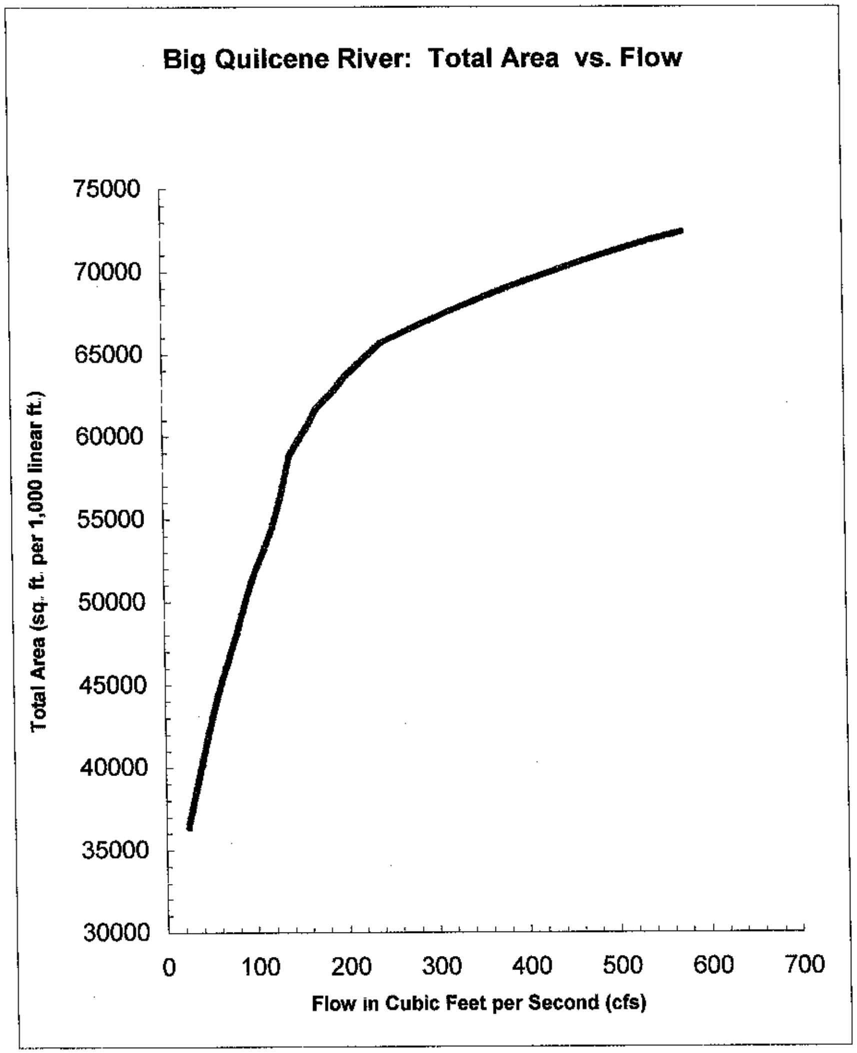
Big Quilcene River Fish Habitat: Weighted Usable Area vs. Flow (in cfs)



Flow in cfs	Steelhead Spawning Habitat	Steelhead Juvenile Habitat	Chinook Juvenile Habitat
575	6806	3924	3494
540	7084	3914	3503
500	7599	3914	3446
460	8093	3965	3379
440	8322	3983	3338
420	8612	4011	3300
400	9100	4018	3271
380	9663	4005	3205
360	10343	3983	3122
320	11166	3955	3090
280	12556	3963	3040
240	13178	3975	2895
200	13606	3990	2895
190	13664	3967	2924
180	13641	3935	2976
170	13649	3924	3019
160	13448	3922	3067
150	13146	3900	3128
140	12994	3857	3182
130	12821	3793	3242
120	12466	3700	3261
110	12018	3573	3320
100	11546	3448	3557
90	11033	3313	3676
80	10399	3157	3710
70	9565	2979	3753
60	8605	2750	3786
50	7615	2462	3723
40	6377	2069	3472
25	3912	1341	2938

Figure 5. WUA vs Flow for spawning steelhead, and rearing steelhead and chinook.

Big Quilcene River: Total Area (square feet per 1,000 linear feet) vs. Flow (in cfs)



Flow in cfs	Total Area
575	72372
540	71894
500	71227
460	70522
440	70154
420	69775
400	69383
380	68977
360	68557
320	67666
280	66696
240	65625
200	63642
190	62844
180	62308
170	61758
160	60708
150	59872
140	58919
130	56500
120	54558
110	53021
100	51709
90	50046
80	48111
70	46371
60	44657
50	42522
40	40190
25	36380

Figure 6. Area vs Flow

Table 1. Percent of optimum WUA vs Flow.

Big Quilcene River Weighted Usable Area (in percent of optimum) vs. Flow (in cfs)						
Flow in cfs	Chinook Spawning Habitat (percent of optimum)	Chinook Juvenile Habitat (percent of optimum)	Chum Spawning Habitat (percent of optimum)	Coho Spawning Habitat (percent of optimum)	Steelhead Spawning Habitat (percent of optimum)	Steelhead Juvenile Habitat (percent of optimum)
575	42%	92%	45%	42%	50%	98%
540	43%	93%	48%	43%	52%	97%
500	44%	91%	52%	44%	56%	97%
460	46%	89%	55%	46%	59%	99%
440	48%	88%	57%	47%	61%	99%
420	50%	87%	60%	47%	63%	100%
400	52%	86%	63%	48%	67%	100%
380	55%	85%	66%	50%	71%	100%
360	57%	82%	70%	52%	76%	99%
320	64%	82%	77%	57%	82%	98%
280	71%	80%	85%	64%	92%	99%
240	80%	76%	92%	69%	96%	99%
200	89%	76%	98%	76%	100%	99%
190	91%	77%	99%	78%	100%	99%
180	93%	79%	100%	81%	100%	98%
170	95%	80%	100%	84%	100%	98%
160	96%	81%	99%	87%	98%	98%
150	97%	83%	98%	90%	96%	97%
140	98%	84%	98%	92%	95%	96%
130	99%	86%	97%	92%	94%	94%
120	100%	86%	96%	93%	91%	92%
110	99%	88%	95%	95%	88%	89%
100	97%	94%	95%	99%	84%	86%
90	95%	97%	94%	100%	81%	82%
80	92%	98%	92%	97%	76%	79%
70	87%	99%	90%	95%	70%	74%
60	81%	100%	86%	92%	63%	68%
50	74%	98%	80%	89%	56%	61%
40	63%	92%	72%	82%	47%	51%
25	38%	78%	52%	63%	29%	33%

Setting the minimum instream flow at the monthly mean during the low flow month sounds reasonable, but under State law it means that one-half of the flow during the low flow month is now available for new diversions. This is because the flow in the stream is higher than the mean about 50% of the time.

