# Tucannon River
# Fish Habitat Analysis Using the
# Instream Flow Incremental Methodology

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Department of Ecology

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# Instream Flow Incremental Methodology

by Brad Caldwell

Water and Shoreland Resources Program
Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

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## SUMMARY

The Washington State Department of Ecology conducted an instream flow study in the Tucannon 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 Tucannon River. The study site was located at River Mile 5.8 on the Tucannon River, approximately 500 feet upstream of Starbuck Dam. Eight transects were chosen to represent the lower fifteen miles of the Tucannon River. Water depths, velocities, substrate and cover information were recorded along the transects 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).

Determining a satisfactory minimum instream flow for the Tucannon River will require setting priorities regarding fish species and lifestages. Different fish species and lifestages exist simultaneously in the river and each has a different flow requirement. No single flow can 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 which have to. be considered include water temperature, water quality, and sediment load. These variables were not addressed in this study.

This study contains no instream flow recommendations. To make such recommendations would require an evaluation of the effect of the environmental variables listed above on the river and long-range fishery management objectives. Key results of the IFIM study are portrayed in the table below:

**Flow and Habitat Relationships for the Tucannon River**

| Species | **Instream Flow Which Provides Maximum Spawning Habitat** | **Instream Flow Which Provides Maximum Juvenile Habitat** |
|---|---|---|
| Chinook | 85 cfs | 40 cfs |
| Steelhead | 105 cfs | 90 cfs |
| Bull Trout | 55 cfs | 160 cfs |



## ACKNOWLEDGEMENTS

Field assistance was provided by Roger Willms and Hal Beecher (Department of Fisheries) and Dave Catterson (Department of Ecology). Hal Beecher also provided the study design and statistical analysis for the fish preference curves. Jeff Marti, Thom Lufkin and John Covert (Department of Ecology) provided assistance in the preparation of the report.

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## Introduction

The Washington Department of 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, Ecology often uses the Instream Flow Incremental Methodology (IFIM) to generate the necessary information. This information may be used by Ecology in the following ways:

1. To determine the impact of future water appropriations on fish habitat.

2. To condition new water rights to protect instream flows for fish habitat.

3. To determine instream flow requirements to be established in an Instream Resource Protection Program (IRPP), in which the State administratively appropriates water for instream purposes, subject to existing water rights.

Study participants included staff from the Washington Department of Ecology and the Washington Department of Fisheries and Wildlife.

## Project Background

**Location and Description**
The Tucannon River Basin is located in Southeastern Washington in Garfield and Columbia Counties. The watershed is approximately 502 square miles in area. The headwaters of the Tucannon River are in the Umatilla National Forest area of the Blue Mountains, at an elevation of 6,837 feet above sea level. The river then drops 5,800 feet in elevation over a distance of 50 miles to reach the Snake River near the town of Starbuck. The Tucannon River has dozens of tributary creeks, most of which are unnamed. Some of the tributary creeks include Cummings Creek, Pataha Creek, Willow Creek, Smith Hollow, Dry Hollow, and Kellogg Creek.

**Water Quality**
Monitoring of water quality data on the lower Tucannon River has revealed excursions of temperature standards. For the reach of river extending from Marengo at river mile 24 (RM 24) to its mouth, water temperatures can be lethal for salmonids from June to October.[1]

The Tucannon River and two of its tributaries are listed on the Washington State Department of Ecology's 303(d) list of water bodies which fail to meet state water quality standards. For the mainstem from its mouth to Tumalum Creek (RM 32.7), the 303(d) report lists excursions of the fecal coliform and temperature standards (fecal coliform - 14 excursions beyond criteria at ambient monitoring station 35B060 between 1/1/90 and 1/1/92; temperature - 2 excursions beyond criteria at Ecology ambient monitoring station 35B060 between 1/1/90 and 1/1/92.

For the mainstem from the National Forest Boundary at RM 38.1 to RM 53.4, the 303(d) report lists excursions of the temperature standards (6 excursions beyond criteria at the USFS station 14030005 between 7/1/87 and 7/1/91). For Pataha Creek the 303(d) report lists fecal coliform and Ammonia-N excursions. For Cummings Creek, the 303(d) report lists excursions of the temperature standards (7 excursions beyond criteria at USFS station 14030017 between 7/1/87 and 7/1/91).[2]

Streamflows in the Tucannon River vary throughout the year. The yearly exceedence flows for the Tucannon River are portrayed in Appendix D. This chart is based upon 10-day averages for a period of record lasting from 1958 to 1990, and also included measurements from 1914-17 and 1928-31.

**Fishery Status**
The Tucannon River watershed is a high priority for fish protection. The American Fisheries Society (AFS) has identified the Tucannon River spring chinook as being at a high risk of extinction and the summer steelhead as being a stock of "special concern."[3] Also, as part of the 1992 Washington State Salmon and Steelhead Stock Inventory (SASSI), the Washington State Department of Fisheries and Wildlife identified both the spring chinook and summer steelhead stocks as being "depressed."[4]

These AFS and SASSI status ratings are described below:

AFS STATUS - A set of ratings ranging from Of Special Concern to Extinct. The rating "High Risk" (at high risk of extinction) refers to those populations whose spawning escapements are declining; fewer than one adult fish returns to spawn from each parent spawner. Populations with escapements of less than 200 in the last one to five years were placed in this category unless the escapements were historically small. A stock in this category is likely to meet the threshold for listing as endangered under the Endangered Species Act. The rating "Special Concern" refers to those populations for which: relatively minor disturbances could threaten them, especially if a specific threat is known; insufficient information on population trends exists, but available information suggests depletion; there are relatively large ongoing releases of nonnative fish, and the potential exists for interbreeding with the native population; or the population is not presently at risk, but requires attention because of a unique character.

SASSI STATUS - A set of status ratings ranging from Healthy to Extinct. The rating "depressed," means a stock of fish whose production is below expected levels based on available habitat and natural variations in survival rates, but above the level where permanent damage to the stock is likely.

## Study Methods

**Overview of IFIM methodology**
The IFIM methodology was selected as the best available method for predicting how fish the quantity of available habitat changes in response to incremental changes in streamflow. This methodology was developed by the U.S. Fish and Wildlife Service in the late 1970s.[5]

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

Preliminary study sites were selected for the IFIM study by reviewing topographic maps. Actual site selection was done during field visits. Eight transects were chosen to represent the lower Tucannon River; these transect sites are shown in the table below.

**TUCANNON RIVER TRANSECT SITES**

| Transect # | Location | Site Description |
|---|---|---|
| 1 | River Mile 5.8 | Tail of a glide |
| 2 | 30 feet upstream of #1 | Middle of a glide |
| 3 | 5 feet upstream of #2 | Split-channel, one side being a deep chute |
| 4 | 49 feet upstream of #3 | End of a riffle |
| 5 | 40 upstream of #4 | Middle of a riffle/run |
| | 60 feet upstream of #5 | Head of riffle/run |
| 7 | 45 feet upstream of #6 | End of riffle/run |
| | 5 feet upstream of #7 | Middle of riffle/run |

## Field Procedures

IFIM measurements were taken in May and September, respectively, of 1992 for medium and low flow, and in April of 1993 for high flow. The measured flows were 52 cfs, 98 cfs and 240 cfs. Measurement of water depth, water velocity, substrate composition, and cover were made at various intervals along each transect.

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 Swoffler 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 bench mark. 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 (see Appendix E).

## 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 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 B2-B4 for mean errors and VAFS for each transect.

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.[6] 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.[7] 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 this study.

**Site Specific Calibration**
A three-flow IFG4 model with eight transects was run for the Tucannon River site. The IFG4 input file, a summary of the calibration details, data changes, and the velocity adjustment factors are included as Appendix B. The mean errors of the stage/discharge regressions range from 0.64 to 9.34, all less than the 10 percent rule of thumb. The velocity adjustment factors range from 0.82 to 1.05 allowing an extrapolation range from 25 to 500 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 (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 Tucannon River site was done using the distances between the transects..

| Transect # | Percent of Total |
|---|---|
| 1 | 4.65 |
| 2 | 10.21 |
| 3 | 13.26 |
| 4 | 14.04 |
| 5 | 15.76 |
| 6 | 16.58 |
| 7 | 16.33 |
| 8 | 9.16 |

### Agency Approval of the Hydraulic Model

Brad Caldwell of the Department of Ecology and Hal Beecher of the Department of Wildlife met May 6, 1994 and after reviewing the calibration details decided the hydraulic model was adequate for an extrapolation range of 25 to 500 cfs.

## 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 00000 00101 00000 00000.

## Habitat Preference Curves

Site specific data on fish preferences for depth, velocity, substrate, arid cover was gathered by Department of Fisheries and Wildlife biologists.

Biologists observed spring chinook, steelhead, and bull trout juveniles at selected transects at regular intervals along the length of the study stream. They 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 they recorded the measurements of depth, velocity, substrate and cover, they also recorded the number of fish of each species in the immediate vicinity of each measurement. The biologists marked fish locations 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 which 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 Tucannon River were agreed to by the Department of Ecology (represented by the author) and the Department of Fisheries and Wildlife (Hal Beecher) at an August 12, 1993 meeting. The site-specific preference curves generated by this study were used with slight modifications for chinook and steelhead juveniles for depth and velocity. Existing agency preference curves were used for chinook and steelhead juvenile substrate and cover, chinook and steelhead spawning, and all lifestages of bull trout. These preference curves are listed in Appendix C. A more detailed report on the habitat preference curves used for the Tucannon River IFIM study is in preparation by the Department of Fisheries and Wildlife.

## Discussion

### Factors To Consider When Developing A Flow Regime

Determining a minimum instream flow for a river or stream in the Tucannon basin requires more than choosing the peak WUA flow for one lifestage of one species at one reach from the IFIM study. For 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.

## Literature Cited


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3. Nehlsen, W., et al., 1991. "Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho and Washington." Fisheries. March - April 1991, Volume 16, No. 2.

4. Washington State Department of Fisheries, et al., 1993. 1992 Washington State Salmon and Steelhead Stock Inventory. March 1993, Olympia, Washington.

5. Bovee, K.D, 1982. A Guide to Stream Habitat Analysis Using the Instream Flow Incremental Methodology. Instream Flow Information Paper No. 12. U.S. Fish and Wildlife Service. Fort Collins, Colorado.

