WASHINGTON STATE DEPARTMENT OF ECOLOGY

Green River Fish Habitat Analysis Using the Instream Flow Incremental Methodology

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Fish Habitat Analysis Using the
Instream Flow Incremental Methodology

by
Brad Caldwell
Stephen Hirschey

Water Resources Program
Department of Ecology
Mail Stop PV-11
Olympia, Washington 98504

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ABSTRACT

A study of the Green River was conducted using the Instream Flow Incremental Methodology. This study provides fish habitat versus flow relationships for use in streamflow management by Ecology. In addition, the study can be used by the Corps of Engineers to examine the downstream effects on fish habitat from increasing water storage behind Howard A. Hanson Dam and the present management of existing storage.

Five study sites, involving a total of 31 transects, represent fish habitat in 40 miles of the Green River. Fish habitat is defined in this study as water depth, velocity, substrate, and cover. Habitat measurements for the computer models were collected at three different flows.

The five site models indicate peak habitat for spawning steelhead at flows ranging from 550 to 700 cfs, spawning chinook 525 to 700 cfs, spawning coho 240 to 375 cfs, spawning chum 260 to 400 cfs, juvenile steelhead 300 to 400 cfs, juvenile chinook and coho 140 to 240 cfs, adult holding chinook 220 to 450 cfs, and adult holding steelhead 300 to 600 cfs.

PREFACE

This publication provides fish habitat versus flow relationships for the Green River. These habitat relationships can be used to help determine how to manage the flow in the river. There is no one flow at which habitat for fish is optimum. The different fish species and lifestages exist simultaneously in the river and each has a different optimum flow requirement. Providing an optimum habitat flow for one lifestage will usually result in habitat loss for another lifestage.

Peak habitat flow does not necessarily equate with peak fish production. Flows higher than peak habitat flows are needed for juvenile fish at certain times of the year to maintain existing production levels.

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LIST OF ACRONYMS

cfs	cubic feet per second
COE	Corps of Engineers
Ecology	Washington Department of Ecology
fps	feet per second
HAH	Howard A. Hanson
HABTAT	Computer program that combines IFG4 with habitat-use curves
IFG4	Instream Flow Group's hydraulic model
IFIM	Instream Flow Incremental Methodology
IRPP	Instream Resource Protection Program
NMFS	National Marine Fisheries Service
PHABSIM	Physical Habitat Simulation computer model
RM	river mile
VAF	Velocity Adjustment Factor
WAC	Washington Administrative Code
WDF	Washington Department of Fisheries
WDW	Washington Department of Wildlife
WUA	Weighted Usable Area
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

I. PROJECT BACKGROUND

Study Objectives

One of the main objectives for this Instream Flow Incremental Methodology (IFIM) study is to provide the Washington Department of Ecology (Ecology) with information to review its Green River minimum instream flows. Additionally, the Corps of Engineers (COE) can use this IFIM study to evaluate present water releases from Howard A. Hanson (HAH) reservoir and alternative flow regimes if HAH reservoir storage is increased.

Ecology's Instream Resource Protection Program

Ecology has conducted IFIM studies since 1983 for setting minimum instream flows through its Instream Resource Protection Program (IRPP). Minimum instream flows for the Green River were set by Ecology under its IRPP in 1980 by regulation (Chapter 173-509 Washington Administrative Code, see Table 1). The minimum instream flows for the Green River were set at 150 cfs for the summer and at 300 cfs for the winter at U.S. Geological Survey (USGS) gage 12106700 near Palmer, and at 300 cfs for the summer and 550 cfs for the winter at gage 12113000 near Auburn.

A study conducted on the Green River (Swift 1979) was an important basis for the minimum instream flows. The USGS methodology used for determining salmon-spawning flows was essentially the same as IFIM except substrate and cover was not included. Other methodologies were used as a basis for salmonid-rearing flows. These methods involved correlations between low, summer flows and adult salmon and steelhead returns. Final minimum flows proposed by the agencies were modified by professional judgment of fish biologists. Ecology's adopted spawning flow of 550 cfs was intended to protect 95 percent of the spawning habitat.

Participants

Project participants included the Washington Department of Fisheries (WDF), Washington Department of Wildlife (WDW), COE, City of Tacoma, Trout Unlimited, Muckleshoot Indian Tribe, National Marine Fisheries Service (NMFS), and U.S. Fish and Wildlife Service (USFWS).

River Description

The Green River begins in the Cascade Mountains near Stampede Pass and flows west through the Snoqualmie National Forest. Thirty miles downstream from its source the river encounters HAH Dam at river mile (RM) 64.5 and then the Tacoma Water Diversion Dam at RM 61. The river continues downstream to the town of Kanasket and the start of the Green River Gorge (RM 58). The 300-foot deep gorge continues for 12 miles to Flaming Geyser State Park (RM 46). Two major tributaries, Newaukum Creek (RM 4.7) and Big Soos Creek (RM 33.7), join the

Table 1. Minimum Instream Flows for the Green River adopted 6/6/80 (Ch. 173-50 WAC).

INSTREAM FLOWS FOR FUTURE WATER RIGHTS
IN THE GREEN-DUWAMISH RIVER BASIN
(in Cubic Feet per Second)

Month	Day	Gage 12113000 Normal Year Green River Near Auburn	Gage 12106700 Normal Year Green River Near Palmer	Gage 12106700 Critical Year Green River Near Palmer
Jan.	1	550	300	300
	15	550	300	300
Feb.	1	550	300	300
	15	550	300	300
Mar.	1	550	300	300
	15	550	300	300
Apr.	1	550	300	300
	15	550	300	300
May	1	550	300	300
	15	550	300	300
June	1	550	300	300
	15	550	300	210
July	1	550	300	150
	15	300	150	150
Aug.	1	300	150	150
	15	300	150	150
Sept.	1	300	150	150
	15	300	150	150
Oct.	1	300	190	150
	15	350	240	150
Nov.	1	550	300	190
	15	550	300	240
Dec.	1	550	300	300
	15	550	300	300

For a definition of “critical year” see Ch. 173-509-303 WAC.

Green River upstream of Auburn (RM 32). Here the river turns northward and flows past Kent (RM 26) and Tukwila (RM 14), becoming the Duwamish River at RM 11. The river flows into Elliott Bay on Puget Sound. Tides affect the lower 12 miles of the river.

Hydrology

The Green River has 483 square miles of drainage area fed by snowmelt, rain, and ground water. The median flow at Auburn (USGS gage 12113000 at RM 31.3) ranges from 1900 to 1400 cubic feet per second (cfs) from December through May and is about 300 cfs during August, the normal low flow month (Figure 1). The median flow at the Purification Plant near Palmer (USGS) gage 12106700 at RM 60.3) ranges from 1400 to 800 cfs from December through May, but is only 150 cfs during August (Figure 2). The Purification Plant gage is just downstream from the City of Tacoma's 113 cfs year-round diversion.

Figures 1 and 2 portray the annual exceedence-frequency hydrographs for both gages. The 90-percent-exceedence flow is equaled or exceeded 90 percent of the time. It can also be thought of as a 1-in-10-year low flow. The 50 percent exceedence flow is the median flow and gives the closest approximation to being the "normal" flow. The exceedence hydrographs are based on a 10-day-average flow thus eliminating some of the variation from daily flows.

History and Water Rights

The Green River was radically altered between 1900 and 1916. Once a tributary of the White River (which was a tributary of the Duwamish River), the Green River was diverted to flow directly into Puget Sound (Figure 3). The lowering of Lake Washington and a major flood in 1906 were the primary causes of this diversion. The lower part of the river retained the name Duwamish River.

The City of Tacoma built the Tacoma Water Diversion Dam on the Green River in 1911. The dam, at RM 61, blocks all upstream migration of salmonids. Presently, no spawning occurs upstream of the diversion dam, but juvenile salmonids are outplanted into tributaries upstream of HAH dam. Tacoma diverts 113 cfs or the natural flow, whichever is less, under a vested water claim (water was diverted before the 1917 Water Code). This claim is not subject to Washington State's 1980 minimum instream flows. An adjudication has not been held to determine if the claim is valid.

In 1985, Tacoma was granted a water-right permit by Ecology for an additional 100 cfs. That water right cannot be certified until a second pipeline is built and the water is put to beneficial use. The additional 100 cfs diversion is subject to Washington State's 1980 minimum instream flows for the Green River.

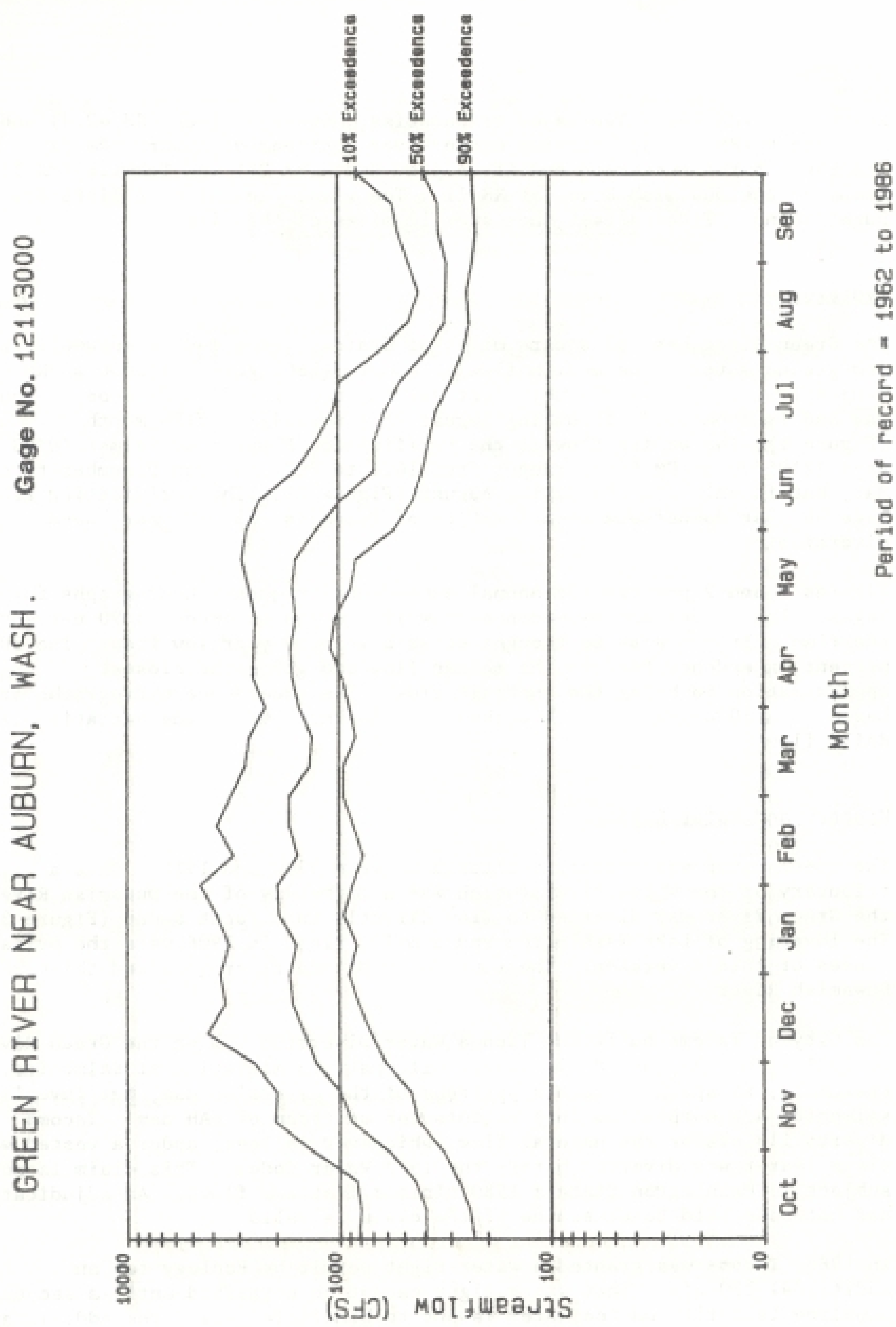


Figure 1. Exceedence-frequency hydrograph of the Green River at Auburn (RM 31.3).

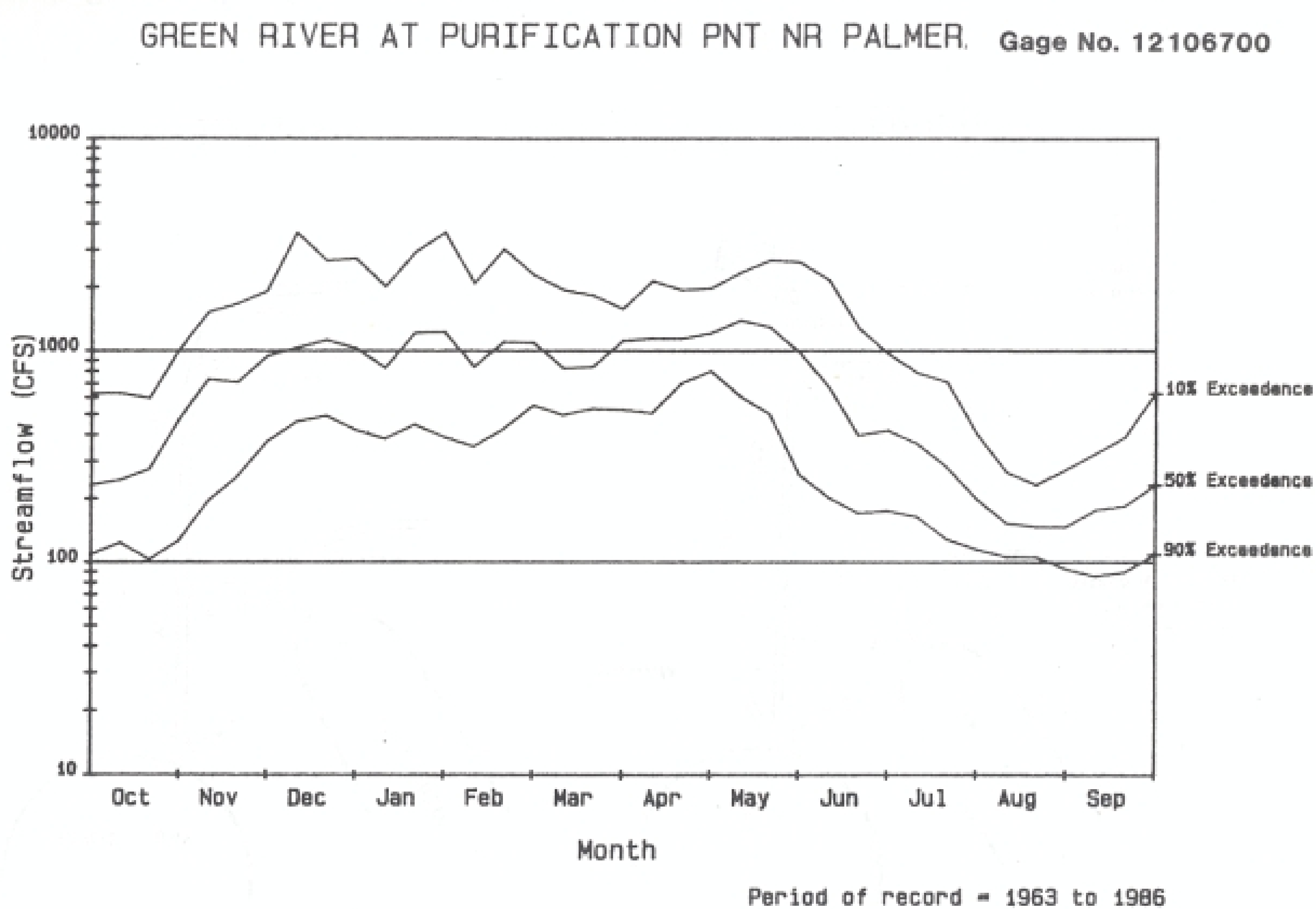


Figure 2. Exceedence-frequency hydrograph of the Green River at the Purification Plant (RM 60.2).

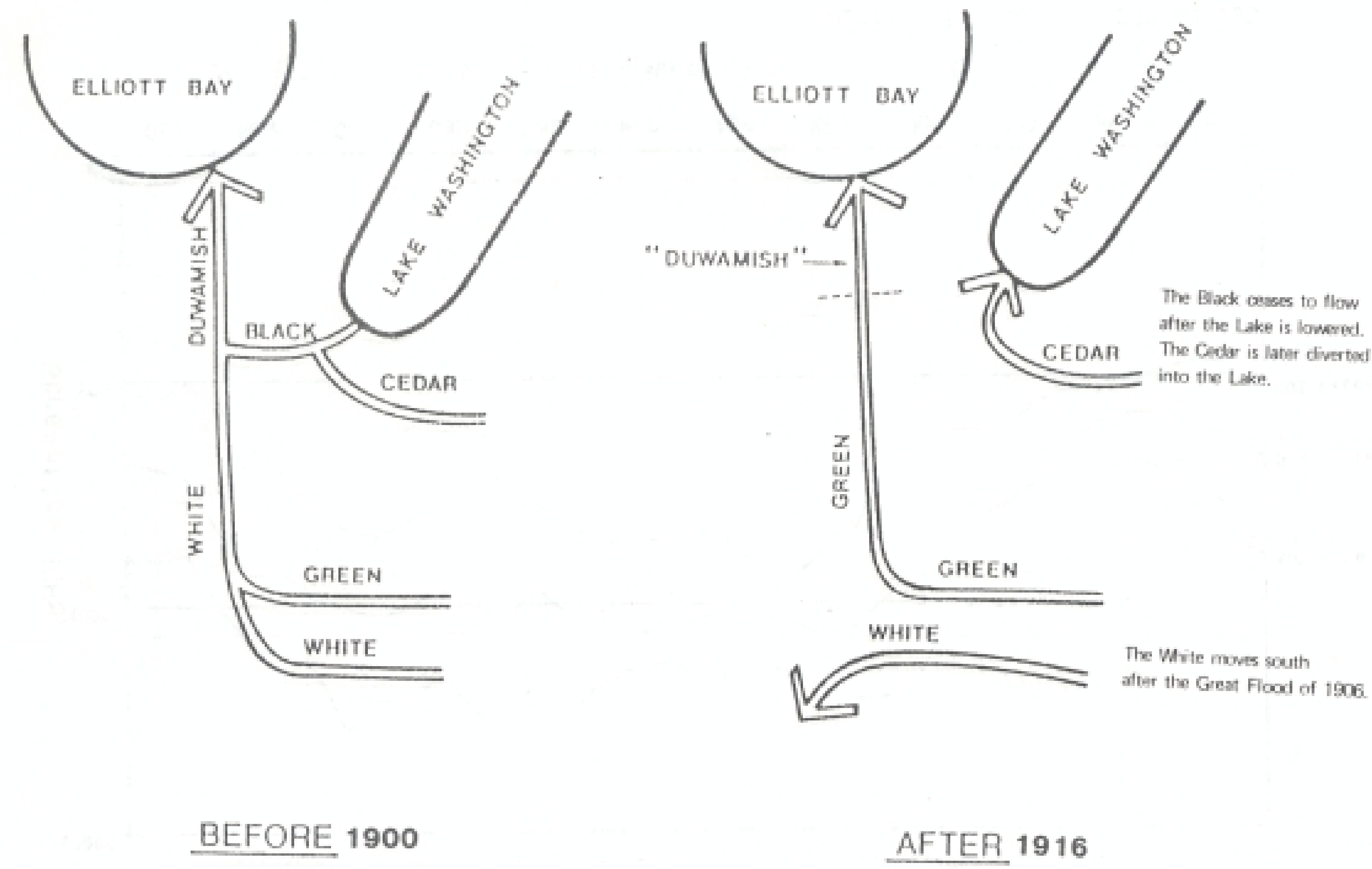


Figure 3. Configuration of the Duwamish basin prior to 1900 and after 1916 (from Grette and Salo, 1986).

Operation of HAH Dam

A second dam, HAH Dam, was built at RM 64.5 by the COE and began filling December 5, 1961. It was authorized by Congress for flood control and conservation storage to augment low summer/fall flows for over 12,000 cfs at Auburn and to provide a minimum flow of 110 cfs with 98 percent reliability. The COE actually releases a minimum flow of 223 cfs to ensure that 110 cfs passes Tacoma's diversion. Overall, the operation of the dam since 1962 has changed flows at Auburn by decreasing high flows in April, May, and June and increasing low flows in July, August, September, and October (Figure 4).

The COE monitors the weather, snowpack, and reservoir inflow to decide whether to start filling the reservoir in April, May, or June to ensure a 110 cfs instream flow. Filling of the reservoir is delayed as late as possible in the spring to allow downstream passage out of HAH reservoir of coho, chinook, and steelhead smolts. But reservoir filling often starts during the peak of smolt outmigration, and the smolts are prevented from migrating to the ocean. However, if reservoir filling is delayed just one week too late, HAH reservoir can run out of water storage before the expected October rain. Flow is then so low with fall chinook spawning is severely disrupted.

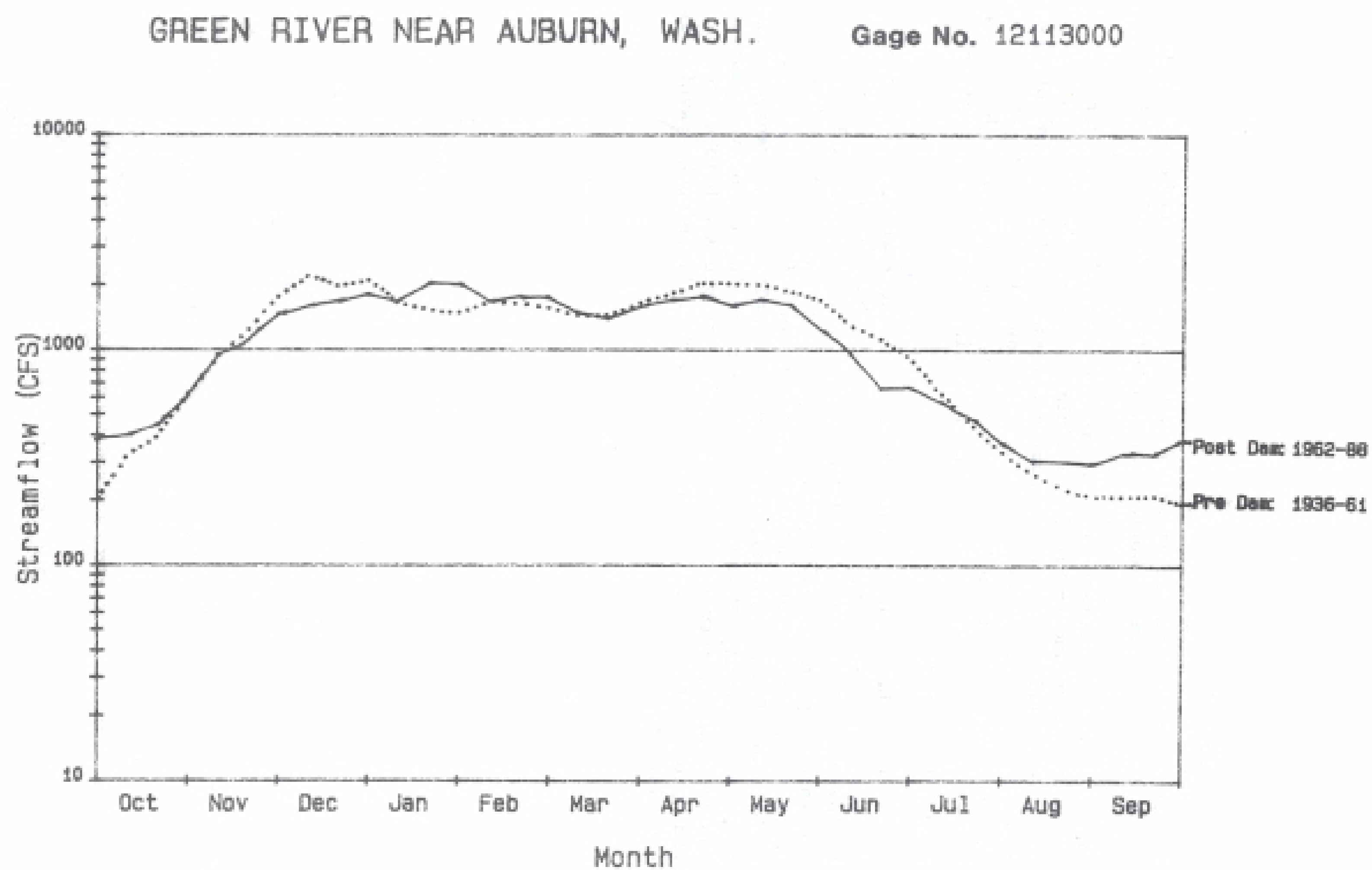


Figure 4. Pre-and post-HAH reservoir median flows for the Green River at Auburn.

II. METHODS OF STUDY

IFIM was selected and used in this study as the best available methodology for predicting how fish habitat is affected by incremental changes in streamflow.

Description of the Instream Flow Incremental Methodology

IFIM, as described by Bovee (1982), was derived by the U.S. Fish and Wildlife Service's Instream Flow Group in the late 1970's. IFIM is a process where certain variables affecting fish habitat are chosen for in-depth analysis. However, the term IFIM is often used when referring to PHABSIM (Physical Habitat Simulation) or IFG4 (hydraulic model). PHABSIM is a collection of computer models in IFIM (Milhous et al 1984). IFG4 is the most commonly used hydraulic model in PHABSIM.

The IFIM process involves several planning steps undertaken with interested groups. First, a "scoping" meeting is held with interested groups to discuss the entire scope-of-work including possible study-site locations. Next, field trips are coordinated with interested groups to select study sites and transect locations. Then field data (water velocities and depths, substrate, and cover) is collected at different flows. The field work should include observations from the study river on the habitat preferred by the fish. A hydraulic model is built and calibrated. The hydraulic model gives a representation of the velocities and depths (associated with substrate and cover) available for fish over a range of flows. Meetings are held with interested groups to reach agreement on the method of calibration of the hydraulic model, the method of transect weighting, and the habitat-use curves to be used with the hydraulic model. Finally, fish biologists from the interested agencies and tribes use professional judgment to interpret the habitat-versus-flow curves to arrive at a flow regime for the fish.

IFG4 uses data from multiple transects to predict the 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 (Figure 5). Each cell is assigned an area, an average water depth, and a velocity associated with a type of substrate and/or cover for a particular flow. Fish habitat is defined in the computer model by the variables of velocity, depth, substrate, and cover.

After the hydraulic model, IFG4, is calibrated, PHABSIM combines IFG4 output with a biological model. The biological model consists of habitat-use curves describing the preference of each fish species for depth, velocity, substrate, and cover. The habitat-use curves for each fish species are defined further for various lifestages, such as adult spawning, juvenile rearing, and adult holding (See Appendix H4).

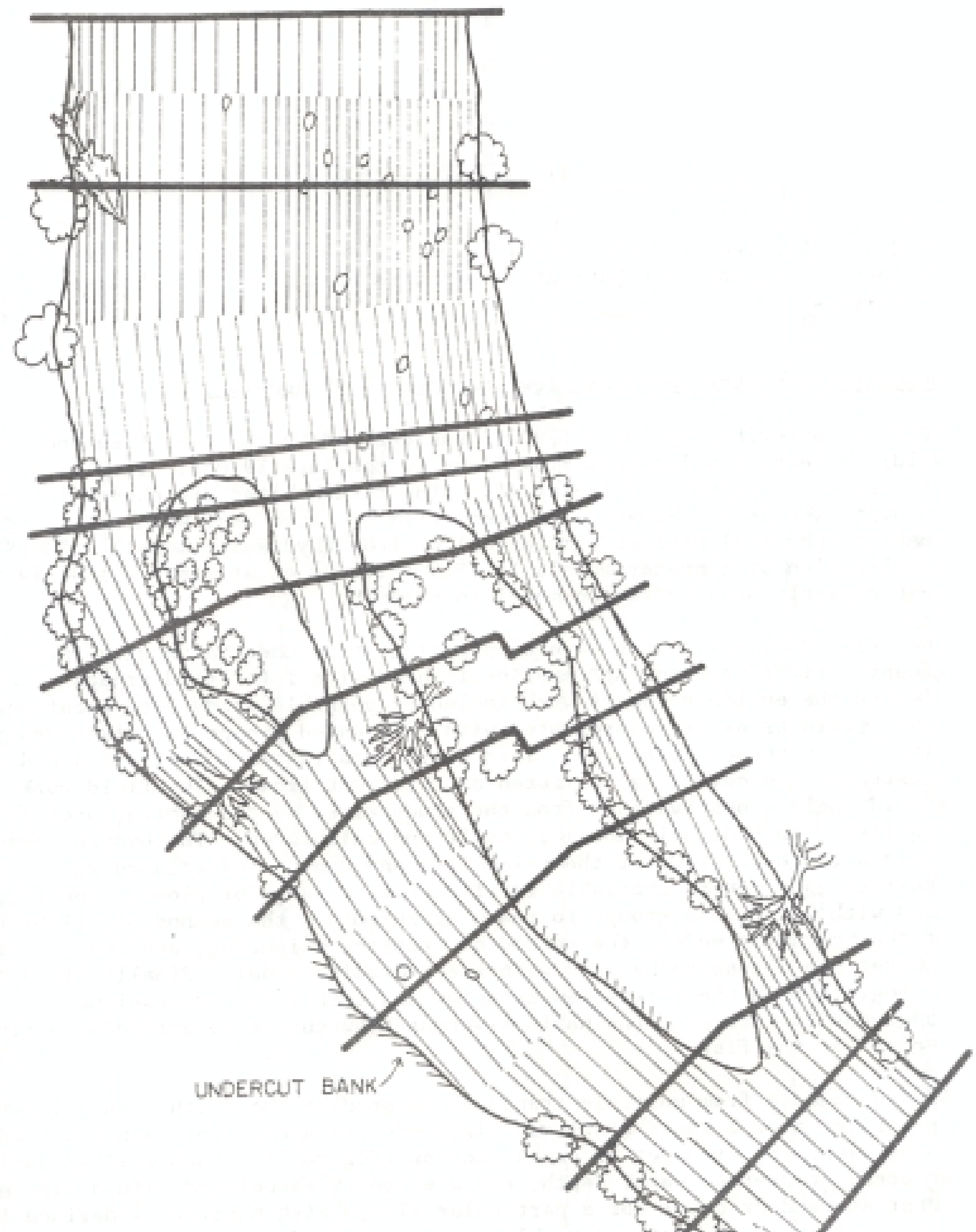


Figure 5. Top view looking down on placement of transects and measurement verticals used to define the distribution of aquatic habitat in an IFIM site (from Bovee, 1982).