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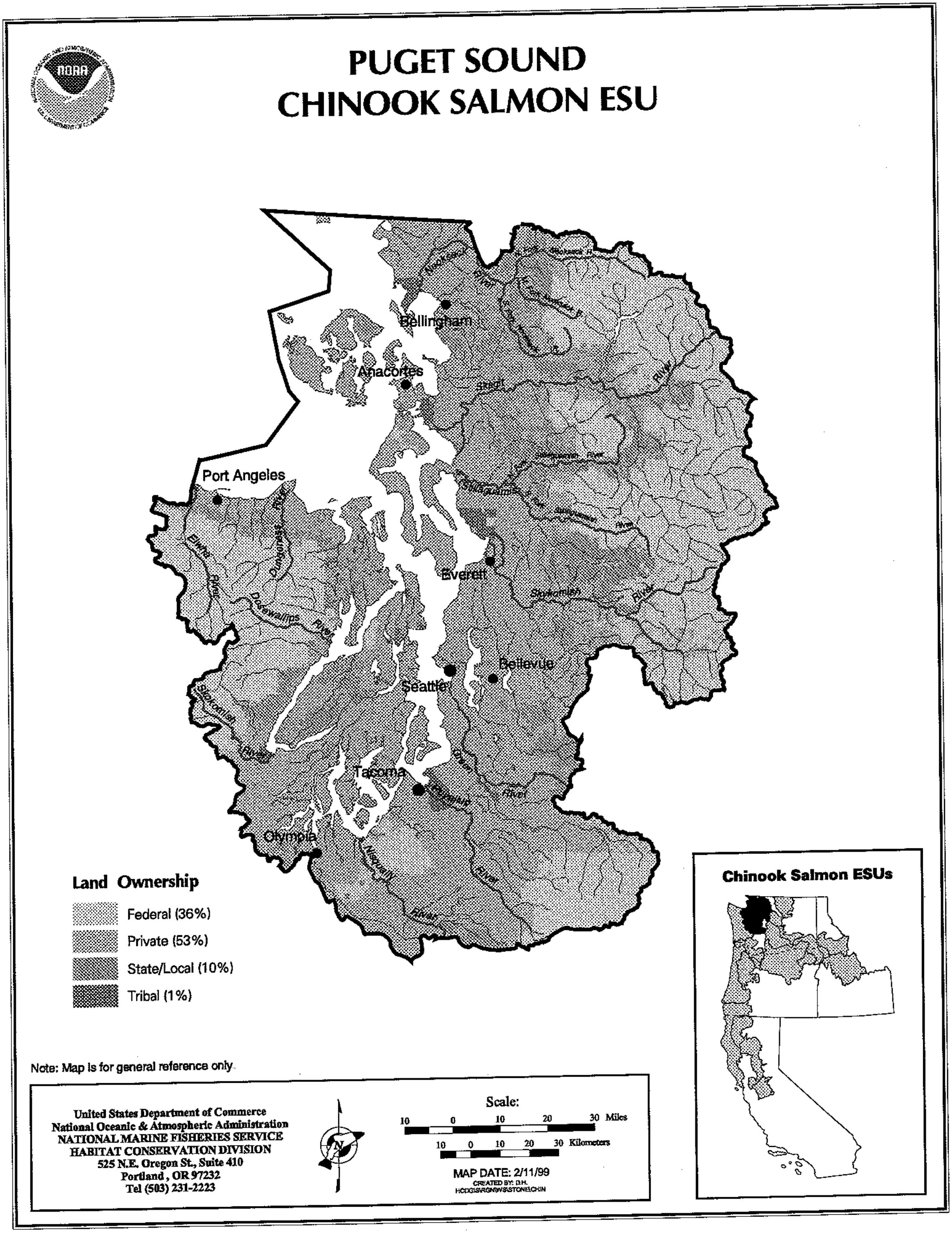
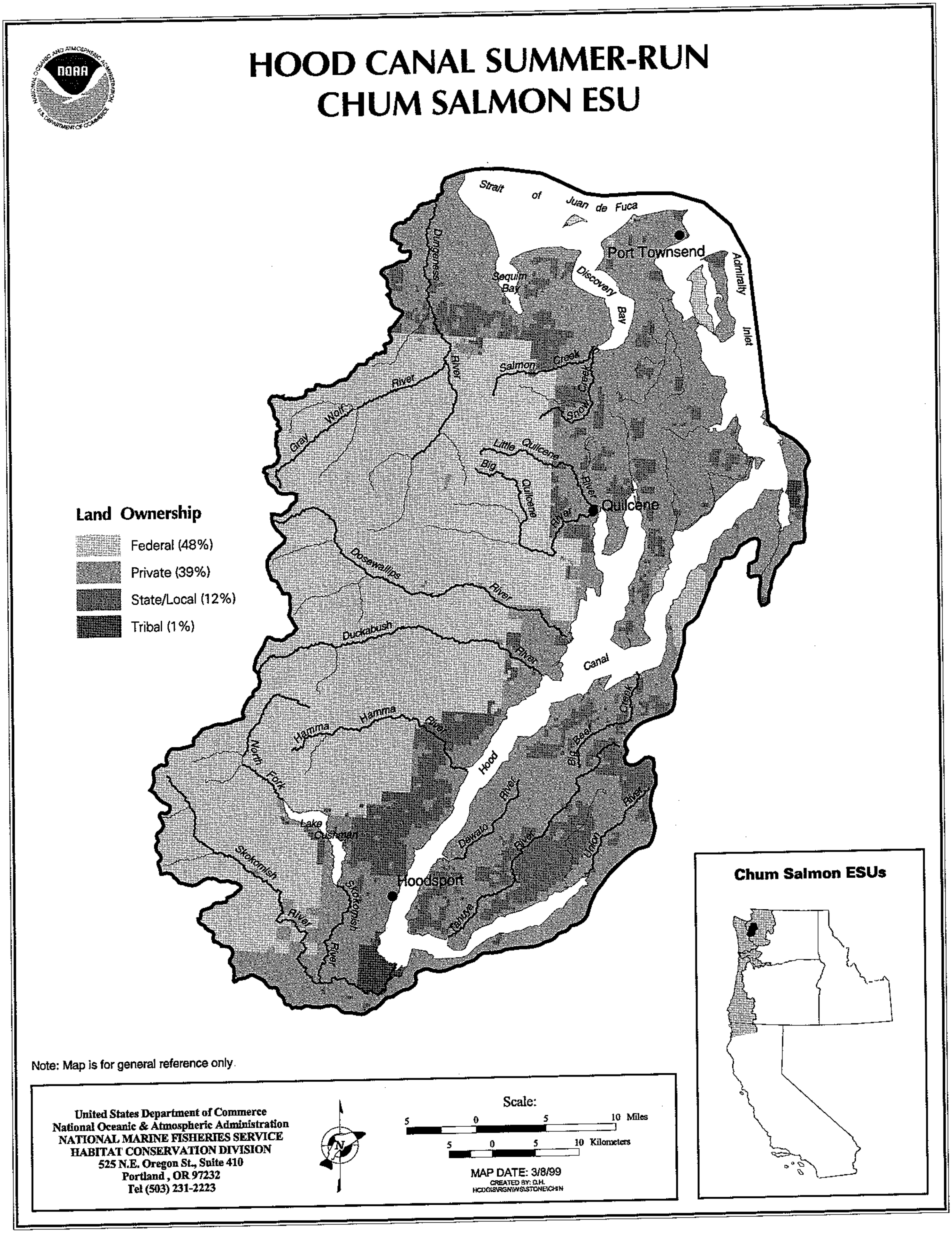
Williams, R.W., Laramie, R.M. and Ames, J.J., 1975. A Catalog of Washington Streams and Salmon Utilization. Volume 1, Puget Sound Region. Washington Department of Fisheries, Olympia, Washington.

Appendix A. Maps of Chinook and Summer-Run Chum ESU Areas


PUGET SOUND
CHINOOK SALMON ESU
Bellingham
Anacortes
Port Angeles
Everett
Seattle
Bellevue
Tacoma
Olympia
Nooksack River
Skagit River
Stillaguamish River
Skykomish River
Elwha River
Dungeness River
Dosewallips River
Skokomish River
Green River
Puyallup
Nisqually River
River
Land Ownership
Federal (36%)
Private (53%)
State/Local (10%)
Tribal (1%)
Chinook Salmon ESUs
Note: Map is for general reference only.
United States Department of Commerce
National Oceanic & Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
HABITAT CONSERVATION DIVISION
525 N.E. Oregon St., Suite 410
Portland, OR 97232
Tel (503) 231-2223
Scale:
10 0 10 20 30 Miles
10 0 10 20 30 Kilometers
MAP DATE: 2/11/99


HOOD CANAL SUMMER-RUN
CHUM SALMON ESU
Strait of Juan de Fuca
Port Townsend
Sequim Bay
Discovery Bay
Admiralty Inlet
Dungeness River
Gray Wolf River
Salmon Creek
Snow Creek
Little Quilcene River
Big Quilcene River
Quilcene
Dosewallips River
Duckabush River
Hamma Hamma River
Canal
Hood
Big Beef Creek
North Fork
Lake Cushman
Skokomish River
Hoodsport
Dewatto River
Tahuya River
Union River
Land Ownership
Federal (48%)
Private (39%)
State/Local (12%)
Tribal (1%)
Chum Salmon ESUs
Note: Map is for general reference only.
United States Department of Commerce
National Oceanic & Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
HABITAT CONSERVATION DIVISION
525 N.E. Oregon St., Suite 410
Portland, OR 97232
Tel (503) 231-2223
Scale:
5 0 5 10 Miles
5 0 5 10 Kilometers
MAP DATE: 3/8/99

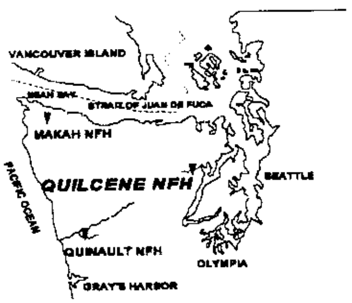
Appendix B. Quilcene National Fish Hatchery Data

QUILCENE NATIONAL FISH HATCHERY
Quilcene, Washington

Summer 1997 — Western Washington Office - Aquatic Resources Division, Olympia, WA

INTRODUCTION

The Western Washington Fishery Resource Office (WWFRO) and the Olympia Fish Health Center (OFHC) serve the three National Fish Hatcheries (NFH) on the Olympic Peninsula -- Makah, Quilcene, and Quinault (see locale map below). The WWFRO, OFHC, and NFH's work together to restore depleted inter-jurisdictional fish for domestic and international fisheries in compliance with Trust responsibilities to tribes, court orders, agreements with states, and international treaties. WWFRO works with cooperators, and programs and evaluates hatchery production to assure obligations are met with minimal impact on wild fish. OFHC provides fish health diagnostic and treatment services to assure high post-release survival of hatchery fish. This annual report provides basic information on Quilcene NFH to inform Service employees, visitors, and our cooperators of their hatchery programs.



Western Washington locale map

Quilcene NFH, located in the Hood Canal area of Puget Sound, began operating in 1911. Its general goals include rebuilding salmon runs in Puget Sound and coastal Washington, and contributing to the fisheries current and future fisheries. Specific objectives to meet these goals vary by species and are described on the following pages.

QUICK REFERENCE DATA

LEGEND:

AVG	=	Average (mean)
BY	=	Brood Year
FL	=	Fork Length
CHS	=	Fall Chum Salmon
COS	=	Coho Salmon
SHS	=	Summer Chum Salmon
♀	=	Female
♂	=	Male

▸ ADULT AGES AT RETURN

	AGE RANGE	1996 AVG. AGE	1985-1996 AVG. AGE
SHS	3-5 yrs	3.9	3.5
CHS	3-5 yrs.	3.5	3.8
COS	2-3 yrs.	3.0	2.9

▸ ADULT FORK LENGTHS in millimeters(inches)

	FL RANGE	FL MEAN
SHS	485-781mm (19-31")	698mm (27")
CHS	509-878mm (20-35")	776mm (30")
COS	246-823mm (10-32")	776mm (30")

▸ ADULT ENTRY DATES TO HATCHERY

	1988-1996 RANGE	1996 MEAN DATE
SHS	Aug - Sept	Sept 14, 1996
CHS	Nov - Dec	Dec 8, 1996
COS	Jul - Dec	Oct 15, 1996

▸ NUMBER AND DATES OF ADULTS SPAWNED

	1996 Date Range	1996 # Spawned ♂	♀	Total	1986-96 Avg # Spawned
SHS	09/05-10/13	335	289	624	341
CHS	11/19-12/23	934	936	1870	1104
COS	10/04-11/07	622	642	1264	1103

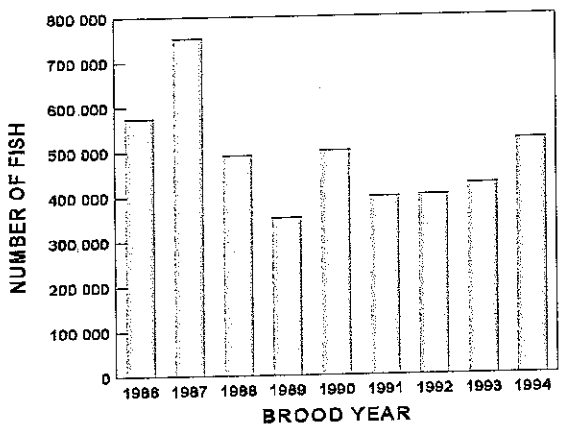
Please direct questions, comments, and suggestions to:

Western WA Office - Aquatic Resources Division
510 Desmond Drive SE, Suite 102
Lacey, WA 98503-1273
(360) 753-9440

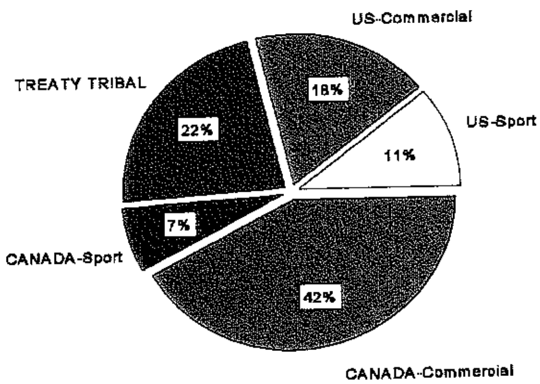
Quilcene National Fish Hatchery
281 Fish Hatchery Road
Quilcene, WA 98376
(360) 765-3334

COHO SALMON

COHO RELEASES (1986 - 1995)



CATCH OF COHO (Brood Years 1987-1990)



OBJECTIVE: Provide coastwide fishing opportunities for all users.