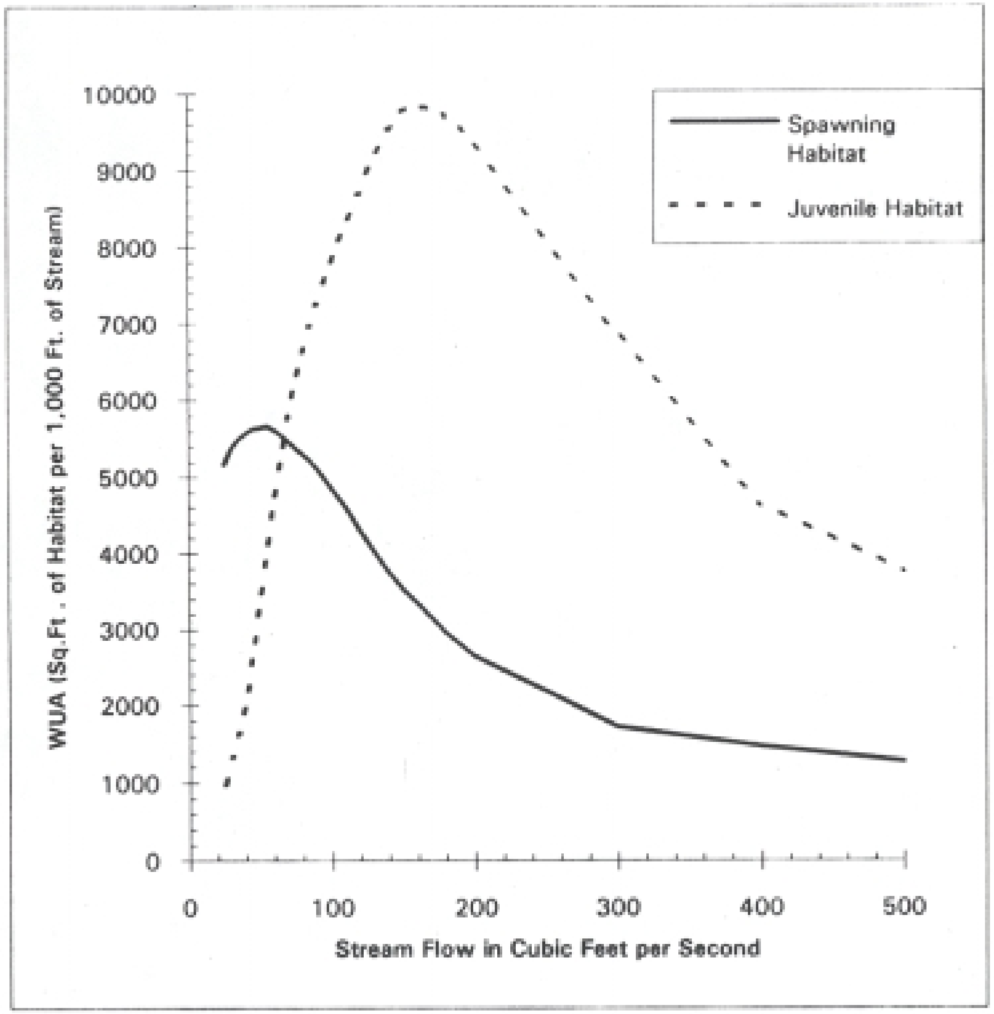
6. Milhous, R.T., et al. 1984. Users Guide to the Physical Habitat Simulation System. Instream Flow Paper 11. U.S. Fish and Wildlife Service, Fort Collins, Colorado. FWS/OBS-81/43 Revised.

7. Milhous, R.T., et al. 1989. Physical Habitat Simulation System Reference Manual - Version II. Instream Flow Information Paper No. 26, U.S. Fish and Wildlife Service, Biological Report 89(16), Fort Collins, Colorado.

# Appendix A

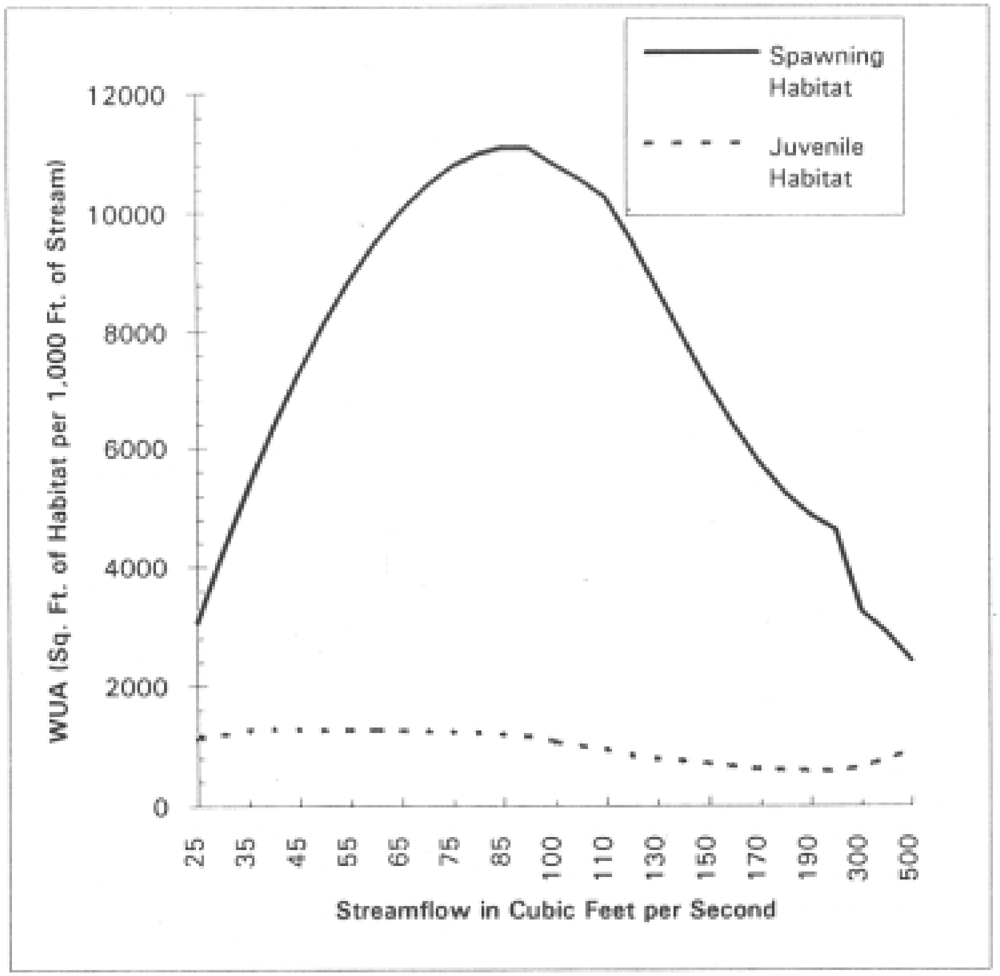
Habitat (Weighted Useable Area) versus Flow Graphs

# Bull Trout Habitat -- Tucannon River (RM 5.8)



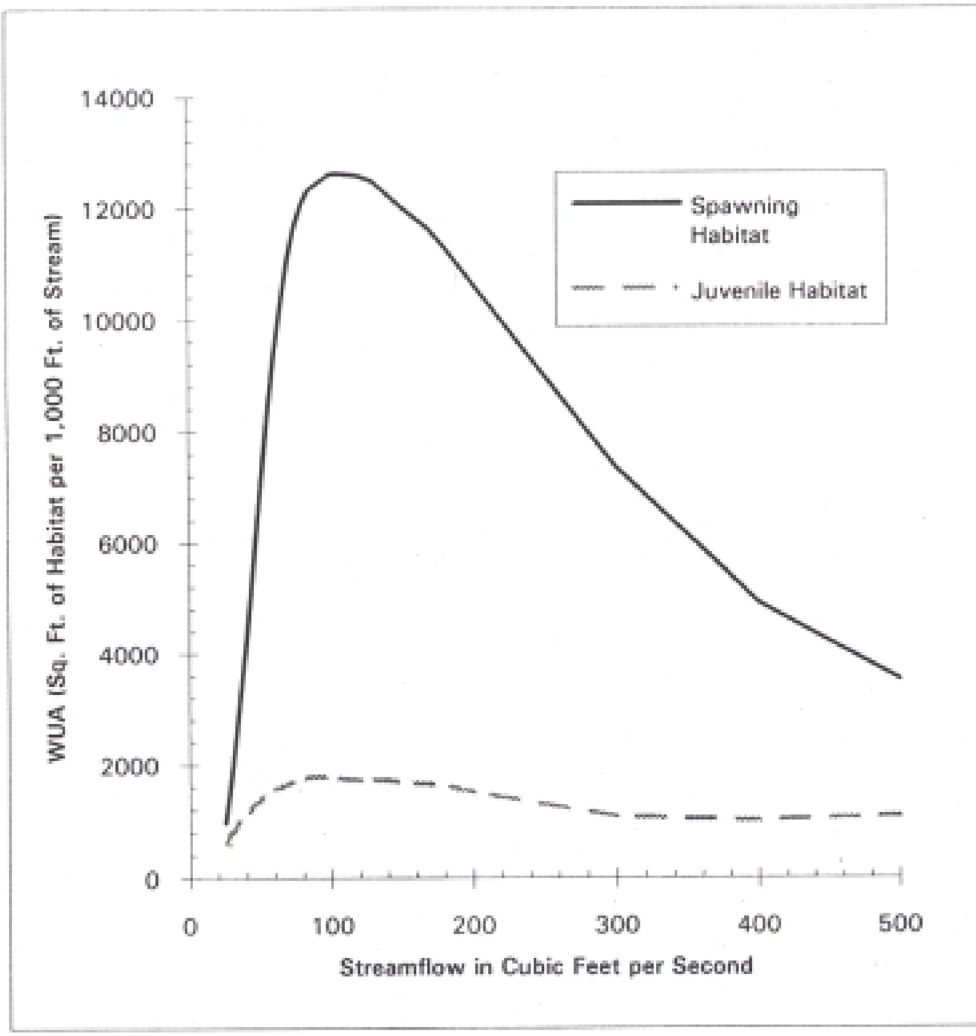

| Discharge in Cfs | Spawning Habitat | Juvenile Habitat |
|---|---|---|
| 25 | 5166 | 982 |
| 30 | 5386 | 1323 |
| 35 | 5494 | 1639 |
| 40 | 5572 | 2057 |
| 45 | 5628 | 2674 |
| 50 | 5640 | 3384 |
| 55 | 5663 | 4041 |
| 60 | 5621 | 4714 |
| 65 | 5552 | 5265 |
| 70 | 5470 | 5791 |
| 75 | 5382 | 6257 |
| 80 | 5310 | 6636 |
| 85 | 5221 | 6969 |
| 90 | 5119 | 7250 |
| 100 | 4862 | 7801 |
| 105 | 4737 | 8055 |
| 110 | 4607 | 8275 |
| 120 | 4305 | 8693 |
| 130 | 4016 | 9166 |
| 140 | 3751 | 9532 |
| 150 | 3529 | 9767 |
| 160 | 3339 | 9837 |
| 170 | 3145 | 9810 |
| 180 | 2954 | 9717 |
| 190 | 2794 | 9543 |
| 200 | 2637 | 9321 |
| 300 | 1715 | 6883 |
| 400 | 1461 | 4645 |
| 500 | 1266 | 3747 |