The habitat for each cell on a transect is calculated by multiplying the habitat-preference factor by the area. The habitat preference factor is calculated as in this example. A velocity preference of 1.0 multiplied times a depth preference of 0.9 times a substrate/cover preference of 0.8 equals a preference factor of 0.72 for that cell. This preference factor is multiplied by the number of square feet of area in that cell. All cells for all transects are summed to arrive at the total number of square feet of preferred habitat at a specified flow. The final result is a listing of fish habitat-values called Weighted Useable Area (WUA). WUA is in units of square feet of habitat per 1,000 feet of stream.

WUA is an index of fish habitat. Transforming WUA into a fish population estimate requires assumptions not considered in the PHABSIM model. To use WUA for a fish population estimate requires assumptions such as: 1) the number of fish that would use a square foot of habitat (averages from streams differ naturally by a factor of 200), 2) that no other factors are affecting the population (such as fishing pressure or disease), and that the population of one lifestage does not limit the population of the following lifestage over time (assumes there will always be enough juvenile fish to fully seed all of the adult-fish habitat).

Interagency Participation in Scope-of-Work

A detailed work plan and river segmentation map for an instream flow study on the Green River was presented by Ecology at a COE, WDF, WDW, City of Tacoma, Muckleshoot Indian Tribe, NMFS, USFWS, Trout Unlimited, and others. Participation was sought from these groups by Ecology for an IFIM study of the Green River. Assistance was given by the groups listed above in field work, site and transect selection, hydraulic-model calibration, and selection of habitat-use curves.

Study Site and Transect Selection

Preliminary sites were selected for the IFIM study by reviewing topographic maps, a draft copy of The Status of Anadromous Fishes of the Green/Duwamish River System (Grette and Salo 1986), and A Catalog of Washington Streams and Salmon Utilization, Volume 1, Puget Sound Region (Williams et al 1975). Further site selection was done during two field surveys. A helicopter survey from Kent to HAH dam was made by Brad Hall (COE), Lance Meyer (COE), and Brad Caldwell (Ecology). A survey by boat from Kent on upstream through Flaming Geyser State Park was performed by Jean Caldwell (WDF), Will Sandoval (Muckleshoot Indian Tribe), and Brad Caldwell (Ecology).

Five study sites were selected and all interested state, federal, tribal, municipal, and environmental groups were invited for a ground tour on two separate occasions to ensure agreement on site and transect selection. Approximately 40 miles of the Green River are represented by the five sites. The lower 12 miles of the Green/Duwamish were not included in the study because of tidal influence. The Green River gorge reach, RM 46 through RM 58, also was excluded because of inaccessibility and time constraints.

Figure 6 shows the IFIM sites with the number of river miles the site represents, gradient of the reach, names we gave the sites, approximate river mile locations of each site, number of transects used to represent the habitat, and a short description of the habitat found in each reach. Figures 7, 8, and 9 are site and transect maps of all five sites.

One site, the Hosey site (just downstream from the Tacoma Water Diversion Dam), was not included initially in Ecology's field work plans and its transects are based on preliminary work by the City of Tacoma. The City of Tacoma had hired Hosey and Associates to conduct an IFIM study on this reach. Agency and tribal scoping on transect selection had been completed and the consultant was ready to collect field measurements. Ecology was informed on June 19, 1986 that the IFIM study on this site was cancelled. Although the site wasn't included in Ecology's initial work plan, we decided that the habitat the site represented was important enough to add the site to Ecology's study.

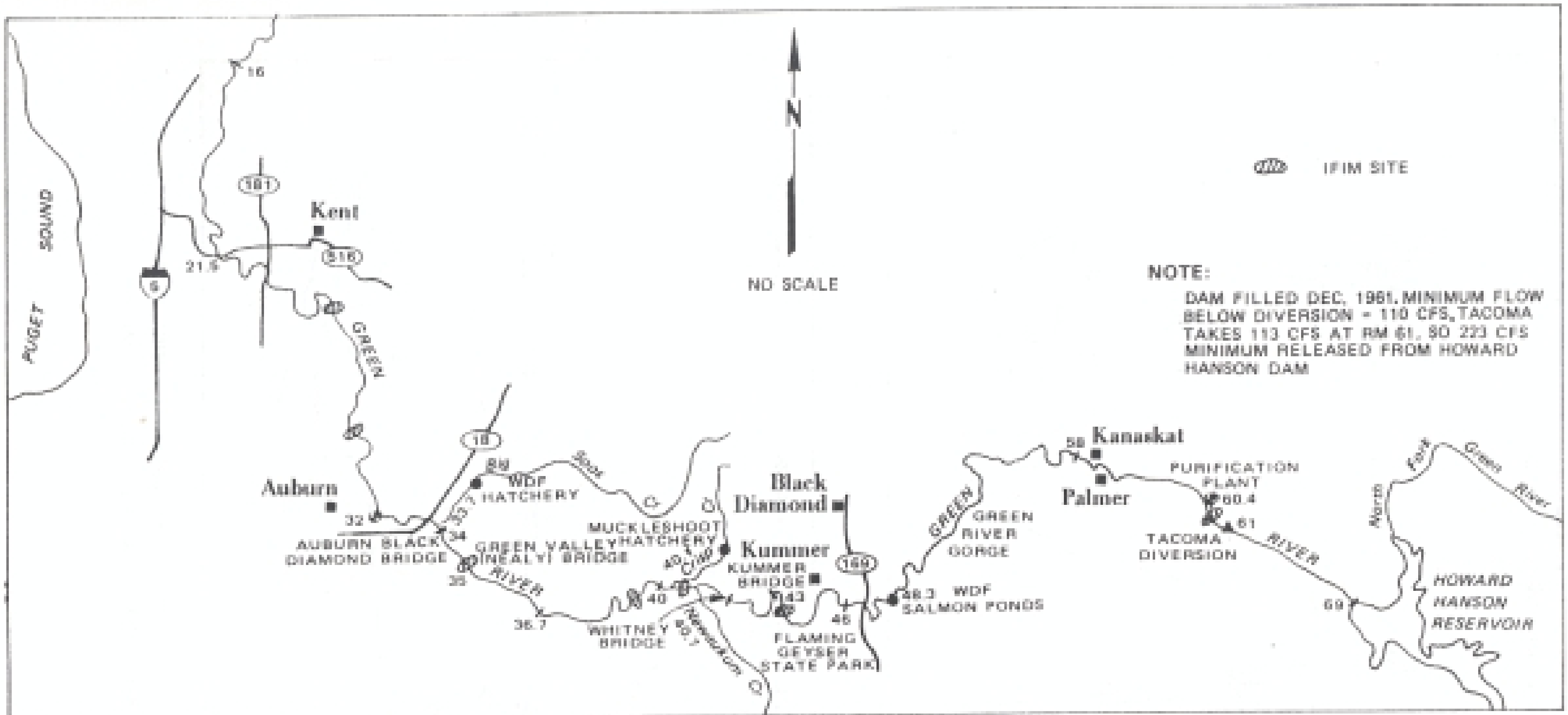
Field Procedures

IFIM measurements were initiated on June 17, 1986 for the five sites:

1. Kent.
2. Nealy Bridge.
3. Car Body.
4. Flaming Geyser.
5. Hosey.

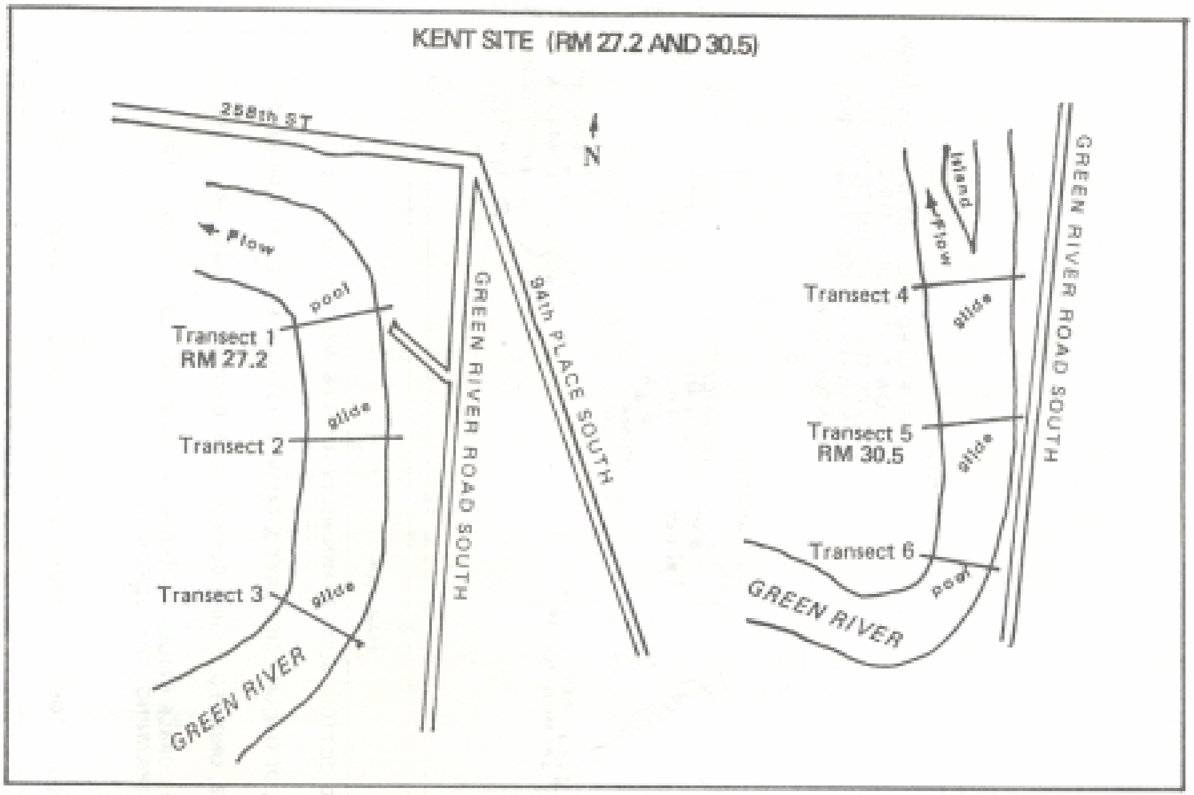
Measurements of water depth, water velocity, substrate composition, and cover were made along each transect. A temporary gage at each site verified steady streamflow during flow measurement. Water velocity was measured with calibrated Swoffer, Pygmy, and Gurley velocity meters mounted on top-set wading rods. Deep water required the use of a USGS boat-mounted apparatus involving a Swoffer velocity meter attached to a 30 lb. weight connected by a cable to a reel mounted on a cross-piece and boom on a boat. The boat was accurately positioned in the river by sliding the boat along a cable marked with beads at five-foot intervals. The beaded cable was strung between fence posts using cable clamps and tension was applied with a winch.

Water-surface elevations and stream-bank profiles were surveyed with a tripod-mounted transit level and stadia rod. Survey 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 WDF and WDW (Appendix H5).



RIVER REACH	% GRADIENT	SITE NAME	RIVER MILE	NO. OF TRANSECTS	HABITAT
12-32	0.08	KENT	27.2, 30.5	6	WIDE, SLOW, DIKED, SILTED BOTTOM, SOME SPAWNING IN RIFFLES, MOSTLY POOL–GLIDE.
32-36.7	0.1	NEALY BRIDGE	35	7	WIDE, MEDIUM VELOCITES, OFTEN ONE SIDE DIKED, GRAVEL BOTTOM, EXCELLENT SPAWNING, LONG GLIDES.
36.7-40	0.2	CAR BODY	39.6	7	WIDER, MEDIUM VELOCITES, UNDIKED, LARGE COBBLE BARS, GRAVEL BOTTOM, EXCELLENT SPAWNING, POOL–RIFFLE.
40-46	0.3	FLAMING GEYSER	40.6, 43.6	5	WIDE–FAST VELOCITIES IN COBBLE GLIDES, NARROW–FAST RIFFLES, MEDIUM VELOCITY GLIDES/POOLS WITH GOOD SPAWNING, GRAVEL/COBBLE.
46-58	1.5	NO SITE			GREEN RIVER GORGE
58-64	0.7	HOSEY	60.6	6	NARROW CANYON, DEEP POOLS, COBBLE BOTTOM, SOME FAST RIFFLES/CASCADES, SOME GOOD SPAWNING.

Figure 6. GREEN RIVER IFIM SITES LISTING RIVER MILES REPRESENTED, GRADIENT, SITE NAME, RIVER MILE LOCATION OF SITES, NUMBER OF TRANSECTS, AND HABITAT DESCRIPTION.



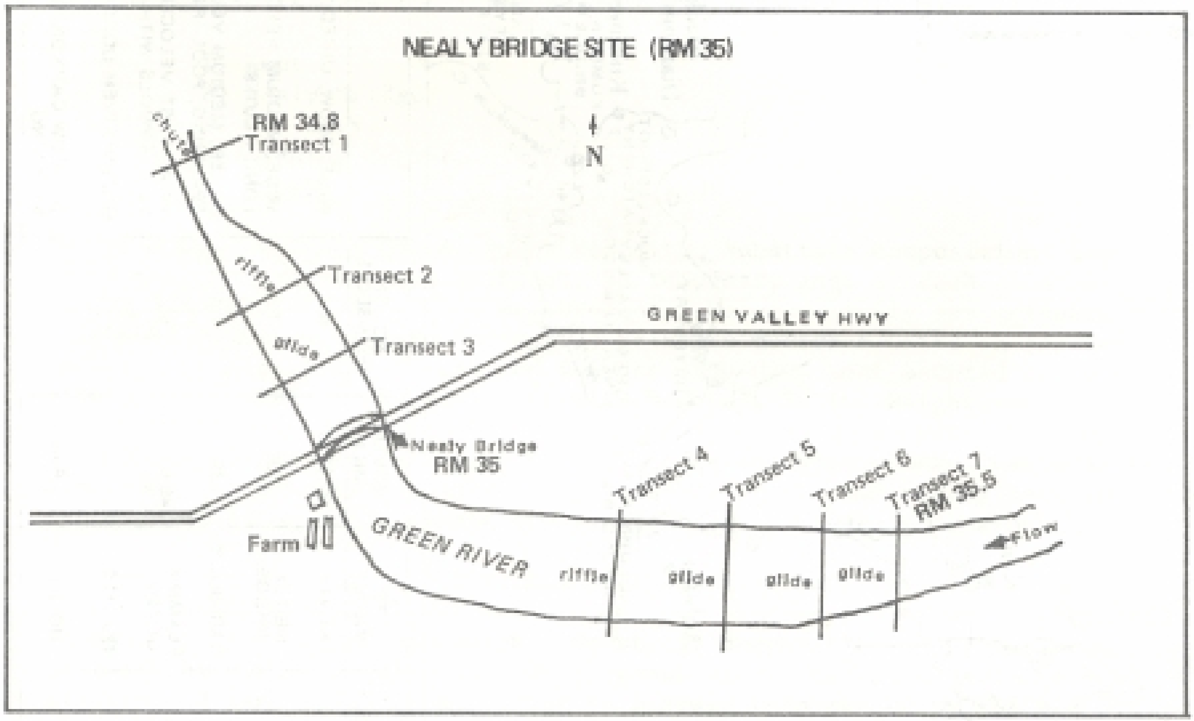
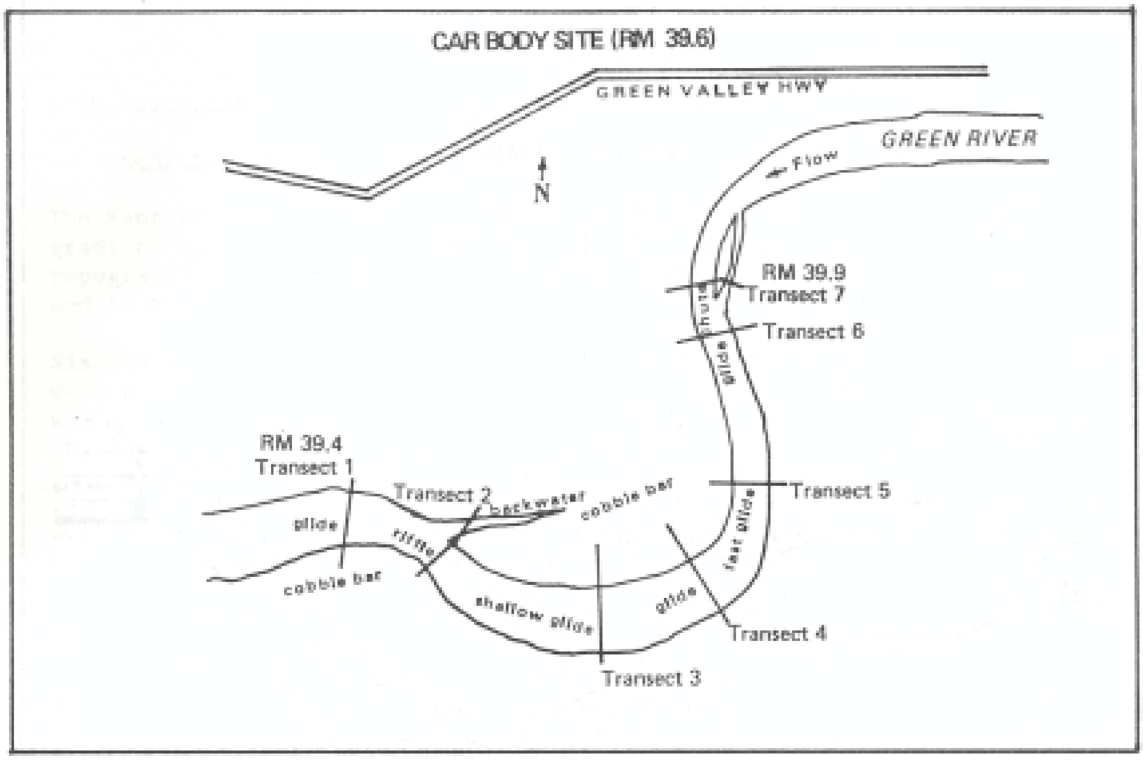


Figure 7. SITE AND TRANSECT MAP OF KENT AND NEALY BRIDGE SITES.



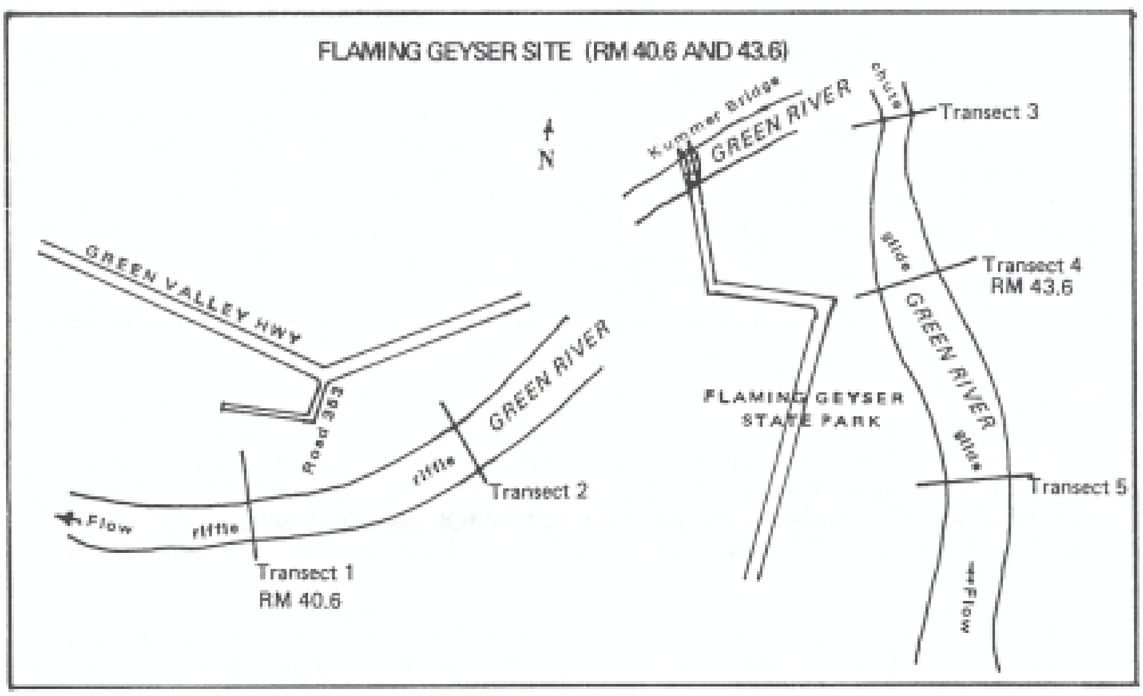


Figure 8. SITE AND TRANSECT MAP OF CAR BODY AND FLAMING GEYSER SITES.

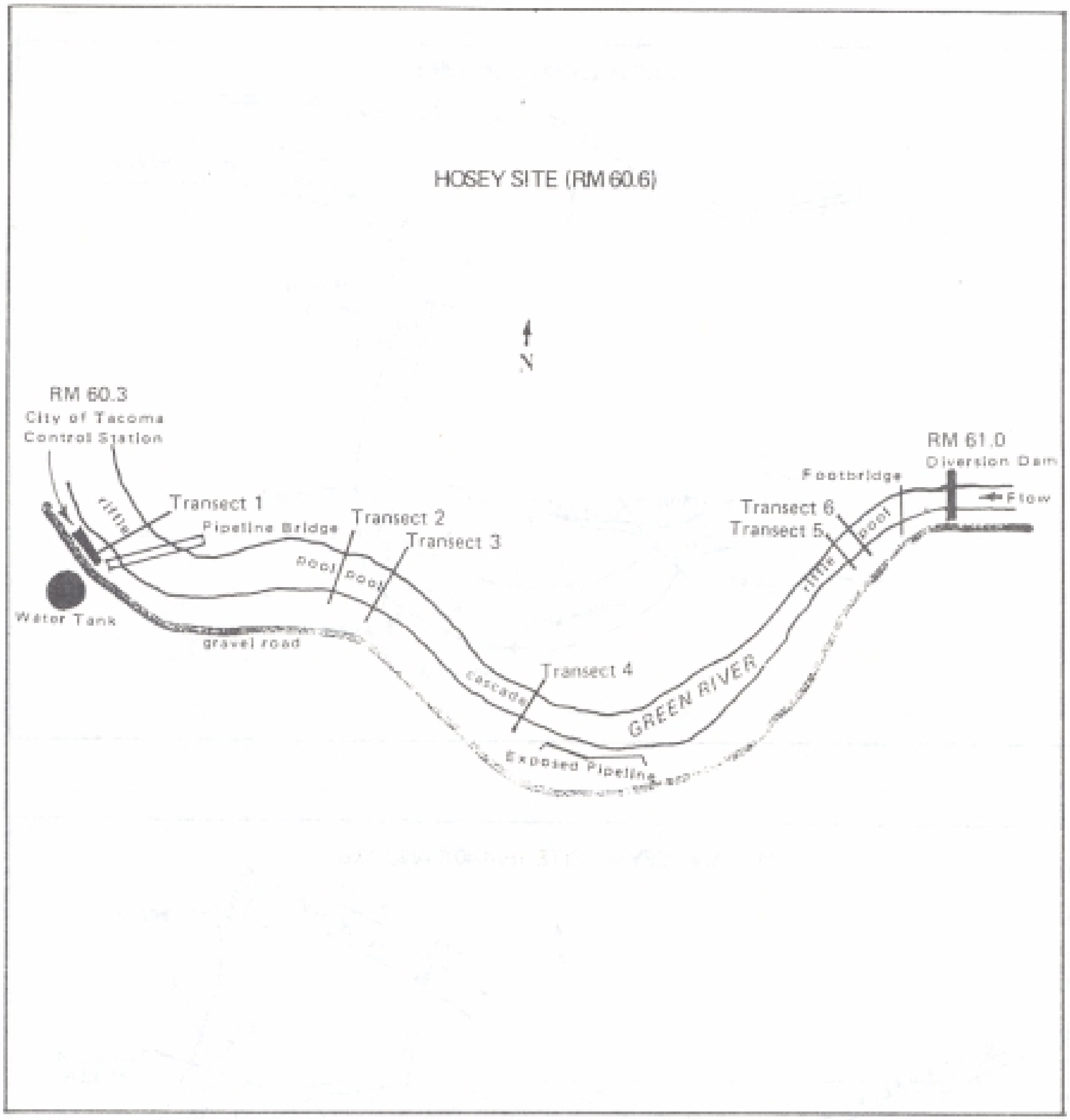


Figure 9. SITE AND TRANSECT MAP OF THE HOSEY SITE.

Site Description and Conditions During Measurements

Kent Site (RM 27.2 and 30.5)

The Kent site represents the river from RM 12 through RM 32. The river gradient in this reach is approximately 0.08 percent, as determined by topographical maps. The river is diked, wide, slow, has a silted bottom, and is mostly pool and glide habitat. Some spawning occurs in the riffles.

Six transects were used to represent the Kent site. Transects 1, 2, and 3 were near RM 27.2 and transects 4, 5, and 6 were near RM 30.5. Transect 1 was a deep pool/glide; transects 2 and 3 were glides; transect 4 was a shallow, fast glide; transect 5 was a deeper glide; and transect 6 was a pool/glide. Field measurements were collected at the Kent site at flows of 262 cfs on 8-8-86, 538 cfs on 6-18-86, and 950 cfs on 11-12-86. The flows were steady during measurement and no significant bed shifts occurred between the low-, medium-, and high-flow measurements on the six transects.

Nealy Bridge Site (RM 35)

The Nealy Bridge site represents the river from RM 32 through 36.7. The gradient in this reach is about 0.1 percent. The Nealy Bridge site is characterized by long glides with gravel and cobble bottom substrate. The river in this reach is wide, with one or both sides diked, and is an excellent salmonid spawning reach.

Seven transects were used to represent the Nealy Bridge site. Transects 1, 2, and 3 were downstream of Nealy Bridge (RM 35) and transects 4 through 7 were upstream of the bridge. Transect 1 was a fast chute; transects 2 and 3 were shallow glide/riffles; transect 4 was a shallow riffle; transect 5 was a glide; transect 6 was a deeper glide; and transect 7 was a narrow, fast glide with a gravel bar. Field measurements were collected at the Nealy Bridge site at flows of 238 cfs on 8-7-86, 425 cfs on 6-17-86, and 887 cfs on 11-11-86. The flows were steady during measurement and no significant bed shifts occurred between the low-, medium-, and high-flow measurements on the seven transects.

Car Body Site (RM 39.6)

The Car Body site represents the river from RM 36.7 through 40. The gradient is about 0.2 percent. The Car Body site is characterized by large cobble-bars, gravel/cobble substrate, and is an excellent salmonid spawning reach. The river is undiked, wider than the other reaches, and has more pool/riffle sequences.

Seven transects were used to represent the Car Body site. The transects were centered around RM 39.6 Transect 1 was a shallow glide; transect 2 was a fast riffle with a large, calm backwater on the right bank; transect 3 was a shallow glide; transect 4 was a deep glide; transect 5 was a deep, fast glide; and transect 6 was a glide. Transects 4 through 6 had a large cobble bar on the right side. Transect 7 had a split channel, with a fast chute on the right side and a riffle on the left. The left side of transect 7 was dry at the two lower measured flows. Field measurements were collected at flows of 234 cfs on 8-5-86, 410 cfs on 6-20-86, and 1048 cfs on 11-14-86. The flows were steady during measurement and no significant bed shifts occurred between the low-, medium-, and high-flow measurements on the seven transects.

Flaming Geyser Site (RM 40.6 and 43.6)

The Flaming Geyser site represents the river from RM 40 through 46. The river gradient is about 0.3 percent. The Flaming Geyser site is a sequence of fast glides; wide, fast riffles; and glide/pools with high-quality gravel/cobble substrate for spawning salmonids.

Five transects were used to represent the Flaming Geyser site. Transects 1 and 2 were at RM 40.6 and transects 3, 4, and 5 were at RM 43.6. Transects 1 and 2 were shallow, fast riffles; transect 3 was a fast chute; and transects 4 and 5 were glides. Field measurements were collected at flows of 220 cfs on 8-6-86, 301 cfs on 6-24-86, and 966 cfs on 11-10-86. The flows were steady during measurement, and no significant bed shifts occurred between the low-, medium-, and high-flow measurements on the five transects.

Hosey Site (RM 60.6)

The Hosey site represents the Green River from RM 58 through RM 64. The river gradient in this reach is about 0.7 percent. The Hosey site is generally a narrow canyon with deep pools and cobble bottoms. Fast riffles and cascades are in this reach. Salmonid spawning occurs in the few riffles and tails of the pools.

Six transects were used to represent the Hosey site. The transects were centered around RM 60.6. Transect 1 was a wide riffle, transects 2 and 3 were deep pools, transect 4 was a cascade, transect 5 was a shallow glide, and transect 6 was a pool/glide. Field measurements were collected at flows of 140 cfs on 8-4-86, 194 cfs on 6-25-86, and 768 cfs on 11-13-86. The flows were steady during measurement and no significant bed shifts occurred between the low-, medium-, and high-flow measurements on the six transects.

HAH flow releases were held steady all summer and fall and then were increased quickly to high flow in November. A higher medium flow could have been measured before 6-25-86, but Ecology was not notified that the City of Tacoma was dropping this study site until 6-19-86.

Only the water surface elevation was measured on transect 4 during high flow measurement. Measurement of water depths and velocities at this transect was judged to be too dangerous due to high velocities in the rapids.

III. HYDRAULIC MODEL

Calibration Philosophy

Calibration of the hydraulic model involves checking the velocities and depths predicted by the model against velocities and depths measured in the field. This includes examining indicators of the model's accuracy such as mean error and Velocity Adjustment Factor (VAF). Velocities and depths predicted at very high and low flows are examined to determine if they are within an acceptable range.

Calibration of the IFG4 model is done cell by cell for each transect to decide whether the accuracy of the predicted cell velocities is adequate. Generally, if the predicted cell velocity at the calibration flow is within 0.2 feet per second (fps) of the measured cell velocity, the predicted velocity is considered adequate. The calibration philosophy is to change data or use a computer calibration option only when doing so would improve the model's ability to extrapolate without significantly changing the accuracy of depths and velocities predicted at the measured flows. Change to a calibration velocity is limited to 0.2 fps. The 0.2 fps limit is reasonable considering the normal range of velocity measurement error. All cell velocities are reviewed at the highest and lowest extrapolated flows to ensure that extreme cell velocities are not predicted.