RELEASES: Since 1990, approximately 431,000 coho yearlings, averaging 5.5 inches, are released each year into the Big Quilcene River in mid-May. In addition, 300,000 pre-smolts are transferred to Quilcene Bay net pens and 500,000 eggs are transferred to George Adams Hatchery (WA Dept. of Fish & Wildlife) to be used in Port Gamble Bay (Point No Point Treaty Council) pens.

CATCH: An average of 6.2% (26,750) of the fish released survive to spawn or are caught in fisheries. Major fisheries are located off the west coast of Vancouver Island, and in the Strait of Juan de Fuca, Puget Sound, northern Hood Canal, and Quilcene Bay.

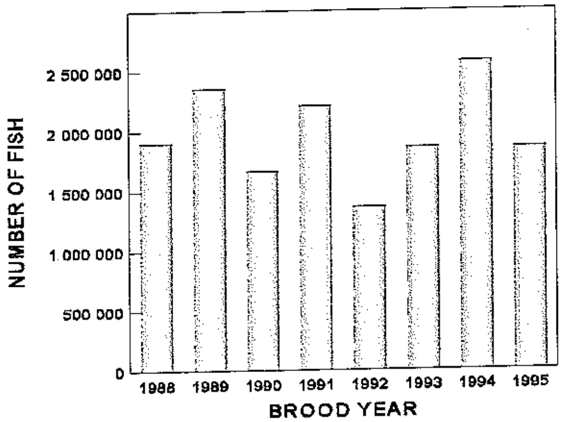
COHO RETURNS TO HATCHERY RACK BY RETURN YEAR

Return Year	Age at Return: 2	Age at Return: 3	Total per Year
1987	0	2,959	2,959
1988	0	3,534	3,534
1989	2	8,217	8,219
1990	1	3,865	3,866
1991	15	2,694	2,709
1992	260	2,625	2,885
1993	320	7,546	7,866
1994	263	14,068	14,331
1995	4414	15,649	20,063
1996	199	7,947	8,146

Quilcene NFH's coho program continues to thrive.

FALL CHUM SALMON

FALL CHUM RELEASES
(1988 - 1995)



CATCH OF FALL CHUM
(Brood Years 1982-1991)

Brood Year	Number Caught	Number Escaped
1982	16,153	7,572
1983	12,854	2,651
1984	4,746	1,629
1985	11,612	4,388
1986	34,440	11,859
1987	12,377	8,780
1988	3,153	2,316
1989	3,008	1,980
1990	43,064	44,149
1991	21,005	20,234

OBJECTIVE: Contribute to Puget Sound fisheries. The chum program is managed as a composite hatchery/natural program, since many fish spawn in the river below the hatchery.

RELEASES: Over the past 8 years, approximately 2.1 million hatchery fry (1.6 inches in length) are released each year into the Big Quilcene River in early May. Natural production from the river is substantial, but undetermined.

CATCH: On average, over 13,000 adults are caught in Puget Sound fisheries. Over 5,000 adults return to the Quilcene River to spawn at the hatchery or in the river.

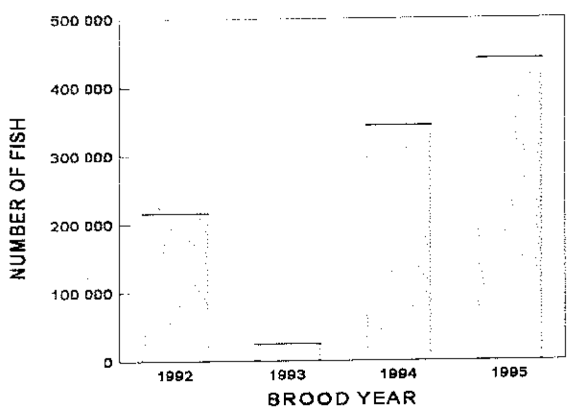
FALL CHUM RETURNS TO HATCHERY RACK BY RETURN YEAR

	Age at Return			Total
Return Year	3	4	5	per Year
1988	890	534	52	1,476
1989	405	715	16	1,136
1990	151	1,460	13	1,624
1991	74	1,461	70	1,605
1992	20	213	125	358
1993	2,673	763	28	3,464
1994	1,115	11,142	28	12,285
1995	366	3,614	594	4,574
1996	1,845	1,845	68	3,758

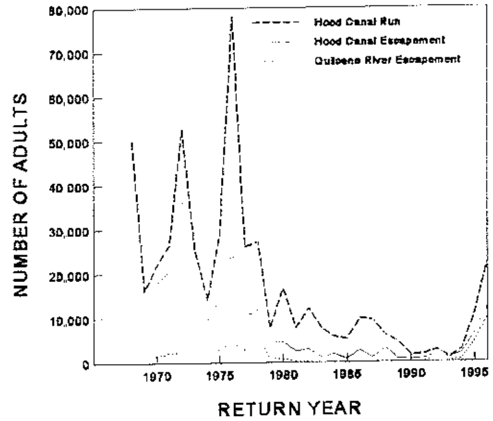
Quilcene fall chum are mainly caught in the later part of the Hood Canal commercial chum fishery.

SUMMER CHUM SALMON

SUMMER CHUM RELEASES (1992 - 1995)



ESTIMATED SUMMER CHUM RUN SIZE AND ESCAPEMENT



OBJECTIVE: Increase survival of Quilcene summer chum. Summer chum runs in Hood Canal streams have declined dramatically since the late 1970's. The stock was petitioned for listing under the Endangered Species Act in 1994. Possible factors contributing to this decline include loss of high quality habitat, overfishing, low water flows, and competition from hatchery releases.

In 1992, the U.S. Fish and Wildlife Service, Point No Point Treaty Council, and Washington Department of Fish and Wildlife began a restoration program using Quilcene NFH as a hatching and release location for Big Quilcene River summer chum. Broodstock are captured from Quilcene Bay and transported to the hatchery for spawning. The resulting fry are released from the hatchery in early spring.

RELEASES: The current goal is to release 400,000 fry annually into the Big Quilcene River and deliver an eyed-egg equivalent of 200,000 fry to Big Beef Creek Hatchery (WDFW).

CATCH: No directed harvest of summer chum occurs in Hood Canal. However, some chum are caught incidental to Quilcene Bay coho fisheries operations and Strait of Juan de Fuca sockeye fisheries. Catch in outside fisheries is unknown at this time.

SUMMER CHUM RETURNS TO HATCHERY BY RETURN YEAR

	Age at Return				Total
Return Year	2	3	4	5	per Year
1993	0	2	7	27	36
1994	3	332	22	5	359
1995	0	478	21	0	499
1996	15	30	726	0	771

Restoration from Quilcene is expected to reverse the current trend in Quilcene Bay returns. Opportunities for stock restoration in other areas of Hood Canal will be addressed through interagency discussions.

Appendix C. Snorkeling Observations in the Big Quilcene River

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Big Quilcene River DATE June 1, 1987

VISIBILITY: excellent, 20 + feet, water was low and clear.

REACH OF RIVER SNORKELED: From our site at river mile 1.1, upstream for one mile to RM. 2.1

SPECIES OBSERVED	NUMBER OBSERVED
* Coho juveniles (2-2.5 inches)	100
* Chinook juveniles(5-6 inches)	3
* Trout (3-9 inches)	12
Trout (3-9 inches)	15
Chinook juveniles (5-6 inches)	3
Coho juveniles (2-2.5 inches)	6
Summer Steelhead (10 lbs.)	1

GENERAL COMMENTS: The * observations were made in a braid of the river, under a rootwad, 4 ft. deep, going 0.5 fps. The other observations were in the main channel. The steelhead had a red stripe, and was in excellent condition.

REACH OF RIVER SNORKELED: From our IFIM site at RM. 1.1 downstream to the old bridge crossing RM. 0.7 (bridge was recently removed).

SPECIES OBSERVED	NUMBER OBSERVED
Spring Chinook (25-30 lbs.)	4
Chinook juveniles (5-6 inches)	3
Trout (3-10 inches)	6

REACH OF RIVER SNORKELED: From the old bridge crossing (RM. 0.7) down to existing bridge @ Linger Longer Road (RM. 0.6)

SPECIES OBSERVED	NUMBER OBSERVED
Searun Cutthroat Trout (8-12 inches)	20
Searun Cutthroat Trout (6-8 inches)	40

GENERAL COMMENTS: The Searun trout were heavily spotted.

OBSERVATIONS BY: Brad Caldwell and Stephen Hirschey.

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Big Quilcene River DATE June 2, 1987

VISIBILITY: good, about 12 feet.

REACH OF RIVER SNORKELED: Snorkeled from RM. 1.1 downstream to the Linger Longer Rd. bridge (RM 0.6).

SPECIES OBSERVED	NUMBER OBSERVED
Spring Chinook (25-30 lbs)	4
Chinook juveniles(5-6 inches)	2
Trout (6 inches)	1
Coho juveniles(2.5 inches)	3
Searun Cutthroat Trout (12 inches)	10
Searun Cutthroat Trout (6-8 inches)	25

GENERAL COMMENTS: The Searun Cutthroat trout were heavily spotted.

OBSERVATIONS BY: Brad Caldwell and Stephen Hirschey.

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Big Quilcene River DATE July 9, 1987

VISIBILITY: excellent about 20 feet, the water was low and very clear.

REACH OF RIVER SNORKELED: From our IFIM site (RM. 1.1) downstream to the Linger Longer Road bridge (RM. 0.6).

SPECIES OBSERVED	NUMBER OBSERVED
Cutthroat (18 inches)	1
Cutthroat (15 inches)	1
Cutthroat (13 inches)	1
Cutthroat (11 inches)	1
Trout (4-6 inches)	60
Coho juveniles (3.5 inches)	30
Chinook juveniles (4.5 inches)	3
Spring Chinook (+20 lbs.)	3
Spring Chinook jack (10 lbs)	1

GENERAL COMMENTS: One of the Spring Chinook was in the pool past the second cliff on the river, the other two were by the house with the concrete wall on the river. A large population of caddis larva was present.

OBSERVATIONS BY: Brad Caldwell, Stephen Hirschey, and Steve Ralph (PNPTC).