## Chinook Habitat -- Tucannon River (RM 5.8)

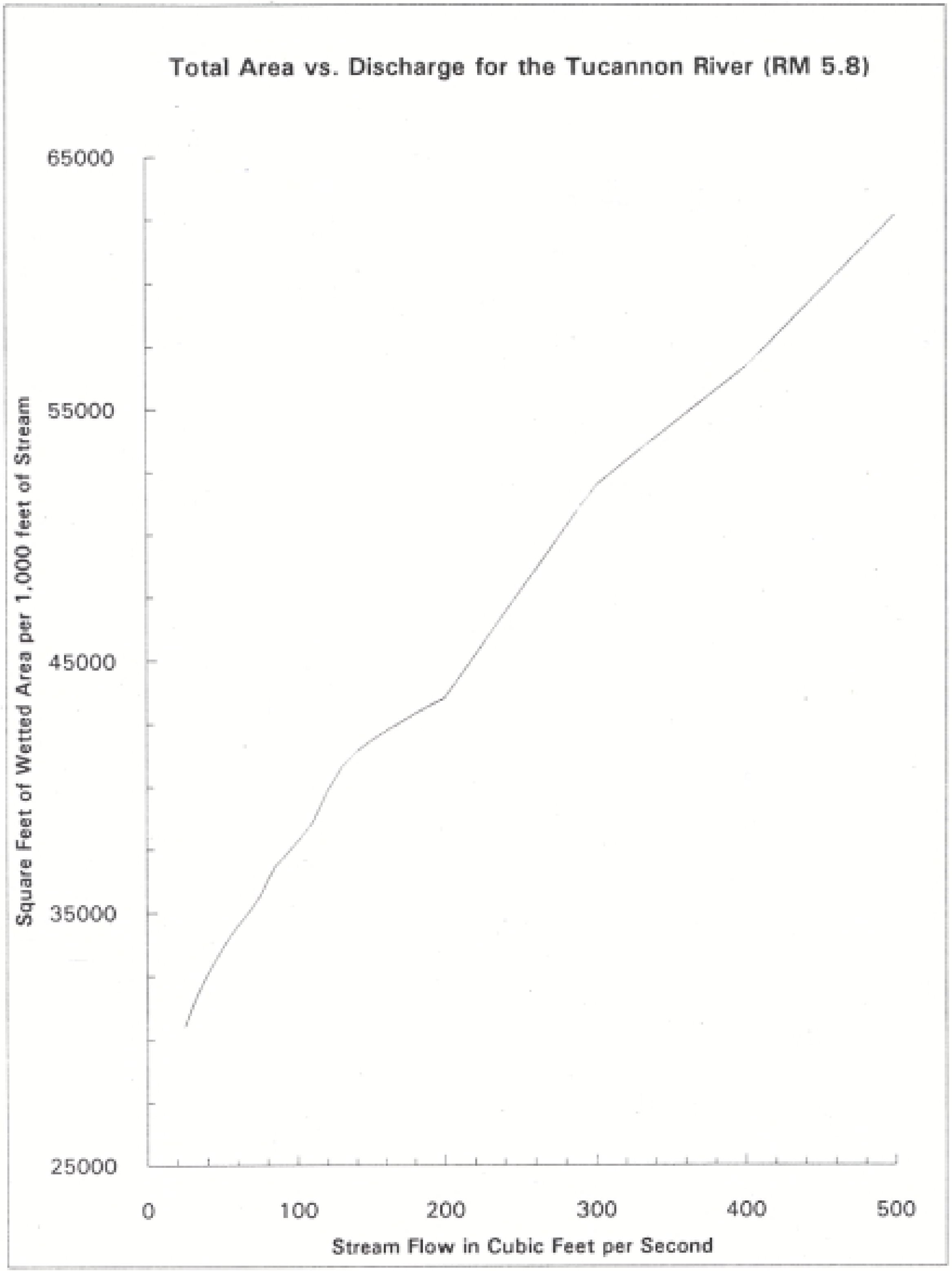



| Discharge in cfs | Spawning Habitat | Juvenile Habitat |
|---|---|---|
| 25 | 3064 | 1125 |
| 30 | 4260 | 1198 |
| 35 | 5352 | 1255 |
| 40 | 6353 | 1284 |
| 45 | 7303 | 1269 |
| 50 | 8162 | 1258 |
| 55 | 8895 | 1256 |
| 60 | 9516 | 1263 |
| 65 | 10021 | 1253 |
| 70 | 10452 | 1246 |
| 75 | 10772 | 1233 |
| 80 | 10983 | 1214 |
| 85 | 11092 | 1188 |
| 90 | 11087 | 1153 |
| 100 | 10812 | 1063 |
| 105 | 10561 | 1005 |
| 110 | 10264 | 936 |
| 120 | 9552 | 840 |
| 130 | 8711 | 782 |
| 140 | 7884 | 750 |
| 150 | 7091 | 705 |
| 160 | 6349 | 656 |
| 170 | 5736 | 617 |
| 180 | 5238 | 599 |
| 190 | 4875 | 587 |
| 200 | 4620 | 572 |
| 300 | 3254 | 649 |
| 400 | 2885 | 777 |
| 500 | 2422 | 912 |

# Steelhead Habitat -- Tucannon River (RM 5.8)




| Discharge in cfs | Spawning Habitat | Juvenile Habitat |
|---|---|---|
| 25 | 971 | 641 |
| 30 | 1908 | 820 |
| 35 | 3005 | 988 |
| 40 | 4216 | 1139 |
| 45 | 5573 | 1274 |
| 50 | 6977 | 1398 |
| 55 | 8229 | 1502 |
| 60 | 9338 | 1577 |
| 65 | 10272 | 1626 |
| 70 | 11068 | 1676 |
| 75 | 11665 | 1726 |
| 80 | 12073 | 1767 |
| 85 | 12333 | 1793 |
| 90 | 12432 | 1803 |
| 100 | 12607 | 1787 |
| 105 | 12629 | 1772 |
| 110 | 12621 | 1750 |
| 120 | 12588 | 1733 |
| 130 | 12491 | 1732 |
| 140 | 12281 | 1727 |
| 150 | 12044 | 1702 |
| 160 | 11832 | 1678 |
| 170 | 11626 | 1666 |
| 180 | 11333 | 1626 |
| 190 | 11008 | 1577 |
| 200 | 10677 | 1520 |
| 300 | 7359 | 1084 |
| 400 | 4909 | 1016 |
| 500 | 3526 | 1096 |



Total Area vs. Discharge for the Tucannon River (RM 5.8)
Square Feet of Wetted Area per 1,000 feet of Stream
65000
55000
45000
35000
25000
0
100
200
300
400
500
Stream Flow in Cubic Feet per Second

## Appendix B

Calibration Information

1. IFG4 Input File
2. Summary of Calibration Details
3. Summary of Data Changes
4. Velocity Adjustment Factors

## Appendix B1  IFG4 Input File

Tucannon River measured 4-26-93 at 240 cfs, 5-21-92 at 98 cfs, and
9-10-92 at 52 cfs

```
IOC               00000002000010000  00  0
QARD    25.0
QARD    30.0
QARD    35.0
QARD    40.0
QARD    45.0
QARD    50.0
QARD    55.0
QARD    60.0
QARD    65.0
QARD    70.0
QARD    75.0
QARD    80.0
QARD    85.0
QARD    90.0
QARD    100.0
QARD    105.0
QARD    110.0
QARD    120.0
QARD    130.0
QARD    140.0
QARD    150.0
QARD    160.0
QARD    170.0
QARD    180.0
QARD    190.0
QARD    200.0
QARD    300.0
QARD    400.0
QARD    500.0
XSEC    1.0          0.0     .50         91.27       .00250
        1.0     -10.0 93.7    0.0 93.7    5.0 93.4    8.0 93.4   10.8 93.1   12.092.76
        1.0     14.0 92.5    16.0 92.3   18.092.07   20.0 91.9   22.091.68   24.091.48
        1.0     27.091.32    28.0 91.3   29.091.27   30.091.32   32.091.38   34.091.52
        1.0     36.0 91.6     8.091.75   40.091.83   42.092.23   44.092.37    46.0 92.6
        1.0     48.092.63    48.8 93.1   49.893.45    51.5 94.3   56.5 95.1    59.5 96.1
NS      1.0          .80         .80         .80         .80         .80       13.60
NS      1.0        51.60       51.70       51.60       61.70       51.70       63.80
NS      1.0        64.80       65.70       65.80       63.70       64.60       65.70
NS      1.0        46.60       62.70       52.60       52.60       51.60         .90
NS      1.0          .90         .90         .90         .80         .80         .80
CAL1    1.0        93.50      240.00
VEL1    1.0                 0.00 0.00   0.00  .68   2.89 3.75   3.93 4.43   4.49 5.22
VEL1    1.0      5.61 5.51  5.73 5.69   5.44 4.40   4.16 4.28   3.63 3.79   3.19 1.77
VEL1    1.0      .06  .05       0.00
CAL2    1.0        92.86       98.00
VEL2    1.0                                  .50    1.60 1.20   2.60 2.59   2.80 2.96
VEL2    1.0      3.33 3.29  3.61 3.53   3.52 3.38   2.97 2.76   2.44 2.75   1.95   .72
VEL2    1.0      .70
CAL3    1.0        92.64       52.00
VEL3    1.0                                         0.00  .70   1.38 1.60   1.83 1.96
VEL3    1.0      2.32 2.61  2.18 2.40   2.72 2.22   2.08 1.60   1.69 1.75     .66
VEL3    1.0
XSEC    2.0         29.5     .50         91.27     .00250
        2.0     -10.0 94.5    0.0 93.9    5.0 93.6   10.0 93.7   13.093.56   14.593.31
        2.0     16.393.01   17.092.86    19.092.49   21.092.26   23.091.94   25.091.91
```