Indicators of Model Accuracy

Two indicators of the IFG4 model's accuracy in predicting depths and velocities are mean error and the VAF.

The mean error is the average of the ratio of the measured discharges to the predicted discharges for one transect. As a rule of thumb, the mean error should be less than 10 percent.

The VAF for a three-flow IFG4 model indicates whether the flow predicted from the velocity/discharge regressions matches the flow predicted from the stage/discharge regression. This is done for each transect. The velocities predicted from the velocity/discharge regressions for a transect are all multiplied by the same VAF to match the flow predicted from the stage/discharge regression. This comparison of flows predicted from two different methods gives an indication as to whether or not the model's assumptions of linear relationships between velocity and flow and stage and flow are valid. A VAF of 1.0 means both methods are predicting the same discharge.

A VAF in the range 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 et al 1984). 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. Model results are generally considered accurate for extrapolating to a 0.4 times the lowest measured flow and 2.5 times the highest measured flow (Milhous et al 1984).

The VAFs for the one-flow IFG4 model do not have the same meaning as with the three-flow UFG4 model. (All sites used a three-flow model, but the Hosey site required the additional use of a one-flow model just for transect four.) The VAF range listed above does not apply to one-flow model VAFs. Instead of predicting velocities from a velocity/discharge regression (three-flow IFG4), the velocities are predicted from Manning's equation using a constant roughness factor (N). The bottom roughness factor is highest at low flow and becomes progressively lower as flow increases. Since the N value calculated by the computer is constant, the N value used to predict velocities at a flow higher than the measured flow is usually too high. The VAF corrects this problem by changing the predicted velocities to achieve the flow predicted from the stage/discharge regression. The VAF in the one-flow model will be nearly one at the measured flow and usually less than one at lower flows and more than one at higher flows.

Normal empirical values for bottom roughness do not apply to these Manning's Ns. These Ns are used only for calibrating the velocities in the IFG4 hydraulic model.

Options in IFG4 Model

Several options are available in the IFG4 hydraulic model (see Milhous et al 1984). The standard method is to set all the options to zero except for option eight which is set at two. The only nonstandard option used in our hydraulic models was option 14 set at three. This was only done for the Kent site.

Site Specific Calibration

The extrapolation ranges of the Green River IFG4 models were held to within the standard range of 0.4 times the lowest measured flow to 2.5 times the highest measured flow. The depths, velocities, VAFS, and mean errors were found to be acceptable within the standard range for all models.

Kent Site Calibration

A three-flow IFG4 model was run for this site using the standard options except option 14 was set at three, the upper BMAX limit option. A BMAX of 1.3 was found by trial and error to improve velocity prediction at high flows without significantly affecting the measured velocities. Option 14 set at three meant the beta coefficients on all velocity/discharge regressions were limited to the specified maximum. BMAX cannot be used on a single transect and must be applied to all transects in the model. Limiting the slope of the velocity/discharge regression improved the extrapolation range of the model, but not at the expense of the accuracy of predicted velocities at the measured flows. Each individual cell velocity on each transect was reviewed after application of the BMAX to determine if any significant changes occurred.

The IFG4 input file, a summary of the calibration details, data changes, a table showing which velocities on each transect were affected by the BMAX option, and the VAFS are included as Appendix B.

The mean errors of the stage/discharge regressions range from 0.26 to 5.77 percent. All are less than the 10 percent calibration guideline mentioned previously.

At 100 cfs the worst VAF is 0.84, and at 2500 cfs the worst VAF is 0.93. The velocity and depth predictions are adequate for the extrapolation range of 100 to 2500 cfs.

Nealy Bridge Site Calibration

A three-flow IFG4 model was run for this site using the standard options.

The IFG4 input file, a summary of the calibration details, data changes, and VAFS are included as Appendix C.

The mean errors of the stage/discharge regressions range from 0.81 to 9.32 percent. All are less than the 10 percent error guideline.

The worst VAFs are 1.12 at 100 cfs and 0.92 at 2000 cfs. The velocity and depth predictions are adequate for the extrapolation range of 100 to 2000 cfs and could possibly be extended higher and lower if necessary.

Car Body Site Calibration

A three-flow IFG4 model was run for this site using the standard options.

The IFG4 input file, a summary of the calibration details, data changes, and VAFS are included as Appendix D.

The mean errors of the stage/discharge regressions range from 0.53 to 5.18 percent. All are less than the 10 percent error guideline.

Two cells had Manning's Ns specified by us. The Ns calculated by the model were too low and causing predicted velocities to be too high. N's were corrected by trial and error with repeated computer runs to achieve correct velocities.

The worse VAFs on transects 1 through 6 are 0.84 at 100 cfs and 0.84 at 2500 cfs. Transect 7 has a VAF of 0.74 for 100 cfs and 0.76 for 2500 cfs. The velocity and depth predictions are adequate for extrapolation from 100 to 2500 cfs.

Flaming Geyser Site Calibration

A three-flow IFG4 model was made for this site using the standard options.

The IFG4 input file, a summary of calibration details, data changes, and VAFS are in Appendix E.

The mean errors of the stage/discharge relationships range from 0.29 to 4.0 percent and are less than the 10 percent error guideline.

The worst VAFs are 0.89 at 80 cfs and 0.95 at 2000 cfs. The IFG4 hydraulic model velocity and depth predictions are adequate for the extrapolation range of 80 to 2500 cfs.

When measured velocities were changed for calibration, a limit of 0.2 fps was used, except on transect 3 where a 0.6 fps velocity was changed to 2.6 fps at high flow. Cell velocities adjacent to this vertical were on the order of 2.5 to 3 fps at the measured flow. This data-point anomaly was due to velocity-meter placement in a small standing wave. The resultant steep velocity/discharge regression slope in this cell caused all other cells to have significantly lowered predicted velocities. This one data point was modified to improve the accuracy of all the other predicted cell velocities.

Hosey Site Calibration

A three-flow IFG4 model was run for this site using the standard options for transects 1, 2, 3, 5, and 6.

A one-flow IFG4 model was also run for this site using the standard options with the medium flow velocity measurements for transect 4. Transect 4 could not be measured at high flow because of dangerously high velocities on the transect.

The IFG4 input files, summaries of the calibration details, data changes, and VAFS are included as Appendix F.

The mean errors of the stage/discharge relationships range from 0.27 to 5.86 percent. All were within the 10 percent error guideline.

The worse VAFs for the three-flow model were 0.74 for 60 cfs and 0.82 for 2000 cfs.

The input file for the one-flow model has a duplicate transect labeled 4.5. Because the one-flow model requires more than one transect to calculate habitat, a duplicate transect was necessary, but the duplicate receives no weighting in the model.

One Manning’s N was specified in the one-flow model.

The velocity and depth predictions are adequate for an extrapolation range of 60 to 2000 cfs.

Transect Weighting

Appendix G lists the percent weighting each transect received relative to the whole site. The model automatically determines weighting for each transect by using the distance between the transects. Transect weight can be set to pre-determined levels by specifying distances between the transects (this is composite weighting). Sometimes composite weighting is done when the transects are physically far apart and the distances between the transects would create incorrect weighting. Some sites received composite weighting while other sites received a combination of actual distances between transects and composite weighting.

Agency and Tribal Approval of the Hydraulic Model

A meeting was held March 7, 1988 by Ecology to judge the adequacy of the Green River hydraulic models. Those in attendance were Hal Beecher (WDW), Paul Hickey and Jean Caldwell (Muckleshoot Indian Tribe), Ken Bruya (WDF), and Steve Hirschey and Brad Caldwell (Ecology). All agreed that the Green River hydraulic models were calibrated adequately, and that the normal extrapolation range of 0.4 times the low measured flow and 2.5 times the high measured flow was appropriate. Attendees also agreed that transect weighting, using a combination of the distances between transects and composite weighting, was appropriate.

IV. HABITAT-USE CURVES

Selection and Verification of Habitat-Use Curves

IFIM requires a biological model of water depths, velocities, substrate, and cover preferred by fish be compared against the same variables predicted by the IFG4 hydraulic model. This biological model is described as habitat-use curves.

Habitat-use curves for salmon were selected from WDF's and Ecology's standard set of "river" curves (Caldwell and Caldwell, 1987, unpublished). Habitat-use curves for trout were from WDW (Hal Beecher, 1987).

Verification of the habitat-use curves was done by observing fish species in the Green River. Snorkel surveys were done at all sites on species of fish present, fish distribution, and abundance (Appendix H1). A periodicity chart is included in Appendix H2 to show which months each fish species and lifestage is present. Field observations of depths and velocities used by spawning chinook and spawning steelhead were collected and summarized into histograms. (Appendix H3).

Agency and Tribal Approval of Habitat-Use Curves

A meeting was held March 7, 1988 by Ecology to get agreement on the habitat-use curves to be used in the Green River IFIM model. The meeting was attended by Hal Beecher (WDW), Paul Hickey and Jean Caldwell (Muckleshoot Indian Tribe), Ken Bruya (WDF), and Steve Hirschey and Brad Caldwell (Ecology).

Standard WDF salmon "river" curves were chosen by the above group except for changing the depth curve to unlimited depth for adult, holding chinook; juvenile chinook; and juvenile coho. These lifestages were observed to utilize deep pools throughout the Green River. The standard trout curves were also chosen. These habitat-use curves are in Appendix H4. The substrate/cover code was chosen with cover use by juvenile salmon included (Appendix H5).

V. FISH SPECIES AND OPTIONS USED IN HABTAT PROGRAM

Fish Species Used in HABTAT

The HABTAT program combines the depths and velocities predicted from the IFG4 hydraulic model with the depths and velocities from the habitat-use curves. The program calculates WUA (fish habitat) versus flow relationships.

Habitat-use curves were run for steelhead trout, and chinook, coho, and chum salmon because these are the predominant species in the river. Pink and sockeye salmon were not included because their numbers are few.

Options Used in HABTAT

There are several options available in the HABTAT program. The standard method was used with options 1, 8, and 10 set at one with all other options set at zero (Milhous et al 1984).

VI. RESULTS

WUA-vs.-Flow Curves

The WUA (Fish habitat)-versus-flow results are presented in Appendix A. The figures are grouped by site; downstream site first (Kent) followed by the next upstream site (Nealy Bridge), etc. Each group of figures is arranged by area, and then by species: steelhead, chinook, coho, chum.

The area-versus-flow graphs indicate that most sites have flat, rectangular channel cross sections. The average wetted widths at 500 cfs are 124 feet at the Kent site, 155 feet at the Nealy Bridge site, 124 feet at the Car Body site, 128 feet at the Flaming Geyser site, and 93 feet at the Hosey site. The Kent and Nealy Bridge sites have little loss of wetted width until the flow drops below 200 cfs.

All of the sites, except the Hosey site, have higher quantities of spawning habitat than rearing habitat. Spawning habitat is limited in the Hosey site by the large amount of deep pools with bedrock and boulder substrate.

The WUA curves are bell-shaped at all sites except the Car Body site. At the Car Body site the habitat curves have two peaks instead of one. The first peak indicates at what flow velocities and depths are optimum in the low-flow channel. The second peak indicates at what flow velocities and depths are optimum over the wide cobble bars which are normally dry except during high flow. This double hump is typical of rivers with large, exposed gravel/cobble bars.

Summary and Comparison of Flows Which Provide Peak Habitat

Table 2 lists the peaks from the WUA (fish habitat) curves from Ecology’s study sites. Many of the peak habitat flows are quite similar throughout the river.

Table 3 lists Chapman’s (1984) optimum flows for the Green River based on his two-flow IFIM study. The details of his study were not available for a complete comparison, however, his results at river miles 30 and 43 agree well with our results.

Table 2. Flows Which Provide Peak Habitat from WUA-vs.-Flow Results.

Peak WUA Flow in cfs

Sites	Steelhead			Chinook		Chinook and Coho	Coho	Chum
	Spawning	Holding	Juveniles	Spawning	Holding	Juveniles	Spawning	Spawning
Kent (RM 27.2, 30.5) represents 20 miles (12-32)	700	600	400	600	450	240	300	260
Nealy Bridge (RM 35) represents 4.7 miles (32-36.7)	600	425	400	675	450	220	375	400
Car Body (RM 39.6) represents 3.3 miles (36.7-40)	550	350	350	600	240	140	240	350
Flaming Geyser (40.6, 43.6) represents 6 miles (40-46)	600	300	400	700	240	180	280	350
Hosey (60.6) represents 6 miles (58-64)	650	600	300	525	220	170	300	260

Table 3. Chapman's Estimated Optimum Flows for the Green River (Chapman, 1984).

	Optimum Flows in cfs		
Study Reach (RM)	Rearing	Salmon Spawning	Steelhead Spawning
21	500	400	500
30	300	600	600
43	300	500	500
60	180	1700	1700

VII. RECOMMENDATION FOR USE OF WUA RESULTS TO SET MINIMUM FLOWS

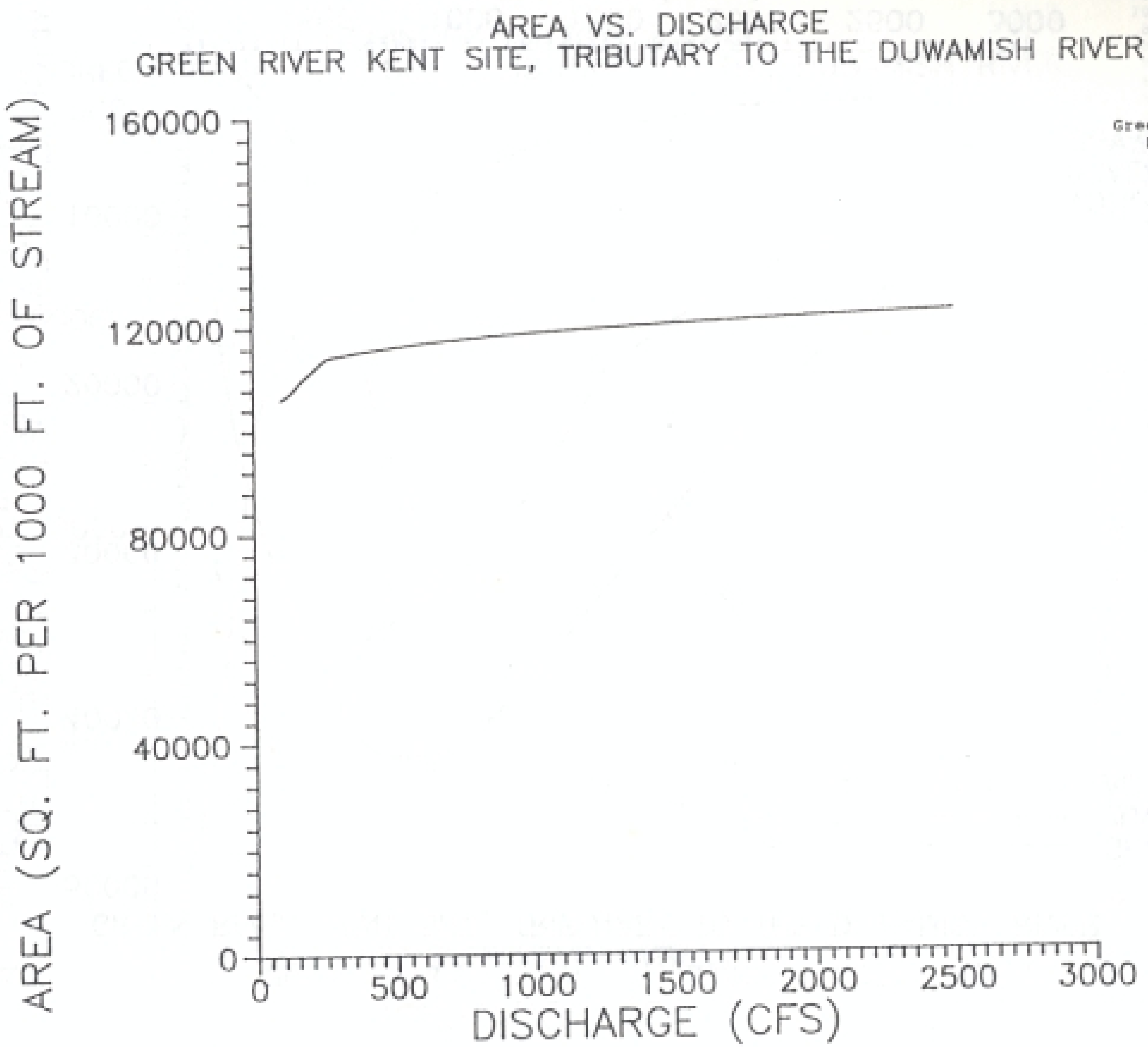
Determining a minimum instream flow for a river requires more thought than choosing the peak WUA flows from an IFIM study. Setting a minimum instream flow for the Green River requires ranking the importance of each river reach, fish species, and lifestage. This ranking requires a consensus on long-range management plans for the fishery resource from several state and federal natural-resource agencies and the Muckleshoot Indian Tribe.

In addition, a minimum instream flow 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, sediment load, and added flows from tributaries and ground water. Significant inflows to the Green River occur from Big Soos Creek, Newaukem Creek, and ground water (Appendix I).

A flow which provides peak habitat for fish may not necessarily provide optimum fish production. At low flows other hard-to-quantify variables not included in this study may be of overriding importance for fish production. Flows higher than peak habitat flows may be needed to provide: (1) water velocity sufficient for downstream transportation of aquatic insect drift needed for food; and (2) more water depth for less competition between fish species, less predation by birds and larger fish, less poaching by humans, and less 4-wheel drive vehicle crossings over spawning salmon and steelhead nests.

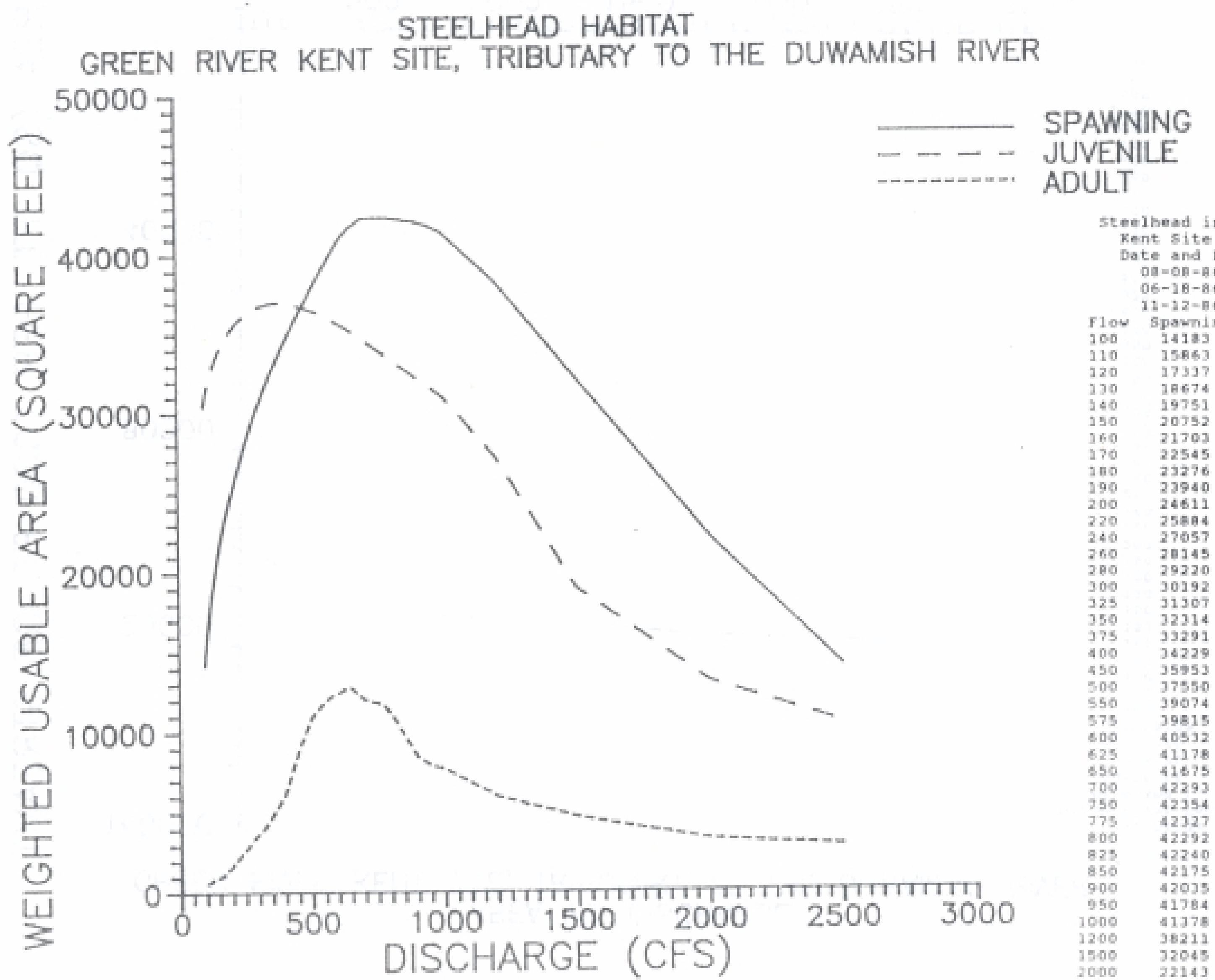
Appendix A

WUA VS FLOW GRAPHS



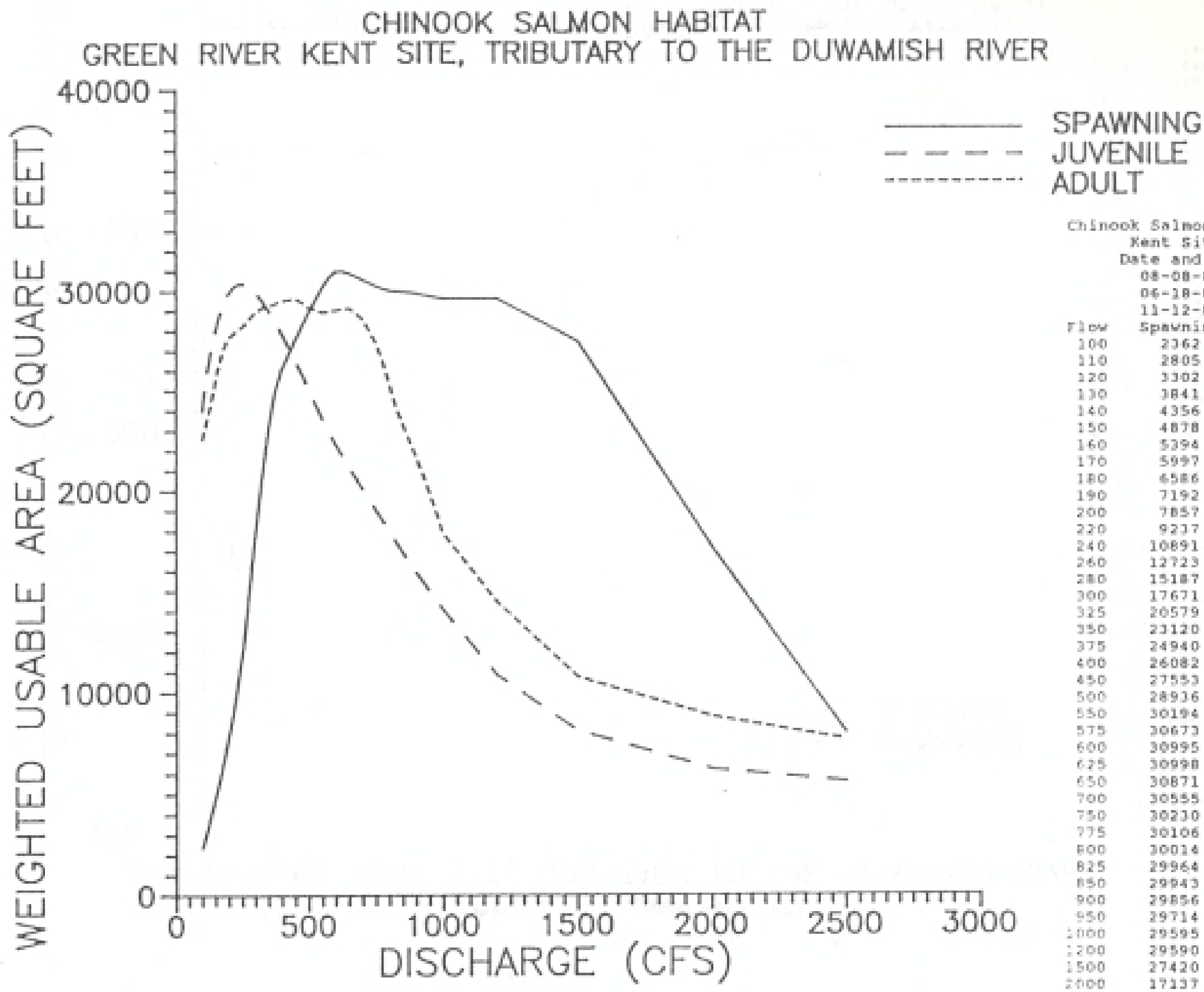
Discharge vs Area
Green River Kent Site RM. 30.5
Date and Flow Measured
08-08-86 262 cfs
06-18-86 530 cfs
11-12-86 950 cfs

Discharge	Area
100	105985
110	106440
120	106864
130	107262
140	107683
150	108285
160	108897
170	109480
180	110036
190	110596
200	111037
220	111870
240	112951
260	113904
280	114213
300	114436
325	114701
350	114940
375	115163
400	115371
450	115758
500	116112
550	116444
575	116601
600	116752
625	116900
650	117042
700	117300
750	117544
775	117661
800	117772
825	117885
850	117992
900	118199
950	118398
1000	118589
1200	119259
1500	120126
2000	121246
2500	122138



Steelhead in the Green River
Kent Site RM. 30.5
Date and Flow Measured
08-08-86 262 cfs
06-18-86 530 cfs
11-12-86 950 cfs

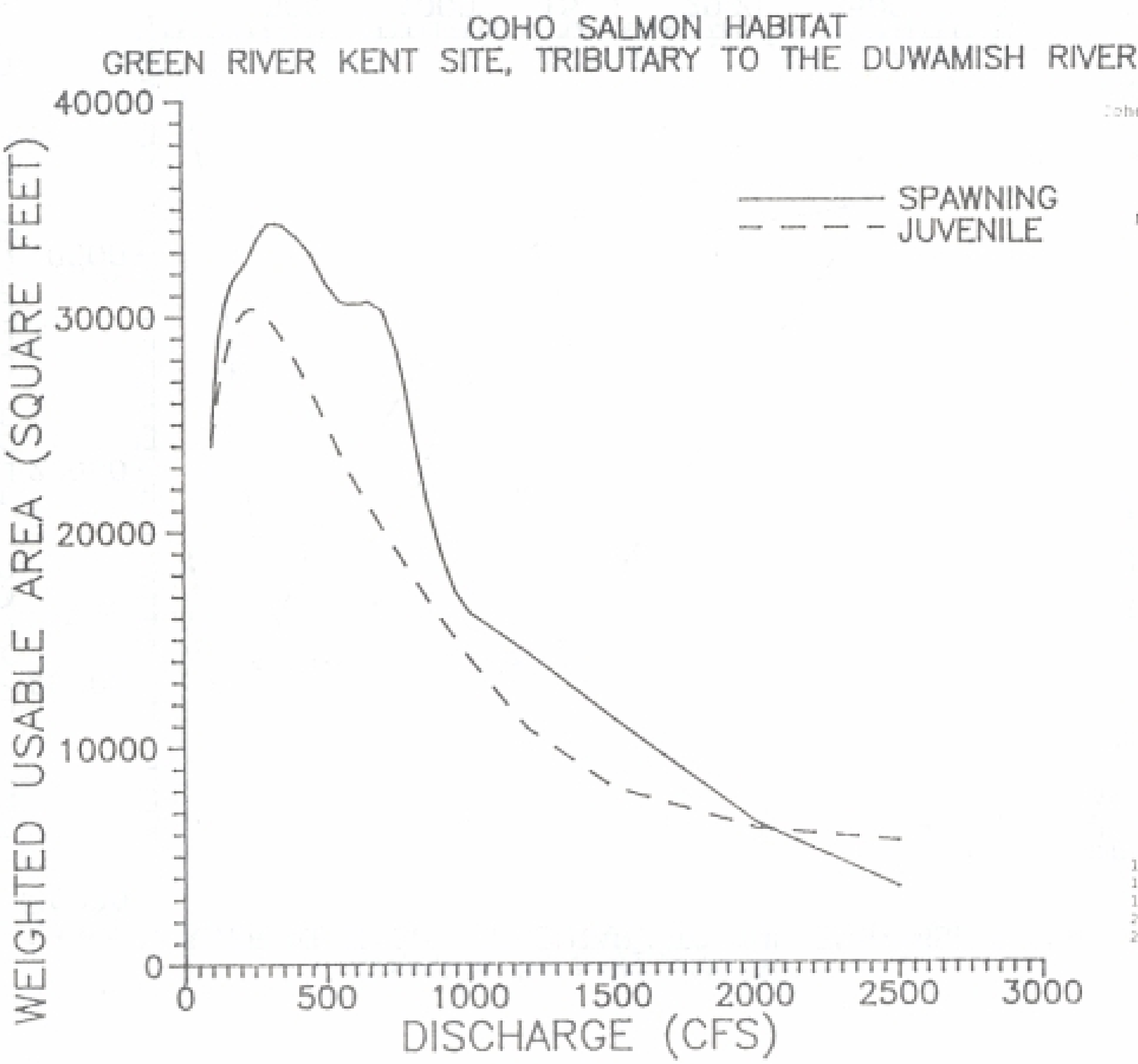
Flow	Spawning	Juvenile	Adult
100	14183	30458	603
110	15863	31351	685
120	17337	32034	804
130	18674	32621	911
140	19751	33123	963
150	20752	33545	1010
160	21703	33937	1082
170	22545	34275	1217
180	23276	34588	1405
190	23940	34866	1582
200	24611	35108	1752
220	25884	35601	2149
240	27057	35955	2521
260	28145	36221	2920
280	29220	36474	3354
300	30192	36690	3738
325	31307	36837	4150
350	32314	36947	4800
375	33291	37019	5468
400	34229	37004	6167
450	35953	36781	8832
500	37550	36537	10879
550	39074	36215	11860
575	39815	35954	12193
600	40532	35702	12405
625	41178	35463	12635
650	41675	35212	12756
700	42293	34610	12009
750	42354	34007	11784
775	42327	33723	11602
800	42292	33389	11082
825	42240	33067	10521
850	42175	32775	9758
900	42035	32184	8411
950	41784	31588	7872
1000	41378	30952	7658
1200	38211	27066	5892
1500	32045	18879	4619
2000	22143	13044	3214
2500	13975	10388	2771