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Big Quilcene River DATE September 9, 1987

VISIBILITY: good, 8-10 feet.

REACH OF RIVER SNORKELED: From the Hwy. 101 bridge (RM. 2.7) downstream to the Linger Longer Road bridge (RM. 0.6)

SPECIES OBSERVED	NUMBER OBSERVED
Chinook adults (mold infested)	12
Chinook jacks (dead)	6
Chinook juvenile (6 inches)	6
Steelhead (10 lbs., one @ 20 lbs.)	10
Coho juveniles (4-5 inches)	250
Coho adult (8-10 lbs.)	200
Coho adult (15 lbs.)	20
Searun Cutthroats (3 lbs.)	10
Trout (11-14 inches)	6
Trout (6-10 inches)	30
Trout (4-6 inches)	300

GENERAL COMMENTS: The steelhead were in the two large pools about .25 miles downstream of the Hwy 101 bridge. Most of the coho adults were in the three large pools downstream from our IFIM transect 1 (RM. 1.1). Six redds (probably chinook) were observed in the reach, and no chum or pinks.

REACH OF RIVER SNORKELED: From just upstream of the Linger Longer Road bridge (RM. 0.6) down to power lines (RM. 0.3).

SPECIES OBSERVED	NUMBER OBSERVED
Coho adult (6-15 lbs.)	15
Coho juveniles (5 inches)	20
Chum (8-12 lbs.)	3
Trout (11-14 inches)	6
Trout (6-7 inches)	25
Trout (3-4 inches)	30

GENERAL COMMENTS: About 80 % of the coho were dark, and 85 % were in the 10-15 lbs. category.

EACH OF RIVER SNORKELED: From the power line crossing (RM. 0.3) down to the estuary (RM. 0.0).

SPECIES OBSERVED	NUMBER OBSERVED
Coho adult (6-15 lbs.)	260
Chum (8-12 lbs.)	8
Trout (11-14 inches)	10
Trout (6-7 inches)	20
Trout (3-4 inches)	30

GENERAL COMMENTS: The deepest part of most riffles was 3 inches. Many redds were built in the last three weeks, probably chinook redds, since no coho were spawning or on redds. No steelhead adults or pinks were seen. Two kids were poaching coho with sharp sticks. The fish have been in for three weeks according to one poacher. A dozen large coho in the pools had large spinners and spoons stuck in their sides. The snags in the pools were covered with very large treble hooks..

OBSERVATIONS BY: Brad Caldwell (RM. 0.6 to 0.0) and Stephen Hirschey RM. 2.7 to 0.6)

Appendix D. Calibration Information for the IFIM Computer Model.