**IFG4 Input File (continued)**

```
        2.0    27.091.69   28.091.56   29.091.49   30.091.42   31.091.42   32.091.36
        2.0    33.091.29   34.091.18   35.091.14   36.091.14   37.091.09   38.091.01
        2.0    39.090.92   40.090.92   41.091.07   43.091.32   45.091.72   46.991.66
        2.0    48.093.56    50.3 93.8   52.3 94.2   57.0 95.2   62.0 95.9
NS      2.0          .80         .80         .80         .80         .80         .80
NS      2.0        16.70       16.80       16.80       14.70       52.60       62.70
NS      2.0        62.80       52.80       63.70       63.70       63.70       63.60
NS      2.0        63.60       62.60       62.60       52.60       25.60       24.70
NS      2.0        25.60       52.60       42.60       11.50       11.50         .80
NS      2.0          .80         .80         .80         .80         .80
CAL1    2.0        93.66      240.00
VEL1    2.0                               0.00  .61   1.71 2.89   3.30 4.48   4.34 4.40
VEL1    2.0     4.93 5.24   5.25 4.84   5.54 5.45   5.29 5.24   5.06 4.13   3.80 3.16
VEL1    2.0     2.91 2.80   2.93 3.10   3.65 3.28         .15
CAL2    2.0       92.9698.00
VEL2    2.0                                         -.02        .71  1.68   2.65 2.69
VEL2    2.0    2.78 2.74   3.03 3.34   3.25 3.56   3.30 3.27   2.84 2.68   2.25 2.00
VEL2    2.0    1.93 1.32   1.20 1.19     1.34
CAL3    2.0       92.70       52.00
VEL3    2.0                                                     0.00  .77   1.49 2.18
VEL3    2.0    2.21 1.98   2.35 2.28   2.43 2.66   2.31 2.29   2.20 1.75   1.04  .82
VEL3    2.0      .80  .95  1.01  .49        .59
XSEC    3.0         35.3     .50     91.27          .00250
        3.0    -10.0 94.3    0.0 94.3    5.0 94.3   10.0 93.8   13.0 93.7   16.1 93.2
        3.0    17.092.79   19.092.32   21.091.72   23.091.24   25.091.77   26.090.67
        3.0    27.090.66   28.090.61   29.090.74   30.090.76   32.090.87   34.091.46
        3.0    36.092.12   38.092.87   40.0 93.2   42.093.25    45.0 93.3  49.093.12
        3.0    51.092.97   52.092.84   54.092.39   56.092.02   58.092.22   59.092.56
        3.0    60.093.15    61.0 93.6   61.4 98.1     64.9 98.1100.0     98.1
NS      3.0          .80         .80         .80         .80         .80       51.60
NS      3.0        51.70       42.60       53.70       64.60       65.60       64.70
NS      3.0        67.70       67.70       67.60       67.60       61.60       11.50
NS      3.0        11.50       11.50       61.60       61.60       51.60       51.60
NS      3.0        16.70       61.60       51.70       62.80       52.60       14.80
NS      3.0        15.60         .80         .80         .80         .80
CAL1    3.0        93.90      240.00
VEL1    3.0                            .11 1.11    1.76 2.57   3.19 4.12   4.13 4.86
VEL1    3.0    5.14 5.24   4.94 5.28   3.75 2.18   1.83 1.38   1.33 1.71   2.84 3.76
VEL1    3.0    3.70 4.21   2.98 3.19   2.05 1.70   .75   .80
CAL2    3.0       93.04       98.00
VEL2    3.0                                        1.31 2.51   3.01 3.25    3.86 4.32
VEL2    3.0    4.06 3.93   2.85 2.60   1.95  .58   .35  .22                      0.00
VEL2    3.0    0.00 0.00   1.75 1.57   .53  .40
CAL3    3.0       92.78       52.00
VEL3    3.0                                        0.00 1.49   1.73 1.96    2.58 2.88
VEL3    3.0    2.58 1.92   1.75 1.65   .96  0.00      0.00
VEL3    3.0         0.00   .66  .91    .72  0.00
XSEC    4.0         48.8   .50         92.45       .00250
        4.0    -10.0 94.6    0.0  94.8   5.0  94.2   7.094.12   10.093.82   14.093.72
        4.0    16.093.59   18.093.49   20.093.34    22.0 93.1  24.093.02   26.092.82
        4.0    28.092.79    30.0 92.8  32.092.74   34.092.54   36.092.62   38.092.47
        4.0    39.092.55   40.092.55   42.092.45   44.092.52   46.092.55   48.092.77
        4.0    50.092.77   52.092.74   54.092.92   55.293.52   56.794.12    59.0 96.1
        4.0     61.5   96.1100.0     98.3
NS      4.0          .80         .80         .80         .80         .80       62.60
NS      4.0        62.70       61.70       62.70       61.70       62.60       56.60
NS      4.0        53.70       63.60       43.70       53.70       73.60       62.70
NS      4.0        63.70       62.60       52.60       52.60       65.70       42.80
NS      4.0        52.80       43.70       32.60         .20         .80         .80
```

**IFG4 Input File (continued)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NS | 4.0 | .80 | .80 | | | | |
| CAL1 | 4.0 | 94.12 | 240.00 | | | | |
| VEL1 | 4.0 | | | 1.09 3.51 | 3.71 4.30 | 4.10 4.89 | 4.15 4.08 |
| VEL1 | 4.0 | 4.56 4.48 | 4.69 4.28 | 4.35 4.41 | 4.27 4.35 | 4.32 4.01 | 4.19 4.22 |
| VEL1 | 4.0 | 4.26 3.84 | .52 0.00 | | | | |
| CAL2 | 4.0 | 93.66 | 98.00 | | | | |
| VEL2 | 4.0 | | | | .35 .55 | 1.45 2.70 | 3.22 2.90 |
| VEL2 | 4.0 | 4.10 4.03 | 3.81 4.27 | 4.41 3.60 | 3.76 3.52 | 3.32 3.62 | 3.47 3.18 |
| VEL2 | 4.0 | 2.90 2.59 | 1.69 | | | | |
| CAL3 | 4.0 | 93.38 | 52.00 | | | | |
| VEL3 | | | | | .20 .20 | 0.00 1.40 | 1.86 1.95 |
| VEL3 | 4.0 | 2.65 3.46 | 3.33 3.06 | 2.93 2.47 | 2.69 2.66 | 2.70 2.30 | 2.72 2.50 |
| VEL3 | 4.0 | 2.02 1.54 | .20 | | | | |
| XSEC | 5.0 | 40.3 | .50 | 92.58 | .00250 | | |
| | 5.0 | -20.0 94.6 | 0.0 94.6 | 1.894.45 | 4.094.35 | 7.893.95 | 9.093.77 |
| | 5.0 | 11.093.47 | 13.093.35 | 15.093.32 | 17.0 93.3 | 19.093.12 | 21.093.17 |
| | 5.0 | 23.0 93.1 | 25.0 93.0 | 27.092.82 | 29.092.82 | 31.092.72 | 32.092.65 |
| | 5.0 | 33.092.68 | 34.092.67 | 36.092.65 | 38.092.62 | 40.092.58 | 42.092.62 |
| | 5.0 | 44.0 92.7 | 46.093.08 | 47.0 93.3 | 48.393.85 | 49.0 93.9 | 50.094.05 |
| NS | 5.0 | .80 | .80 | .80 | .80 | 51.60 | 25.70 |
| NS | 5.0 | 61.80 | 51.70 | 51.60 | 52.70 | 41.60 | 52.60 |
| NS | 5.0 | 62.70 | 62.60 | 41.80 | 35.80 | 46.70 | 53.80 |
| NS | 5.0 | 52.60 | 64.60 | 76.60 | 63.60 | 62.70 | 62.60 |
| NS | 5.0 | 56.70 | 52.60 | 42.60 | 51.60 | .80 | .80 |
| NS | 5.0 | .80 | .80 | .80 | .80 | | |
| CAL1 | 5.0 | 94.45 | 240.00 | | | | |
| VEL1 | 5.0 | | .10 | 1.10 1.40 | 2.64 2.82 | 3.36 3.50 | 3.79 3.47 |
| VEL1 | 5.0 | 3.96 3.78 | 3.99 4.90 | 4.50 4.65 | 4.67 4.35 | 5.08 4.85 | 4.96 4.64 |
| VEL1 | 5.0 | 4.41 4.33 | 2.07 1.40 | .86 .25 | | | |
| CAL2 | 5.0 | 93.89 | 98.00 | | | | |
| VEL2 | 5.0 | | | 0.00 | 1.25 1.79 | .63 1.22 | 1.82 2.34 |
| VEL2 | 5.0 | 2.32 2.74 | 3.24 3.67 | 3.65 3.05 | 3.51 3.51 | 4.05 3.32 | 3.82 3.25 |
| VEL2 | 5.0 | 3.22 2.16 | 1.36 | | | | |
| CAL3 | 5.0 | 93.61 | 52.00 | | | | |
| VEL3 | 5.0 | | | | 0.00 .83 | .75 .74 | 1.00 1.26 |
| VEL3 | 5.0 | 1.46 1.82 | 2.01 2.65 | 2.48 2.55 | 2.72 2.79 | 2.84 2.96 | 2.96 2.63 |
| VEL3 | 5.0 | 2.00 1.09 | .27 | | | | |
| XSEC | 6.0 | 59.7 | .50 | 92.74 | .00250 | | |
| | 6.0 | -20.0 95.5 | 0.0 95.5 | 6.294.67 | 9.094.35 | 13.3 94.1 | 14.093.96 |
| | 6.0 | 16.093.99 | 18.093.91 | 20.093.81 | 22.093.61 | 24.093.31 | 26.093.18 |
| | 6.0 | 28.093.21 | 29.093.07 | 30.092.98 | 31.093.01 | 32.092.96 | 33.092.94 |
| | 6.0 | 34.092.91 | 35.092.94 | 36.092.79 | 37.092.74 | 38.092.86 | 39.092.78 |
| | 6.0 | 40.092.78 | 41.092.74 | 42.092.78 | 43.092.89 | 44.092.81 | 45.092.84 |
| | 6.0 | 46.092.78 | 47.092.88 | 48.494.08 | 49.6 94.7 | 52.1 98.8 | 55.1 99.0 |
| | 6.0 | 100.0 99.0 | | | | | |
| NS | 6.0 | .80 | .80 | .80 | .80 | .80 | .80 |
| NS | 6.0 | 51.80 | 51.90 | 51.90 | 54.60 | 56.60 | 56.60 |
| NS | 6.0 | 65.60 | 56.70 | 56.80 | 56.80 | 56.80 | 56.90 |
| NS | 6.0 | 56.90 | 56.90 | 56.90 | 56.90 | 56.90 | 56.90 |
| NS | 6.0 | 56.90 | 51.90 | .20 | .80 | .80 | .80 |
| NS | 6.0 | .80 | | | | | |
| CAL1 | 6.0 | 94.70 | 240.00 | | | | |
| VEL1 | 6.0 | | 1.43 | 2.65 3.38 | 3.41 3.58 | 3.05 3.86 | 4.26 4.89 |
| VEL1 | 6.0 | 4.93 4.91 | 5.35 5.42 | 4.59 5.36 | 5.47 5.35 | 4.87 4.96 | 5.23 4.89 |
| VEL1 | 6.0 | 5.01 4.57 | 3.08 1.88 | 1.87 3.51 | 2.88 .93 | 0.00 | |
| VEL1 | 6.0 | | | | | | |
| CAL2 | 6.0 | 94.02 | 98.00 | | | | |