Chinook Salmon in the Green River
Kent Site RM. 30.5
Date and Flow Measured

08-08-86	262
06-18-86	530
11-12-86	950

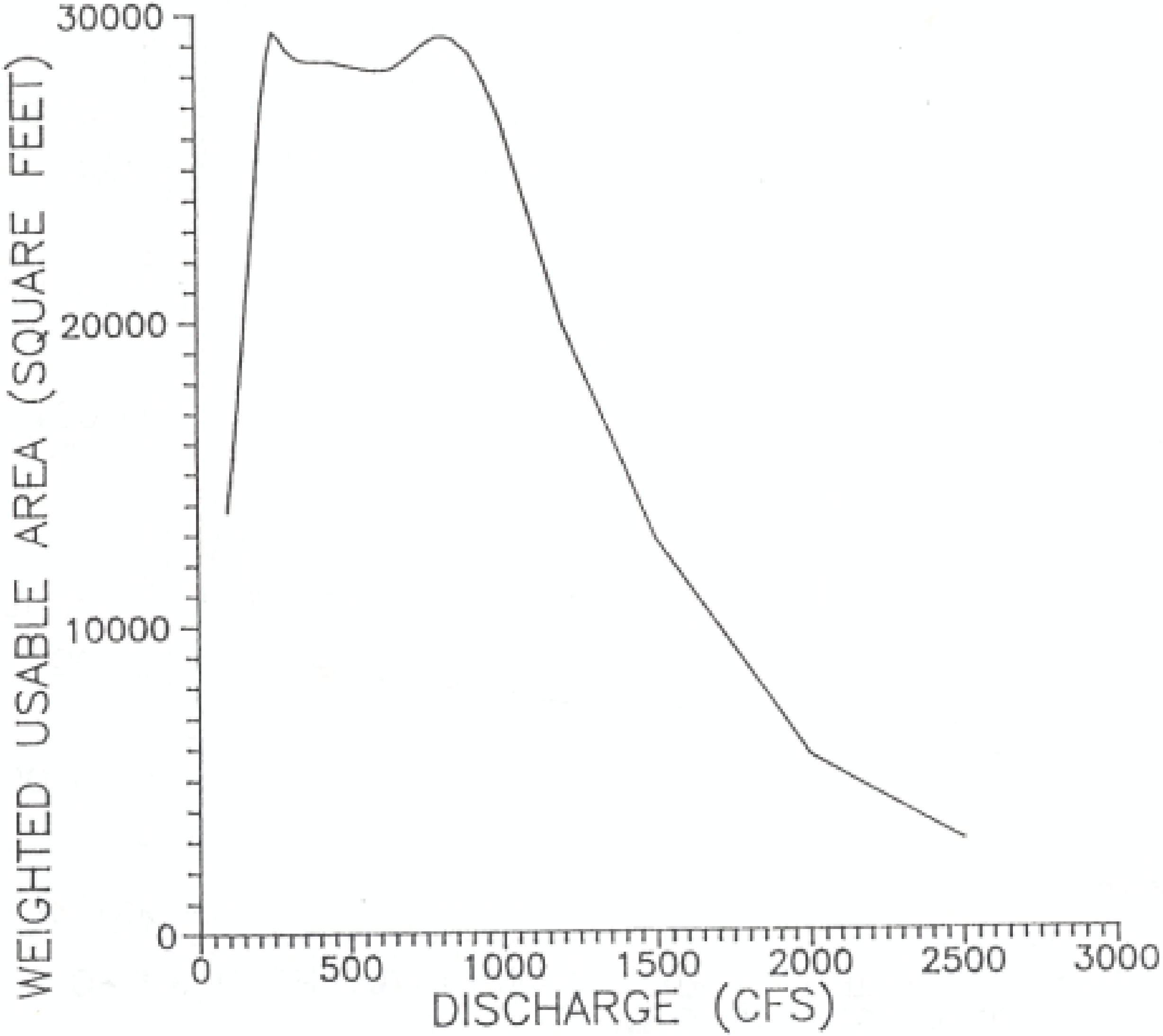
Flow	Spawning	Juvenile	Adult
100	2362	23986	22584
110	2805	25111	23086
120	3302	26030	23619
130	3841	26794	24132
140	4356	27423	24789
150	4878	27974	25438
160	5394	28501	26073
170	5997	28965	26590
180	6586	29361	27048
190	7192	29653	27395
200	7857	29879	27654
220	9237	30248	27878
240	10891	30373	28103
260	12723	30342	28308
280	15187	30198	28625
300	17671	29939	28930
325	20579	29505	29154
350	23120	28983	29227
375	24940	28430	29365
400	26082	27820	29485
450	27553	26519	29628
500	28936	25066	29135
550	30194	23598	28901
575	30673	22910	28956
600	30995	22303	29019
625	30998	21730	29079
650	30871	21150	29128
700	30555	20042	28564
750	30230	18991	27355
775	30106	18464	26430
800	30014	17932	25295
825	29964	17412	24139
850	29943	16899	23283
900	29856	15901	21673
950	29714	14966	19845
1000	29595	14052	17848
1200	29590	10829	14443
1500	27420	8069	10719
2000	17137	6175	8764
2500	7943	5558	7611



Coho Salmon in the Green River
Kent Site RM. 30.5
Date and Flow Measured
08-08-86 262 cfs
06-18-86 530 cfs
11-12-86 950 cfs

Flow	Spawning	Juvenile
100	24204	23986
110	26006	25111
120	27621	26030
130	29163	26794
140	29922	27423
150	30547	27974
160	30975	28501
170	31372	28965
180	31702	29361
190	31915	29653
200	32080	29879
220	32426	30248
240	32910	30373
260	33519	30342
280	33931	30198
300	34286	29939
325	34321	29505
350	34230	28983
375	33940	28430
400	33669	27820
450	32896	26519
500	31556	25066
550	30689	23598
575	30581	22909
600	30572	22303
625	30600	21730
650	30685	21148
700	30231	20042
750	28315	18991
775	26803	18464
800	24964	17932
825	23176	17412
850	21473	16899
900	18991	15901
950	17159	14966
1000	16190	14052
1200	14325	10829
1500	11273	8069
2000	6461	6175
2500	3449	5558

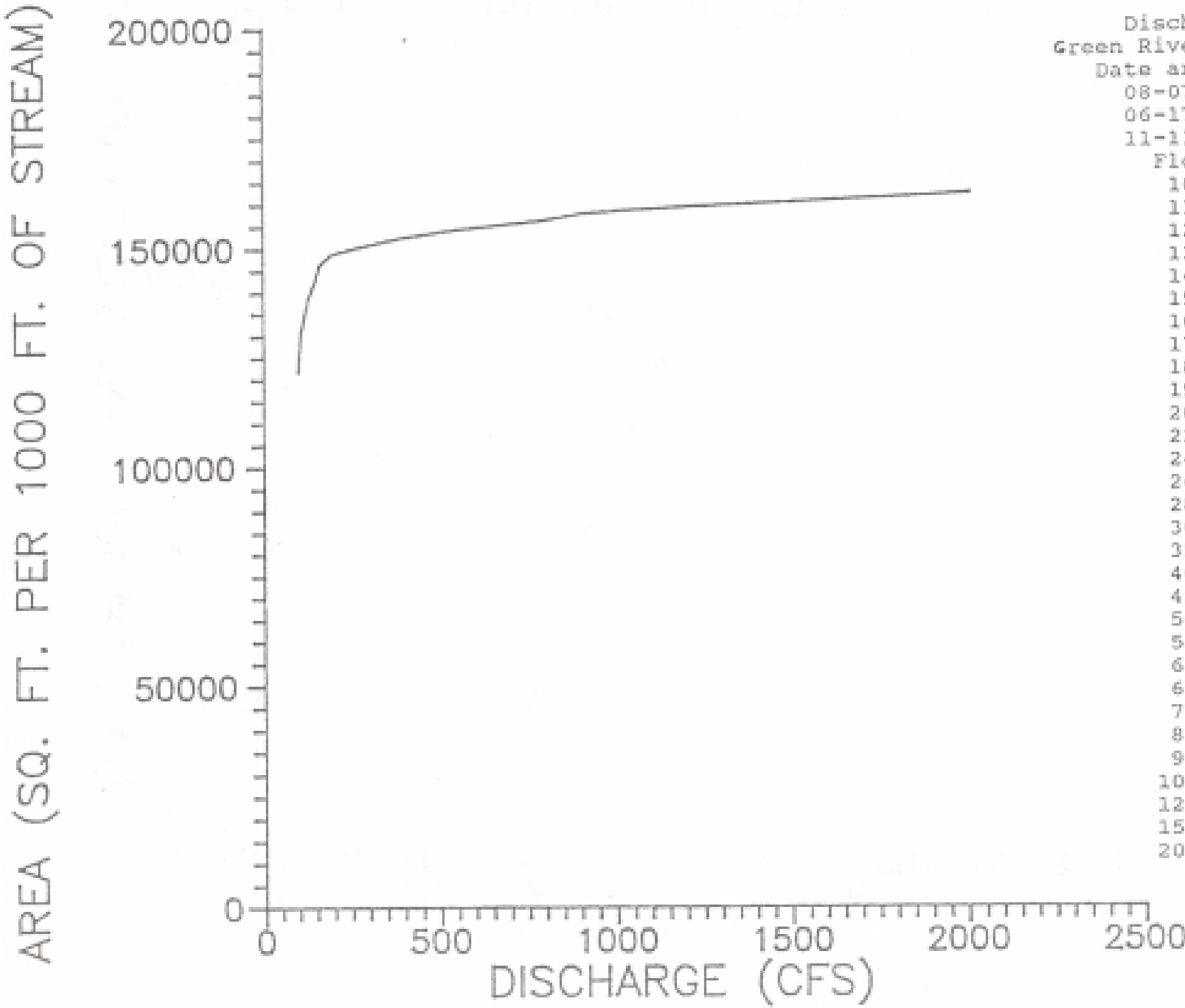
CHUM SALMON SPAWNING HABITAT
GREEN RIVER KENT SITE, TRIBUTARY TO THE DUWAMISH RIVER



hum Salmon in the Green River
Kent Site RM. 30.5
Flow and Date Measured
08-08-86 262 cfs
06-18-86 530 cfs
11-12-86 950 cfs

Flow	Spawning
100	13730
110	14574
120	15478
130	16625
140	17781
150	19035
160	20215
170	21247
180	22271
190	23425
200	24724
220	27073
240	28595
260	29424
280	29204
300	28866
325	28608
350	28470
375	28425
400	28417
450	28420
500	28304
550	28195
575	28153
600	28136
625	28134
650	28183
700	28524
750	28947
775	29107
800	29233
825	29232
850	29127
900	28698
950	27777
1000	26589
1200	19849
1500	12740
2000	5640
2500	2897

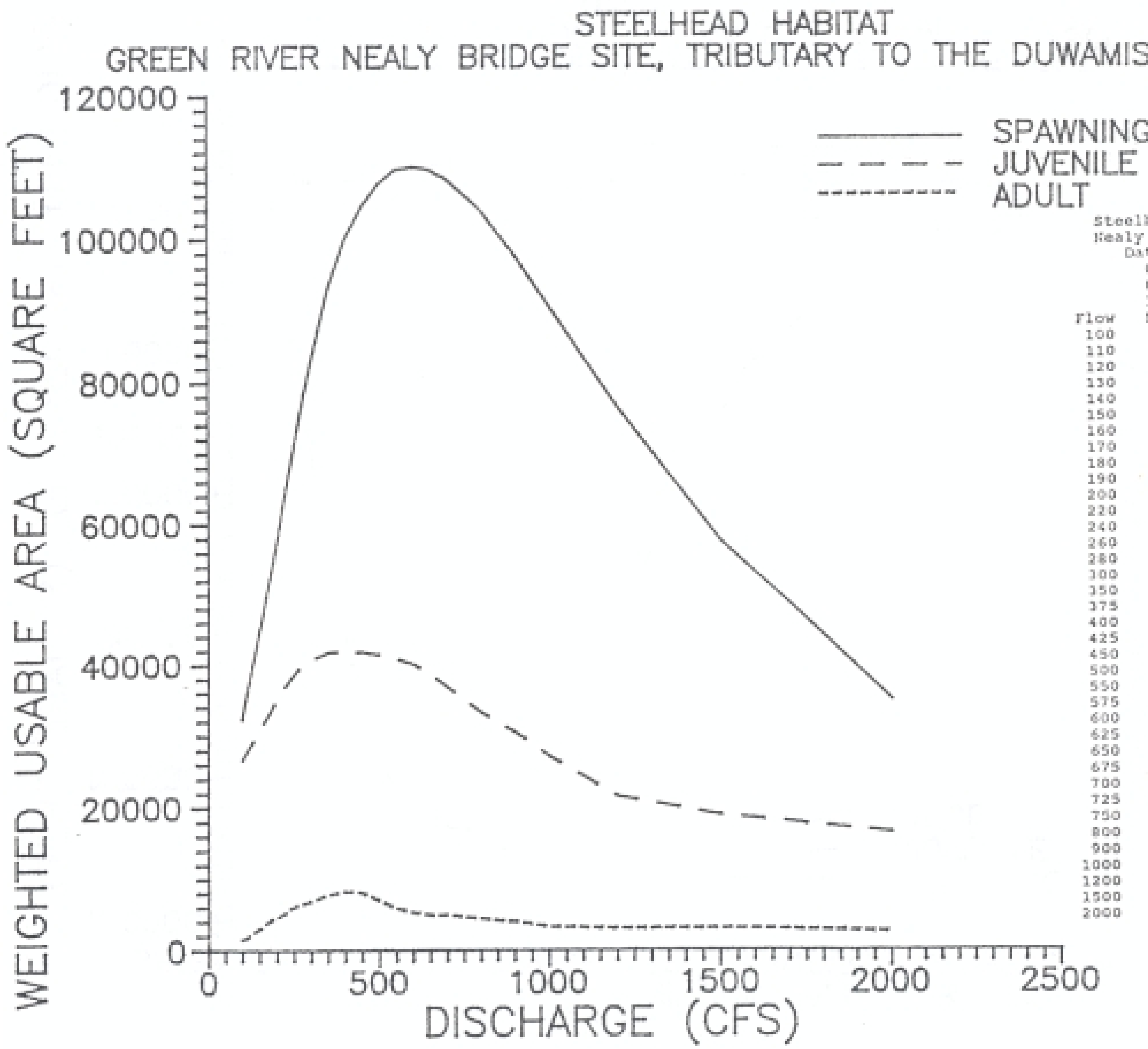
AREA VS. DISCHARGE
GREEN RIVER NEALY BRIDGE SITE, TRIBUTARY TO THE DUWAMISH RIVER



Discharge vs. Area
Green River Nealy Bridge Site
Date and Flow Measured

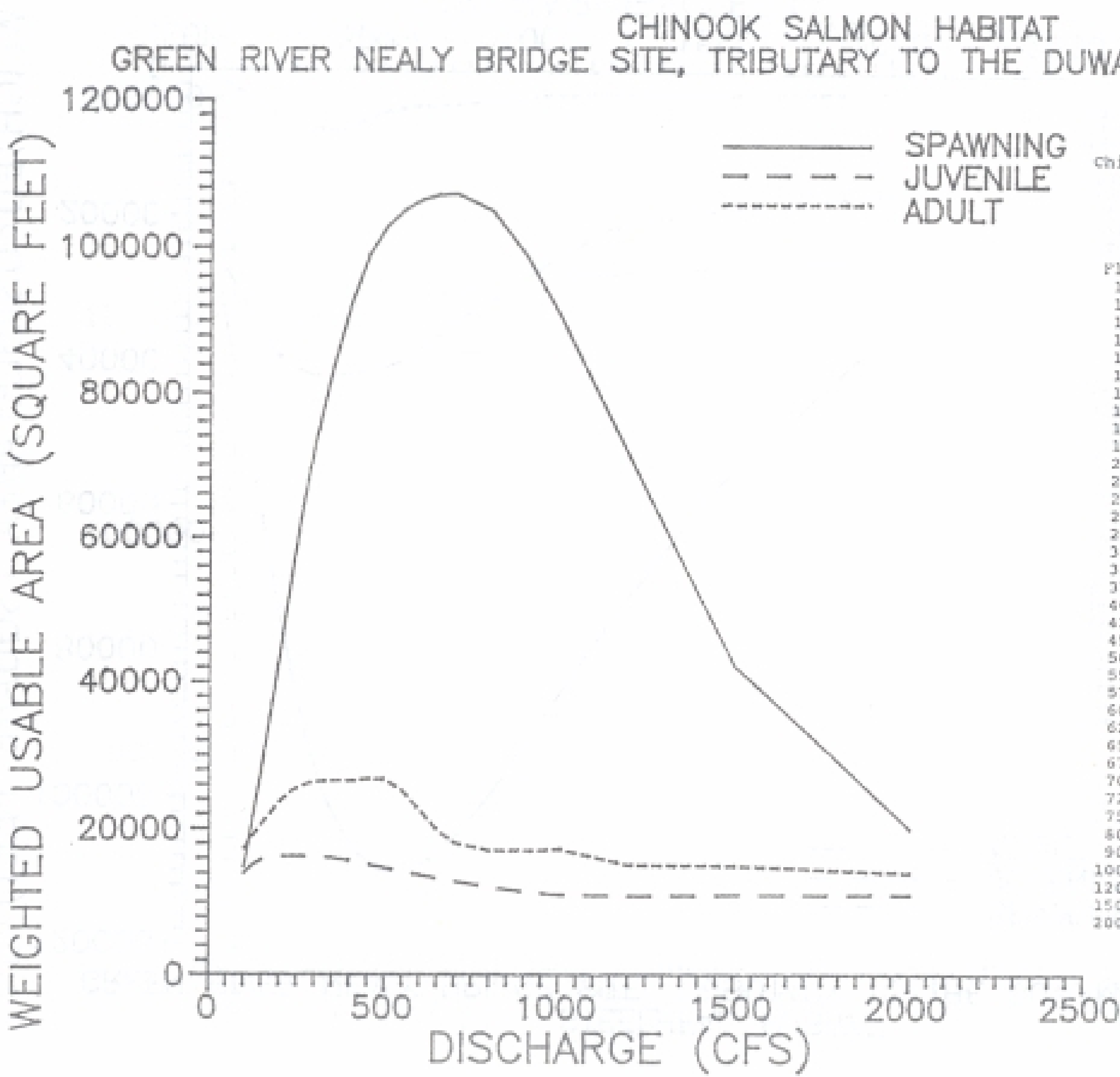
08-07-86	239	cfs
06-17-86	425	cfs
11-11-86	887	cfs

Flow	AREA
100	121489
110	131377
120	134961
130	138658
140	140820
150	142793
160	146119
170	146917
180	147680
190	148613
200	148868
220	149337
240	149761
260	150160
280	150538
300	150897
350	151800
400	152639
450	153177
500	153816
550	154335
600	154782
650	155203
700	155589
800	156422
900	157847
1000	158514
1200	159363
1500	160436
2000	162268



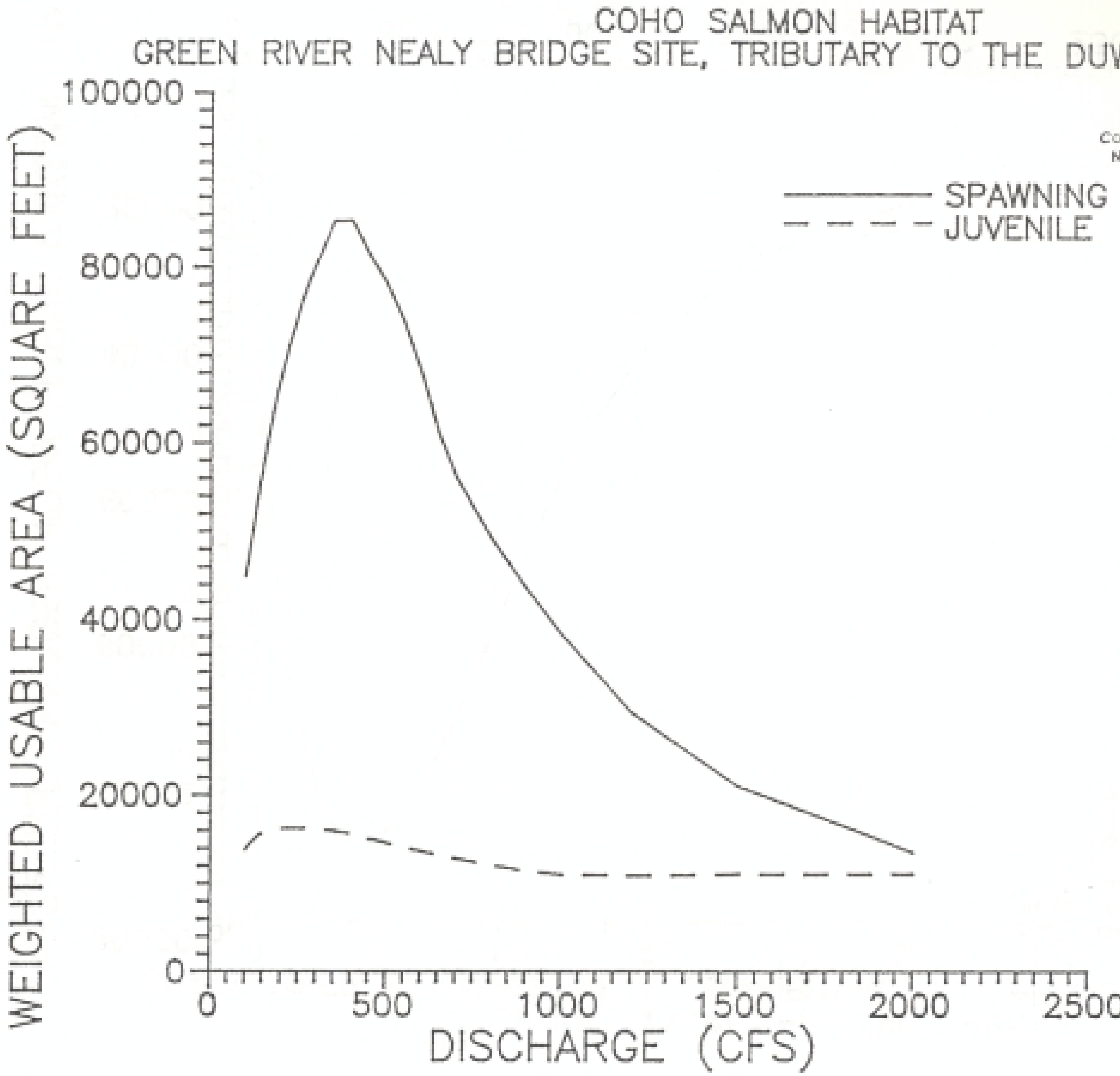
Steelhead in the Green River
Nealy Bridge Site RM. 35.0
Date and Flow Measured
08-07-86 239 cfs
06-17-86 425 cfs
11-11-86 887 cfs

Flow	Spawning	Juvenile	Adult
100	32304	26615	1533
110	34995	27510	1729
120	37481	28348	2059
130	39859	29137	2444
140	42122	29943	2749
150	44530	30797	.3104
160	47066	31635	3505
170	49609	32428	3811
180	52197	33257	4155
190	54690	34174	4432
200	57256	35043	4605
220	62851	36620	5070
240	68213	37954	5849
260	73397	39154	6301
280	78164	40100	6551
300	82875	40770	6853
350	93058	41716	7794
375	97076	41862	8068
400	99896	41916	8245
425	102331	41859	8370
450	104437	41730	8043
500	107728	41296	6910
550	109654	40784	5835
575	110040	40463	5486
600	110104	39985	5240
625	109981	39347	4992
650	109600	38527	4865
675	109070	37719	4829
700	108323	36738	4864
725	107476	35743	4773
750	106546	34745	4584
800	104056	33173	4331
900	97791	30398	3916
1000	90654	27109	3218
1200	76366	21505	2985
1500	57555	18823	3031
2000	34812	16406	2511



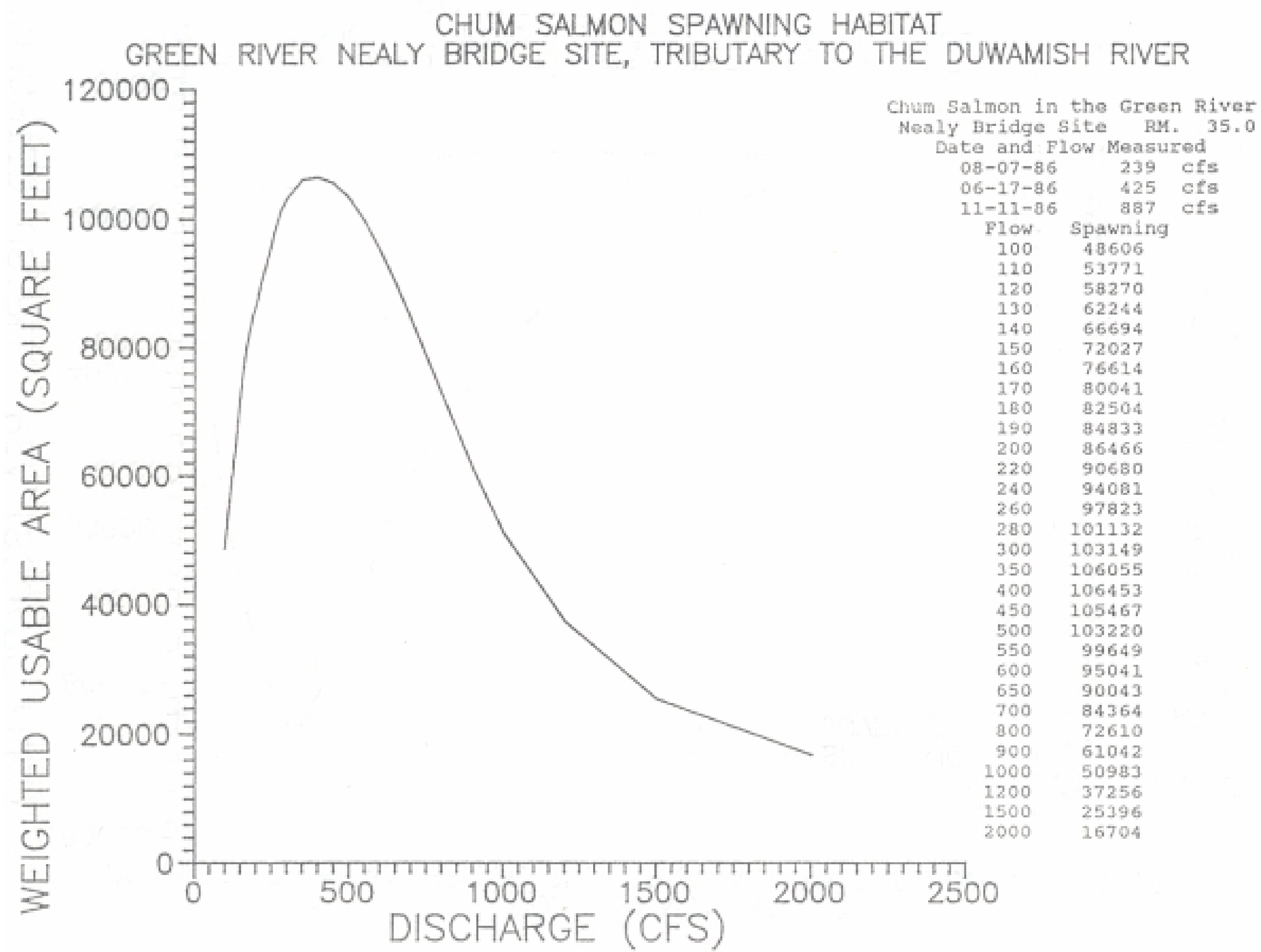
Chinook Salmon in the Green River
Nealy Bridge Site RM. 35.0
Date and Flow Measured
08-07-86 239 cfs
06-17-86 425 cfs
11-11-86 887 cfs

Flow	Spawning	Juvenile	Adult
100	14659	13902	17265
110	17361	14411	18034
120	20166	14851	18706
130	22880	15211	19307
140	25641	15501	19982
150	28380	15733	20625
160	31271	15943	21250
170	34284	16077	21828
180	37346	16158	22410
190	40397	16211	23002
200	43605	16240	23576
220	50312	16258	24522
240	56860	16241	25277
260	62760	16211	25741
280	68079	16171	26078
300	73088	16135	26381
350	83800	15949	26509
375	88340	15767	26303
400	92440	15579	26446
425	96103	15344	26578
450	99000	15100	26785
500	102782	14614	26579
550	104976	14105	25099
575	105806	13871	23959
600	106379	13665	22456
625	106759	13448	20996
650	107053	13233	19729
675	107259	13026	18660
700	107161	12839	18037
725	106918	12628	17619
750	106476	12439	17326
800	104864	12054	16990
900	98678	11406	17018
1000	90425	11001	17222
1200	70879	10857	15064
1500	42092	11081	14984
2000	19940	11025	14000