Appendix D1. IFG4 Input File

```
Big Quilcene River  RM 1.4   measured by Brad Caldwell for Ecology
at 231 cfs on 5-1-87, at 108 cfs on 6-2-87, and at 67 cfs on 7-9-87.
IOC       11000002000010000 10 1
QARD 575.0
QARD 540.0
QARD 500.0
QARD 460.0
QARD 440.0
QARD 420.0
QARD 400.0
QARD 380.0
QARD 360.0
QARD 320.0
QARD 280.0
QARD 240.0
QARD 200.0
QARD 190.0
QARD 180.0
QARD 170.0
QARD 160.0
QARD 150.0
QARD 140.0
QARD 130.0
QARD 120.0
QARD 110.0
QARD 100.0
QARD  90.0
QARD  80.0
QARD  70.0
QARD  60.0
QARD  50.0
QARD  40.0
QARD  25.0
XSEC   1.0       0.0 .50     96.13    .00250
       1.0-10.0103.7  2.398.66  3.098.56  4.098.46  5.098.06  6.097.88
       1.0  7.097.58  8.097.53  9.097.83 10.097.71 11.598.66 24.6100.7
       1.0 33.798.66 34.098.46 37.097.58 40.096.88 43.096.58 46.096.13
       1.0 49.096.28 51.096.28 53.096.48 55.096.58 57.096.58 59.096.68
       1.0 61.097.23 64.097.48 67.097.58 70.097.63 73.097.48 76.097.78
       1.0 79.097.83 82.098.06 85.098.26 88.098.36 91.098.56 93.198.66
       1.0104.0100.7124.0100.7126.798.66127.098.56128.098.06129.098.01
       1.0130.099.66130.798.66140.0103.7
NS     1.0       .80       .80       .80       .80     11.50     11.50
NS     1.0     11.50     11.50     11.50     11.50       .80       .80
NS     1.0       .80       .80       .20     45.80     46.70     46.70
NS     1.0     46.70     56.80     56.80     56.80     57.70     57.70
NS     1.0     57.70     57.70     56.60     56.60     56.60     56.80
NS     1.0     56.80     56.50     56.50     56.50     56.70     56.70
NS     1.0     54.60     54.60       .20       .20       .20       .20
NS     1.0       .80       .80       .80
CAL1   1.0     98.66    231.00
VEL1   1.0                -.02  .03  .38  .95  .78  .44  .43
VEL1   1.0       .45 1.59 2.54 3.21 3.96 3.92 4.05 3.66 3.53 3.65 2.99
VEL1   1.0 2.11 3.64 3.23 2.66 2.90 2.15 1.33 1.35 1.44 1.10  .66
VEL1   1.0                      .15  .35
CAL2   1.0     98.16    107.80
VEL2   1.0                      .05  .14  .47
VEL2   1.0           1.04 2.06 2.52 2.87 2.74 3.02 2.58 2.68 2.84 2.34
VEL2   1.0 2.41 2.43 1.99 1.79  .59  .52  .74  .49
VEL2   1.0                      .05  .05
CAL3   1.0     97.88     66.70
VEL3   1.0
```

```
VEL3  1.0             .76 1.43 1.85 2.22 2.40 2.34 2.01 2.25 1.95 1.67
VEL3  1.0 1.95 1.53 1.16  .61  .99  .33
VEL3  1.0
XSEC  2.0      88.0  .50      96.13     .00250
      2.0  1.7103.4  5.798.44  6.097.18  7.095.68  9.095.98 11.095.83
      2.0 13.095.48 15.095.18 17.094.88 18.095.08 19.095.23 20.095.38
      2.0 22.095.64 24.095.98 26.096.38 28.096.48 30.096.78 32.096.78
      2.0 34.097.28 36.097.38 38.097.68 40.097.68 42.097.93 44.098.13
      2.0 46.098.23 48.097.94 50.098.14 52.098.24 54.098.34 56.898.44
      2.0 60.0100.4 90.0100.4 94.498.44 96.098.04 98.098.04102.198.44
      2.0112.0103.4
NS    2.0       .80       .10     15.80     15.80     15.80     15.80
NS    2.0       .50     25.50     25.50     25.50     25.50     25.50
NS    2.0     25.50     24.80     25.50     25.50     25.50     25.50
NS    2.0     42.70     42.70     42.80     42.80     42.80     42.80
NS    2.0     42.80     42.80     42.80     42.80     42.80     42.80
NS    2.0     42.80     42.80     23.50     23.50     23.50     23.90
NS    2.0       .80
CAL1  2.0     98.44    231.00
VEL1  2.0             .09 1.50 1.57 1.69 1.23 1.90 3.41 3.48 3.73 3.48
VEL1  2.0 3.14 3.32 3.41 3.32 2.89 2.79 2.72 2.45 2.10 1.74 1.52 1.11
VEL1  2.0 1.06  .61  .44  .20  .05                      .05
VEL1  2.0
CAL2  2.0     98.28    107.80
VEL2  2.0             .05 1.03 1.17  .71  .91 1.09 2.23 2.34 2.28 2.14
VEL2  2.0 1.79 1.85 2.20 1.89 1.76 1.60 1.36 1.23 1.03  .75  .62  .29
VEL2  2.0 0.00
VEL2  2.0
CAL3  2.0     97.98     66.70
VEL3  2.0                  .73  .84  .50  .41  .73 1.54 1.43 1.68 1.58
VEL3  2.0 1.34 1.25 1.44 1.36 1.21 1.00  .79  .74  .60  .25 0.00
VEL3  2.0
VEL3  2.0
XSEC  3.0      57.0  .50      96.13     .00250
      3.0  0.0104.0  4.099.02  6.098.32  8.097.83 10.097.73 12.0 97.9
      3.0 14.097.03 16.096.73 18.096.03 20.095.43 22.095.33 24.095.53
      3.0 26.095.73 28.095.93 30.096.03 32.096.23 34.096.28 36.096.53
      3.0 38.096.73 40.096.93 42.097.13 44.097.23 48.097.43 52.097.63
      3.0 56.097.93 60.0 98.1 64.098.25 68.098.42 72.098.52 76.098.52
      3.0 80.098.42 84.098.52 87.099.02121.0104.0
NS    3.0       .80       .80       .20       .20       .20       .50
NS    3.0       .50     71.70     71.50     71.50     17.90     31.70
NS    3.0     31.70     31.70     31.70     23.80     23.80     42.60
NS    3.0     42.80     42.80     42.80     42.80     42.80     45.80
NS    3.0     45.80     45.80     45.80     54.60     54.60     34.80
NS    3.0       .30       .80       .80       .80
CAL1  3.0     99.02    231.00
VEL1  3.0                  .34  .34  .46  .28  .65 1.05 1.32 1.42 2.04
VEL1  3.0 1.74 2.05 2.55 2.61 2.84 2.69 2.62 2.62 2.79 2.70 2.68 2.39
VEL1  3.0 2.15 1.73 1.50 1.29 1.03 1.07  .44  .03
CAL2  3.0     98.35    107.80
VEL2  3.0                  .13  .12            .34  .77 1.04 1.16 1.23
VEL2  3.0 1.51 1.66 1.88 1.91 1.84 1.72 1.70 1.86 1.62 1.78 1.62 1.28
VEL2  3.0  .93  .64 0.00
CAL3  3.0     98.03     66.70
VEL3  3.0                                      .24  .77  .89  .96 1.13
VEL3  3.0 1.19 1.21 1.34 1.19 1.29 1.35 1.22 1.19 1.16 1.20  .98  .48
VEL3  3.0 0.00
XSEC  4.0     105.0 .50      96.13     .00250
      4.0  1.0104.0 11.299.03 14.098.33 16.098.18 18.098.63 19.899.03
      4.0 25.0100.0 31.099.03 32.098.73 34.097.76 35.097.46 36.096.86
      4.0 38.096.76 40.096.16 42.095.86 44.095.76 46.095.76 48.095.76
      4.0 50.095.66 52.095.66 54.095.56 56.095.46 58.095.36 60.095.26
      4.0 62.095.26 64.095.21 66.095.36 68.095.66 70.095.86 72.095.86
      4.0 74.097.06 76.097.16 78.098.18 80.097.26 82.097.93 82.199.03
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        4.0 84.2104.0
NS      4.0      .80      .80      .80      .80      .80    24.50
NS      4.0    42.80    42.80    42.80    42.80    42.80    42.80
NS      4.0    16.50    16.50    26.90    26.90    26.90    26.90
NS      4.0    26.90    26.90    26.90    26.90    42.60    42.60
NS      4.0    42.60    22.50    22.50    22.50    22.50    22.50
NS      4.0      .50      .50      .50      .50      .80      .80
NS      4.0      .80
CAL1    4.0    99.03   231.00
VEL1    4.0              -.01                         .03  .36  .69
VEL1    4.0 1.20 1.50 1.71 2.07 1.89 2.45 2.27 2.77 2.81 2.77 2.12 2.47
VEL1    4.0 2.08 1.72  .67  .43  .12  .12  .21 -.10 -.09 -.16 -.05
VEL1    4.0
CAL2    4.0    98.38   107.80
VEL2    4.0              0.00                        0.00  .14  .09
VEL2    4.0  .47  .70  .78 1.21 1.36 1.41 1.44 1.52 1.62 1.54 1.42 1.28
VEL2    4.0 1.48 1.29  .39  .44  .06 -.16 -.17 -.30 -.28 -.05
VEL2    4.0
CAL3    4.0    98.06    66.70
VEL3    4.0                                          0.00 -.28 -.25
VEL3    4.0 -.15  .17  .40  .65  .94  .99 1.20 1.05  .98 1.23 1.20 1.10
VEL3    4.0 1.10  .92  .51  .18  .16 -.05 -.05 -.13      0.00
VEL3    4.0
XSEC    5.0     91.0 .50     96.30     .00250
        5.0 21.0104.1 31.099.06 35.0 97.6 40.0 97.3 42.5 97.2 45.0 97.0
        5.0 47.5 96.9 50.0 96.6 52.5 96.5 55.0 96.3 57.5 96.3 60.0 96.4
        5.0 62.5 96.4 65.0 96.5 67.5 96.6 70.0 96.7 72.5 96.8 75.0 97.2
        5.0 77.597.92 80.098.32 82.598.76 83.599.06 93.3104.1
NS      5.0    56.80    56.80    56.80    56.80    56.80    56.80
NS      5.0    56.60    56.60    56.60    56.60    56.60    45.80
NS      5.0    45.80    45.90    65.70    65.70    65.70    65.70
NS      5.0    22.50    22.50      .80      .80      .80
CAL1    5.0    99.06   231.00
VEL1    5.0            .57 1.09 1.97 2.50 2.78 3.36 3.67 3.50 3.58 3.76
VEL1    5.0 3.19 2.62 1.95 1.76  .81  .75  .27  .12 0.00
CAL2    5.0    98.42   107.80
VEL2    5.0            .10  .86 1.27 1.31 1.75 2.11 2.15 2.23 1.83 2.13
VEL2    5.0 1.88 1.71 1.40 1.21  .90  .53  .39 0.00
CAL3    5.0    98.10    66.70
VEL3    5.0            .34  .49  .80  .90 1.00 1.31 1.53 1.67 1.62 1.76
VEL3    5.0 1.59 1.68 1.28 1.08  .27  .52
XSEC    6.0     73.0 .50     96.30     .00250
        6.0 55.0104.1 65.099.12 67.598.52 70.097.92 72.597.42 75.097.32
        6.0 76.097.12 77.097.02 78.096.82 80.096.72 82.095.62 85.095.42
        6.0 87.595.42 90.095.62 92.595.62 95.095.82 97.595.92100.396.52
        6.0102.097.02103.598.12107.099.12119.5104.1
NS      6.0      .40    56.60    56.60    56.60    56.50    56.50
NS      6.0    67.50    67.50    65.60    65.60    65.60    65.60
NS      6.0    65.60    42.50    42.50    42.50    42.50    42.50
NS      6.0    42.50      .50    22.50      .80
CAL1    6.0    99.12   231.00
VEL1    6.0            .80 2.46 2.99 3.73 3.59 3.95 4.52 4.77 3.76 3.70
VEL1    6.0 4.09 2.59 1.55 1.32  .18  .23  .07 0.00
CAL2    6.0    98.43   107.80
VEL2    6.0                 .63 1.90 2.75 2.34 2.13 2.40 2.97 2.33 1.81
VEL2    6.0 2.32 1.74 1.12  .32 0.00 -.10 0.00 0.00
CAL3    6.0    98.11    66.70
VEL3    6.0                0.00 1.31 1.27 1.62 1.86 1.82 2.32 1.87 1.39
VEL3    6.0 1.95 1.41  .95  .10 0.00 0.00 0.00
XSEC    7.0     72.0 .50     99.64     .00250
        7.0  0.0106.2  8.0101.2 12.5101.1 15.0101.1 17.5100.8 20.0100.4
        7.0 22.5100.6 25.0100.3 27.5100.0 30.0100.0 32.5100.1 35.099.74
        7.0 37.5100.0 40.099.64 42.599.74 45.099.74 47.599.74 50.099.64
        7.0 52.599.64 55.099.64 57.599.94 60.0100.1 62.5100.3 65.0100.4
        7.0 67.5100.4 70.0100.6 72.5100.9 75.0100.7 77.5100.7 80.0100.9
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         7.0 82.0100.9 85.0100.9 87.5101.0 90.0100.7 92.5100.5 95.0100.6
         7.0 97.5100.6 99.0101.2103.4106.2
NS       7.0       .80     46.80     56.60     56.60     56.60       .50
NS       7.0     65.80     65.80     65.80     56.70     65.70     67.60
NS       7.0     67.60     67.60     65.70     65.70     65.70     56.50
NS       7.0     56.50     56.50     56.50     56.50     56.50     56.60
NS       7.0     56.60     56.60     56.60     56.60     46.60     46.60
NS       7.0     46.60     46.60     46.60       .20       .20       .20
NS       7.0       .80       .80       .80
CAL1     7.0    101.19    231.00
VEL1     7.0                .57 1.33  .54 2.03 2.45 1.64 3.54 3.86 3.16 3.30
VEL1     7.0 4.99 4.47 3.60 5.02 4.14 4.98 4.77 3.74 3.96 3.32 3.67 2.49
VEL1     7.0 2.41 3.11 2.14 2.04 2.04 2.58 2.02 1.87  .45 1.47 2.03 2.63
VEL1     7.0  .48
CAL2     7.0    100.81    107.80
VEL2     7.0                               .87 1.44 2.53 1.77 3.28 2.43 1.49
VEL2     7.0 3.80 3.56 2.88 3.76 3.15 3.74 3.73 3.17 2.60 2.35 1.68 1.14
VEL2     7.0 1.35 1.25       .76 0.00                     0.00  .94 1.59
VEL2     7.0  .40
CAL3     7.0    100.64     66.70
VEL3     7.0                                    0.00  .20 1.27 2.18  .60 1.90
VEL3     7.0 3.29 2.82 2.39 3.18 2.71 3.26 3.52 3.07 2.49 2.10  .94  .94
VEL3     7.0  .46                                                0.00 0.00
VEL3     7.0 0.00
XSEC     8.0      63.0 .50      99.64      .00250
         8.0 23.0106.5 33.8101.5 35.0101.4 37.5100.7 40.099.89 42.599.29
         8.0 45.098.89 47.599.19 50.099.09 52.599.29 55.099.59 57.599.79
         8.0 60.099.99 62.5100.2 65.0100.3 67.5100.5 70.0100.7 72.5100.8
         8.0 75.0101.0 77.5101.0 80.0101.2 82.5101.3 85.0101.3 87.5101.2
         8.0 90.0101.3 92.5101.3 95.0101.3 97.5100.9100.0100.7102.5100.7
         8.0105.0100.9107.5100.9109.8101.5110.8106.5
NS       8.0     42.50     46.60     46.60     46.60     46.60     46.60
NS       8.0     46.60     46.60     46.60     46.60     42.50     42.50
NS       8.0     32.50     32.50     32.50     32.50     32.50     32.50
NS       8.0     42.70     42.70     42.70     42.70     42.70     42.70
NS       8.0     42.70     42.70     42.70     42.70     42.70     42.70
NS       8.0     22.50     22.50       .80       .80
CAL1     8.0    101.53    231.00
VEL1     8.0                .89 2.60 3.87 3.97 4.02 3.70 3.76 3.70 3.89 3.86
VEL1     8.0 3.50 3.23 2.54 2.18 1.82 1.49 1.26 1.42 1.05  .97  .68  .78