## IFG4 Input File (continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| VEL2 | 6.0 | | | 0.00 | 0.00 0.00 | .77 1.28 | 2.22 2.54 |
| VEL2 | 6.0 | 3.15 3.45 | 3.68 4.52 | 3.58 3.45 | 4.00 4.08 | 3.08 4.45 | 4.10 4.13 |
| VEL2 | 6.0 | 4.21 3.70 | 4.16 4.60 | 4.09 3.73 | 3.29 2.80 | 0.00 | |
| VEL2 | 6.0 | | | | | | |
| CAL3 | 6.0 | 93.81 | 52.00 | | | | |
| VEL3 | 6.0 | | | | | 0.00 | 1.23 1.63 |
| VEL3 | 6.0 | 2.28 2.58 | 2.33 3.01 | 2.46 2.41 | 2.34 3.17 | 2.73 3.36 | 3.74 3.26 |
| VEL3 | 6.0 | 3.05 3.27 | 3.00 3.74 | 2.83 2.32 | 1.95 .44 | | |
| VEL3 | 6.0 | | | | | | |
| XSEC | 7.0 | 4.5 | .50 | 93.29 | .00250 | | |
| | 7.0 | -20.0 95.6 | 0.0 95.6 | 5.0 95.4 | 8.894.92 | 9.594.77 | 10.094.22 |
| | 7.0 | 12.094.09 | 14.093.95 | 16.093.79 | 18.093.74 | 20.093.74 | 22.093.69 |
| | 7.0 | 24.093.77 | 26.093.65 | 28.093.49 | 30.093.35 | 31.093.29 | 32.093.32 |
| | 7.0 | 33.0 93.4 | 34.093.42 | 35.093.35 | 36.093.34 | 37.0 93.3 | 38.093.35 |
| | 7.0 | 39.093.34 | 40.093.44 | 41.0 93.5 | 42.093.45 | 43.093.55 | 45.093.57 |
| | 7.0 | 47.093.69 | 49.093.72 | 51.0 93.8 | 52.094.52 | 53.094.92 | 54.0 94.9 |
| | 7.0 | 58.0 99.2 | 90.0 99.2 | | | | |
| NS | 7.0 | .80 | .80 | .80 | .80 | .80 | .80 |
| NS | 7.0 | .80 | .60 | .60 | .60 | .60 | .60 |
| NS | 7.0 | .60 | .30 | .30 | 56.90 | 56.90 | 56.90 |
| NS | 7.0 | 54.50 | 54.50 | 54.60 | 56.90 | 56.90 | 54.70 |
| NS | 7.0 | .60 | .60 | .60 | .60 | .60 | .60 |
| NS | 7.0 | .60 | .60 | 54.50 | .20 | .80 | .80 |
| NS | 7.0 | .80 | .80 | | | | |
| CAL1 | 7.0 | 95.02 | 240.00 | | | | |
| VEL1 | 7.0 | | 0.00 | .15 1.17 | 3.03 3.34 | 3.93 3.75 | 3.87 4.46 |
| VEL1 | 7.0 | 4.47 5.03 | 4.71 5.02 | 4.63 4.61 | 4.87 4.21 | 4.24 4.51 | 4.20 4.59 |
| VEL1 | 7.0 | 4.27 3.78 | 4.58 4.38 | 4.20 4.16 | 4.06 3.35 | 1.45 .20 | 0.00 |
| VEL1 | 7.0 | | | | | | |
| CAL2 | 7.0 | 94.52 | 98.00 | | | | |
| VEL2 | | | | .50 | .66 1.88 | 1.57 1.89 | 1.84 1.60 |
| VEL2 | 7.0 | 1.81 2.90 | 1.78 3.37 | 3.26 3.15 | 3.31 3.33 | 3.63 3.41 | 3.64 3.08 |
| VEL2 | 7.0 | 3.46 3.52 | 3.35 3.62 | 2.86 3.15 | 3.01 2.64 | 1.98 | |
| VEL2 | 7.0 | | | | | | |
| CAL3 | 7.0 | 94.22 | 52.00 | | | | |
| VEL3 | 7.0 | | | | 0.00 .75 | 1.04 1.00 | 1.28 .69 |
| VEL3 | 7.0 | 1.49 2.46 | .83 3.23 | 3.13 2.69 | 2.90 2.56 | 2.75 2.97 | 3.22 2.65 |
| VEL3 | 7.0 | 3.02 3.10 | 2.29 2.98 | 2.06 2.56 | 2.47 1.75 | 1.06 | |
| VEL3 | 7.0 | | | | | | |
| XSEC | 8.0 | 58.1 | .50 | 93.39 | .00250 | | |
| | 8.0 | -20.0 96.2 | 0.0 95.7 | 4.0 95.2 | 4.295.14 | 4.694.84 | 5.094.58 |
| | 8.0 | 7.094.17 | 9.093.82 | 11.093.75 | 13.093.77 | 15.093.62 | 17.093.47 |
| | 8.0 | 19.0 93.4 | 20.093.42 | 21.093.42 | 22.093.47 | 23.093.39 | 24.0 93.4 |
| | 8.0 | 25.0 93.5 | 26.093.52 | 27.0 93.5 | 28.093.49 | 29.093.45 | 30.093.52 |
| | 8.0 | 31.093.49 | 32.093.54 | 33.0 93.6 | 34.0 93.6 | 35.0 93.6 | 37.093.64 |
| | 8.0 | 39.093.62 | 41.093.82 | 41.794.44 | 43.095.24 | 46.3 95.9 | 47.3 99.7 |
| | 8.0 | 90.0 99.7 | | | | | |
| NS | 8.0 | .80 | .80 | .80 | .80 | .80 | .80 |
| NS | 8.0 | .60 | .60 | .60 | .60 | .60 | .60 |
| NS | 8.0 | .60 | .60 | 56.80 | 56.80 | 54.50 | 45.80 |
| NS | 8.0 | 45.90 | 45.70 | .60 | .60 | 45.70 | 45.80 |
| NS | 8.0 | 45.60 | 45.80 | 45.60 | 45.60 | 45.60 | .60 |
| NS | 8.0 | .60 | 51.60 | .80 | .80 | .80 | .80 |
| NS | 8.0 | .80 | | | | | |
| CAL1 | 8.0 | 95.24 | 240.00 | | | | |
| VEL1 | 8.0 | | 0.00 | .34 1.50 | 2.71 3.77 | 3.67 4.23 | 4.43 3.68 |
| VEL1 | 8.0 | 4.41 4.63 | 4.75 4.36 | 5.14 4.97 | 4.81 4.38 | 5.20 5.19 | 5.16 5.00 |
| VEL1 | 8.0 | 4.16 4.59 | 4.72 4.95 | 4.71 4.06 | 3.15 .20 | .10 | |
| VEL1 | 8.0 | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CAL2 | 8.0 | 94.71 | 98.00 | | | | |
| VEL2 | 8.0 | | | 0.00 | 1.44 1.49 | 1.90 2.25 | 1.71 2.06 |
| VEL2 | 8.0 | 2.43 2.22 | 2.47 2.99 | 2.65 2.61 | 3.23 3.13 | 3.21 2.99 | 2.54 2.56 |
| VEL2 | 8.0 | 2.96 2.75 | 3.01 3.06 | 2.61 2.09 | 1.72 1.40 | | |
| VEL2 | 8.0 | | | | | | |
| CAL3 | 8.0 | 94.46 | 52.00 | | | | |
| VEL3 | 8.0 | | | | .29 1.26 | 1.19 1.20 | 1.24 1.36 |
| VEL3 | 8.0 | 1.69 1.65 | 1.75 1.76 | 2.15 2.23 | 2.40 2.38 | 2.36 1.83 | 2.18 2.15 |
| VEL3 | 8.0 | 2.15 2.11 | 2.31 2.24 | 2.20 1.63 | 1.23 .50 | | |
| VEL3 | 8.0 | | | | | | |
| ENDJ | | | | | | | |

## Appendix B2 Summary of Calibration Details

**Tucannon River**
**Calibration Information for Calculated Discharges**

| Transect Number | 1 | 2 | 3.00 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Discharge | 254 | 258 | 252 | 216 | 238 | 216 | 237 | 241 |
| | 101 | 89 | 92 | 110 | 103 | 96 | 96 | 91 |
| | 54 | 48 | 44 | 55 | 54 | 54 | 53 | 51 |
| Stage | 93.5 | 93.66 | 93.90 | 94.12 | 94.45 | 94.7 | 95.02 | 95.24 |
| | 92.86 | 92.96 | 93.04 | 93.66 | 93.89 | 94.02 | 94.52 | 94.71 |
| | 92.64 | 92.7 | 92.78 | 93.38 | 93.61 | 93.81 | 94.22 | 94.46 |
| Plotting Stage | 2.23 | 2.39 | 2.63 | 1.67 | 1.87 | 1.96 | 1.73 | 1.85 |
| | 1.59 | 1.69 | 1.77 | 1.21 | 1.31 | 1.28 | 1.23 | 1.32 |
| | 1.37 | 1.43 | 1.51 | 0.93 | 1.03 | 1.07 | 0.93 | 1.07 |
| Ratio of Measured vs. Predicted Discharge | | | | | | | | |
| | 0.97 | 0.98 | 0.96 | 0.98 | 0.99 | 0.97 | 1.01 | 1.00 |
| | 1.10 | 1.05 | 1.15 | 1.06 | 1.03 | 1.108 | 0.96 | 0.99 |
| | 0.93 | 0.96 | 0.90 | 0.97 | 0.98 | 0.931 | 1.02 | 1.01 |
| Mean Error of stage/discharge relationship for calculated Q | | | | | | | | |
| | 6.46 | 3.23 | 9.34 | 3.58 | 2.12 | 6.76 | 2.37 | 0.64 |
| Mean Error of stage/discharge relationship for given Q | | | | | | | | |
| | 6.96 | 5.77 | 8.12 | 2.4 | 0.75 | 7.54 | 2.46 | 2.05 |
| Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF | | | | | | | | |
| A= | 0.3699 | 0.4269 | 0.42 | 0.1641 | 0.2072 | 0.1705 | 0.182 | 0.2696 |
| B = | 0.3226 | 0.3092 | 0.33 | 0.4296 | 0.4008 | 0.4515 | 0.413 | 0.3512 |
| SZF = | 91.2 | 91.2 | 91.20 | 92.4 | 92.58 | 92.74 | 93.29 | 93.39 |
| Beta coefficient log/log discharge/stage relationship | | | | | | | | |
| | 3.1 | 3.23 | 3.02 | 2.33 | 2.49 | 2.21 | 2.42 | 2.85 |

**Appendix B3 Summary of Data Changes**

| Cell Velocities Changed for Calibration | | | |
|---|---|---|---|
| | | | |
| **Transect** | **Vertical** | **Velocity Set** | **Velocity Change** |
| 2 | 9 | 1 | 3.5 to 3.3 |
| 2 | 9 | 2 | .51 to .71 |
| 3 | 18 | 2 | .38 to .58 |
| 3 | 18 | 3 | .10 to 0 |
| 3 | 19 | 2 | .15 to .35 |
| 3 | 20 | 2 | .02 to .22 |
| 3 | 24 | 2 | .05 to 0 |
| 3 | 25 | 2 | .10 to 0 |
| 3 | 26 | 2 | .11 to 0 |
| 3 | 30 | 2 | .20 to .40 |
| 4 | 7 | 1 | 3.91 to 3.71 |
| 4 | 8 | 1 | 4.50 to 4.3 |
| 4 | 8 | 2 | .75 to .55 |
| 4 | 9 | 1 | 4.30 to 4.10 |
| 4 | 9 | 2 | 1.25 to 1.45 |
| 4 | 27 | 3 | 0 to .20 |
| 5 | 6 | 2 | .05 to 0 |
| 6 | 6 | 2 | .10 to 0 |
| 6 | 7 | 2 | .05 to 0 |
| 6 | 8 | 2 | .05 to 0 |
| 6 | 9 | 2 | .57 to .77 |
| 6 | 9 | 1 | 3.25 to 3.05 |
| 6 | 10 | 3 | .10 to 0 |
| 6 | 28 | 1 | 1.68 to 1.88 |
| 6 | 28 | 3 | 3.94 to 3.74 |
| 8 | 6 | 2 | .10 to 0 |