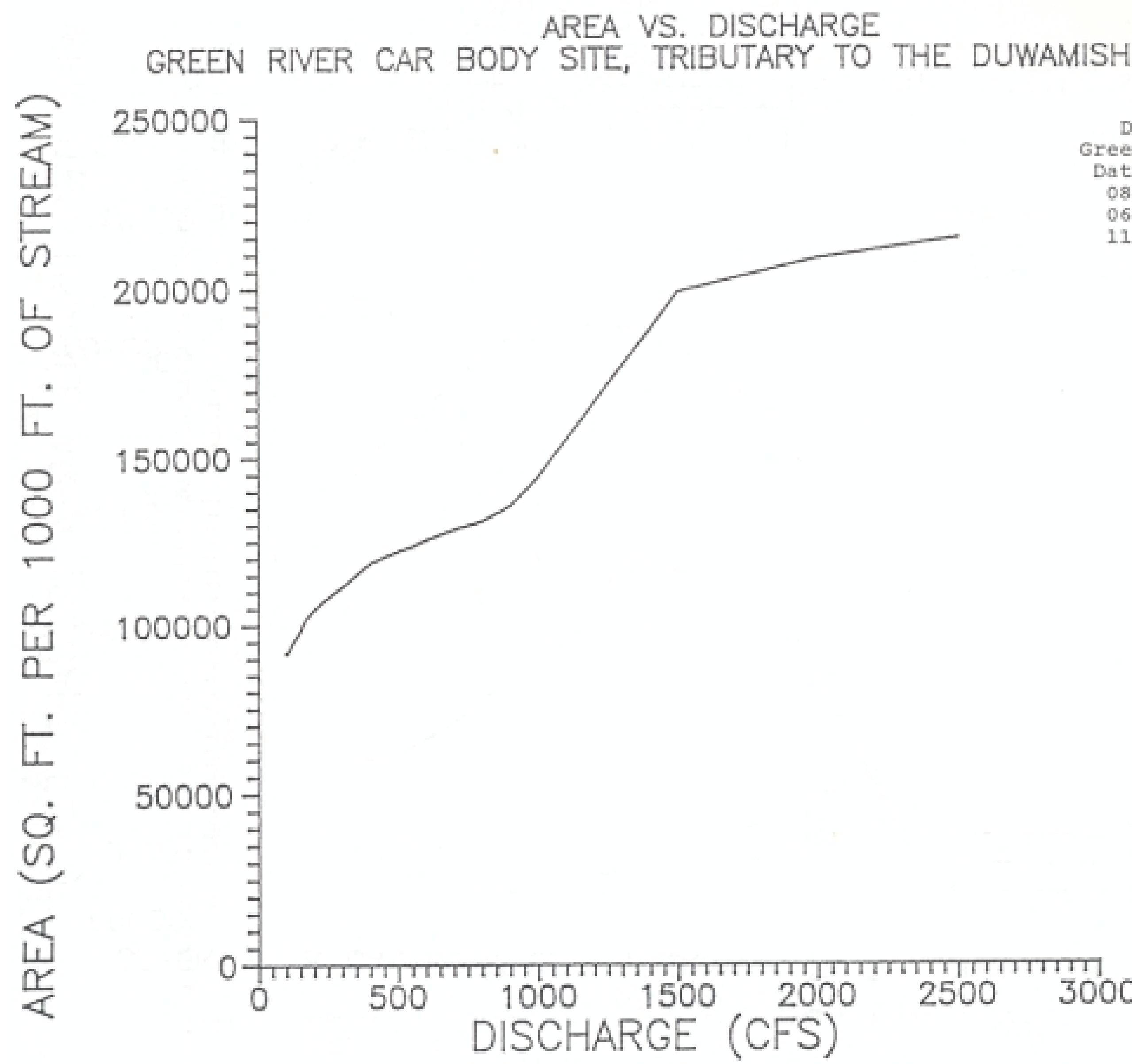


Coho Salmon in the Green River
Nealy Bridge Site RM. 35.0
Date and Flow Measured
08-07-86 239 cfs
06-17-86 425 cfs
11-11-86 887 cfs

Flow	Spawning	Juvenile
100	44956	13902
110	47560	14411
120	50172	14851
130	52792	15211
140	55140	15501
150	57413	15733
160	59686	15943
170	61879	16077
180	64071	16158
190	66037	16211
200	67650	16240
220	70901	16258
240	73510	16241
260	76309	16211
280	78610	16171
300	80508	16135
350	85248	15949
375	86194	15767
400	85350	15579
425	83378	15344
450	81392	15100
500	78142	14614
550	73865	14105
575	71066	13871
600	67999	13665
625	64560	13447
650	61139	13233
675	58497	13025
700	56059	12839
725	53905	12628
750	52275	12429
800	49288	12054
900	43623	11406
1000	38360	11001
1200	29303	10857
1500	20984	11081
2000	13536	11025

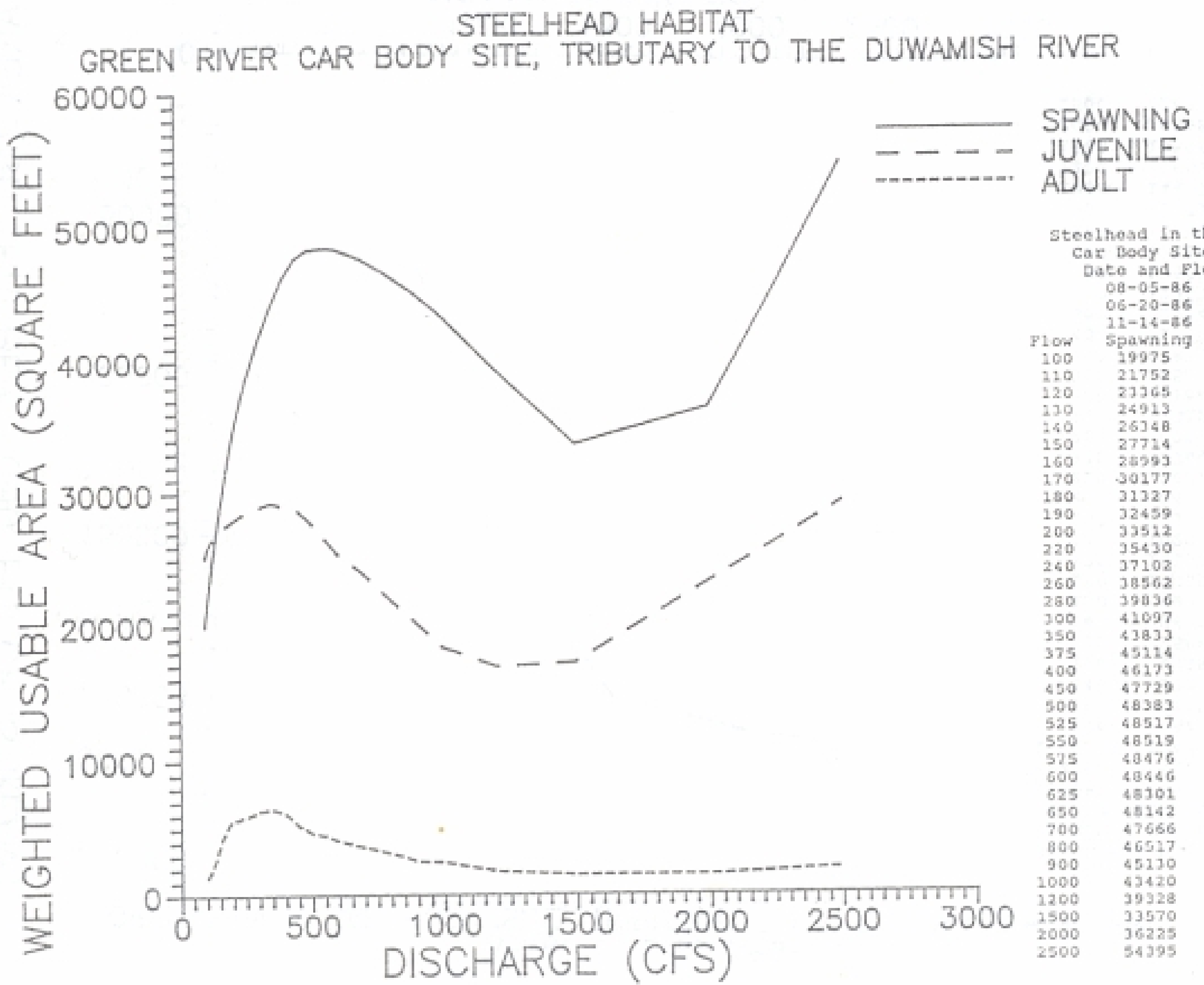


Flow	Spawning
100	48606
110	53771
120	58270
130	62244
140	66694
150	72027
160	76614
170	80041
180	82504
190	84833
200	86466
220	90680
240	94081
260	97823
280	101132
300	103149
350	106055
400	106453
450	105467
500	103220
550	99649
600	95041
650	90043
700	84364
800	72610
900	61042
1000	50983
1200	37256
1500	25396
2000	16704



Discharge vs. Area
Green River Car Body Site
Date and Flow Measured
08-05-86 234 cfs
06-20-86 410 cfs
11-14-86 1048 cfs

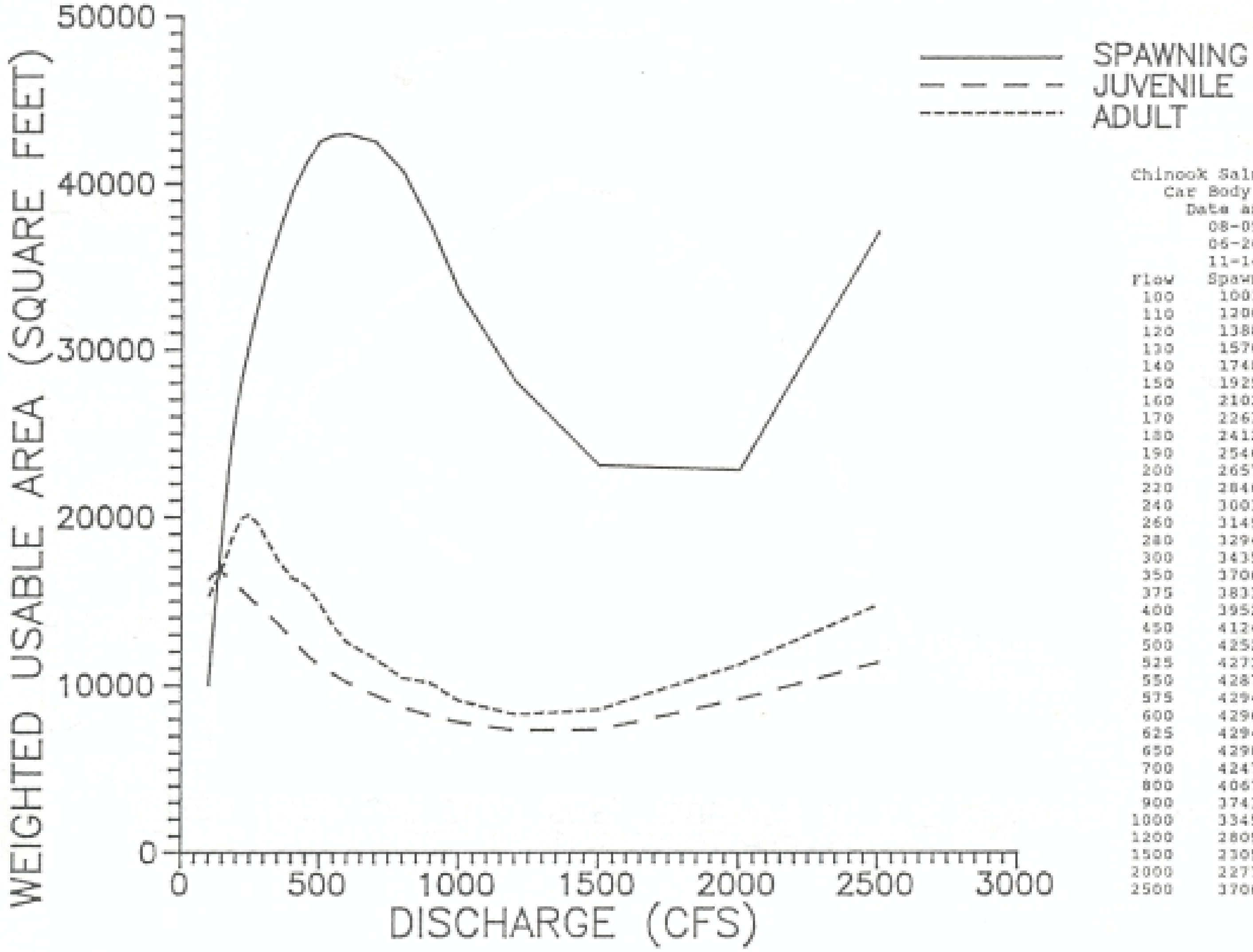
Flow	Area
100	91427
110	92360
120	94354
130	95880
140	96879
150	98301
160	100395
170	101986
180	102916
190	103857
200	104736
220	106251
240	107647
260	108942
280	110182
300	111541
350	115357
400	118717
450	120506
500	122140
550	123618
600	125526
700	128606
800	131007
900	135728
1000	144075
1200	166576
1500	198862
2000	208688
2500	214300



Steelhead in the Green River
Car Body Site RM. 39.6
Date and Flow Measured
08-05-86 234 cfs
06-20-86 410 cfs
11-14-86 1048 cfs

Flow	Spawning	Juvenile	Adult
100	19975	25152	1421
110	21752	25830	1754
120	23365	26279	2145
130	24913	26586	2688
140	26348	26860	3301
150	27714	27079	3961
160	28993	27288	4471
170	30177	27467	4841
180	31327	27585	5232
190	32459	27721	5546
200	33512	27852	5753
220	35430	28161	5723
240	37102	28393	5940
260	38562	28592	5988
280	39836	28727	6152
300	41097	28914	6358
350	43833	29294	6489
375	45114	29245	6448
400	46173	29018	6111
450	47729	28757	5199
500	48383	27834	4645
525	48517	27290	4518
550	48519	26680	4455
575	48476	26044	4282
600	48446	25479	4057
625	48301	25052	3938
650	48142	24718	3671
700	47666	23889	3592
800	46517	21957	3122
900	45130	20143	2531
1000	43420	18282	2441
1200	39328	16854	1738
1500	33570	17142	1445
2000	36225	23105	1443
2500	54395	29101	1907

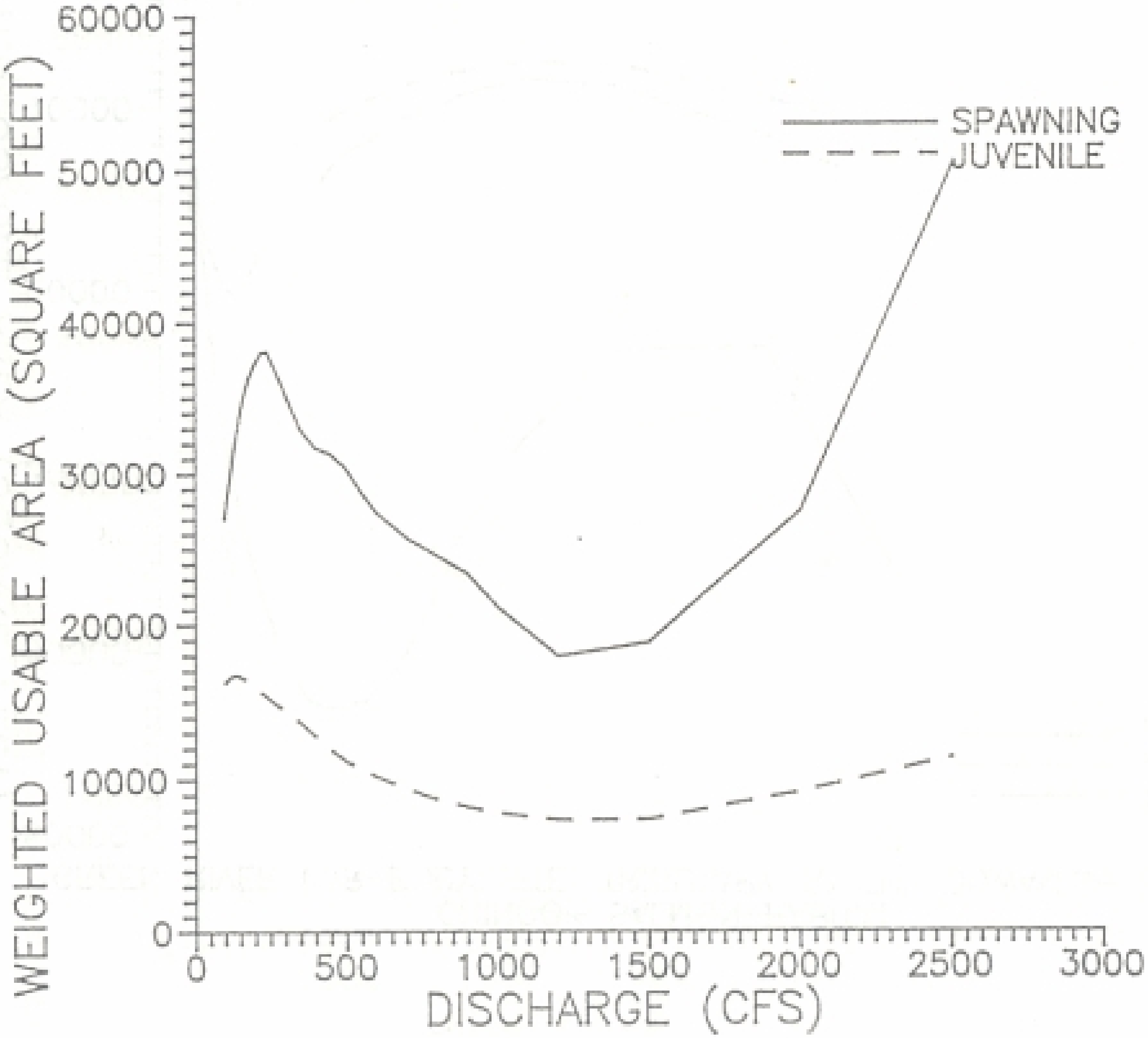
CHINOOK SALMON HABITAT
GREEN RIVER CAR BODY SITE, TRIBUTARY TO THE DUWAMISH RIVER



Chinook Salmon in the Green River
Car Body Site RM. 39.6
Data and Flow Measured
08-05-86 234 cfs
06-20-86 410 cfs
11-14-86 1048 cfs

Flow	Spawning	Juvenile	Adult
100	10016	16251	15324
110	12002	16463	15651
120	13883	16625	15956
130	15709	16716	16236
140	17484	16716	16601
150	19259	16623	17054
160	21025	16494	17530
170	22639	16371	18027
180	24126	16199	18550
190	25465	16028	18962
200	26576	15865	19349
220	28462	15582	19946
240	30014	15265	20091
260	31493	14960	19843
280	32944	14676	19502
300	34356	14358	18885
350	37063	13637	17384
375	38335	13218	16755
400	39527	12731	16352
450	41248	11876	15870
500	42527	11158	14827
525	42738	10894	14045
550	42876	10652	13479
575	42944	10407	12963
600	42961	10161	12514
625	42940	9939	12276
650	42904	9749	12036
700	42471	9395	11581
800	40676	8667	10404
900	37416	8180	10104
1000	33456	7790	9047
1200	28092	7299	8248
1500	23057	7372	8542
2000	22777	9166	11221
2500	37063	11344	14743

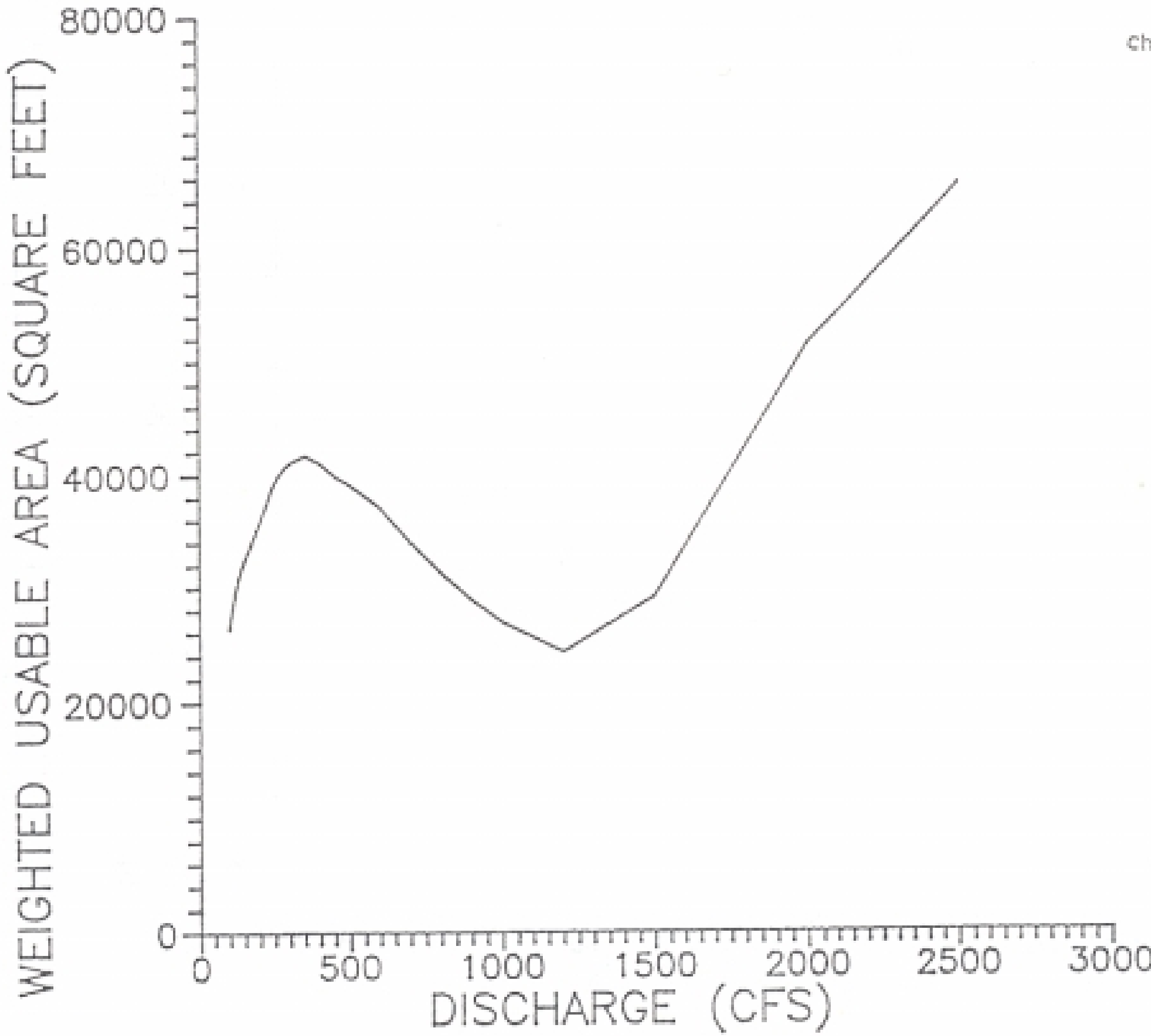
COHO SALMON HABITAT
GREEN RIVER CAR BODY SITE, TRIBUTARY TO THE DUWAMISH RIVER



Coho Salmon in the Green River
Car body Site RM. 39.6
Date and Flow Measured
08-05-86 234 cfs
06-20-86 410 cfs
11-14-86 1048 cfs

Flow	Spawning	Juvenile
100	27023	16251
110	28846	16463
120	30256	16625
130	31703	16716
140	32875	16716
150	33945	16623
160	34927	16494
170	35717	16371
180	36312	16199
190	36814	16028
200	37283	15865
220	37996	15582
240	38075	15265
260	37205	14960
280	36315	14676
300	35252	14358
350	32951	13637
400	31693	12731
450	31269	11876
500	30345	11158
550	28748	10652
600	27399	10161
700	25692	9395
800	24487	8667
900	23314	8180
1000	21114	7790
1200	17880	7299
1500	18776	7372
2000	27438	9166
2500	50203	11344

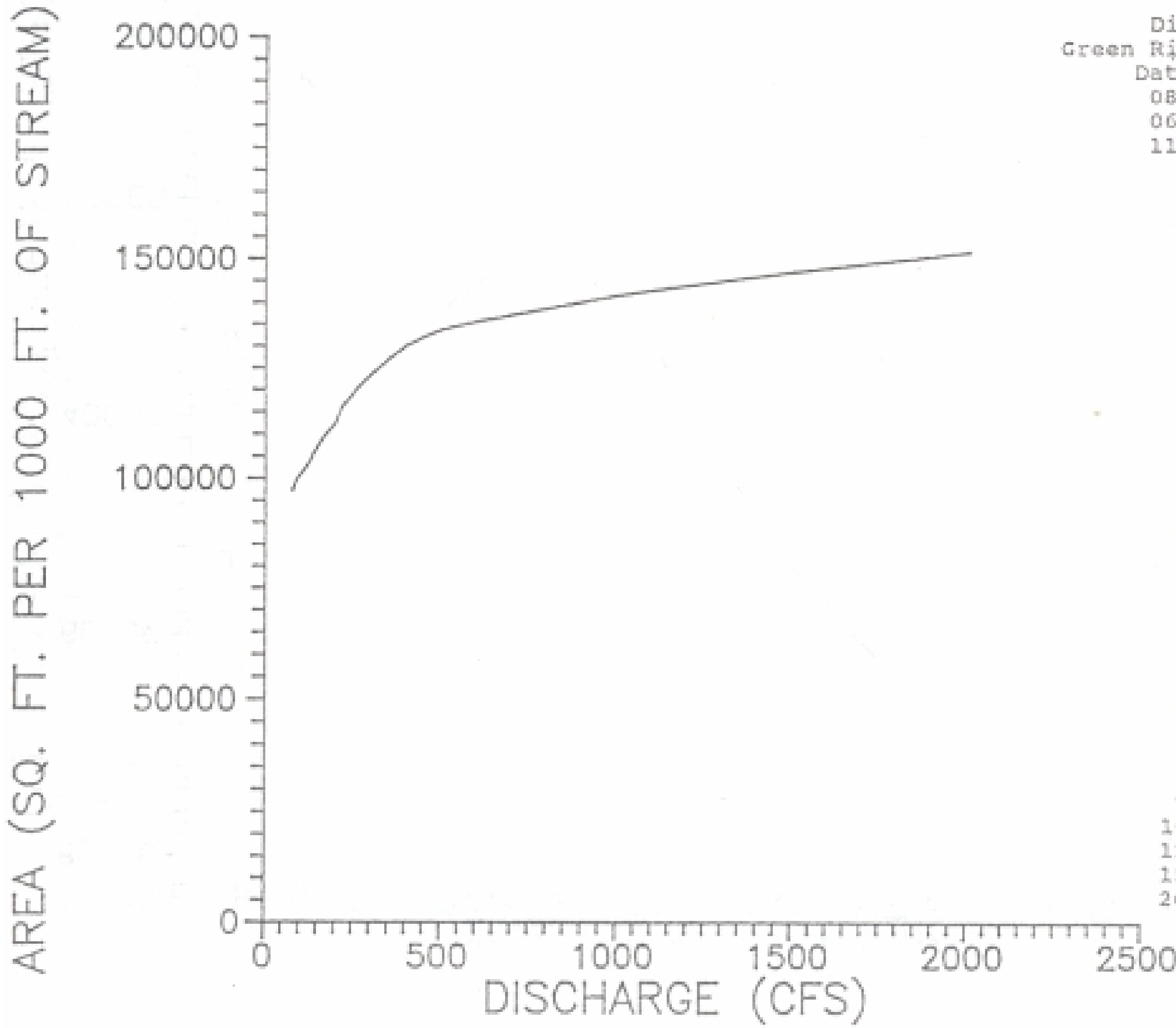
CHUM SALMON SPAWNING HABITAT
GREEN RIVER CAR BODY SITE, TRIBUTARY TO THE DUWAMISH RIVER



Chum Salmon in the Green River
Car Body Site RM. 39.6
Date and Flow Measured
08-05-86 234 cfs
06-20-86 410 cfs
11-14-86 1048 cfs

Flow	Spawning
100	26371
110	28113
120	29608
130	30801
140	31746
150	32477
160	33079
170	33716
180	34385
190	35166
200	35788
220	37182
240	38815
260	39839
280	40576
300	41064
350	41703
400	40986
450	39846
500	39060
550	38106
600	37039
700	33992
800	31239
900	28860
1000	26823
1200	24272
1500	29027
2000	51306
2500	65157

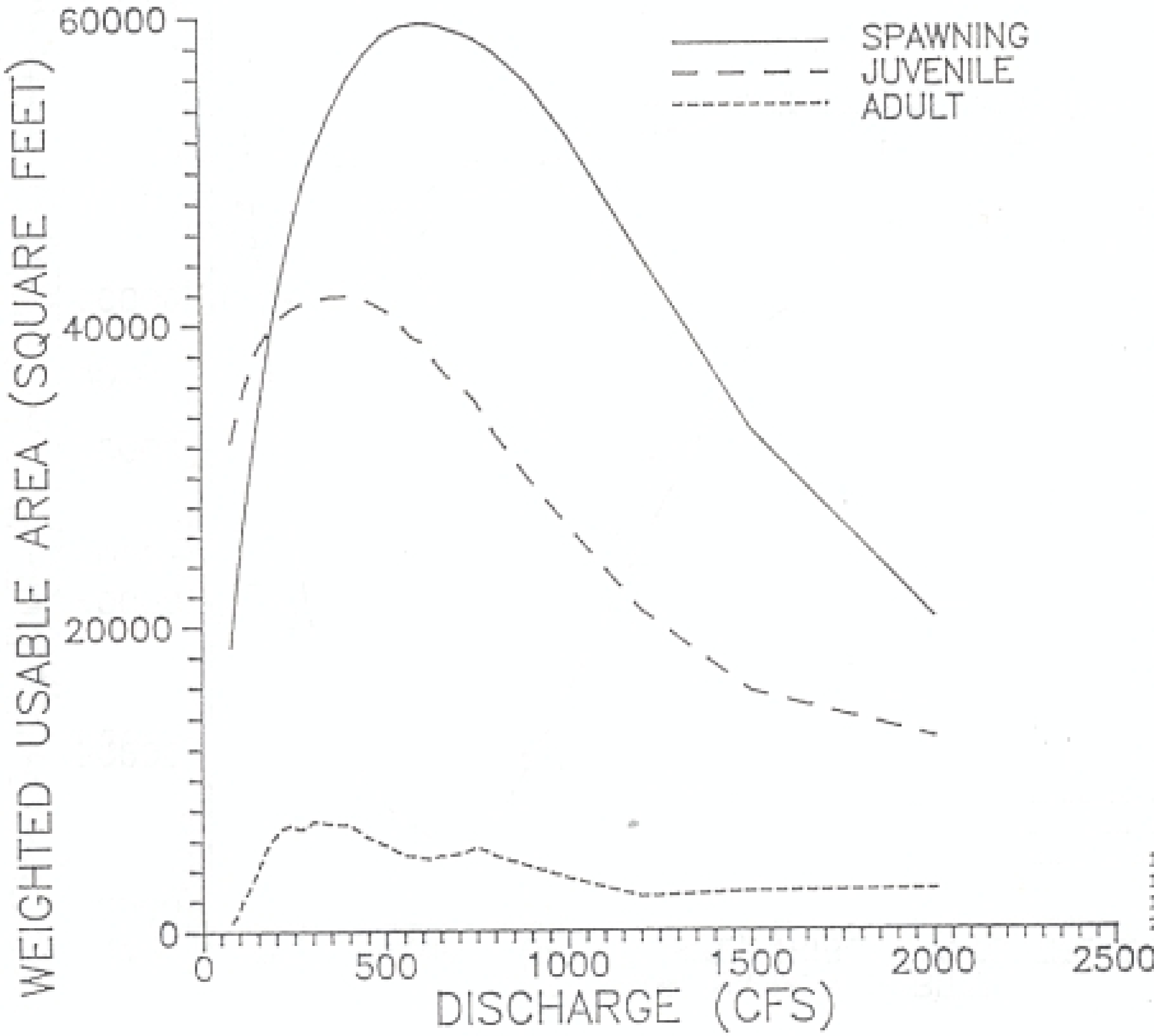
AREA VS. DISCHARGE
GREEN RIVER FLAMING GEYSER SITE, TRIBUTARY TO THE DUWAMISH RIVER