VEL1     8.0  .45  .61  .56 1.05 1.86 1.61 1.16  .40
CAL2     8.0    101.06    107.80
VEL2     8.0                    2.56 3.30 2.97 3.25 2.94 2.48 2.56 2.25 2.60
VEL2     8.0 1.85 1.60 1.23  .73  .82  .47  .30 0.00
VEL2     8.0                0.00  .68  .93  .69
CAL3     8.0    100.89     66.70
VEL3     8.0                     .72 2.28 2.32 2.47 2.22 1.88 2.04 1.96 1.72
VEL3     8.0 1.34 1.11  .77  .49  .36 0.00
VEL3     8.0                     0.00 0.00
ENDJ
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Appendix D2. Summary of Calibration Details

Big Quilcene River
Calibration Information for Calculated Discharges

Transect Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Discharge	233.87 114.83 68.16	200.23 109.98 63.50	236.79 103.56 61.27	214.69 100.50 63.01	233.70 15.54 66.22	244.66 103.04 67.60	249.85 115.55 74.47	231.29 109.53 70.33
Stage	98.66 98.16 97.88	98.44 98.28 97.98	99.02 98.35 98.03	99.03 98.38 98.06	99.06 98.42 98.10	99.12 98.43 98.11	101.19 100.81 100.64	101.53 101.06 100.89
Plotting Stage	2.53 2.03 1.75	2.31 2.15 1.85	2.89 2.22 1.90	2.90 2.50 1.93	2.76 2.12 1.80	2.82 2.13 1.81	1.55 1.17 1.00	1.89 1.42 1.25
Ratio of Measured vs. Predicted Discharge								
	0.99 1.02 0.99	1.10 0.86 1.05	0.99 1.02 0.99	1.00 1.00 1.00	1.00 0.99 1.01	1.01 0.97 1.02	1.00 1.00 1.00	0.99 1.05 0.97
Mean Error of Stage/Discharge Relationship for Calculated Q								
	1.10	9.91	1.01	0.22	0.73	2.21	0.25	3.20
Mean Error of Stage/Discharge Relationship for Given Q								
	1.01	15.87	0.83	0.53	0.20	1.04	1.51	4.08
Stage/Discharge Relationship (S vs. Q) S=A*QB+SZF**								
A=	0.4922	0.8061	0.5265	0.4866	0.4368	0.4307	0.2096	0.2756
B=	0.2997	0.2024	0.3111	0.3324	0.3383	0.3424	0.3624	0.3527
SZF=	96.13	96.13	96.13	96.13	96.30	96.30	99.64	99.64
Beta Coefficient Log/Log Discharge/Stage Relationship								
	3.38	5.23	2.95	3.05	2.96	2.79	2.82	2.95

Appendix D3. Summary of Data Changes

Data changes for calibration

Transect	Vertical	Vel	Changed Velocity from
1	28	1	2.86 to 2.66
1	32	1	1.55 to 1.35
1	42	1	0.55 to 0.35
1	32	2	0.29 to 0.49
1	30	3	0.13 to 0.33
2	23	3	0.10 to 0.00
3	27	2	0.05 to 0.00
3	25	3	0.20 to 0.00
6	4	1	2.66 to 2.46
6	4	2	0.43 to 0.63
7	7	1	2.65 to 2.45
7	11	1	3.36 to 3.16
7	29	2	0.10 to 0.00
7	7	3	0.20 to 0.00
7	8	3	0.00 to 0.20
7	11	3	0.40 to 0.60
7	23	3	0.74 to 0.94
7	35	3	0.10 to 0.00
7	36	3	0.20 to 0.00
8	4	1	2.80 to 2.60
8	19	1	1.46 to 1.26
8	19	2	0.10 to 0.30
8	4	3	0.52 to 0.72
8	29	3	0.08 to 0.00
8	30	3	0.05 to 0.00

Appendix D4. Velocity Adjustment Factors

Big Quilcene River RM 1.4 measured by Brad Caldwell for Ecology

at 231 cfs on 5-1-87, at 108 cfs on 6-2-87, and at 67 cfs on 7-9-87.

1.00	575.0	0.891
1.00	540.0	0.901
1.00	500.0	0.913
1.00	460.0	0.925
1.00	440.0	0.931
1.00	420.0	0.937
1.00	400.0	0.943
1.00	380.0	0.949
1.00	360.0	0.956
1.00	320.0	0.969
1.00	280.0	0.983
1.00	240.0	0.996
1.00	200.0	1.008
1.00	190.0	1.010
1.00	180.0	1.012
1.00	170.0	1.013
1.00	160.0	1.014
1.00	150.0	1.015
1.00	140.0	1.015
1.00	130.0	1.014
1.00	120.0	1.013
1.00	110.0	1.011
1.00	100.0	1.008
1.00	90.0	1.005
1.00	80.0	1.000
1.00	70.0	0.994
1.00	60.0	0.987
1.00	50.0	0.978
1.00	40.0	0.966
1.00	25.0	0.938
2.00	575.0	0.907
2.00	540.0	0.914
2.00	500.0	0.923
2.00	460.0	0.932
2.00	440.0	0.937
2.00	420.0	0.941
2.00	400.0	0.946
2.00	380.0	0.950
2.00	360.0	0.955
2.00	320.0	0.964
2.00	280.0	0.973
2.00	240.0	0.983
2.00	200.0	0.992
2.00	190.0	0.994
2.00	180.0	0.996
2.00	170.0	0.998
2.00	160.0	1.000
2.00	150.0	1.002
2.00	140.0	1.004
2.00	130.0	1.006
2.00	120.0	1.007
2.00	110.0	1.008
2.00	100.0	1.008
2.00	90.0	1.007

2.00	80.0	1.006
2.00	70.0	1.004
2.00	60.0	1.000
2.00	50.0	0.995
2.00	40.0	0.986
2.00	25.0	0.964
3.00	575.0	0.887
3.00	540.0	0.894
3.00	500.0	0.903
3.00	460.0	0.913
3.00	440.0	0.918
3.00	420.0	0.923
3.00	400.0	0.929
3.00	380.0	0.934
3.00	360.0	0.940
3.00	320.0	0.953
3.00	280.0	0.967
3.00	240.0	0.983
3.00	200.0	1.001
3.00	190.0	1.005
3.00	180.0	1.010
3.00	170.0	1.014
3.00	160.0	1.018
3.00	150.0	1.022
3.00	140.0	1.024
3.00	130.0	1.025
3.00	120.0	1.024
3.00	110.0	1.021
3.00	100.0	1.015
3.00	90.0	1.007
3.00	80.0	0.996
3.00	70.0	0.981
3.00	60.0	0.961
3.00	50.0	0.934
3.00	40.0	0.895
3.00	25.0	0.807
4.00	575.0	0.930
4.00	540.0	0.937
4.00	500.0	0.945
4.00	460.0	0.953
4.00	440.0	0.956
4.00	420.0	0.960
4.00	400.0	0.964
4.00	380.0	0.968
4.00	360.0	0.971
4.00	320.0	0.979
4.00	280.0	0.986
4.00	240.0	0.992
4.00	200.0	0.998
4.00	190.0	0.999
4.00	180.0	1.001
4.00	170.0	1.002
4.00	160.0	1.003
4.00	150.0	1.004
4.00	140.0	1.005
4.00	130.0	1.006
4.00	120.0	1.007
4.00	110.0	1.008
4.00	100.0	1.009
4.00	90.0	1.010
4.00	80.0	1.006
4.00	70.0	1.007
4.00	60.0	1.008
4.00	50.0	1.010
4.00	40.0	1.014

4.00	25.0	1.026
5.00	575.0	0.994
5.00	540.0	0.995
5.00	500.0	0.996
5.00	460.0	0.996
5.00	440.0	0.997
5.00	420.0	0.997
5.00	400.0	0.997
5.00	380.0	0.998
5.00	360.0	0.998
5.00	320.0	0.999
5.00	280.0	1.000
5.00	240.0	1.001
5.00	200.0	1.001
5.00	190.0	1.002
5.00	180.0	1.002
5.00	170.0	1.002
5.00	160.0	1.002
5.00	150.0	1.002
5.00	140.0	1.002
5.00	130.0	1.002
5.00	120.0	1.002
5.00	110.0	1.002
5.00	100.0	1.002
5.00	90.0	1.003
5.00	80.0	1.003
5.00	70.0	1.004
5.00	60.0	1.004
5.00	50.0	1.006
5.00	40.0	1.013
5.00	25.0	1.022
6.00	575.0	0.865
6.00	540.0	0.879
6.00	500.0	0.894
6.00	460.0	0.910
6.00	440.0	0.917
6.00	420.0	0.925
6.00	400.0	0.933
6.00	380.0	0.940
6.00	360.0	0.948
6.00	320.0	0.963
6.00	280.0	0.976
6.00	240.0	0.989
6.00	200.0	1.000
6.00	190.0	1.002
6.00	180.0	1.004
6.00	170.0	1.005
6.00	160.0	1.007
6.00	150.0	1.008
6.00	140.0	1.009
6.00	130.0	1.009
6.00	120.0	1.009
6.00	110.0	1.008
6.00	100.0	1.006
6.00	90.0	1.003
6.00	80.0	1.000
6.00	70.0	0.995
6.00	60.0	0.989
6.00	50.0	0.981
6.00	40.0	0.971
6.00	25.0	0.945
7.00	575.0	0.840
7.00	540.0	0.852
7.00	500.0	0.866
7.00	460.0	0.880

7.00	440.0	0.888
7.00	420.0	0.896
7.00	400.0	0.904
7.00	380.0	0.913
7.00	360.0	0.922
7.00	320.0	0.941
7.00	280.0	0.962
7.00	240.0	0.984
7.00	200.0	1.006
7.00	190.0	1.011
7.00	180.0	1.015
7.00	170.0	1.020
7.00	160.0	1.024
7.00	150.0	1.027
7.00	140.0	1.029
7.00	130.0	1.031
7.00	120.0	1.029
7.00	110.0	1.026
7.00	100.0	1.022
7.00	90.0	1.015
7.00	80.0	1.006
7.00	70.0	0.993
7.00	60.0	0.983
7.00	50.0	0.957
7.00	40.0	0.923
7.00	25.0	0.850
8.00	575.0	0.853
8.00	540.0	0.865
8.00	500.0	0.879
8.00	460.0	0.893
8.00	440.0	0.901
8.00	420.0	0.909
8.00	400.0	0.917
8.00	380.0	0.925
8.00	360.0	0.934
8.00	320.0	0.952
8.00	280.0	0.970
8.00	240.0	0.990
8.00	200.0	1.009
8.00	190.0	1.014
8.00	180.0	1.018
8.00	170.0	1.021
8.00	160.0	1.024
8.00	150.0	1.025
8.00	140.0	1.025
8.00	130.0	1.024
8.00	120.0	1.023
8.00	110.0	1.020
8.00	100.0	1.015
8.00	90.0	1.009
8.00	80.0	1.000
8.00	70.0	0.989
8.00	60.0	0.971
8.00	50.0	0.948
8.00	40.0	0.922
8.00	25.0	0.843

Appendix E. Fish Habitat Preference Curves

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Fishcrv for Big Quilcene approved by Hal Beecher 12-3-98
H     101   9   7 75   0 Chinook                                           Spawning
V     101   0.00   0.00   0.50   0.00   1.00   0.10   1.30   0.70   1.75   1.00   3.00   1.00
V     101   3.50   0.70   4.00   0.00  99.90   0.00
D     101   0.00   0.00   0.50   0.00   1.00   0.75   1.20   1.00   3.40   1.00   5.00   0.00
D     101  99.90   0.00
S     101   0.10   0.00  12.50   0.00  14.80   0.20  15.50   0.50  15.80   0.20  16.50   0.50
S     101  17.50   0.15  17.90   0.03  18.50   0.00  22.90   0.00  23.50   0.15  23.90   0.03
S     101  24.50   0.50  24.80   0.20  25.50   0.50  25.60   0.40  26.50   0.50  26.90   0.10
S     101  27.50   0.15  27.80   0.06  28.60   0.00  29.50   0.00  31.70   0.21  34.80   0.44
S     101  42.50   0.50  42.80   0.80  43.50   0.65  45.50   1.00  46.80   1.00  48.50   0.50
S     101  51.50   0.50  51.80   0.80  52.50   0.50  52.80   0.80  54.50   1.00  56.80   1.00
S     101  57.50   0.65  57.80   0.86  58.50   0.50  58.60   0.60  61.50   0.50  61.90   0.90
S     101  62.50   0.50  62.90   0.90  64.60   1.00  65.90   1.00  67.50   0.65  67.90   0.93
S     101  68.50   0.50  68.80   0.80  71.50   0.15  71.80   0.24  72.50   0.15  72.90   0.27
S     101  74.50   0.65  74.90   0.37  75.50   0.65  75.90   0.37  76.50   0.65  76.90   0.37
S     101  78.50   0.15  78.80   0.24  81.50   0.00  82.70   0.00  83.80   0.06  84.80   0.20
S     101  84.90   0.10  85.50   0.50  85.90   0.10  86.50   0.50  86.90   0.10  87.50   0.15
S     101  87.90   0.03  88.50   0.00  99.90   0.00
H     102  12   8 87   0 Chinook                                           Juvenile
V     102   0.00   0.09   0.20   0.20   0.30   0.26   0.40   0.93   0.60   1.00   1.10   0.90
V     102   1.30   0.75   2.00   0.50   2.20   0.08   2.70   0.03   3.60   0.00  99.00   0.00
D     102   0.00   0.00   0.40   0.00   0.50   0.05   1.00   0.33   1.20   0.50   1.50   0.80
D     102   2.20   1.00  99.00   1.00
S     102   0.10   1.00   0.40   1.00   0.50   0.80   0.80   0.10  12.50   0.10  14.80   0.14
S     102  15.50   0.20  15.80   0.14  16.50   0.30  17.50   0.40  17.90   0.16  18.50   0.55
S     102  18.70   0.37  22.50   0.10  23.90   0.10  24.50   0.20  24.80   0.14  25.50   0.20
S     102  25.60   0.18  26.50   0.30  26.90   0.14  27.50   0.40  27.80   0.22  28.60   0.46
S     102  29.50   0.20  31.70   0.10  34.80   0.14  42.50   0.20  42.80   0.26  43.50   0.20
S     102  45.50   0.30  45.90   0.30  46.60   0.38  46.80   0.34  48.50   0.65  51.50   0.20
S     102  51.80   0.26  52.50   0.20  52.80   0.26  54.50   0.30  54.80   0.30  56.50   0.40
S     102  56.80   0.34  57.50   0.50  57.80   0.38  58.50   0.65  58.60   0.58  61.50   0.30
S     102  61.90   0.46  62.50   0.30  62.90   0.46  64.60   0.42  64.90   0.48  65.50   0.40
S     102  65.90   0.48  67.50   0.60  67.90   0.52  68.50   0.75  68.80   0.60  71.50   0.40
S     102  71.80   0.58  72.50   0.40  72.90   0.64  74.50   0.50  74.90   0.66  75.50   0.50
S     102  75.90   0.66  76.50   0.60  76.90   0.68  78.50   0.85  78.80   0.76  81.50   0.55
S     102  81.90   0.91  82.50   0.55  82.70   0.73  83.80   0.82  84.80   0.86  84.90   0.93
S     102  85.50   0.65  85.90   0.93  86.50   0.75  86.90   0.95  87.50   0.85  87.90   0.97
S     102  88.50   1.00  88.90   1.00  99.90   0.30
H     201  11   9 75   0 Steelhead                                         Spawning
V     201   0.00   0.00   1.10   0.45   2.10   0.97   2.90   1.00   3.20   1.00   3.30   0.62
V     201   3.60   0.40   4.00   0.20   4.50   0.10   5.00   0.00  99.00   0.00
D     201   0.00   0.00   0.60   0.00   0.70   0.50   1.00   1.00   1.50   1.00   1.60   0.75
D     201   2.20   0.60   2.40   0.50  99.00   0.50
S     201   0.10   0.00  12.50   0.00  14.80   0.20  15.50   0.50  15.80   0.80  16.50   0.50
S     201  17.50   0.15  17.90   0.03  18.50   0.00  22.90   0.00  23.50   0.25  23.90   0.05
S     201  24.50   0.50  24.80   0.20  25.50   0.50  25.60   0.40  26.50   0.50  26.90   0.10
S     201  27.50   0.15  27.80   0.06  28.60   0.00  29.50   0.00  31.70   0.35  34.80   0.60
S     201  42.50   0.50  42.80   0.80  43.50   0.75  45.50   1.00  46.80   1.00  48.50   0.50
S     201  51.50   0.50  51.80   0.80  52.50   0.50  52.80   0.80  54.50   1.00  56.80   1.00
S     201  57.50   0.65  57.80   0.86  58.50   0.50  58.60   0.60  61.50   0.50  61.90   0.90
S     201  62.50   0.50  62.90   0.90  64.60   1.00  65.90   1.00  67.50   0.65  67.90   0.93
S     201  68.50   0.50  68.80   0.80  71.50   0.15  71.80   0.24  72.50   0.15  72.90   0.27
S     201  74.50   0.65  74.90   0.37  75.50   0.65  75.90   0.37  76.50   0.65  76.90   0.37
S     201  78.50   0.15  78.80   0.24  81.50   0.00  82.70   0.00  83.80   0.10  84.80   0.20
S     201  84.90   0.10  85.50   0.50  85.90   0.10  86.50   0.50  86.90   0.10  87.50   0.15
S     201  87.90   0.03  88.50   0.00  99.90   0.00
H     202  13  14 87   0 Steelhead                                         Juvenile
V     202   0.00   0.23   0.20   0.30   0.50   0.50   0.90   0.80   1.30   1.00   1.50   0.97
V     202   2.40   0.80   3.00   0.35   3.60   0.22   3.70   0.19   5.00   0.16   6.00   0.00
```