## Appendix B4  Velocity Adjustment Factors

Tucannon River measured 4-26-93 at 240 cfs, 5-21-92 at 98 cfs, and 9-10-92 at 52 cfs

| Transect | Flow (cfs) | VAF |
|---|---|---|
| 1.00 | 25.0 | 1.013 |
| 1.00 | 30.0 | 1.011 |
| 1.00 | 35.0 | 1.010 |
| 1.00 | 40.0 | 1.009 |
| 1.00 | 45.0 | 1.006 |
| 1.00 | 50.0 | 1.005 |
| 1.00 | 55.0 | 1.002 |
| 1.00 | 60.0 | 1.000 |
| 1.00 | 65.0 | 0.999 |
| 1.00 | 70.0 | 0.998 |
| 1.00 | 75.0 | 0.996 |
| 1.00 | 80.0 | 0.996 |
| 1.00 | 85.0 | 0.996 |
| 1.00 | 90.0 | 0.995 |
| 1.00 | 100.0 | 0.995 |
| 1.00 | 105.0 | 0.995 |
| 1.00 | 110.0 | 0.995 |
| 1.00 | 120.0 | 0.995 |
| 1.00 | 130.0 | 0.995 |
| 1.00 | 140.0 | 0.995 |
| 1.00 | 150.0 | 0.995 |
| 1.00 | 160.0 | 0.995 |
| 1.00 | 170.0 | 0.995 |
| 1.00 | 180.0 | 0.995 |
| 1.00 | 190.0 | 0.994 |
| 1.00 | 200.0 | 0.994 |
| 1.00 | 300.0 | 0.987 |
| 1.00 | 400.0 | 0.974 |
| 1.00 | 500.0 | 0.960 |
| 2.00 | 25.0 | 0.889 |
| 2.00 | 30.0 | 0.903 |
| 2.00 | 35.0 | 0.914 |
| 2.00 | 40.0 | 0.924 |
| 2.00 | 50.0 | 0.941 |
| 2.00 | 55.0 | 0.948 |
| 2.00 | 60.0 | 0.954 |
| 2.00 | 65.0 | 0.960 |
| 2.00 | 70.0 | 0.965 |
| 2.00 | 75.0 | 0.969 |
| 2.00 | 80.0 | 0.975 |
| 2.00 | 85.0 | 0.978 |
| 2.00 | 90.0 | 0.981 |
| 2.00 | 100.0 | 0.986 |
| 2.00 | 105.0 | 0.987 |
| 2.00 | 110.0 | 0.989 |
| 2.00 | 120.0 | 0.992 |
| 2.00 | 130.0 | 0.993 |
| 2.00 | 140.0 | 0.995 |
| 2.00 | 150.0 | 0.995 |
| 2.00 | 160.0 | 0.996 |
| 2.00 | 170.0 | 0.996 |
| 2.00 | 180.0 | 0.996 |
| 2.00 | 190.0 | 0.995 |
| 2.00 | 200.0 | 0.995 |
| 2.00 | 300.0 | 0.981 |

| Transect | Flow (cfs) | VAF |
|---|---|---|
| 2.00 | 400.0 | 0.959 |
| 2.00 | 500.0 | 0.938 |
| 3.00 | 25.0 | 0.823 |
| 3.00 | 30.0 | 0.857 |
| 3.00 | 35.0 | 0.886 |
| 3.00 | 40.0 | 0.911 |
| 3.00 | 45.0 | 0.933 |
| 3.00 | 50.0 | 0.952 |
| 3.00 | 55.0 | 0.969 |
| 3.00 | 60.0 | 0.979 |
| 3.00 | 65.0 | 0.991 |
| 3.00 | 70.0 | 1.000 |
| 3.00 | 75.0 | 1.009 |
| 3.00 | 80.0 | 1.017 |
| 3.00 | 85.0 | 1.024 |
| 3.00 | 90.0 | 1.030 |
| 3.00 | 100.0 | 1.039 |
| 3.00 | 105.0 | 1.042 |
| 3.00 | 110.0 | 1.045 |
| 3.00 | 120.0 | 1.047 |
| 3.00 | 130.0 | 1.046 |
| 3.00 | 140.0 | 1.043 |
| 3.00 | 150.0 | 1.038 |
| 3.00 | 160.0 | 1.033 |
| 3.00 | 170.0 | 1.028 |
| 3.00 | 180.0 | 1.023 |
| 3.00 | 190.0 | 1.018 |
| 3.00 | 200.0 | 1.012 |
| 3.00 | 300.0 | 0.967 |
| 3.00 | 400.0 | 0.931 |
| 3.00 | 500.0 | 0.899 |
| 4.00 | 25.0 | 0.970 |
| 4.00 | 30.0 | 0.974 |
| 4.00 | 35.0 | 0.979 |
| 4.00 | 40.0 | 0.985 |
| 4.00 | 45.0 | 0.990 |
| 4.00 | 50.0 | 0.993 |
| 4.00 | 55.0 | 0.997 |
| 4.00 | 60.0 | 1.001 |
| 4.00 | 65.0 | 1.005 |
| 4.00 | 70.0 | 1.008 |
| 4.00 | 75.0 | 1.011 |
| 4.00 | 80.0 | 1.014 |
| 4.00 | 85.0 | 1.017 |
| 4.00 | 90.0 | 1.019 |
| 4.00 | 100.0 | 1.022 |
| 4.00 | 105.0 | 1.024 |
| 4.00 | 110.0 | 1.025 |
| 4.00 | 120.0 | 1.027 |
| 4.00 | 130.0 | 1.028 |
| 4.00 | 140.0 | 1.028 |
| 4.00 | 150.0 | 1.026 |
| 4.00 | 160.0 | 1.024 |
| 4.00 | 170.0 | 1.022 |
| 4.00 | 180.0 | 1.019 |
| 4.00 | 190.0 | 1.016 |
| 4.00 | 200.0 | 1.012 |
| 4.00 | 300.0 | 0.967 |
| 4.00 | 400.0 | 0.914 |

| Transect | Flow (cfs) | VAF |
|---|---|---|
| 4.00 | 500.0 | 0.869 |
| 5.00 | 25.0 | 0.960 |
| 5.00 | 30.0 | 0.969 |
| 5.00 | 35.0 | 0.977 |
| 5.00 | 40.0 | 0.983 |
| 5.00 | 45.0 | 0.988 |
| 5.00 | 50.0 | 0.992 |
| 5.00 | 55.0 | 0.996 |
| 5.00 | 60.0 | 0.999 |
| 5.00 | 65.0 | 1.002 |
| 5.00 | 70.0 | 1.004 |
| 5.00 | 75.0 | 1.006 |
| 5.00 | 80.0 | 1.008 |
| 5.00 | 85.0 | 1.009 |
| 5.00 | 90.0 | 1.010 |
| 5.00 | 100.0 | 1.011 |
| 5.00 | 105.0 | 1.012 |
| 5.00 | 110.0 | 1.012 |
| 5.00 | 120.0 | 1.012 |
| 5.00 | 130.0 | 1.012 |
| 5.00 | 140.0 | 1.011 |
| 5.00 | 150.0 | 1.010 |
| 5.00 | 160.0 | 1.009 |
| 5.00 | 170.0 | 1.008 |
| 5.00 | 180.00 | 1.007 |
| 5.00 | 190.0 | 1.006 |
| 5.00 | 200.0 | 1.004 |
| 5.00 | 300.0 | 0.988 |
| 5.00 | 400.0 | 0.969 |
| 5.00 | 500.0 | 0.951 |
| 6.00 | 25.0 | 0.842 |
| 6.00 | 30.0 | 0.878 |
| 6.00 | 35.0 | 0.906 |
| 6.00 | 40.0 | 0.930 |
| 6.00 | 45.0 | 0.951 |
| 6.00 | 50.0 | 0.968 |
| 6.00 | 55.0 | 0.983 |
| 6.00 | 60.0 | 0.995 |
| 6.00 | 65.0 | 1.006 |
| 6.00 | 70.0 | 1.015 |
| 6.00 | 75.0 | 1.023 |
| 6.00 | 80.0 | 1.030 |
| 6.00 | 85.0 | 1.035 |
| 6.00 | 90.0 | 1.039 |
| 6.00 | 100.0 | 1.043 |
| 6.00 | 105.0 | 1.044 |
| 6.00 | 110.0 | 1.045 |
| 6.00 | 120.0 | 1.045 |
| 6.00 | 130.0 | 1.044 |
| 6.00 | 140.0 | 1.041 |
| 6.00 | 150.0 | 1.038 |
| 6.00 | 160.0 | 1.034 |
| 6.00 | 170.0 | 1.029 |
| 6.00 | 180.0 | 1.024 |
| 6.00 | 190.0 | 1.019 |
| 6.00 | 200.0 | 1.014 |
| 6.00 | 300.0 | 0.961 |
| 6.00 | 400.0 | 0.915 |
| 6.00 | 500.0 | 0.875 |

| Transect | Flow (cfs) | VAF |
|---|---|---|
| 7.00 | 25.0 | 0.957 |
| 7.00 | 30.0 | 0.966 |
| 7.00 | 35.0 | 0.974 |
| 7.00 | 40.0 | 0.981 |
| 7.00 | 45.0 | 0.987 |
| 7.00 | 50.0 | 0992 |
| 7.00 | 55.0 | 0.996 |
| 7.00 | 60.0 | 1.000 |
| 7.00 | 65.0 | 1.003 |
| 7.00 | 70.0 | 1.006 |
| 7.00 | 75.0 | 1.008 |
| 7.00 | 80.0 | 1.010 |
| 7.00 | 85.0 | 1.012 |
| 7.00 | 90.0 | 1.013 |
| 7.00 | 100.0 | 1.015 |
| 7.00 | 105.0 | 1.016 |
| 7.00 | 110.0 | 1.016 |
| 7.00 | 120.0 | 1.016 |
| 7.00 | 130.0 | 1.016 |
| 7.00 | 140.0 | 1.015 |
| 7.00 | 150.0 | 1.014 |
| 7.00 | 160.0 | 1.013 |
| 7.00 | 170.0 | 1.011 |
| 7.00 | 180.0 | 1.009 |
| 7.00 | 190.0 | 1.007 |
| 7.00 | 200.0 | 1.005 |
| 7.00 | 300.0 | 0.975 |
| 7.00 | 400.0 | 0.942 |
| 7.00 | 500.0 | 0.908 |
| 8.00 | 25.0 | 0.981 |
| 8.00 | 30.0 | 0.987 |
| 8.00 | 35.0 | 0.991 |
| 8.00 | 40.0 | 0.994 |
| 8.00 | 45.0 | 0.997 |
| 8.00 | 50.0 | 0.999 |
| 8.00 | 55.0 | 1.001 |
| 8.00 | 60.0 | 1.002 |
| 8.00 | 65.0 | 1.004 |
| 8.00 | 70.0 | 1.005 |
| 8.00 | 75.0 | 1.005 |
| 8.00 | 80.0 | 1.005 |
| 8.00 | 85.0 | 1.006 |
| 8.00 | 90.0 | 1.006 |
| 8.00 | 100.0 | 1.006 |
| 8.00 | 105.0 | 1.006 |
| 8.00 | 110.0 | 1.006 |
| 8.00 | 120.0 | 1.006 |
| 8.00 | 130.0 | 1.006 |
| 8.00 | 140.0 | 1.005 |
| 8.00 | 150.0 | 1.005 |
| 8.00 | 160.0 | 1.005 |
| 8.00 | 170.0 | 1.004 |
| 8.00 | 180.0 | 1.004 |
| 8.00 | 190.0 | 1.003 |
| 8.00 | 200.0 | 1.002 |
| 8.00 | 300.0 | 0.995 |
| 8.00 | 400.0 | 0.987 |
| 8.00 | 500.0 | 0.979 |