Discharge vs. Area
Green River Flaming Geyser Site
Date and Flow Measured
08-06-86 220 cfs
06-24-86 301 cfs
11-10-86 966 cfs

Flow	Area
80	97246
90	99470
100	100627
110	101657
120	102856
130	103987
140	105903
150	107108
160	108351
170	109577
180	110503
190	111392
200	112251
220	116221
240	118047
260	120028
280	121694
300	123267
350	126870
400	129947
450	132005
500	133742
600	135600
700	137106
800	138682
900	140140
1000	141727
1200	144009
1500	147170
2000	151720

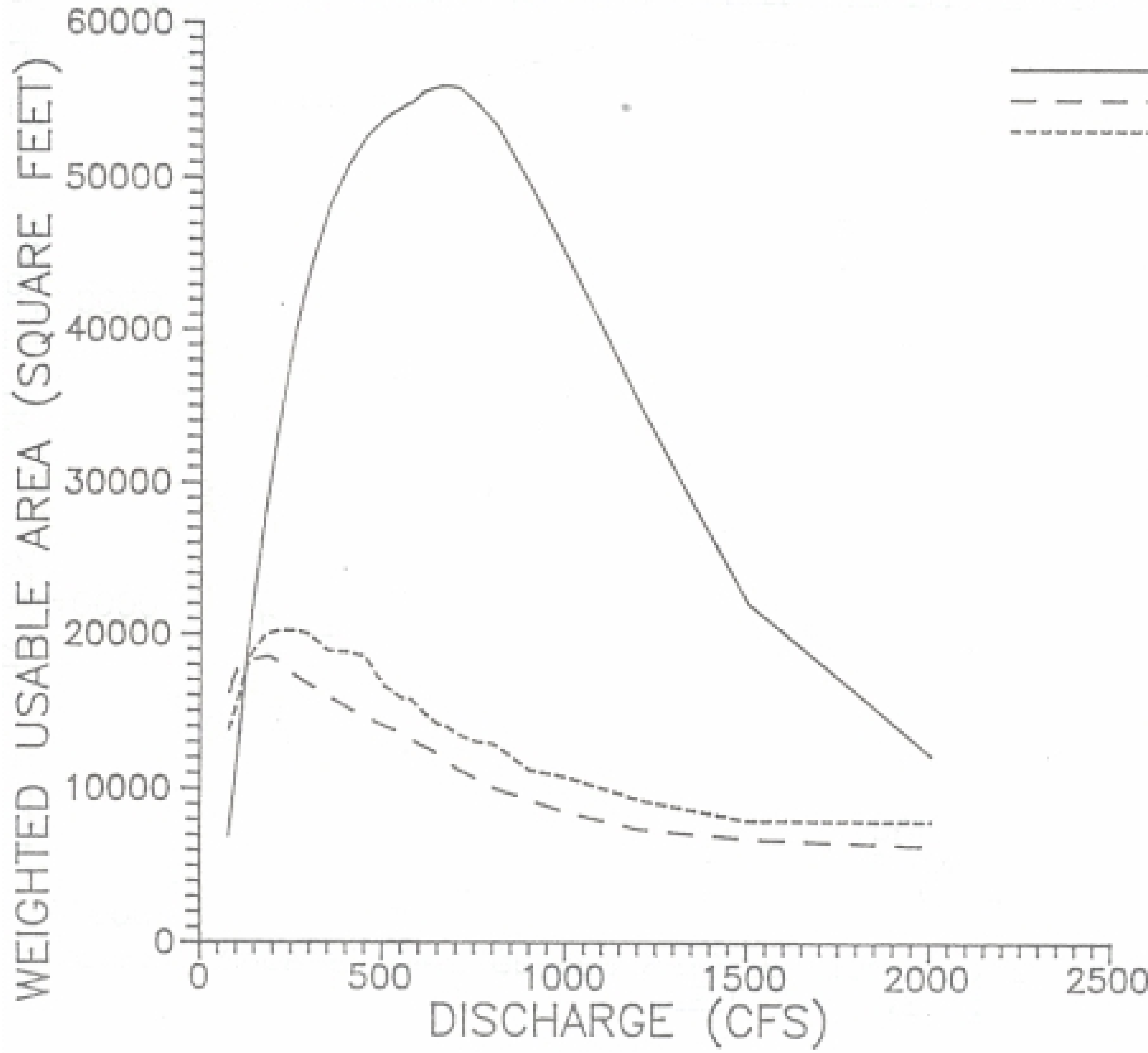
STEELHEAD HABITAT
GREEN RIVER FLAMING GEYSER SITE, TRIBUTARY TO THE DUWAMISH RIVER



Steelhead in the Green River
Flaming Geyser Site RM. 43.6
Date and Flow Measured
08-06-86 220 cfs
06-24-86 301 cfs
11-10-86 966 cfs

Flow	Spawning	Juvenile	Adult
80	18660	32310	669
90	20981	33343	956
100	23299	34272	1429
110	25495	35179	2018
120	27527	36019	2428
130	29450	36763	2941
140	31380	37546	3434
150	33240	38240	3947
160	34959	38689	4610
170	36564	39067	5225
180	38081	39396	5734
190	39533	39718	6056
200	40912	39981	6335
220	43298	40524	6808
240	45398	40931	7020
260	47400	41188	6731
280	49133	41416	6775
300	50646	41519	7240
350	53512	41801	7057
400	55819	41850	6972
450	57530	41565	6160
500	58756	40933	5625
550	59356	39789	4974
575	59453	39118	4894
600	59578	38786	4781
625	59521	37901	4716
650	59440	37139	4961
675	59208	36448	4969
700	59025	36082	5062
725	58800	35490	5263
750	58524	34822	5505
800	57759	32753	4900
900	55558	29531	4136
1000	52370	26578	3401
1200	44580	20918	2172
1500	32943	15548	2499
2000	20367	12565	2600

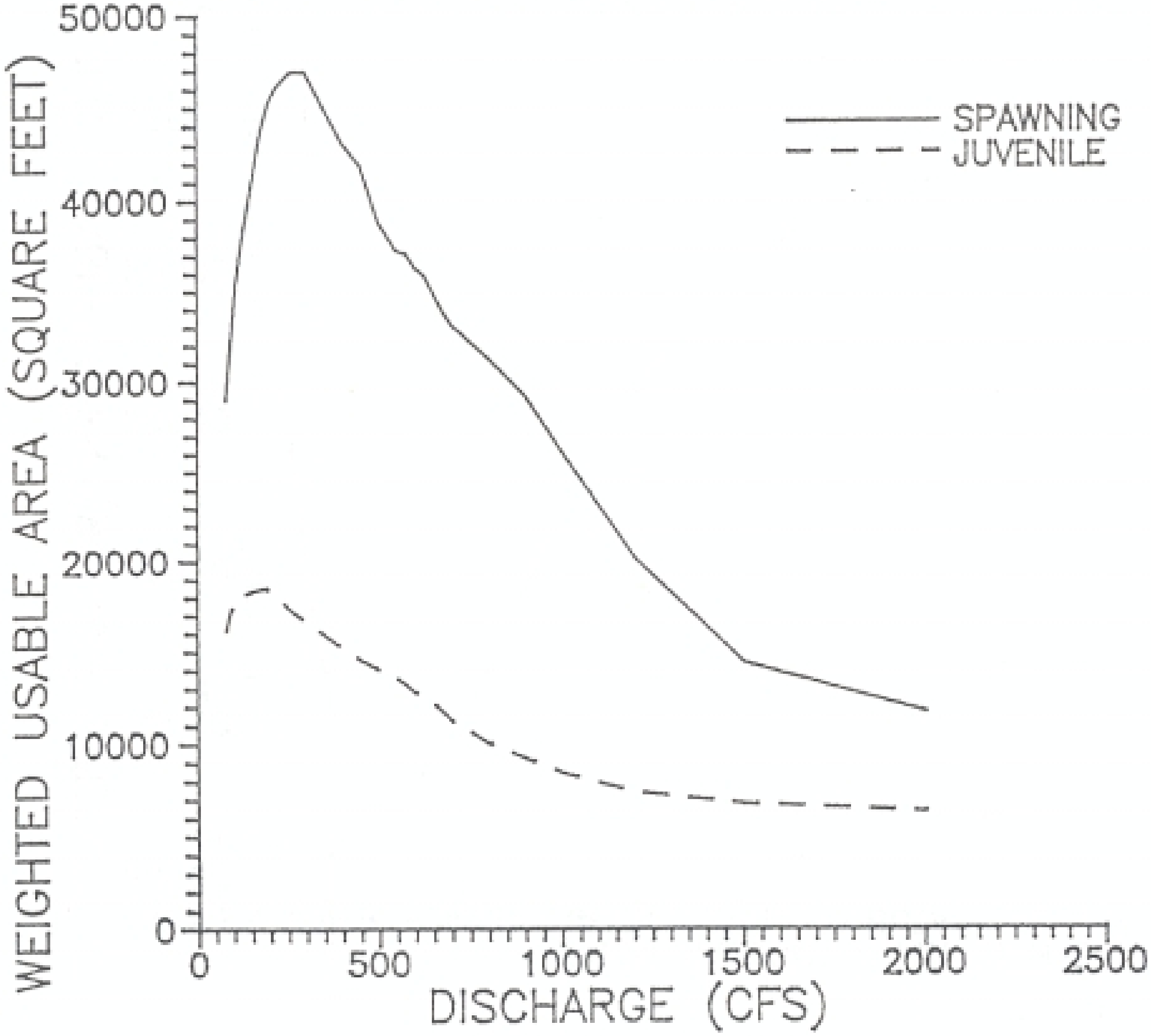
CHINOOK SALMON HABITAT
GREEN RIVER FLAMING GEYSER SITE, TRIBUTARY TO THE DUWAMISH RIVER



Chinook Salmon in the Green River
Flaming Geyser Site RM. 43.6
Date and Flow Measured
08-06-86 220 cfs
06-24-86 301 cfs
11-10-86 966 cfs

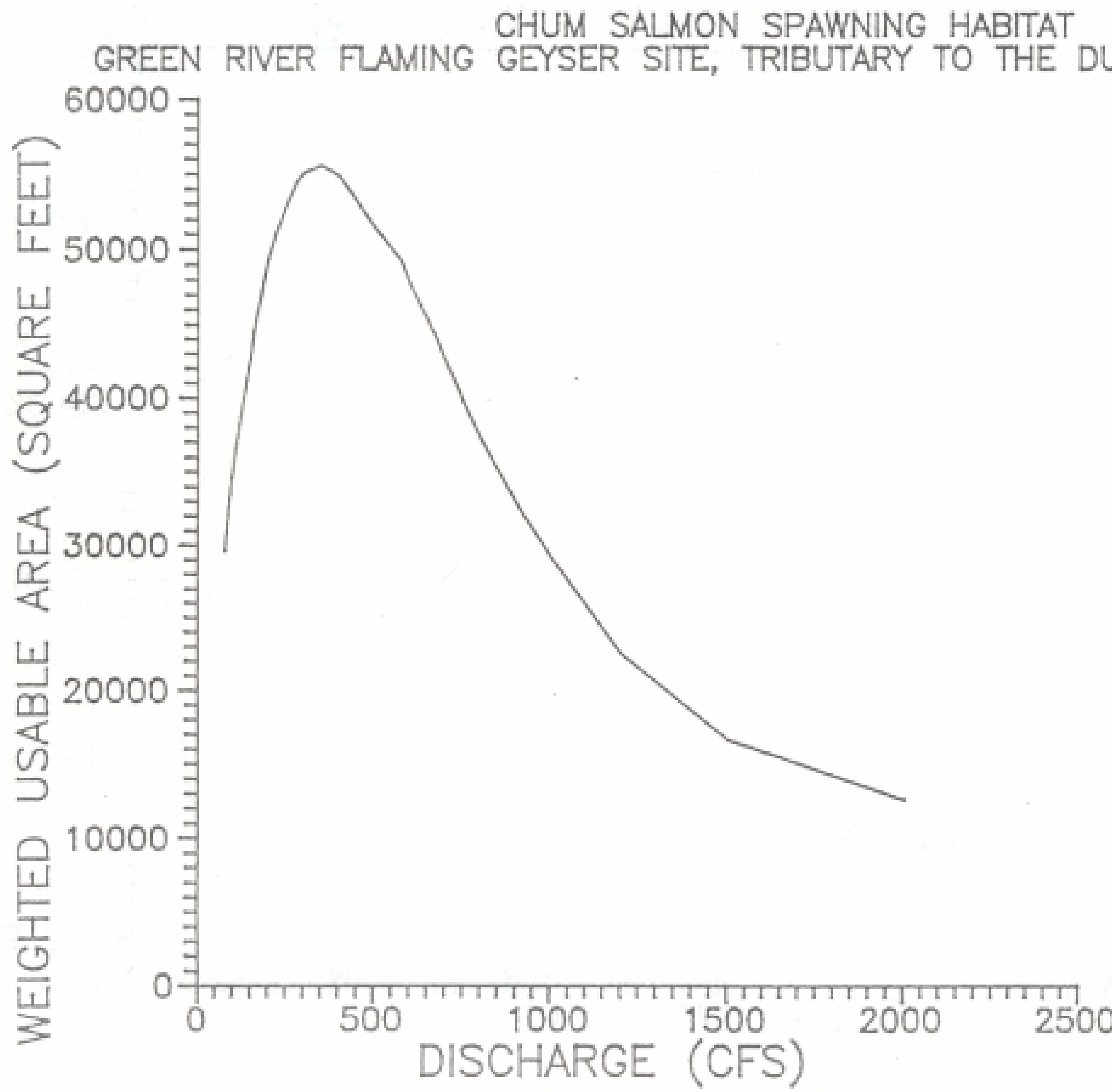
Flow	Spawning	Juvenile	Adult
80	6871	16159	13767
90	8803	17017	14525
100	11130	17539	15315
110	13642	17906	16231
120	16160	18165	17225
130	18613	18204	18023
140	20865	18248	18652
150	22880	18335	19028
160	24669	18401	19327
170	26445	18455	19642
180	28207	18494	19931
190	29879	18487	20043
200	31521	18346	20122
220	34575	18055	20197
240	37516	17613	20217
260	40127	17239	20176
280	42297	16925	20077
300	44254	16642	19882
350	48211	15899	18853
400	50776	15189	18773
450	52681	14518	18519
500	53810	14012	16615
550	54575	13526	15761
575	54866	13172	15691
600	55462	12761	15061
625	55692	12509	14503
650	55854	12137	14090
675	55853	11718	13903
700	55722	11219	13476
725	55233	10953	13217
750	54659	10622	12972
800	53355	10016	12813
900	49202	9211	11141
1000	44819	8438	10702
1200	34970	7374	9259
1500	21959	6743	7911
2000	12138	6293	7885

COHO SALMON HABITAT
GREEN RIVER FLAMING GEYSER SITE, TRIBUTARY TO THE DUWAMISH RIVER



Coho Salmon in the Green River
Flaming Geyser Site RM. 43.6
Date and Flow Measured
08-06-86 220 cfs
06-24-86 301 cfs
11-10-86 966 cfs

Flow	Spawning	Juvenile
80	28960	16159
90	31175	17017
100	33471	17539
110	35702	17906
120	37242	18165
130	38543	18204
140	39605	18248
150	40743	18335
160	41893	18401
170	43005	18455
180	43965	18494
190	44680	18487
200	45352	18346
220	46126	18055
240	46574	17613
260	46948	17239
280	46963	16925
300	46959	16642
350	45052	15899
400	43159	15189
450	41911	14518
500	38838	14012
550	37242	13526
575	37080	13172
600	36292	12761
625	35849	12509
650	34826	12137
675	33847	11719
700	33045	11219
725	32626	10953
750	32134	10622
800	31214	10016
900	29147	9211
1000	26079	8438
1200	20111	7374
1500	14370	6743
2000	11651	6293

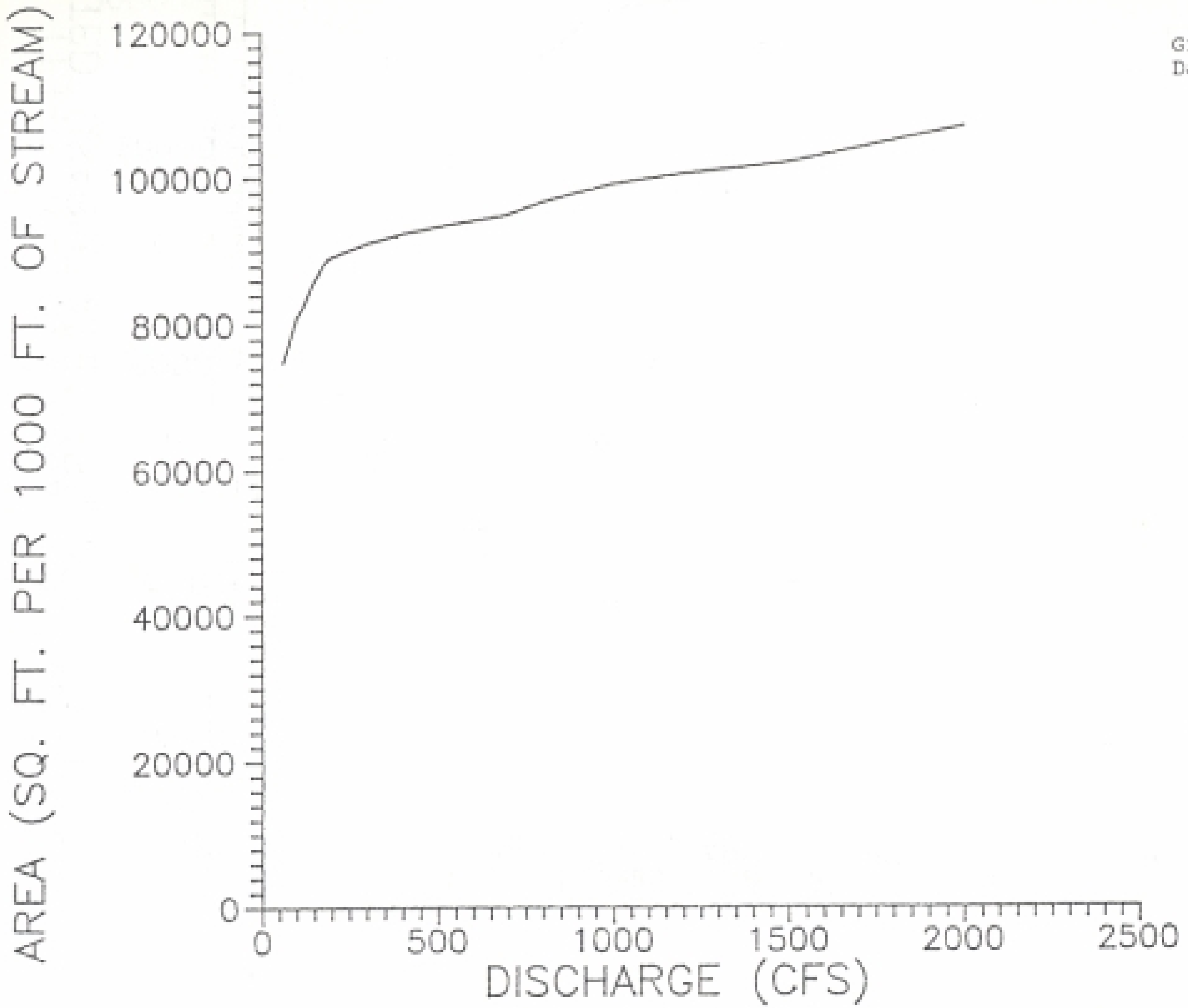


Chum Salmon in the Green River
Flaming Geyser Site RM. 43.6
Date and Flow Measured

08-06-86	220 cfs
06-24-86	301 cfs
11-10-86	966 cfs

Flow	Spawning
80	29566
90	32616
100	34780
110	36671
120	38264
130	39768
140	41298
150	42663
160	44470
170	45737
180	46851
190	48110
200	49338
220	50994
240	52187
260	53373
280	54425
300	55075
350	55546
400	54846
450	53174
500	51423
550	49977
575	49191
600	47681
625	46505
650	45228
675	44013
700	42462
725	41174
750	39733
800	37184
900	32859
1000	29187
1200	22474
1500	16620
2000	12588

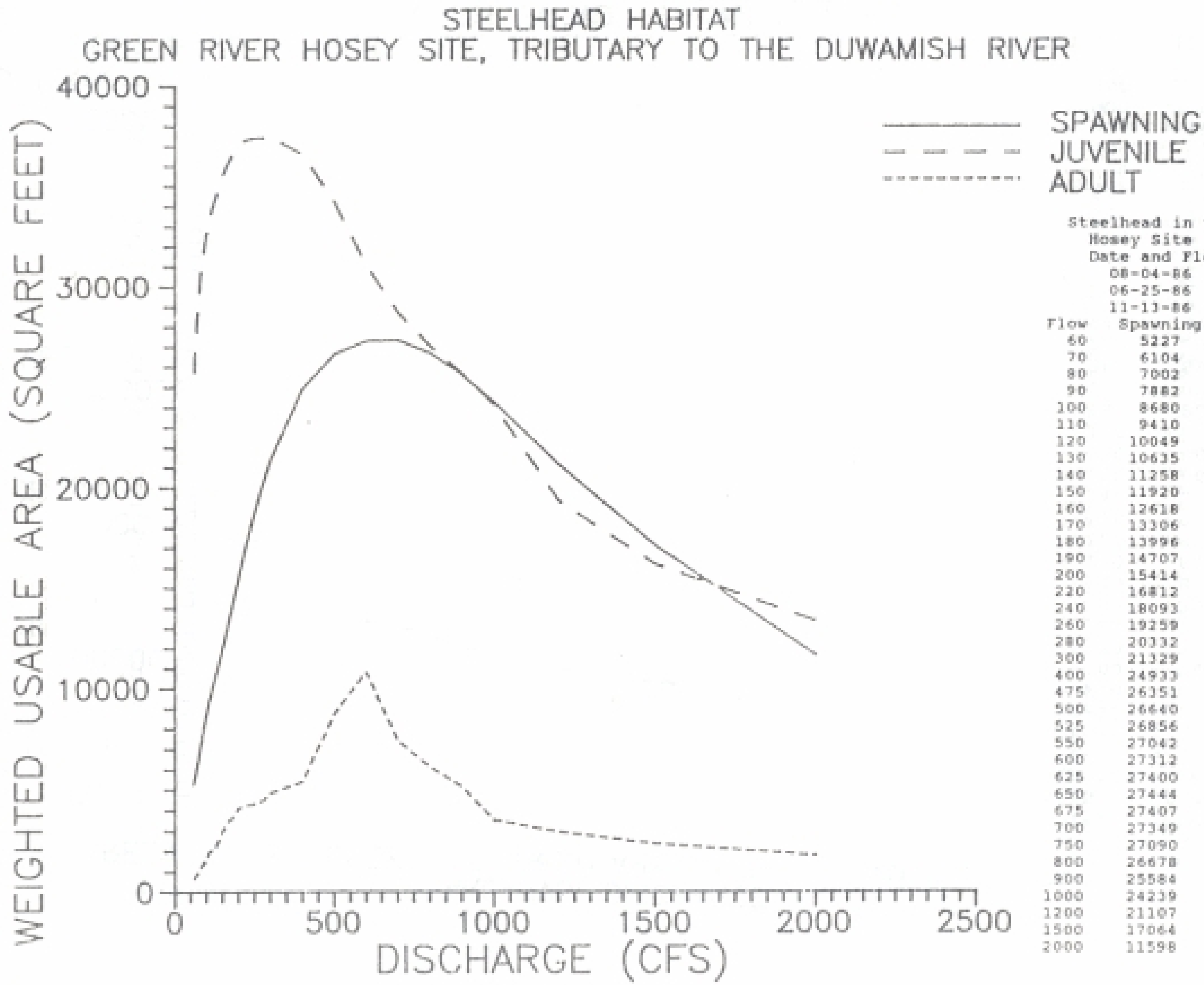
AREA VS. DISCHARGE
GREEN RIVER HOSEY SITE, TRIBUTARY TO THE DUWAMISH RIVER



Discharge vs. Area
Green River Hosey Site
Date and Flow Measured

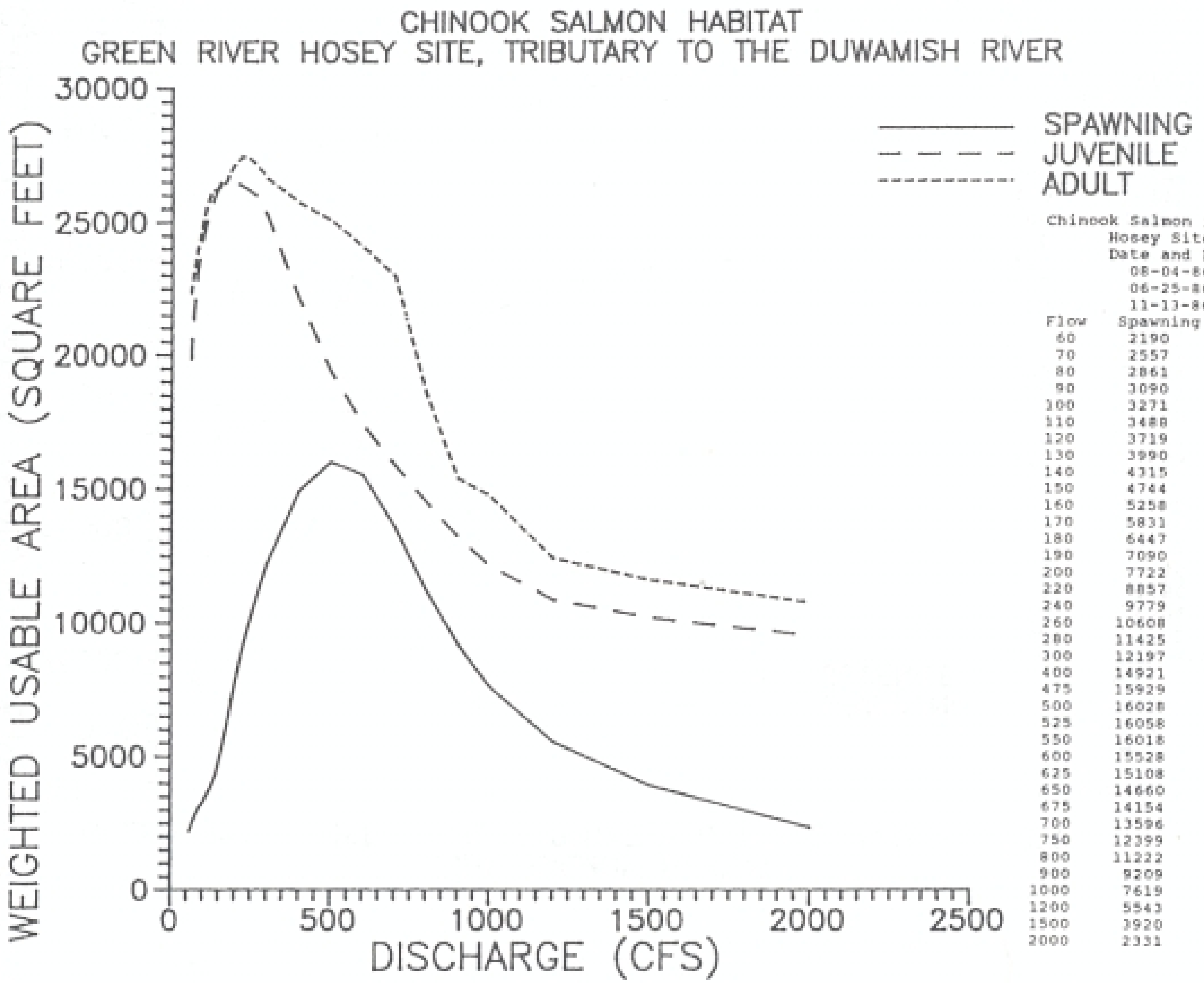
08-04-86	140	cfs
06-25-86	194	cfs
11-13-86	768	cfs

Flow	Area
60	74733
70	76192
80	77841
90	79455
100	81038
110	81767
120	82609
130	83760
140	85042
150	86088
160	86676
170	87603
180	88504
190	88990
200	89210
220	89626
240	90021
260	90394
280	90746
300	91081
400	92437
500	93382
600	94194
700	95004
800	96755
900	97964
1000	99101
1200	100486
1500	101982
2000	106667



Steelhead in the Green River
Hosey Site RM. 60.6
Date and Flow Measured
08-04-86 140 cfs
06-25-86 194 cfs
11-13-86 768 cfs