V	202	99.00	0.00										
D	202	0.00	0.00	0.50	0.03	0.70	0.07	0.90	0.11	1.10	0.25	1.60	0.35
D	202	1.90	0.40	2.10	0.65	2.20	0.85	2.50	0.90	2.60	1.00	3.40	0.86
D	202	4.50	0.64	99.00	0.64								
S	202	0.10	1.00	0.40	1.00	0.50	0.80	0.80	0.10	12.50	0.10	14.80	0.14
S	202	15.50	0.20	15.80	0.14	16.50	0.30	17.50	0.40	17.90	0.16	18.50	0.55
S	202	18.70	0.37	22.50	0.10	23.90	0.10	24.50	0.20	24.80	0.14	25.50	0.20
S	202	25.60	0.18	26.50	0.30	26.90	0.14	27.50	0.40	27.80	0.22	28.60	0.46
S	202	29.50	0.20	31.70	0.10	34.80	0.14	42.50	0.20	42.80	0.26	43.50	0.20
S	202	45.50	0.30	45.90	0.30	46.60	0.38	46.80	0.34	48.50	0.65	51.50	0.20
S	202	51.80	0.26	52.50	0.20	52.80	0.26	54.50	0.30	54.80	0.30	56.50	0.40
S	202	56.80	0.34	57.50	0.50	57.80	0.38	58.50	0.65	58.60	0.58	61.50	0.30
S	202	61.90	0.46	62.50	0.30	62.90	0.46	64.60	0.42	64.90	0.48	65.50	0.40
S	202	65.90	0.48	67.50	0.60	67.90	0.52	68.50	0.75	68.80	0.60	71.50	0.40
S	202	71.80	0.58	72.50	0.40	72.90	0.64	74.50	0.50	74.90	0.66	75.50	0.50
S	202	75.90	0.66	76.50	0.60	76.90	0.68	78.50	0.85	78.80	0.76	81.50	0.55
S	202	81.90	0.91	82.50	0.55	82.70	0.73	83.80	0.82	84.80	0.86	84.90	0.93
S	202	85.50	0.65	85.90	0.93	86.50	0.75	86.90	0.95	87.50	0.85	87.90	0.97
S	202	88.50	1.00	88.90	1.00	99.90	0.30						
H	301	13 11	75 0	Coho							Spawning		
V	301	0.00	0.00	0.20	0.00	0.25	0.40	0.40	0.59	0.75	0.80	1.00	0.92
V	301	1.10	0.98	1.20	1.00	2.00	1.00	2.25	0.42	3.40	0.16	4.20	0.00
V	301	99.00	0.00										
D	301	0.00	0.00	0.20	0.00	0.40	0.04	0.55	0.08	0.65	0.16	0.75	0.40
D	301	0.95	0.80	1.00	1.00	3.40	1.00	4.00	0.10	99.00	0.00		
S	301	0.10	0.00	12.50	0.00	14.80	0.20	15.50	0.50	15.80	0.20	16.50	0.50
S	301	17.50	0.15	17.90	0.03	18.50	0.00	22.90	0.00	23.50	0.15	23.90	0.03
S	301	24.50	0.50	24.80	0.20	25.50	0.50	25.60	0.40	26.50	0.50	26.90	0.10
S	301	27.50	0.15	27.80	0.06	28.60	0.00	29.50	0.00	31.70	0.21	34.80	0.44
S	301	42.50	0.50	42.80	0.80	43.50	0.65	45.50	1.00	46.80	1.00	48.50	0.50
S	301	51.50	0.50	51.80	0.80	52.50	0.50	52.80	0.80	54.50	1.00	56.80	1.00
S	301	57.50	0.65	57.80	0.86	58.50	0.50	58.60	0.60	61.50	0.50	61.90	0.90
S	301	62.50	0.50	62.90	0.90	64.60	1.00	65.90	1.00	67.50	0.65	67.90	0.93
S	301	68.50	0.50	68.80	0.80	71.50	0.15	71.80	0.24	72.50	0.15	72.90	0.27
S	301	74.50	0.65	74.90	0.37	75.50	0.65	75.90	0.37	76.50	0.65	76.90	0.37
S	301	78.50	0.15	78.80	0.24	81.50	0.00	82.70	0.00	83.80	0.06	84.80	0.20
S	301	84.90	0.10	85.50	0.50	85.90	0.10	86.50	0.50	86.90	0.10	87.50	0.15
S	301	87.90	0.03	88.50	0.00	99.90	0.00						
H	401	12 8	75 0	Chum							Spawning		
V	401	0.00	0.09	0.20	0.10	0.40	0.20	0.80	0.40	1.90	1.00	2.20	1.00
V	401	2.70	0.80	3.20	0.70	3.50	0.35	3.70	0.10	5.00	0.00	99.00	0.00
D	401	0.00	0.00	0.40	0.17	0.70	1.00	1.50	1.00	1.80	0.44	2.50	0.23
D	401	5.00	0.00	99.00	0.00								
S	401	0.10	0.00	12.50	0.00	14.80	0.20	15.50	0.50	15.80	0.20	16.50	0.50
S	401	17.50	0.15	17.90	0.03	18.50	0.00	22.90	0.00	23.50	0.15	23.90	0.03
S	401	24.50	0.50	24.80	0.20	25.50	0.50	25.60	0.40	26.50	0.50	26.90	0.10
S	401	27.50	0.15	27.80	0.06	28.60	0.00	29.50	0.00	31.70	0.21	34.80	0.44
S	401	42.50	0.50	42.80	0.80	43.50	0.65	45.50	1.00	46.80	1.00	48.50	0.50
S	401	51.50	0.50	51.80	0.80	52.50	0.50	52.80	0.80	54.50	1.00	56.80	1.00
S	401	57.50	0.65	57.80	0.86	58.50	0.50	58.60	0.60	61.50	0.50	61.90	0.90
S	401	62.50	0.50	62.90	0.90	64.60	1.00	65.90	1.00	67.50	0.65	67.90	0.93
S	401	68.50	0.50	68.80	0.80	71.50	0.15	71.80	0.24	72.50	0.15	72.90	0.27
S	401	74.50	0.65	74.90	0.37	75.50	0.65	75.90	0.37	76.50	0.65	76.90	0.37
S	401	78.50	0.15	78.80	0.24	81.50	0.00	82.70	0.00	83.80	0.06	84.80	0.20
S	401	84.90	0.10	85.50	0.50	85.90	0.10	86.50	0.50	86.90	0.10	87.50	0.15
S	401	87.90	0.03	88.50	0.00	99.90	0.00						
H	501	10 12	75 0	Pink							Spawning		
V	501	0.00	0.30	0.39	0.60	0.40	0.70	0.79	0.90	0.80	1.00	0.99	1.00
V	501	1.00	0.90	1.80	0.80	5.00	0.00	99.00	0.00				
D	501	0.00	0.00	0.49	0.80	0.50	1.00	0.69	1.00	0.70	1.00	0.99	0.80
D	501	1.00	0.79	1.20	0.60	1.30	0.30	2.10	0.05	5.00	0.01	99.00	0.00
S	501	0.10	0.00	12.50	0.00	14.80	0.20	15.50	0.50	15.80	0.20	16.50	0.50
S	501	17.50	0.15	17.90	0.03	18.50	0.00	22.90	0.00	23.50	0.15	23.90	0.03
S	501	24.50	0.50	24.80	0.20	25.50	0.50	25.60	0.40	26.50	0.50	26.90	0.10
S	501	27.50	0.15	27.80	0.06	28.60	0.00	29.50	0.00	31.70	0.21	34.80	0.44