# Appendix C

## Fish Habitat Preference Curves

FISHCRV for Tucannon (spawn, rear), changed substrate from Methow 6/18/92

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | 101 | 9 10 | 67 | Steelhead | | | | | | | Spawning | | |
| V | 101 | 0.00 | 0.00 | 1.00 | 0.00 | 1.60 | 0.44 | 2.50 | 0.97 | 2.90 | 1.00 | 3.25 | 1.00 |
| V | 101 | 3.80 | 0.62 | 6.00 | 0.00 | 100.0 | 0.00 | | | | | | |
| D | 101 | 0.00 | 0.00 | 0.65 | 0.00 | 0.85 | 0.44 | 1.00 | 1.00 | 1.50 | 1.00 | 1.90 | 0.73 |
| D | 101 | 2.30 | 0.58 | 3.70 | 0.06 | 6.00 | 0.06 | 100.0 | 0.00 | | | | |
| S | 101 | 0.00 | 0.00 | 16.50 | 0.50 | 16.90 | 0.10 | 20.50 | 0.00 | 23.90 | 0.05 | 24.50 | 0.50 |
| S | 101 | 24.90 | 0.10 | 26.50 | 0.50 | 26.90 | 0.10 | 27.50 | 0.15 | 27.90 | 0.03 | 28.50 | 0.00 |
| S | 101 | 29.90 | 0.00 | 32.50 | 0.25 | 32.90 | 0.45 | 37.50 | 0.40 | 37.90 | 0.48 | 40.50 | 0.50 |
| S | 101 | 40.90 | 0.90 | 44.90 | 1.00 | 46.90 | 1.00 | 52.50 | 0.50 | 52.90 | 0.90 | 54.50 | 1.00 |
| S | 101 | 56.90 | 1.00 | 57.50 | 0.65 | 57.90 | 0.93 | 62.50 | 0.50 | 62.90 | 0.90 | 64.50 | 1.00 |
| S | 101 | 66.90 | 1.00 | 67.50 | 0.65 | 67.90 | 0.93 | 68.50 | 0.50 | 68.90 | 0.90 | 69.50 | 0.50 |
| S | 101 | 69.90 | 0.90 | 72.50 | 0.15 | 72.90 | 0.27 | 73.50 | 0.40 | 73.90 | 0.32 | 75.50 | 0.65 |
| S | 101 | 75.90 | 0.37 | 76.50 | 0.65 | 76.90 | 0.37 | 77.50 | 0.30 | 77.90 | 0.30 | 78.50 | 0.15 |
| S | 101 | 78.90 | 0.27 | 79.50 | 0.15 | 79.90 | 0.27 | 80.50 | 0.00 | 82.90 | 0.00 | 85.50 | 0.50 |
| S | 101 | 85.90 | 0.10 | 86.50 | 0.50 | 86.90 | 0.10 | 87.50 | 0.15 | 87.90 | 0.03 | 88.50 | 0.00 |
| S | 101 | 92.90 | 0.00 | 96.50 | 0.50 | 96.90 | 0.10 | 97.50 | 0.15 | 97.90 | 0.03 | 98.50 | 0.00 |
| S | 101 | 100.0 | 0.00 | | | | | | | | | | |
| H | 102 | 8 8 | 90 0 | Steelhead | | changed 8-12-93 D&V Tucannonjuvenile | | | | | | | |
| V | 102 | 0.00 | 0.28 | 1.10 | 0.85 | 1.40 | 1.00 | 2.10 | 1.00 | 2.40 | 1.00 | 3.40 | 0.20 |
| V | 102 | 5.00 | 0.00 | 100. | 0.00 | | | | | | | | |
| D | 102 | 0.00 | 0.00 | 0.60 | 0.00 | 1.00 | 0.22 | 1.40 | 0.40 | 1.60 | 1.00 | 4.00 | 1.00 |
| D | 102 | 5.00 | 0.67 | 100. | 0.67 | | | | | | | | |
| S | 102 | 0.00 | 0.00 | 0.10 | 1.00 | 0.20 | 1.00 | 0.30 | 1.00 | 0.40 | 1.00 | 0.50 | 0.80 |
| S | 102 | 0.60 | 0.80 | 0.70 | 0.20 | 0.80 | 0.20 | 0.90 | 0.10 | 10.50 | 0.10 | 13.90 | 0.10 |
| S | 102 | 20.50 | 0.10 | 23.90 | 0.10 | 24.50 | 0.15 | 24.90 | 0.11 | 26.50 | 0.30 | 26.90 | 0.14 |
| S | 102 | 27.50 | 0.40 | 27.90 | 0.16 | 28.50 | 0.55 | 28.90 | 0.19 | 29.50 | 0.20 | 29.90 | 0.12 |
| S | 102 | 30.50 | 0.10 | 33.90 | 0.10 | 37.50 | 0.40 | 37.90 | 0.16 | 40.50 | 0.15 | 40.90 | 0.19 |
| S | 102 | 45.50 | 0.25 | 45.90 | 0.21 | 46.50 | 0.35 | 46.90 | 0.23 | 52.50 | 0.20 | 52.90 | 0.28 |
| S | 102 | 56.50 | 0.40 | 56.90 | 0.32 | 57.50 | 0.50 | 57.90 | 0.34 | 62.50 | 0.30 | 62.90 | 0.46 |
| S | 102 | 64.50 | 0.35 | 64.90 | 0.47 | 65.50 | 0.40 | 65.90 | 0.48 | 66.50 | 0.50 | 66.90 | 0.50 |
| S | 102 | 67.50 | 0.60 | 67.90 | 0.52 | 68.50 | 0.75 | 68.90 | 0.55 | 69.50 | 0.40 | 69.90 | 0.48 |
| S | 102 | 72.50 | 0.40 | 72.90 | 0.64 | 73.50 | 0.40 | 73.90 | 0.64 | 75.50 | 0.50 | 75.90 | 0.66 |
| S | 102 | 76.50 | 0.60 | 76.90 | 0.68 | 77.50 | 0.70 | 77.90 | 0.70 | 78.50 | 0.85 | 78.90 | 0.73 |
| S | 102 | 79.50 | 0.50 | 79.90 | 0.66 | 82.50 | 0.55 | 82.90 | 0.91 | 85.50 | 0.65 | 85.90 | 0.93 |
| S | 102 | 86.50 | 0.75 | 86.90 | 0.95 | 87.50 | 0.85 | 87.90 | 0.97 | 88.50 | 1.00 | 88.90 | 1.00 |
| S | 102 | 89.50 | 0.65 | 89.90 | 0.93 | 92.50 | 0.20 | 92.90 | 0.30 | 96.50 | 0.30 | 96.90 | 0.32 |
| S | 102 | 97.50 | 0.50 | 97.90 | 0.34 | 98.50 | 0.65 | 98.90 | 0.37 | 99.50 | 0.30 | 100.0 | 0.30 |
| H | 201 | 7 7 | 64 0 | Bull Trout | | | | | | | Spawning | | |
| V | 201 | 0.00 | 1.00 | 0.55 | 1.00 | 0.80 | 0.84 | 1.20 | 0.76 | 1.80 | 0.53 | 4.50 | 0.00 |
| V | 201 | 100.0 | 0.00 | | | | | | | | | | |
| D | 201 | 0.00 | 0.00 | 0.39 | 0.00 | 0.65 | 1.00 | 0.85 | 1.00 | 1.70 | 0.91 | 10.00 | 0.91 |
| D | 201 | 100.0 | 0.00 | | | | | | | | | | |
| S | 201 | 0.00 | 0.00 | 10.50 | 0.00 | 13.90 | 0.10 | 16.50 | 0.25 | 16.90 | 0.05 | 20.50 | 0.00 |
| S | 201 | 23.90 | 0.10 | 24.50 | 0.50 | 24.90 | 0.10 | 26.50 | 0.25 | 26.90 | 0.05 | 27.50 | 0.00 |
| S | 201 | 29.90 | 0.00 | 32.50 | 0.50 | 32.90 | 0.90 | 37.50 | 0.50 | 37.90 | 0.90 | 40.50 | 0.50 |
| S | 201 | 40.90 | 0.90 | 45.50 | 1.00 | 45.90 | 1.00 | 46.50 | 0.75 | 46.90 | 0.95 | 52.50 | 0.50 |
| S | 201 | 52.90 | 0.90 | 56.50 | 0.75 | 56.90 | 0.95 | 57.50 | 0.50 | 57.90 | 0.90 | 62.50 | 0.25 |
| S | 201 | 62.90 | 0.45 | 64.50 | 0.75 | 64.90 | 0.55 | 65.50 | 0.75 | 65.90 | 0.55 | 66.50 | 0.50 |
| S | 201 | 66.90 | 0.50 | 67.50 | 0.25 | 67.90 | 0.45 | 68.50 | 0.25 | 68.90 | 0.45 | 69.50 | 0.25 |
| S | 201 | 69.90 | 0.45 | 70.50 | 0.00 | 72.90 | 0.00 | 73.50 | 0.50 | 73.90 | 0.10 | 75.50 | 0.50 |
| S | 201 | 75.90 | 0.10 | 76.50 | 0.25 | 76.90 | 0.05 | 77.50 | 0.00 | 77.90 | 0.00 | 82.90 | 0.00 |
| S | 201 | 85.50 | 0.50 | 85.90 | 0.10 | 86.50 | 0.25 | 86.90 | 0.05 | 87.50 | 0.00 | 92.90 | 0.00 |
| S | 201 | 96.50 | 0.25 | 96.90 | 0.05 | 97.50 | 0.00 | 100.0 | 0.00 | | | | |