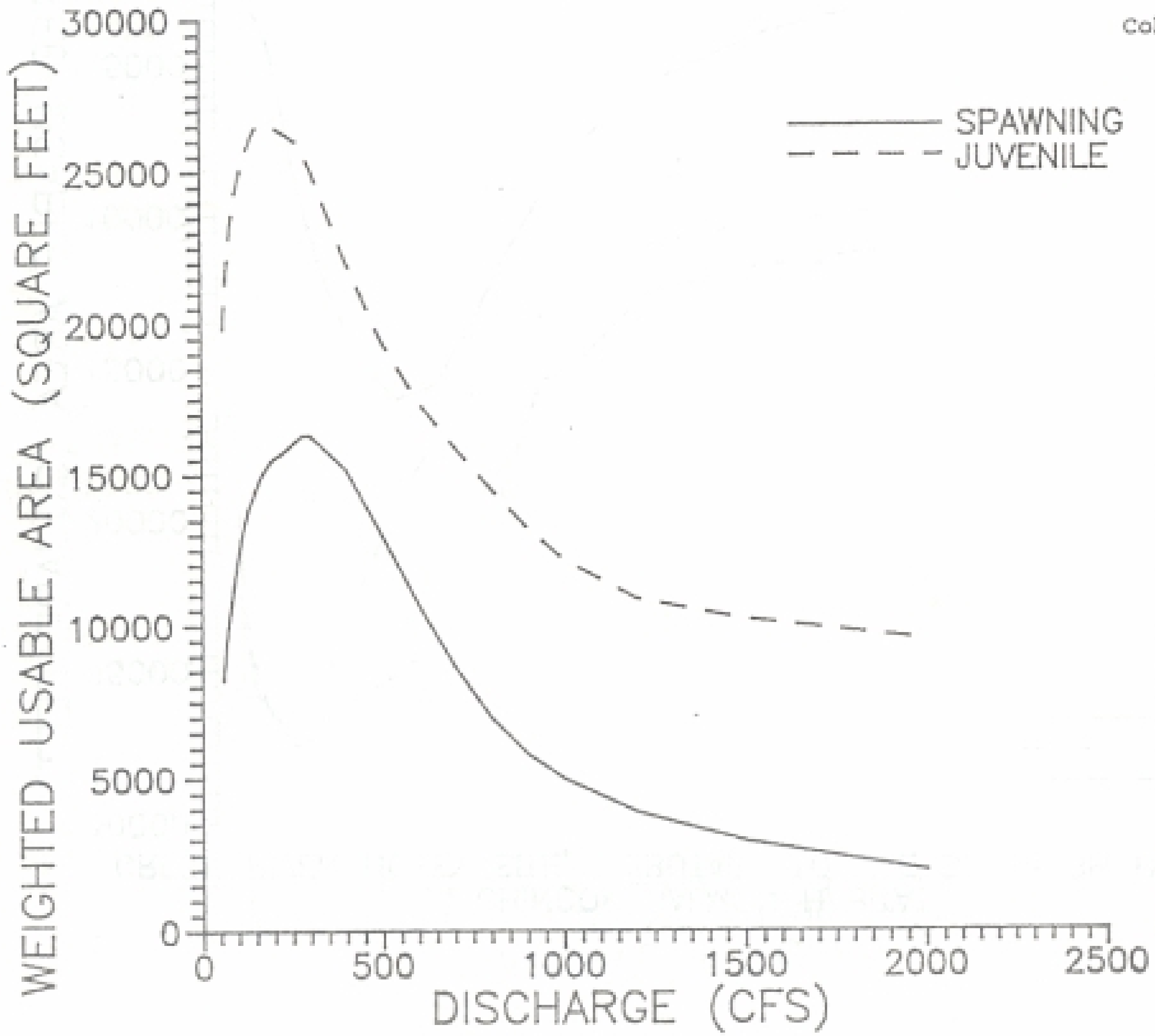
Flow	Spawning	Juvenile	Adult
60	5227	25725	633
70	6104	28350	874
80	7002	30321	1153
90	7882	31597	1396
100	8680	32585	1591
110	9410	33422	1980
120	10049	33985	2081
130	10635	34471	2240
140	11258	34978	2554
150	11920	35490	2917
160	12618	35906	3274
170	13306	36249	3484
180	13996	36523	3615
190	14707	36797	3807
200	15414	37031	4091
220	16812	37271	4248
240	18093	37380	4280
260	19259	37420	4369
280	20332	37418	4529
300	21329	37455	4835
400	24933	36586	5398
475	26351	34814	7135
500	26640	34214	8702
525	26856	33514	10141
550	27042	32708	10588
600	27312	31061	10815
625	27400	30470	10637
650	27444	29816	9626
675	27407	29156	8298
700	27349	28688	7375
750	27090	27805	6816
800	26678	27015	6097
900	25584	25658	5122
1000	24239	24069	3493
1200	21107	19298	2929
1500	17064	16123	2342
2000	11598	13295	1771



Chinook Salmon in the Green River
Hosey Site RM. 60.6
Date and Flow Measured
08-04-86 140 cfs
06-25-86 194 cfs
11-13-86 768 cfs

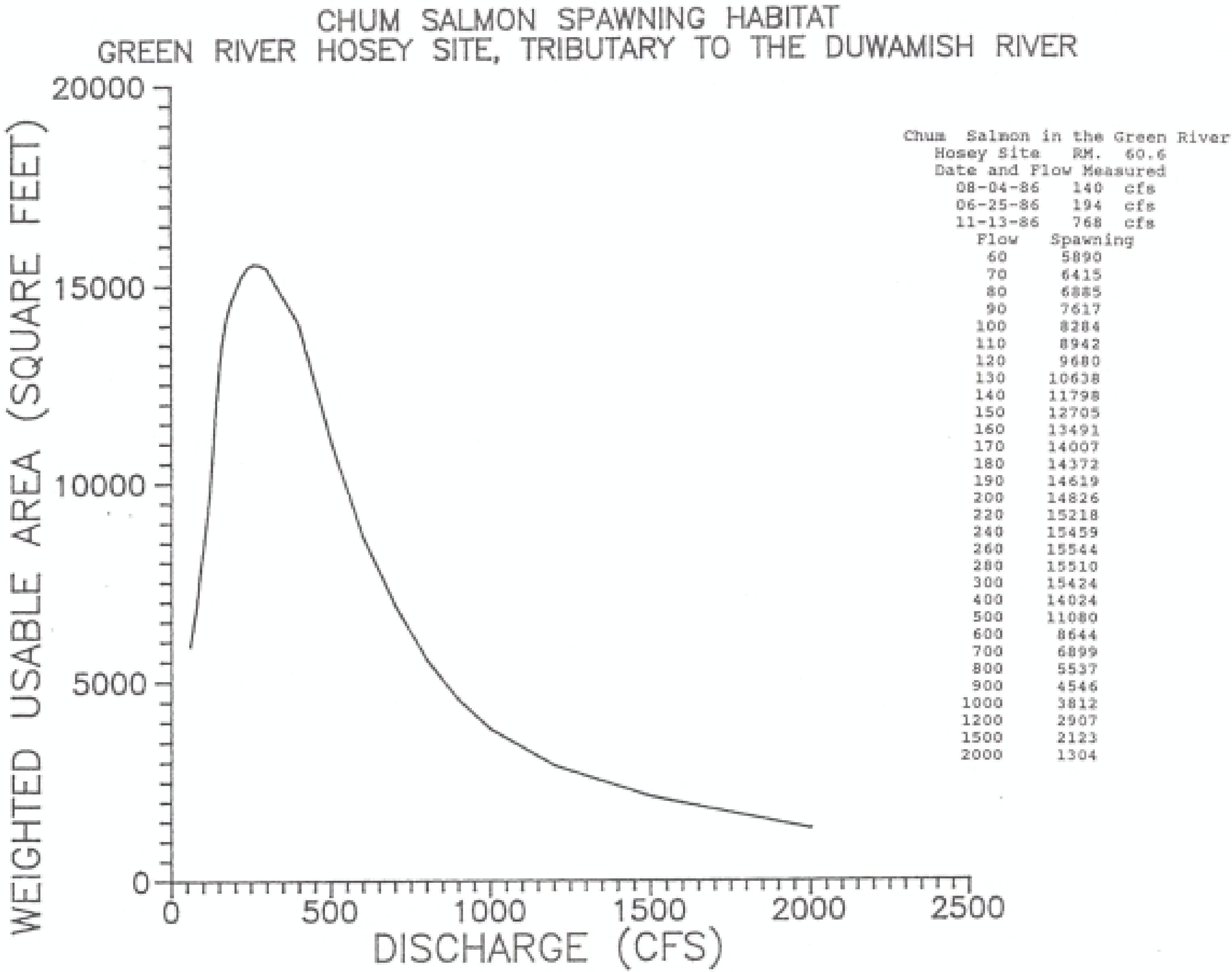
Flow	Spawning	Juvenile	Adult
60	2190	19833	22338
70	2557	21552	23219
80	2861	22951	23883
90	3090	23883	24510
100	3271	24535	25108
110	3488	25018	25638
120	3719	25435	26005
130	3990	25804	26184
140	4315	26132	26212
150	4744	26400	26305
160	5258	26525	26343
170	5831	26567	26489
180	6447	26553	26784
190	7090	26519	27027
200	7722	26468	27207
220	8857	26324	27435
240	9779	26180	27412
260	10608	26016	27178
280	11425	25756	26904
300	12197	25215	26605
400	14921	22072	25706
475	15929	19910	25161
500	16028	19359	25051
525	16058	18805	24896
550	16018	18303	24590
600	15528	17401	24049
625	15108	16980	23823
650	14660	16577	23617
675	14154	16219	23365
700	13596	15893	22954
750	12399	15207	21245
800	11222	14513	18556
900	9209	13211	15373
1000	7619	12135	14748
1200	5543	10846	12412
1500	3920	10175	11597
2000	2331	9497	10731

COHO SALMON HABITAT
GREEN RIVER HOSEY SITE, TRIBUTARY TO THE DUWAMISH RIVER



Coho Salmon in the Green River
Hosey Site RM. 60.6
Date and Flow Measured
08-04-86 140 cfs
06-25-86 194 cfs
11-13-86 768 cfs

Flow	Spawning	Juvenile
60	8192	19833
70	9504	21552
80	10466	22951
90	11305	23883
100	12114	24535
110	12826	25018
120	13394	25435
130	13861	25804
140	14183	26132
150	14503	26400
160	14802	26525
170	15073	26567
180	15250	26553
190	15431	26519
200	15551	26468
220	15697	26324
240	15895	26180
260	16120	26016
280	16312	25756
300	16330	25215
400	15173	22072
500	12975	19359
600	10686	17401
700	8632	15893
800	6976	14513
900	5774	13211
1000	4953	12135
1200	3870	10846
1500	2926	10175
2000	1949	9497


CHUM SALMON SPAWNING HABITAT
GREEN RIVER HOSEY SITE, TRIBUTARY TO THE DUWAMISH RIVER
WEIGHTED USABLE AREA (SQUARE FEET)
20000
15000
10000
5000
0
0
500
1000
1500
2000
2500
DISCHARGE (CFS)
Chum Salmon in the Green River
Hosey Site RM. 60.6
Date and Flow Measured
08-04-86 140 cfs
06-25-86 194 cfs
11-13-86 768 cfs
Flow Spawning
60 5890
70 6415
80 6885
90 7617
100 8284
110 8942
120 9680
130 10638
140 11798
150 12705
160 13491
170 14007
180 14372
190 14619
200 14826
220 15218
240 15459
260 15544
280 15510
300 15424
400 14024
500 11080
600 8644
700 6899
800 5537
900 4546
1000 3812
1200 2907
1500 2123
2000 1304

Appendix B

KENT SITE CALIBRATION INFORMATION

Appendix B1 IFG4 Input File Kent Site

```
Green River at Kent              Split site, Lower at RM 27.2, Upper at RM 30.5
Q/DATE MEASURED   950 cfs on 11-12-86,  538 on 06-18-86, 262 on 08-08-86
IOC          000000200000300000
BMAX    1.3
QARD        100
QARD        262
QARD        538
QARD        950
QARD       2500
XSEC        1.0          0.001.00          85.10
            1.0   -5.0  97.4     0.0  93.4     3.0  91.9     5.0  90.7    10.0 88.6    15.0 87.0
            1.0   20.0 86.6     25.0 86.2     30.0 86.0     35.0 85.7    40.0 85.4    45.0 85.3
            1.0   47.5 85.1     50.0 85.3     52.5 85.3     55.0 85.3    57.5 85.4    60.0 85.4
            1.0   65.0 85.8     70.0 86.0     75.0 86.7     80.0 87.4    85.0 88.4    90.0 89.0
            1.0   95.0 89.5    100.0 90.0    105.0 90.2    108.4 91.7   110.0 93.0   114.0 94.9
            1.0    124.0101.3
NS          1.0    0.0   0.8     0.0   0.8     0.0   0.8     0.0   0.8     0.0  11.5    0.0  26.6
NS          1.0    0.0  26.5     0.0  26.6     0.0  26.6     0.0  16.6     0.0  13.5    0.0  13.8
NS          1.0    0.0  13.8     0.0  15.8     0.0  15.8     0.0  15.7     0.0  16.6    0.0  61.6
NS          1.0    0.0  65.8     0.0  65.9     0.0  56.7     0.0  56.7     0.0  36.8    0.0  61.5
NS          1.0    0.0  61.5     0.0  16.7     0.0  15.8     0.0   0.8     0.0   0.8    0.0   0.8
NS          1.0    0.0   0.8     0.0           0.0           0.0           0.0          0.0
CAL1        1.0    91.66         950.00
VEL1        1.0                    0.2         0.4   1.4     2.2   2.1     2.4   2.4    2.6   2.7
VEL1        1.0    2.8   3.0     2.6   2.6     2.7   2.7     2.5   2.4     2.0   1.7    1.1   1.2
VEL1        1.0    0.7   0.6     0.3
CAL2        1.0      91.02         538.00
VEL2        1.0                        0.0     0.3   0.9       1.3 1.3     1.3   1.7    1.7   1.6
VEL2        1.0    1.8   1.9      1.8  1.9     1.8   1.8      1.6  1.3     1.3   0.9    0.7   0.6
VEL2        1.0    0.6   0.0      0.0
CAL3        1.0        90.50         262.00
VEL3        1.0                                0.3   0.5      0.6  0.6     0.9   0.9     0.8  0.9
VEL3        1.0    0.9   1.0      1.0  1.2     1.0   0.9      0.8  0.6     0.6   0.4     0.2  0.1
VEL3        1.0    0.0   0.0      0.0
XSEC        2.0       160.0001.00        86.30
            2.0   -5.0  97.8     0.0  93.3     2.0  92.9     5.0  90.4    10.0 88.5     15.0 87.5
            2.0   20.0 87.8     25.0 87.7     30.0 87.7     35.0 87.6    40.0 87.4     45.0 87.4
            2.0   50.0 87.3     55.0 87.3     57.5 87.3     60.0 87.3    62.5 87.4     65.0 87.4
            2.0   67.5 87.5     70.0 87.6     72.5 87.6     75.0 87.4    77.5 87.4     80.0 87.2
            2.0   82.5 87.1     85.0 86.9     90.0 86.5     95.0 86.3   100.0 86.5    105.0 87.1
            2.0  110.0 88.0    115.0 89.3    120.3 93.5    121.3 95.2   126.3100.2
NS          2.0    0.00  0.8     0.0  88.5     0.0  88.5     0.0  88.5     0.0  88.5     0.0  11.5
NS          2.0    0.0  22.5     0.0  23.9     0.0  23.9     0.0  23.9     0.0  25.9     0.0  25.9
NS          2.0    0.0  23.9     0.0  42.7     0.0  42.7     0.0  63.6     0.0  63.6      0.0  53.8
NS          2.0    0.0  56.8     0.0  56.8     0.0  54.9     0.0  54.9     0.0  56.9      0.0  56.9
NS          2.0    0.0  55.5     0.0  62.6     0.0  26.6     0.0  26.5     0.0  62.8      0.0  68.9
NS          2.0    0.0  68.9     0.0  68.9     0.0   0.8     0.0   0.8     0.0   0.8           0.0
CAL1        2.0        91.70         950.00
```

```
VEL1     2.0                          0.3     0.9   1.6   1.8   1.9   2.2   2.3   2.5   2.7
VEL1     2.0       2.9   3.0      2.9   3.1     3.0   3.0   2.9   3.1   3.3   3.8   3.4   3.2
VEL1     2.0       3.0   2.8      2.1   1.3     0.5   0.1   0.1   0.4
CAL2     2.0          91.02       538.00
VEL2     2.0                          0.0     0.6   0.9   1.0   1.0   1.4   1.4   1.5   1.6
VEL2     2.0       1.8   2.0      2.1   2.1     2.2   2.5   2.4   2.3   2.5   2.7   2.6   2.6
VEL2     2.0       1.9   2.1      1.6   1.2     0.7   0.4   0.1   0.0
CAL3     2.0          90.49       262.00
VEL3     2.0                          0.0     0.5   0.5   0.5   0.8   1.1   1.1   1.2   1.2
VEL3     2.0       1.4   1.5      1.4   1.6     1.5   1.3   1.3   1.6   1.2   1.1   1.0   0.9
VEL3     2.0       0.8   0.3      0.3   0.2     0.3   0.4   0.3   0.2
XSEC     3.0      170.0001.00          86.30
         3.0    -30.0  96.5      0.0  94.5   12.0  93.0   19.0  91.5   20.0  91.3   25.0  90.5
         3.0     30.0  90.0     35.0  90.5   40.0  90.2   45.0  89.3   50.0  89.1   55.0  88.5
         3.0     60.0  87.7     65.0  86.8   70.0  86.1   75.0  85.5   77.5  85.4   80.0  85.5
         3.0     82.5  85.7     85.0  85.7   87.5  86.0   90.0  86.2   92.5  86.5   95.0  86.6
         3.0     97.5  87.0    100.0  87.2  102.5  87.5  105.0  87.9  110.0  88.8  115.0  88.9
         3.0    120.0  89.2    125.0  91.0  129.5  92.3  134.5  95.5  144.5  98.5
NS       3.0      0.0   0.8      0.0   0.8    0.0   0.8    0.0  43.6    0.0  43.6    0.0  43.6
NS       3.0      0.0  13.9      0.0  41.5    0.0  41.8    0.0  22.5    0.0  22.5    0.0  22.5
NS       3.0      0.0  23.7      0.0  23.8    0.0  23.9    0.0  23.9    0.0  23.9    0.0  25.6
NS       3.0      0.0  25.6      0.0  56.6    0.0  56.6    0.0  56.6    0.0  56.6    0.0  56.6
NS       3.0      0.0  56.7      0.0  56.7    0.0  56.7    0.0  52.9    0.0  52.9    0.0  36.9
NS       3.0      0.0  54.8      0.0  88.5    0.0  88.5    0.0   0.8    0.0   0.8    0.0
CAL1     3.0          91.72          950.00
VEL1     3.0                         0.0     0.0   0.4    1.2   1.9    1.4   1.3    1.7   1.6
VEL1     3.0       2.0   1.9      2.2   2.6     2.7   2.8    3.0   3.2    3.3   3.3    3.6   3.8
VEL1     3.0       3.8   3.7      4.2   4.1     2.8   1.4    1.7   0.6
CAL2     3.0          91.04          538.00
VEL2     3.0                                         0.0    0.3   0.4    0.4   0.4    0.7   0.7
VEL2     3.0       0.9   1.0      1.2   1.3     1.5   1.8    2.0   2.3    2.5   2.5    2.7   2.7
VEL2     3.0       2.8   3.4      3.4   3.9     3.3   2.1    2.1   0.8
CAL3     3.0          90.53          262.00
VEL3     3.0                                                       0.0    0.0   0.3    0.3   0.2
VEL3     3.0       0.2   0.3      0.6   0.9     1.3   1.3    1.7   1.5    1.8   1.7    1.7   2.1
VEL3     3.0       1.7   1.8      2.6   2.5     2.0   1.4          1.0
XSEC     4.0      170.0001.00          94.60
         4.0    -30.0107.8       0.0  99.9    1.0100.2    5.0  96.0   10.0  94.9   15.0  94.8
         4.0     20.0  94.9     25.0  95.1   30.0  95.1   40.0  95.1   50.0  95.2   60.0  95.2
         4.0     70.0  95.2     80.0  95.290.0  95.3100.095.1110.0  95.2120.0           94.9
         4.0    125.0 94.8     130.0 94.8  135.0 94.8  140.0 95.0  145.0 95.0  150.0 94.8
         4.0    160.0 94.6     170.0 94.7175.0 96.7177.0  98,3179.0  99.9
NS       4.0     0.0   0.8      0.0   88.5    0.0   88.5    0.0   82.9    0.0   82.5    0.0   65.6
NS       4.0     0.0   65.5     0.0   65.6    0.0   65.5    0.0   56.6    0.0   56.6    0.0   65.5
NS       4.0     0.0   65.5     0.0   56.8    0.0   65.6    0.0   65.6    0.0   65.6    0.0   65.7
NS       4.0     0.0   65.8     0.0   65.9    0.0   75.6    0.0   67.7    0.0   65.7    0.0   56.7
         4.0     0.0   65.5     0.0   85.8    0.0   88.5    0.0   88.5    0.0    0.8    0.0
CAL1     4.0          97.45          950.00
```

Appendix B1 IFG4 Input File Kent Site Continued

VEL1	4.0				0.6	1.6	2.2	2.2	2.4	2.5	2.2	2.3	2.2
VEL1	4.0	2.4	2.4	2.5	2.6	2.4	2.6	2.0	2.5	2.5	2.2	2.6	2.2
VEL1	4.0	2.5	1.4		0.1								
CAL2	4.0		96.97		538.00								
VEL2	4.0				0.4	0.8	1.3	1.4	1.7	1.6	1.5	1.6	1.6
VEL2	4.0	1.5	1.7	1.5	2.0	1.6	1.6	1.8	1.5	1.5	1.8	1.7	1.4
VEL2	4.0	1.5	1.1		00								
CAL3	4.0		96.57		262.00								
VEL3	4.0				0.0	0.5	1.0	1.1	1.3	1.3	1.0	1.2	1.2
VEL2	4.0	1.1	0.9	1.1	1.0	1.0	1.0	1.1	1.0	1.1	1.2	1.2	1.1
VEL2	4.0	1.0	0.3										
XSEC	5.0	170.0000.50			94.60								
	5.0	-35.0109.5		0.0100.5		5.0	99.3	10.0	99.0	12.5	95.5	15.0	95.4
	5.0	20.0	95.0	25.0	94.6	30.0	94.4	35.0	94.4	40.0	94.4	45.0	94.3
	5.0	50.0	94.1	55.0	93.9	60.0	93.6	65.0	93.3	70.0	92.8	75.0	92.1
	5.0	80.0	91.4	85.0	91.1	90.0	91.1	92.5	90.9	95.0	90.8	97.5	90.5
	5.0	100.0	90.2	102.5	90.0	105.0	90.0	110.0	90.7	115.0	93.4120.0		96.4
	5.0	123.6	98.5	125.6	99.7	139.6	106.9						
NS	5.0	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.1	0.0	16.8	0.0	16.8
NS	5.0	0.0	27.8	0.0	27.8	0.0	27.8	0.0	26.6	0.0	26.6	0.0	26.5
NS	5.0	0.0	26.5	0.0	26.5	0.0	26.5	0.0	26.5	0.0	61.5	0.0	61.5
NS	5.0	0.0	16.8	0.0	16.9	0.0	61.6	0.0	61.7	0.0	61.9	0.0	61.9
NS	5.0	0.0	61.9	0.0	61.9	0.0	61.9	0.0	88.5	0.0	88.5	0.0	88.5
NS	5.0	0.0	0.2	0.0	0.8	0.0	0.8	0.0		0.0		0.0	
CAL1	5.0		97.66		950.00								
VEL1	5.0					0.9	0.9	1.2	1.0	1.4	1.6	1.5	1.7
VEL1	5.0	1.7	1.4	1.9	2.0	1.9	2.1	2.1	2.1	2.2	2.4	2.3	2.4
VEL1	5.0	2.3	2.4	2.4	2.0	0.9	0.3						
CAL2	5.0		97.13		538.00								
VEL2	5.0					0.5	0.7	0.8	0.8	1.0	0.8	1.2	1.0
VEL2	5.0	1.1	1.0	1.1	1.5	1.3	1.4	1.5	1.4	1.5	1.5	1.6	1.6
VEL2	5.0	1.6	1.6	1.6	0.9	0.5	0.1						
CAL3	5.0		96.57		262.00								
VEL3	5.0					0.3	0.4	0.4	0.4	0.4	0.4	0.6	0.6
VEL3	5.0	0.6	0.6	0.6	0.8	0.6	0.7	0.7	0.8	0.9	0.8	0.8	0.8
VEL3	5.0	0.8	0.9	0.9	0.5	0.2	0.0						
XSEC	6.0	340.0000.00			94.60								
	6.0	-50.0	109.6	-30.0	99.9	0.0	99.3	1.0	98.9	5.0	96.6	10.0	96.5
	6.0	15.0	96.2	20.0	95.9	25.0	95.5	30.0	95.0	35.0	94.3	40.0	93.3
	6.0	45.0	92.3	50.0	91.2	52.5	90.7	55.0	90.4	57.5	89.9	60.0	89.7
	6.0	62.5	88.5	70.0	87.7	72.5	87.2	75.0	87.6	77.5	87.9	80.0	88.7
	6.0	85.0	90.0	90.0	91.7	95.0	94.2	100.0	97.0	102.0	98.8104.0		100.1
	6.0	119.0	107.4										
NS	6.0	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.8	0.0	16.9	0.0	65.6
NS	6.0	0.0	64.6	0.0	56.6	0.0	46.6	0.0	63.5	0.0	16.6	0.0	16.7
NS	6.0	0.0	27.7	0.0	62.5	0.0	62.5	0.0	26.6	0.0	26.8	0.0	26.9
NS	6.0	0.0	26.9	0.0	26.9	0.0	26.9	0.0	26.9	0.0	26.9	0.0	78.8
NS	6.0	0.0	78.5	0.0	87.7	0.0	88.5	0.0	88.5	0.0	0.8	0.0	0.8

Appendix B1 IFG4 Input File Kent Site Continued

NS	6.0	0.0	0.8		0.0		0.0		0.0		0.0		0.0
CAL1	6.0		97.68		950.00								
VEL1	6.0					0.6	0.9	1.0	1.2	1.2	1.5	1.7	1.9
VEL1	6.0	1.9	1.9	1.9	2.0	2.0	1.8	1.8	1.9	1.9	2.2	2.2	2.0
VEL1	6.0	2.1	2.1	0.8	0.9								
CAL2	6.0		97.16		538.00								
VEL2	6.0					0.3	0.1	0.2	0.6	0.6	0.7	0.8	1.0
VEL2	6.0	1.1	1.2	1.2	1.2	1.3	1.3	1.2	1.2	1.1	1.2	1.3	1.2
VEL2	6.0	1.2	1.2	0.9	0.0								
CAL3	6.0		96.61		262.00								
VEL3	6.0					0.0	0.0	0.0	0.3	0.2	0.3	04	0.5
VEL3	6.0	0.4	0.6	0.6	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.7	0.7
VEL3	6.0	0.6	0.6	0.6									
ENDJ													

Appendix B2 Summary of Calibration Details Kent Site

Kent Site Calibration Information for Calculated Discharges

Transect Number 1	2	3	4	5	6
Discharge					
989	972	944	922	940	929
547	576	554	493	552	507
251	275	299	260	254	232
Stage					
91.66	91.70	91.72	97.45	97.66	97.68
91.02	91.02	91.04	96.97	97.13	97.16
90.50	90.49	90.53	96.57	96.57	96.61
Plotting Stage					
6.56	5.40	5.42	2.85	3.06	3.08
5.92	4.72	4.74	2.37	2.53	2.56
5.40	4.19	4.23	1.97	1.97	2.01
Ratio of measured versus predicted discharge					
0.96	0.96	0.97	1.00	1.00	1.00
1.09	1.10	1.06	1.00	1.02	1.00
0.96	0.95	0.97	1.00	0.99	1.00
Mean error of stage/discharge relationship for calculated Q					
5.77	6.43	3.89	0.26	1.40	0.23
Mean error of stage/discharge relationship for given Q					
4.88	5.05	5.62	3.30	0.54	0.46
Stage/discharge relationship (S vs Q) S=A*QB+SZF**					
A =2.446	1.334	1.223	0.388	0.304	0.375
B =.1422	.2019	.2165	.2919	.3363	.3082
SZF= 85.1	86.3	86.3	94.6	94.6	94.6
B coefficient log/log discharge/stage relationship					
7.03	4.95	4.62	3.43	2.97	3.24

Appendix B3 Data Changes Kent Site

BMAX of 1.3

Verticals affected by an upper BMAX of 1.3

Transect 1	Vertical	24 = 1.8340
Transect 2	Vertical	26 = 1.8264
Transect 2	Vertical	27 = 1.5893
Transect 2	Vertical	28 = 1.5450
Transect 3	Vertical	7 = 2.5902
Transect 3	Vertical	8 = 2.9113
Transect 3	Vertical	9 = 2.3407
Transect 3	Vertical	11 = 1.5030
Transect 3	Vertical	12 = 1.8115
Transect 3	Vertical	13 = 2.0106
Transect 3	Vertical	14 = 1.6117
Transect 5	Vertical	30 = 2.0634
Transect 6	Vertical	6 = 3.6297
Transect 6	Vertical	7 = 2.6587

Appendix B4 Velocity Adjustment Factors Kent Site

Transect	Flow	VAF
1.00	1.00.0	.962
1.00	262.0	.988
1.00	538.0	.998
1.00	950.0	1.000
1.00	2500.0	.988
2.00	100.0	.840
2.00	262.0	.992
2.00	538.0	1.018
2.00	950.0	1.007
2.00	2500.0	.938
3.00	100.0	.892
3.00	262.0	.977
3.00	538.0	1.017
3.00	950.0	1.031
3.00	2500.0	.984
4.00	100.0	1.017
4.00	262.0	1.002
4.00	538.0	1.000
4.00	950.0	1.000
4.00	2500.0	.998
5.00	100.0	.954
5.00	262.0	.997
5.00	538.0	1.007
5.00	950.0	.998
5.00	2500.0	.953
6.00	100.0	.920
6.00	262.0	.992
6.00	538.0	1.009
6.00	950.0	.998
6.00	2500.0	.932