S	501	42.50	0.50	42.80	0.80	43.50	0.65	45.50	1.00	46.80	1.00	48.50	0.50
S	501	51.50	0.50	51.80	0.80	52.50	0.50	52.80	0.80	54.50	1.00	56.80	1.00
S	501	57.50	0.65	57.80	0.86	58.50	0.50	58.60	0.60	61.50	0.50	61.90	0.90
S	501	62.50	0.50	62.90	0.90	64.60	1.00	65.90	1.00	67.50	0.65	67.90	0.93
S	501	68.50	0.50	68.80	0.80	71.50	0.15	71.80	0.24	72.50	0.15	72.90	0.27
S	501	74.50	0.65	74.90	0.37	75.50	0.65	75.90	0.37	76.50	0.65	76.90	0.37
S	501	78.50	0.15	78.80	0.24	81.50	0.00	82.70	0.00	83.80	0.06	84.80	0.20
S	501	84.90	0.10	85.50	0.50	85.90	0.10	86.50	0.50	86.90	0.10	87.50	0.15
S	501	87.90	0.03	88.50	0.00	99.90	0.00						

Appendix F. Substrate and Cover Codes

Instream Flow Studies Substrate and Cover Code Application
November 23, 1987

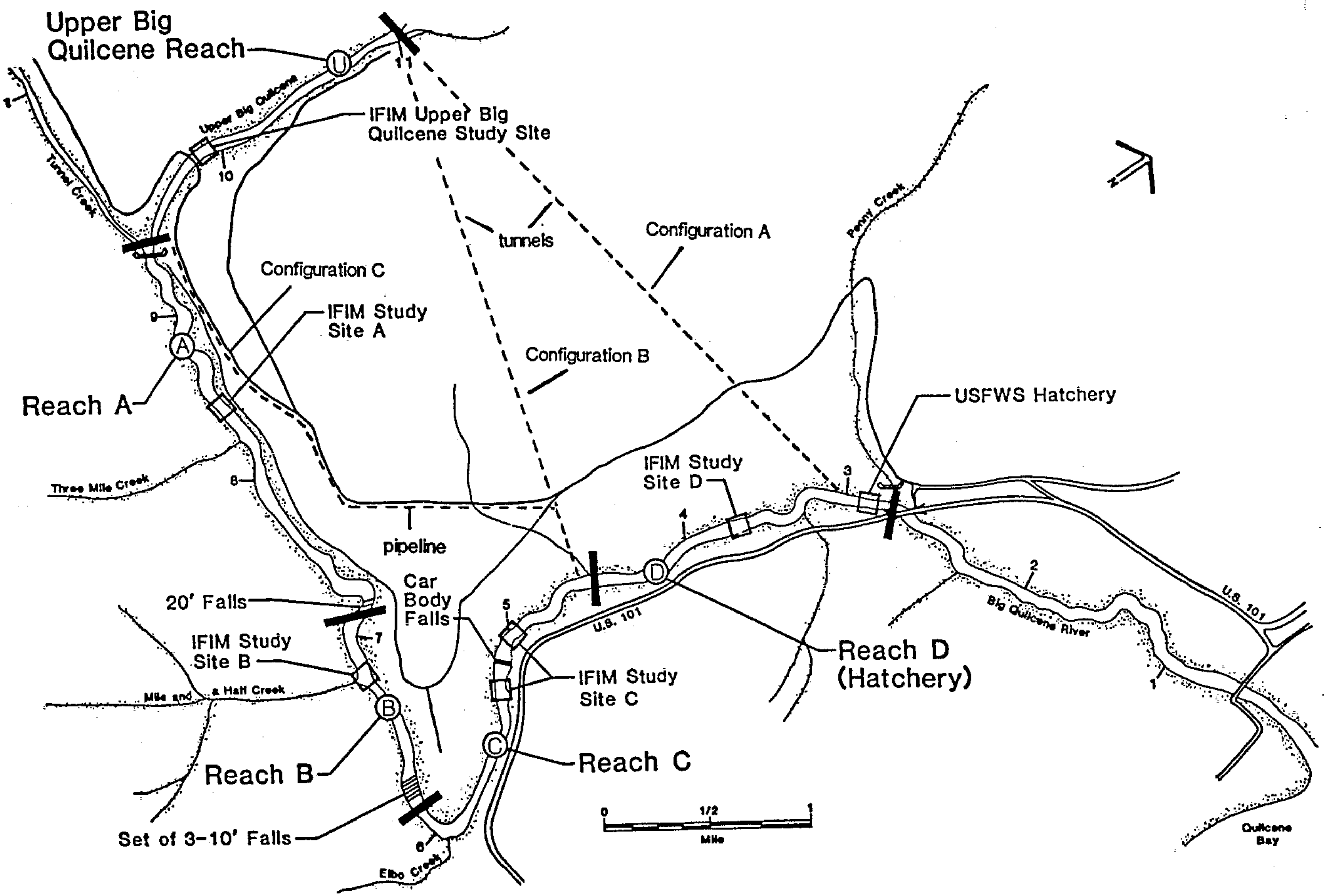
The three-digit code used describes the dominant substrate (the first number, the subdominant substrate (the second number), and the percent of only the dominant substrate (the third number). The percent of the sulxiominant substrate can be determined by subtraction. Dominant substrate is determined by the largest quantity of a certain substrate not the size of the substrate. The sum of the percent dominant and the percent sulxiominant will total 100 percent. The coding will not allow the dominant percent to be less than 50 percent, or greater than 90 percent. All other preference values are determined by using weighted averages. The value of the dominant substrate is multiplied by the percent of the dominant substrate, and the product is added to the product of the subdominant substrate times the percent of subdominant substrate. The sum of all the codes observed times their preference value will be a value between 0.0 and 1.0. The coding should also give a preference value of zero for the entire substrate observation when the code is class zero, one, or two, and is 50 percent or more of the observation. Where there is a situation where addition of two values could equal more than 1.0, the value will default to 1.0. Overhanging vegetation should be counted as cover if it is within 3 to 4 feet of the water surface. Cover values should be incorporated with the substrate values for both salmon and steelhead juvenile life stages and for Chinook and steelhead adult holding.

Life Stage and Value of Substrate

			Salmon			Steelhead and Trout			
						Spawning		Rearing/Holdi	
Code	**Substrate Size In Inches**		**Juvenile Rearing**	**Spawning**	**Adult Holding**	**Steelhead**	**Trout**	**Juvenile & Adult**	**Ste Ad**
0	Detritus		.1	0	.1	0	0	.1	.1
1	Silt, Clay		.1	0	.1	0	0	.1	.1
2	Sand		.1	0	.1	0	0	.1	.1
3	Small Gravel	.1-0.5	.1	.3	.1	.5	1	.1	.1
4	Medium Gravel	.5-1.5	.3	1	.3	1.0	1	.3	.3
5	Large Gravel.	1.5-3.0	.3	1	.3	1.0	1	.3	.3
6	Small Cobble	3.0-6.0	.5	1	.3	1.0	.5	.5	.3
7	Large Cobble	6.0-12.0	.7	.3*	.3	.3	.0	.7	.3
8	Boulder		1.0	0	1.0	0	0	1.0	1.0
9	Bedrock		.3	0	.3	0	0	.3	.3
0.1	Undercut Bank		1.0	0	1.0	0	0	1.0	1.0
0.2	Overhanging Vegetation		1.0	0	1.0	0	0	1.0	1.0
0.3	Root Wad		1.0	0	1.0	0	0	1.0	1.0
0.4	Log Jam		1.0	0	1.0	0	0	1.0	1.0
0.5	Log Instream		.8	0	.8	0	0	.8	.3
0.6	Submerged Vegetation		1.0	0	.8	0	0	1.0	.8
0.8	Grass/Bushes Up on Bank		.1	0	.1	0	0	.1	.1
0.9	Fine Organic Substrate		.1	0	.1	0	0	.1	.1

(*0.6 for chinook spawning can be used, depending on river size)

Appendix G Hosey and Associates IFIM Site Map



Big Quilcene Hydroelectric Project Configurations and study reaches