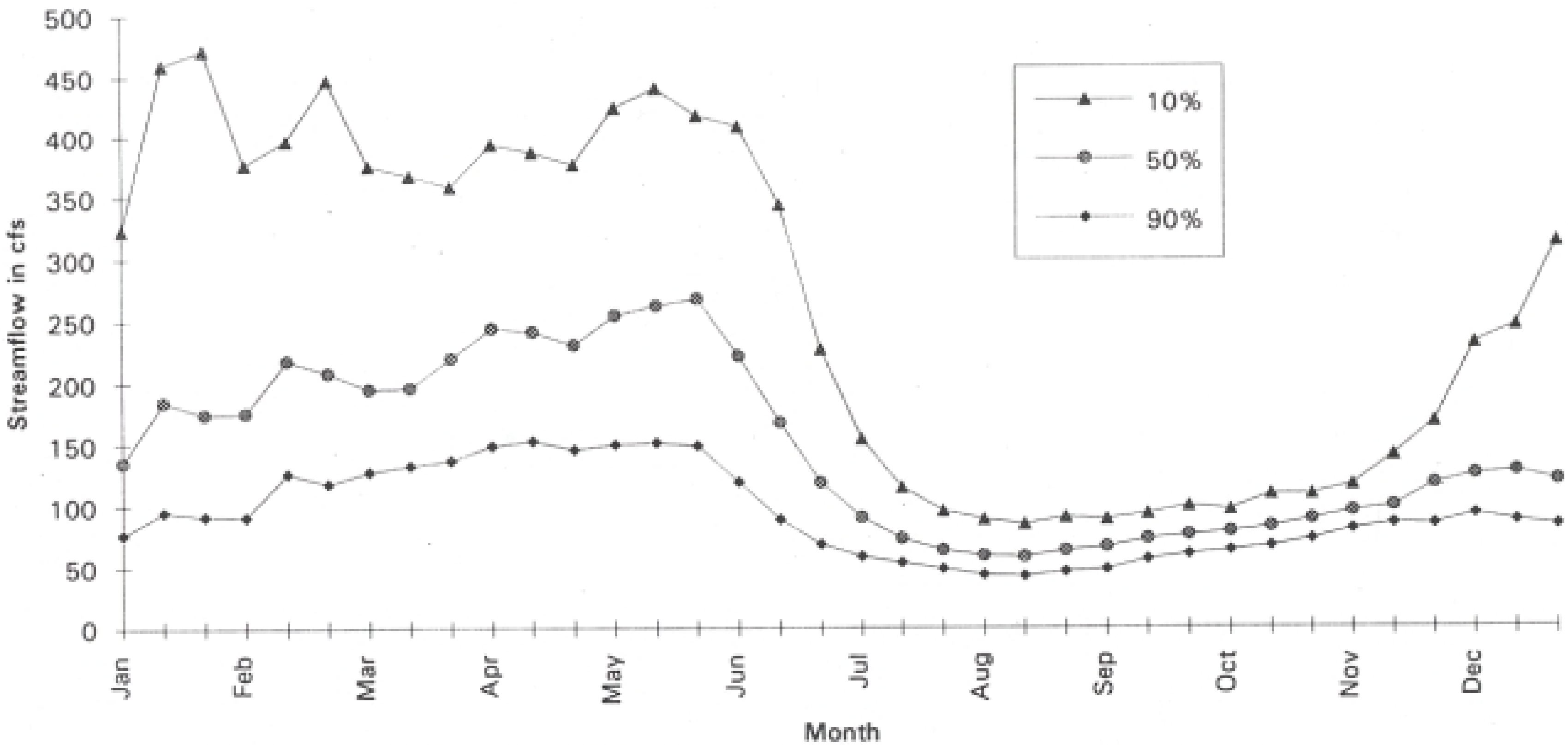
**Appendix C: Habitat Use Curves (continued)**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | 202 | 6 7 | 90 0 | Bull Trout | | | | | | Juvenile | | | |
| V | 202 | 0.00 | 0.13 | 0.35 | 0.19 | 1.30 | 1.00 | 3.20 | 1.00 | 6.00 | 0.00 | 100.0 | 0.00 |
| D | 202 | 0.00 | 0.00 | 0.49 | 0.00 | 0.60 | 0.02 | 0.85 | 0.11 | 1.00 | 1.00 | 5.00 | 1.00 |
| D | 202 | 100.0 | 0.00 | | | | | | | | | | |
| S | 202 | 0.00 | 0.00 | 0.10 | 1.00 | 0.20 | 1.00 | 0.30 | 1.00 | 0.40 | 1.00 | 0.50 | 0.80 |
| S | 202 | 0.60 | 0.80 | 0.70 | 0.20 | 0.80 | 0.20 | 0.90 | 0.10 | 10.50 | 0.10 | 13.90 | 0.10 |
| S | 202 | 20.50 | 0.10 | 23.90 | 0.10 | 24.50 | 0.15 | 24.90 | 0.11 | 26.50 | 0.30 | 26.90 | 0.14 |
| S | 202 | 27.50 | 0.40 | 27.90 | 0.16 | 28.50 | 0.55 | 28.90 | 0.19 | 29.50 | 0.20 | 29.90 | 0.12 |
| S | 202 | 30.50 | 0.10 | 33.90 | 0.10 | 37.50 | 0.40 | 37.90 | 0.16 | 40.50 | 0.15 | 40.90 | 0.19 |
| S | 202 | 45.50 | 0.25 | 45.90 | 0.21 | 46.50 | 0.35 | 46.90 | 0.23 | 52.50 | 0.20 | 52.90 | 0.28 |
| S | 202 | 56.50 | 0.40 | 56.90 | 0.32 | 57.50 | 0.50 | 57.90 | 0.34 | 62.50 | 0.30 | 62.90 | 0.46 |
| S | 202 | 64.50 | 0.35 | 64.90 | 0.47 | 65.50 | 0.40 | 65.90 | 0.48 | 66.50 | 0.50 | 66.90 | 0.50 |
| S | 202 | 67.50 | 0.60 | 67.90 | 0.52 | 68.50 | 0.75 | 68.90 | 0.55 | 69.50 | 0.40 | 69.90 | 0.48 |
| S | 202 | 72.50 | 0.40 | 72.90 | 0.64 | 73.50 | 0.40 | 73.90 | 0.64 | 75.50 | 0.50 | 75.90 | 0.66 |
| S | 202 | 76.50 | 0.60 | 76.90 | 0.68 | 77.50 | 0.70 | 77.90 | 0.70 | 78.50 | 0.85 | 78.90 | 0.73 |
| S | 202 | 79.50 | 0.50 | 79.90 | 0.66 | 82.50 | 0.55 | 82.90 | 0.91 | 85.50 | 0.65 | 85.90 | 0.93 |
| S | 202 | 86.50 | 0.75 | 86.90 | 0.95 | 87.50 | 0.85 | 87.90 | 0.97 | 88.50 | 1.00 | 88.90 | 1.00 |
| S | 202 | 89.50 | 0.65 | 89.90 | 0.93 | 92.50 | 0.20 | 92.90 | 0.30 | 96.50 | 0.30 | 96.90 | 0.32 |
| S | 202 | 97.50 | 0.50 | 97.90 | 0.34 | 98.50 | 0.65 | 98.90 | 0.37 | 99.50 | 0.30 | 100.0 | 0.30 |
| H | 301 | 9 7 | 37 0 | Chinook (Rivers) | | | | | | Spawning | | | |
| V | 301 | 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 | 301 | 3.50 | 0.70 | 4.00 | 0.00 | 100.0 | 0.00 | | | | | | |
| D | 301 | 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 | 301 | 100.0 | 0.00 | | | | | | | | | | |
| S | 301 | 0.00 | 0.00 | 25.70 | 0.00 | 32.60 | 0.18 | 35.80 | 0.44 | 41.60 | 0.60 | 41.80 | 0.80 |
| S | 301 | 42.60 | 0.60 | 42.80 | 0.80 | 43.70 | 0.79 | 45.60 | 1.00 | 46.70 | 1.00 | 51.60 | 0.60 |
| S | 301 | 51.70 | 0.70 | 51.80 | 0.80 | 51.90 | 0.90 | 52.60 | 0.60 | 52.70 | 0.70 | 52.80 | 0.80 |
| S | 301 | 53.70 | 0.79 | 53.80 | 0.89 | 54.50 | 1.00 | 56.90 | 1.00 | 61.80 | 0.80 | 61.60 | 0.60 |
| S | 301 | 61.70 | 0.70 | 62.70 | 0.70 | 62.60 | 0.60 | 62.80 | 0.80 | 63.60 | 0.72 | 63.70 | 0.79 |
| S | 301 | 63.80 | 0.86 | 64.60 | 1.00 | 65.80 | 1.00 | 67.60 | 0.72 | 67.70 | 0.79 | 73.60 | 0.30 |
| S | 301 | 76.60 | 0.58 | | | | | | | | | | |
| H | 302 | 9 7 | 69 | Chinook (Rivers) change 8-12-93 Tucannon juvenile | | | | | | | | | |
| V | 302 | 0.00 | 0.30 | 0.50 | 1.00 | 0.90 | 1.00 | 1.80 | 0.60 | 2.20 | 0.15 | 3.60 | 0.00 |
| V | 302 | 5.00 | 0.00 | 6.00 | 0.00 | 100.0 | 0.00 | | | | | | |
| D | 302 | 0.00 | 0.00 | 0.49 | 0.00 | 0.80 | 0.28 | 1.20 | 0.75 | 1.60 | 1.00 | 5.00 | 1.00 |
| D | 302 | 100.0 | 1.00 | | | | | | | | | | |
| S | 302 | 0.00 | 0.00 | 0.10 | 1.00 | 0.20 | 1.00 | 0.30 | 1.00 | 0.40 | 1.00 | 0.50 | 0.80 |
| S | 302 | 0.60 | 1.00 | 0.70 | 0.10 | 0.80 | 0.10 | 0.90 | 0.10 | 10.50 | 0.10 | 13.90 | 0.10 |
| S | 302 | 13.60 | 0.10 | 14.70 | 0.16 | 14.80 | 0.14 | 15.60 | 0.18 | 16.70 | 0.22 | 16.80 | 0.18 |
| S | 302 | 24.70 | 0.16 | 25.60 | 0.18 | 25.70 | 0.16 | 32.60 | 0.10 | 35.80 | 0.14 | 41.60 | 0.22 |
| S | 302 | 41.80 | 0.36 | 42.60 | 0.28 | 42.80 | 0.34 | 43.70 | 0.24 | 45.60 | 0.30 | 45.70 | 0.30 |
| S | 302 | 45.80 | 0.30 | 45.90 | 0.30 | 46.60 | 0.38 | 46.70 | 0.36 | 51.60 | 0.22 | 51.70 | 0.24 |
| S | 302 | 51.80 | 0.26 | 51.90 | 0.28 | 52.60 | 0.22 | 52.70 | 0.24 | 52.80 | 0.26 | 53.70 | 0.24 |
| S | 302 | 53.80 | 0.26 | 54.50 | 0.30 | 54.60 | 0.30 | 54.70 | 0.30 | 56.60 | 0.38 | 56.70 | 0.36 |
| S | 302 | 56.80 | 0.34 | 56.90 | 0.32 | 61.80 | 0.42 | 61.60 | 0.34 | 61.70 | 0.38 | 62.70 | 0.38 |
| S | 302 | 62.60 | 0.34 | 62.80 | 0.42 | 63.60 | 0.34 | 63.70 | 0.38 | 63.80 | 0.42 | 64.60 | 0.42 |
| S | 302 | 64.70 | 0.44 | 64.80 | 0.46 | 65.60 | 0.42 | 65.70 | 0.44 | 65.80 | 0.46 | 67.60 | 0.58 |
| S | 302 | 67.70 | 0.56 | 73.60 | 0.46 | 76.60 | 0.62 | | | | | | |

# Appendix D

**Exceedence Flow Hydrograph**

Exceedence Flows for the Tucannon River at RM 7.9




As Measured at USGS Station #13344500 (Period of Record = 1915-17, 1928-31, 1958-90)

# Appendix E

## WDWF Substrate and Cover Code Application

Departments of Fisheries & Wildlife
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 quality of a certain substrate, not be 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/Holding | |
| Code | Substrate Size | In Inches | Juvenile Rearing | Spawning | Adult Holding | Steelhead | Trout | Juvenile & Adult | Steelhead Adult |
| 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)