Appendix C

NEALY BRIDGE SITE CALIBRATION INFORMATION

Appendix C1   IFG4 Input File   Nealy Bridge Site

```
Green River at Nealy Bridge RM 35.0
Q/DATE MEASURED   887 cfs on 11-11-86, 425 on 06-17-86, 238 on 08-07-86
IOC      000000020000000000
QARD     100.0
QARD     238.0
QARD     425.0
QARD     887.0
QARD    2000.0
XSEC     1.0          0.0000.50        86.10
         1.0    -5.0  98.2    0.0  93.2     5.0  91.2    10.0  88.7    12.5  88.5  15.0  88.6
         1.0    17.5  88.6   20.0  88.7    22.5  88.5    25.0  87.8    27.5  87.3  30.0  87.0
         1.0    32.5  87.1   35.0  87.1    40.0  86.9    42.5  86.8    45.0  86.8  47.5  86.7
         1.0    50.0  86.6   52.5  86.8    55.0  86.7    60.0  86.3    62.5  86.2  65.0  86.1
         1.0    67.5  86.3   70.0  86.6    72.5  87.2    75.0  87.6    80.0  88.8  82.5  89.1
         1.0    85.0  89.8   87.5  89.9    90.0  90.5   100.0  91.4   150.0  94.0 200.0  91.5
         1.0   228.0  93.4  258.0  94.7
NS       1.0     0.0   0.8    0.0  45.8     0.0  45.8     0.0  45.8     0.0  54.8   0.0  54.8
NS       1.0     0.0  54.9    0.0  56.9     0.0  56.9     0.0  56.9     0.0  64.8   0.0  64.6
NS       1.0     0.0  56.6    0.0  65.7     0.0  63.7     0.0  63.7     0.0  64.6   0.0  64.6
NS       1.0     0.0  64.6    0.0  64.6     0.0  64.6     0.0  64.5     0.0  64.5   0.0  46.6
NS       1.0     0.0  46.6    0.0  46.6     0.0  64.5     0.0  65.5     0.0  46.9   0.0  46.9
NS       1.0     0.0  46.9    0.0  46.9     0.0  46.9     0.0  64.6     0.0   0.8   0.0  56.8
NS       1.0     0.0  56.8    0.0  56.8    0.0           0.0            0.0        0.0
CAL1     1.0         90.46        887.00
VEL1     1.0                         1.4     1.9   2.6     3.1   3.5     2.8   1.9   2.1   2.0
VEL1     1.0     2.3   2.9    4.6   5.0     5.1   5.3     4.0   4.8     4.9   4.9   4.6   4.6
VEL1     1.0     4.4   4.6    4.6   3.7     2.2   2.0     0.9   0.7
VEL1     1.0
CAL2     1.0         89.78        425.00
VEL2     1.0                         1.5     1.6   1.9     1.9   2.4     2.1   1.6   1.1   1.1
VEL2     1.0     1.8   1.8    2.7   3.0     3.2   2.7     2.7   3.1     3.1   3.0   2.9   2.8
VEL2     1.0     2.8   2.6    2.2   2.0     1.0   0.7     0.0
VEL2     1.0
CAL3     1.0         89.17        239.00
VEL3     1.0                         1.0     1.1   1.1     1.1   1.3     1.3   1.0   0.7   0.6
VEL3     1.0     0.8   1.3    1.3   2.1     2.2   2.2     2.3   1.8     2.1   2.4   2.3   2.2
VEL3     1.0     2.1   2.2    1.9   1.6     1.2   0.7
VEL3     1.0
XSEC     2.0    298.0000.50        89.20
         2.0    -7.0  97.3    0.0  94.7     2.0  93.7     4.0  92.0     5.0  91.0  10.0  89.2
         2.0    15.0  89.7   20.0  89.7    25.0  90.0    30.0  90.3    35.0  90.6  40.0  90.8
         2.0    50.0 91.1    60.0 91.5     70.0 91.5     80.0 91.4     90.0 91.3 100.0 91.2
         2.0   110.0 91.2   120.0 91.1    130.0 91.0    140.0 91.0    150.0 90.9 160.0 90.5
         2.0   170.0 90.6   180.0 90.8    190.0 91.3    200.0 91.6    205.0 91.3 210.0 91.4
         2.0   215.0 93.4   217.0 95.4    219.0 97.4
NS       2.0     0.0   0.8    0.0   0.8     0.0   0.8     0.0  88.5     0.0  88.5   0.0  53.6
NS       2.0     0.0 65.6     0.0 56.8      0.0   4.7     0.0   5.7     0.0  46.6   0.0  45.8
NS       2.0     0.0 26.6     0.0 56.9      0.0 54.5      0.0 46.7      0.0 46.8    0.0 45.8
```

Appendix C1 IFG4 Input File Nealy Bridge Site Continued

NS	2.0	0.0 46.9	0.0 56.9	0.0 56.9	0.0 56.9	0.0 56.9	0.0 56.9
NS	2.0	00 56.9	0.0 56.9	0.0 0.2	0.0 0.2	0.0 0.2	0.0 0.2
NS	2.0	0.0 0.8	0.0 0.8	0.0 0.8	0.0	0.0	0.0
CAL1	2.0	92.53	887.00				
VEL1	2.0			0.7 3.8	2.9 4.0	3.5 3.3	3.4 3.1
VEL1	2.0	2.3 2.3	2.3 2.8	2.8 2.6	3.0 3.1	3.0 3.0	3.5 2.9
VEL1	2.0	2.7 2.8	2.1 1.2	0.3 0.1			
CAL2	2.0	92.08	425.00				
VEL2	2.0			0.4 2.7	2.7 2.8	2.4 2.3	2.0 1.7
VEL2	2.0	1.1 1.0	1.4 1.5	1.3 1.6	1.6 2.0	2.0 2.0	2.3 2.3
VEL2	2.0	2.4 2.1	1.7 0.8	0.4 0.5			
CAL3	2.0	91.72	239.00				
VEL3	2.0			0.0 1.8	2.5 2.3	1.9 1.6	1.2 0.9
VEL3	2.0	0.5 1.5	1.6 1.7	0.7 1.2	1.5 1.5	1.6 1.7	1.8 1.7
VEL3	2.0	2.2 1.7	0.9 0.0	0.2 0.3			
XSEC	3.0	250.0000.50	90.40				
	3.0	-5.0 97.3	0.0 95.0	5.0 90.4	7.5 90.0	10.0 90.4	15.0 91.7
	3.0	20.0 91.9	25.0 91.9	30.0 91.8	35.0 91.8	40.0 91.7	45.0 91.5
	3.0	50.0 91.4	55.0 91.5	60.0 91.4	65.0 91.3	70.0 91.0	75.0 91.0
	3.0	80.0 91.0	85.0 91.0	90.0 91.0	95.0 91.0	100.0 91.0	105.0 90.9
	3.0	110.0 90.9	1115.0 90.9	120.0 90.9	125.0 90.8	130.0 90.7	135.0 90.7
	3.0	140.0 90.7	145.0 90.6	150.0 90.6	155.0 90.6	160.0 90.6	165.0 90.5
	3.0	170.0 90.4	175.0 90.5	180.0 90.6	185.0 90.9	190.0 91.2	195.0 91.7
	3.0	200.0 92.5	203.0 92.9	209.0 95.1	211.0 97.2		
NS	3.0	0.0 0.8	0.0 88.5	0.0 0.2	0.0 0.2	0.0 51.8	0.0 45.6
NS	3.0	0.0 46.7	0.0 45.8	0.0 54.6	0.0 45.5	0l.0 45.6	0.0 45.6
NS	3.0	0.0 45.7	0.0 45.7	0.0 45.6	0.0 46.6	0.0 56.8	0.0 56.6
NS	3.0	0.0 46.7	0.0 45.7	0.0 46.6	0.0 46.7	0.0 46.7	0.0 46.7
NS	3.0	0.0 46.7	0.0 46.7	0.0 46.5	0.0 54.6	0.0 56.6	0.0 54.7
NS	3.0	0.0 45.6	0.0 45.7	0.0 45.5	0.0 54.6	0.0 45.8	0.0 45.7
NS	3.0	0.0 45.8	0.0 54.6	0.0 45.7	0.0 54.7	0.0 42.7	0.0 22.5
NS	3.0	0.0 0.2	0.0 0.2	0.0 0.8	0.0 0.8	0.0	0.0
CAL1	3.0	92.95	887.00				
VEL1	3.0		0.3 0.1	1.9 1.8	1.7 1.5	1.5 1.6	2.3 2.7
VEL1	3.0	2.6 2.8	2.5 2.7	2.7 2.5	2.4 2.8	2.6 2.9	2.6 2.7
VEL1	3.0	3.0 2.6	2.9 2.7	2.8 2.7	2.5 2.6	2.4 2.6	2.4 24
VEL1	3.0	2.6 2.4	2.1 1.0	0.6 0.0	0.0		
CAL2	3.0	92.35	425.00				
VEL2	3.0		0.5 0.4	1.0 0.7	0.9 1.2	1.3 1.4	1.6 1.7
VEL2	3.0	1.6 1.8	1.7 1.6	1.7 1.9	1.9 2.0	1.9 1.8	1.9 1.7
VEL2	3.0	1.6 1.9	1.6 1.9	1.7 1.6	1.6 1.5	1.7 1.6	1.6 1.8
VEL2	3.0	1.7 1.7	1.5 1.0	0.8 0.4			
CAL3	3.0	92.17	239.0				
VEL3	3.0		.05 .05	0.5 0.0	0.8 0.8	0.7 0.9	1.0 1.2
VEL3	3.0	1.2 1.2	1.3 1.4	1.4 1.3	1.3 1.4	1.6 1.1	1.3 1.3
VEL3	3.0	1.3 1.4	1.2 1.2	1.4 1.3	1.3 1.0	1.2 1.3	1.0 1.2
VEL3	3.0	1.2 1.4	0.9 0.7	0.6 0.3			
XSEC	4.0	298.0000.50	83.00				

	4.0	-10.0 95.3	0.0 89.4	2.0 88.4	5.0 86.9	10.0 86.5	15.0 86.5
	4.0	2.0 86.6	25.0 86.6	30.0 86.4	35.0 86l.3	40.0 86.3	45.0 86.4
	4.0	50.0 86.5	55.0 86.6	60.0 86.5	65.0 86.6	70.0 86.6	75.0 86.6
	4.0	80.0 86.6	85.0 86.5	90.0 86.2	95.0 85.8	100.0 85.6	105.0 85.4
	4.0	110.0 85.0	115.0 84.6	120.0 83.9	125.0 83.6	130.0 83.0	135.0 83.7
	4.0	140.0 87.0	143.0 88.5	145.0 89.4	165.0 93.8	195.0 93.8	
NS	4.0	0.0 22.5	0.0 22.5	0.0 0.2	0.0 22.5	0.0 32.8	0.0 42.6
NS	4.0	0.0 54.5	0.0 45.8	0.0 45.8	0.0 45.8	0.0 45.8	0.0 45.8
NS	4.0	0.0 45.8	0.0 45.8	0.0 45.8	0.0 45.8	0.0 45.8	0.0 45.8
NS	4.0	0.0 45.8	0.0 54.6	0.0 52.8	0.0 52.8	0.0 32.6	0.0 54.5
NS	4.0	0.0 42.8	0.0 42.8	0.0 42.8	0.0 37.8	0.0 84.6	0.0 88.5
NS	4.0	0.0 88.5	0.0 88.5	0.0 0.8	0.0 0.8	0.0 0.8	0.0
CAL1	4.0	88.46	887.00				
VEL1	4.0		0.5	1.2 1.5	1.9 3.1	3.7 3.5	3.6 3.8
VEL1	4.0	3.3 3.1	3.5 3.0	3.4 3.5	3.3 3.4	2.9 3.4	3.4 3.7
VEL1	4.0	3.8 3.4	3.0 1.5	0.3 0.1	0.0		
CAL2	4.0	87.62	425.00				
VEL2	4.0		0.6	1.6 1.6	1.4 2.2	2.6 2.9	3.1 3.0
VEL2	4.0	2.4 2.1	2.4 1.9	2.1 1.7	1.9 1.6	1.4 1.6	1.7 2.0
VEL2	4.0	2.2 2.2	2.4 1.3	0.8 0.6	0.0		
CAL3	4.0	87.26	239.00				
VEL3	4.0		0.5	1.3 1.3	1.3 1.5	1.8 2.3	2.8 2.3
VEL3	4.0	2.3 2.0	2.1 1.4	1.7 1.3	1.2 1.0	0.9 0.8	0.8 1.0
VEL3	4.0	1.3 1.5	1.3 1.0	0.4 0.4	0.0		
XSEC	5.0	446.0000.50	85.60				
	5.0	-10.0 96.4	0.0 90.4	2.0 89.5	5.0 88.5	10.0 87.5	15.0 87.4
	5.0	20.0 87.5	25.0 87.5	30.0 87.5	35.0 87.5	40.0 87.5	45.0 87.4
	5.0	50.0 87.4	55.0 87.3	60.0 87.2	65.0 87.0	70.0 87.0	75.0 86.8
	5.0	80.0 86.8	85.0 86.7	90.0 86.7	95.0 86.6	100.0 86.4	105.0 86.3
	5.0	110.0 86.3	115.0 86.1	120.0 86.1	125.0 86.1	130.0 85.9	135.0 85.6
	5.0	140.0 85.6	145.0 86.2	150.0 88.9	154.0 91.5	164.0 96.2	179.0 96.2
NS	5.0	0.0 0.8	0.0 0.8	0.0 0.8	0.0 0.2	0.0 56.6	0.0 56.7
NS	5.0	0.0 43.9	0.0 43.8	0.0 43.8	0.0 54.6	0.0 54.6	0.0 54.5
NS	5.0	0.0 54.6	0.0 54.6	0.0 54.7	0.0 54.6	0.0 54.7	0.0 54.7
NS	5.0	0.0 54.7	0.0 54.9	0.0 56.9	0.0 56.8	0.0 56.8	0.0 65.6
NS	5.0	0.0 87.8	0.0 88.5	0.0 88.5	0.0 88.5	0.0 0.8	0.0 0.8
CAL1	5.0	89.11	887.00				
VEL1	5.0		0.3	0.6 1.5	2.0 2.3	2.4 2.2	2.4 2.8
VEL1	5.0	2.8 2.8	2.9 2.9	3.0 3.0	3.3 3.5	3.3 3.2	3.2 3.1
VEL1	5.0	3.2 3.1	2.9 2.7	2.6 2.3	1.3 1.2	0.0	
CAL2	5.0	88.62	425.00				
VEL2	5.0		0.2	0.8 0.7	1.3 1.3	1.4 1.6	1.5 1.7
VEL2	5.0	1.6 1.9	1.8 1.7	2.1 2.0	2.3 2.0	2.0 2.3	2.1 2.3
VEL2	5.0	2.1 1.8	2.0 2.0	1.9 1.7	0.5 0.0		
CAL3	5.0	88.13	239.00				
VEL3	5.0		0.0	0.5 0.3	0.9 0.7	0.8 0.7	0.8 0.9
VEL3	5.0	1.1 1.1	1.3 1.4	1.2 1.5	1.5 1.7	1.8 1.8	1.6 1.8

Appendix C1 IFG4 Input File Nealy Bridge Site Continued

VEL3	5.0	1.6 1.6	1.5 1.6	1.3 1.0	0.4 0.0		
XSEC	6.0	204.0000.50	86.50				
	6.0	-10.0 97.5	0.0 91.4	2.0 89.1	5.0 88.1	10.0 87.5	15.0 87.0
	6.0	20.0 87.0	25.0 86.7	30.0 86.6	35.0 86.7	40.0 86.6	45.0 86.6
	6.0	50.0 86.6	55.0 86.6	60.0 86.5	65.0 86.6	70.0 86.6	75.0 86.7
	6.0	80.0 87.0	85.0 87.3	90.0 87.5	95.0 87.7	100.0 87.8	105.0 87.8
	6.0	110.0 88.0	115.0 88.0	120.0 88.2	125.0 88.0	130.0 88.0	135.0 87.9
	6.0	140.0 87.7	145.0 87.3	150.0 89.4	152.0 90.7	172.0 97.2	
NS	6.0	0.0 0.8	0.0 0.8	0.0 0.2	0.0 0.2	0.0 0.2	0.0 45.6
NS	6.0	0.0 54.8	0.0 54.8	0.0 46.6	0.0 45.6	0.0 45.5	0.0 46.6
NS	6.0	0.0 47.6	0.0 45.5	0.0 54.6	0.0 45.8	0.0 45.5	0.0 54.6
NS	6.0	0.0 45.6	0.0 45.8	0.0 45.6	0.0 4.6	0.0 35.8	0.0 34.6
NS	6.0	0.0 54.8	0.0 45.5	0.0 56.7	0.0 45.8	0.0 45.7	0.0 45.5
NS	6.0	0.0 45.7	0.0 56.7	0.0 88.5	0.0 88.5	0.0 0.8	0.0
CAL1	6.0	89.36	887.00				
VEL1	6.0		0.5	1.6 2.2	3.0 3.1	3.5 3.5	3.3 3.4
VEL1	6.0	3.7 3.8	3.8 4.1	4.2 3.8	3.5 3.7	3.4 3.5	2.6 2.1
VEL1	6.0	2.3 2.1	1.9 1.4	0.8 0.7	0.6 0.5		
CAL2	6.0	88.71	425.00				
VEL2	6.0		0.3	1.2 1.9	2.3 2.2	2.2 2.4	2.3 2.4
VEL2	6.0	2.6 2.9	2.9 2.8	2.6 2.6	2.5 2.5	2.3 2.4	1.7 1.5
VEL2	6.0	1.2 1.1	0.8 0.6	0.2 0.0	0.0 0.0		
CAL3	6.0	88.35	239.0				
VEL3	6.0		0.0	1.0 1.3	1.7 1.8	1.7 1.l7	1.8 1.9
VEL3	6.0	1.7 1.9	2.0 2.1	2.1 2.0	1.9 2.0	1.4 1.3	1.0 0.8
VEL3	6.0	0.5 0.7	0.7 0.3	0.3 0.2	0.0 0.0		
XSEC	7.0	290.0000.50	86.50				
	7.0	-10.0 97.8	0.0 90.6	1.0 90.3	5.0 88.0	10.0 87.6	15.0 87.3
	7.0	20.0 87.3	25.0 87.2	30.0 87.0	32.5 87.0	35.0 86.9	37.5 86.9
	7.0	40.0 86.8	42.5 86.8	45.0 86.7	47.5 86.6	50.0 86.6	52.5 86.5
	7.0	55.0 86.5	57.5 86.4	60.0 86.5	62.5 86.5	65.0 86.6	70.0 87.0
	7.0	75.0 87.3	80.0 87.8	85.0 88.3	90.0 88.7	95.0 88.8	100.0 89.4
	7.0	105.0 89.5	110.0 89.5	115.0 89.6	120.0 88.7	125.0 88.4	130.0 88.1
	7.0	135.0 88.3	140.0 88.3	144.7 90.3	151.0 91.6	171.0 91.7	200.0 97.9
	7.0	215.0 97.9					
NS	7.0	0.0 0.8	0.0 0.8	0.0 0.8	0.0 24.8	0.0 34.8	0.0 36.6
NS	7.0	0.0 64.7	0.0 64.8	0.0 65.7	0.0 46.7	0.0 46.7	0.0 46.7
NS	7.0	0.0 46.7	0.0 56.5	0.0 56.7	0.0 56.8	0.0 56.8	0.0 56.9
NS	7.0	0.0 56.8	0.0 56.6	0.0 56.5	0.0 56.8	0.0 56.8	0.0 56.9
NS	7.0	0.0 52.6	0.0 56.8	0.0 56.8	0.0 56.8	.08 56.8	0.0 56.8
NS	7.0	0.0 56.8	0.0 56.8	0.0 56.8	0.0 56.8	0.0 56.8	0.0 56.8
NS	7.0	0.0 53.9	0.0 11.5	0.0 0.8	0.0 0.8	0.0 0.8	0.0 0.8
NS	7.0	0.0 0.8	0.0	0.0	0.0	0.0	0.0
CAL1	7.0	89.55	887.00				
VEL1	7.0		2.5	3.0 3.5	4.0 4.5	4.3 4.6	4.4 4.2
VEL1	7.0	4.6 4.7	5.3 5.5	5.1 5.3	5.0 5.2	5.3 5.4	5.1 4.8
VEL1	7.0	4.1 2.7	0.9 0.3	0.1 0.0	0.0 0.0	0.8	1.2 2.1
VEL1	7.0	2.2 0.2					

Appendix C1 IFG4 Input File Nealy Bridge Site Continued

CAL2	7.0		88.87		425.00								
VEL2	7.0				1.5	30.	2.7	2.8	2.5	2.8	3.0	3.0	3.6
VEL2	7.0	3.5	3.6	3.8	3.8	3.5	3.7	3.8	3.4	3.4	3.2	2.8	1.9
VEL2	7.0	1.2	0.8	0.3	0.2		0.0				0.0	0.4	0.9
VEL2	7.0	0.8	0.8										
CAL3	7.0		88.47		239.00								
VEL3	7.0				0.7	1.7	2.1	2.5	2.1	1.7	1.9	1.9	1.9
VEL3	7.0	2.3	3.2	3.2	3.2	2.9	3.2	2.8	29	2.6	2.1	1.9	1.4
VEL3	7.0	0.8	0.3	0.2								0.3	0.6
VEL3	7.0	0.6	0.3										
ENDJ													

Appendix C2 Summary of Calibration Details Nealy Bridge Site

Nealy Bridge Calibration Information for Calculated Discharges

Transect Number							
	1	2	3	4	5	6	7
Discharge							
	891	919	845	912	848	875427	917
	432	455	393	420	431	245	418
	237	252	242	222	230		243
Stage							
	90.46	92.53	92.95	88.46	89.11	89.36	89.55
	89.78	92.08	92.35	87.62	88.62	88.71	88.87
	89.17	91.72	92.17	87.26	88.13	88.35	88.47
Plotting Stage							
	4.36	3.33	2.55	5.46	3.51	2.86	3.05
	3.68	2.88	1.95	4.62	3.02	2.21	2.37
	3.07	2.52	1.77	4.26	2.53	1.85	1.97
Ratio of measured versus predicted discharge							
	1.03	1.01	0.98	0.96	1.03	1.00	1.00
	0.94	0.98	1.10	1.12	0.95	1.02	0.99
	1.03	1.01	0.93	0.93	1.02	0.99	1.01
Mean error of stage/discharge relationship for calculated Q							
	3.86	1.29	6.25	7.41	3.48	1.57	.81
Mean error of stage/discharge relationship for given Q							
	4.57	2.35	9.32	6.22	5.99	1.77	0.93
Stage/discharge relationship (S vs Q) S=A*Q**B+SZF							
A	= .7239	.7666	.3287	1.580	.6456	.2778	.3251
B	= .2655	.2156	.3029	.1809	.2521	.3437	.3284
SZF	= 86.1	.89.2	90.4	83.0	85.6	86.5	86.5
B coefficient log/log discharge/stage relationship							
	3.77	4.64	3.30	5.53	3.97	2.91	3.04

Appendix C3 Data Changes   Nealy Bridge Site

Cell velocities changed for calibration

Transect 1	Vertical	15	VEL1	Changed 4.8 to 4.6
Transect 1	Vertical	15	VEL3	Changed 1.1 to 1.3
Transect 1	Vertical	29	VEL3	Changed 1.1 to 1.3
Transect 1	Vertical	30	VEL2	Changed 0.6 to 0.7
Transect 2	Vertical	12	VEL1	Changed 3.3 to 3.1
Transect 2	Vertical	12	VEL3	Changed 0.7 to 0.9
Transect 2	Vertical	17	VEL1	Changed 3.3 to 3.1
Transect 2	Vertical	17	VEL3	Changed 0.5 to 0.7
Transect 2	Vertical	28	VEL3	Changed 0.1 to 0.0
Transect 3	Vertical	3	VEL3	Changed 0.0 to .05
Transect 3	Vertical	4	VEL3	Changed 0.0 to .05
Transect 3	Vertical	5	VEL3	Changed 0.3 to 0.5
Transect 3	Vertical	6	VEL3	Changed 0.2 to 0.0
Transect 4	Vertical	24	VEL3	Changed 0.8 to 1.0
Transect 4	Vertical	25	VEL3	Changed 1.1 to 1.3
Transect 5	Vertical	10	VEL3	Changed 0.5 to 0.7
Transect 7	Vertical	24	VEL3	Changed 1.2 to 1.4
Transect 7	Vertical	25	VEL3	Changed 0.6 to 0.8
Transect 7	Vertical	38	VEL1	Changed 0.0 to 0.2

Appendix C4 Velocity Adjustment Factors Nealy Bridge

Transect	Flow	VAF
1.00	1.00	1.034
1.00	239.0	1.006
1.00	425.0	1.000
1.00	887.0	1.000
1.00	2000.0	1.000
2.00	100.0	1.073
2.00	239.0	.997
2.00	425.0	.988
2.00	887.0	1.009
2.00	2000.0	1.042
3.00	100.0	1.058
3.00	239.0	1.009
3.00	425.0	.996
3.00	887.0	.993
3.00	2000.0	.998
4.00	100.0	1.124
4.00	239.0	1.011
4.00	425.0	.991
4.00	887.0	1.003
4.00	2000.0	1.030
5.00	100.0	.984
5.00	239.0	.974
5.00	425.0	.981
5.00	887.0	.997
5.00	2000.0	1.013
6.00	100.0	.988
6.00	239.0	.990
6.00	425.0	.993
6.00	887.0	.997
6.00	2000.0	.993
7.00	100.0	.956
7.00	239.0	.996
7.00	425.0	1.010
7.00	887.0	.998
7.00	2000.0	.923

Appendix D

CAR BODY SITE CALIBRATION INFORMATION

Appendix D1   IFG4 Input file   Car Body Site.

```
Green River at Car Body Site    RM 39.6
Q/DATE MEASURED 1048 cfs on 11-14-86, 410 on 06-20-86, 234 on 08-05-86
OC              0000000200000000000
QARD    100.0
QARD    234.0
QARD    410.0
QARD    1048.0
QARD    2500.0
XSEC    1.0        0.0000.50           83.40
        1.0     -50.0 92.9   -2.0 90.9     0.0 90.9    20.0 91.1    30.0 90.0   35.0 88.0
        1.0      40.0 88.0   45.0 87.6    50.0 87.5    55.0 87.3    60.0 87.3   65.0 87.2
        1.0      70.0 87.0   75.0 87.0    80.0 87.0    85.0 87.1    90.0 87.1   95.0 87.3
        1.0     100.0 87.2  105.0 87.0    80.0 87.0    85.0 87.1    90.0 87.1   95.0 87.3
        1.0     130.0 85.8  132.5 85.6   135.0 85.1   137.5 84.6   140.0 84.1 142.5 83.4
        1.0     145.0 83.4  147.5 83.8   150.0 84.5   152.5 85.0   153.5 85.2 155.0 87.9
        1.0     157.0 87.9  160.0 91.7   162.0 94.8
NS      1.0       0.0  0.8    0.0  0.8     0.0  0.8     0.0 36.7     0.0 36.7    0.8 56.7
NS      1.0       0.0 75.7    0.0 75.7     0.0 56.7     0.0 46.7     0.0 46.7    0.0 45.5
NS      1.0       0.0 45.5    0.0 46.7     0.0 65.5     0.0 65.5     0.0 65.5    0.0 46.7
NS      1.0       0.0 56.7    0.0 56.6     0.0 56.7     0.0 56.6     0.0 56.6    0.0 65.5
NS      1.0       0.0 65.5    0.0 65.6     0.0 65.7     0.0 65.7     0.0 65.7    0.0 65.7
NS      1.0       0.0 65.7    0.0 65.7     0.0 65.7     0.0 65.7     0.0 65.7    0.7  0.1
NS      1.0       0.0  0.8    0.0  0.8     0.0  0.8     0.0          0.0         0.0
CAL1    1.0         89.05     1048.00
VEL1    1.0                                    0.0      1.5  2.4     2.7  3.1    3.3  3.0
VEL1    1.0       3.2  3.2    3.4  3.8     3.8  3.9     3.8  3.7     3.6  4.0    4.0  4.7
VEL1    1.0       4.3  4.6    4.6  4.4     3.8  4.4     4.3  4.4     4.4  2.8    3.0  0.0
VEL1    1.0
CAL2    1.0         88.03      410.00
VEL2    1.0                                                  0.6     1.0  1.5    1.5  1.8
VEL2    1.0       1.8  1.8    2.1  2.1     1.8  1.8     1.8  2.2     2.1  2.2    2.3  2.2
VEL2    1.0       2.5  2.7    2.9  3.2     3.0  3.1     3.3  3.4     3.5  2.2    1.9
VEL2    1.0
CAL3    1.0         87.60      234.00
VEL3    1.0                                                          0.0  0.6    0.7  1.0
VEL3    1.0       1.1  0.7    1.0  1.2     1.0  1.0     0.8  0.9     0.9  1.3    1.3  1.3
VEL3    1.0       1.8  1.9    2.2  2.4     2.8  2.7     2.7  3.1     2.6  1.9
VEL3    1.0
XSEC    2.0        260.0000.50        84.00
        2.0       0.0 90.4   11.0 89.7    15.0 89.1    20.0 88.6    25.0 88.2   30.0 88.1
        2.0      35.0 87.0   40.0 86.2    45.0 86.0    50.0 85.9    55.0 85.9   60.0 85.8
        2.0      65.0 85.5   70.0 85.5    75.0 85.6    80.0 85.4    85.0 85.7   90.0 86.1
        2.0      95.0 86.5  100.0 87.4   105.0 87.8   110.0 88.2   115.0 89.2 120.0 89.6
        2.0     125.0 89.1  130.0 88.4   135.0 87.4   140.0 86.7   145.0 86.2 150.0 85.8
        2.0     155.0 85.6  160.0 85.1   165.0 84.5   170.0 84.0   175.0 84.2 180.0 84.5
        2.0     185.0 85.2  190.0 85.4   195.0 86.1   200.0 86.8   205.0 87.4 207.0 89.2
        2.0     209.0 91.8  212.7 92.1
NS      2.0       0.0  0.8    0.0  0.8     0.0  56.8    0.0  56.8    0.0  56.8   0.0  56.8
```

Appendix D1 IFG4 Input File Car Body Site Continued

```
NS      2.0    0.0  56.6   0.0  24.7    0.0  62.5    0.0  62.6    0.0  62.7   0.0  62.7
NS      2.0    0.0  62.5   0.0  62.8    0.0  62.8    0.0  67.7    0.0  65.5   0.0  65.7
NS      2.0     0.0 67.7    0.0 67.9     0.0 99.5     0.0 44.5     0.0 42.5    0.0 42.5
NS      2.0     0.0 36.9    0.0 36.9     0.0 21.5     0.0 21.5     0.0 11.5    0.0 11.5
NS      2.0     0.0 11.5    0.0 11.5     0.0 16.8     0.0 61.7     0.0 61.7    0.0 61.7
NS      2.0     0.0 61.9    0.0 61.9     0.0 61.9     0.0 61.9     0.0 71.8    0.0   0.8
NS      2.0     0.0   0.8   0.0   0.8    0.0          0.0          0.0         0.0
CAL1    2.0        89.22    0148.00
VEL1    2.0                 0.0   0.9    1.8   1.5    2.4   2.7    3.2   3.5   4.2   3.8
VEL1    2.0     4.6   5.8   5.9   6.6    5.3   5.0    4.0   3.6    2.8   2.6
VEL1    2.0     0.0   0.0   0.0   0.2    0.0   0.1    0.0   0.1    0.0   0.0   0.1   0.0
VEL1    2.0     0.0   0.0   0.1   0.0    0.0
CAL2    2.0        88.23      410.00
VEL2    2.0                                    0.0    0.9   1.7    1.9   2.0   2.6   2.6
VEL2    2.0     2.8   3.2   2.9   3.1    3.5   3.0    2.4   1.9    1.4
VEL2    2.0                 0.0   0.0    0.0   0.0    0.0   0.0    0.0   0.0   0.0   0.0
VEL2    2.0     0.0   0.0   0.0   0.0    0.0
CAL3    2.0        87.88      234.00
VEL3    2.0                                           0.5   1.1    1.4   1.6   2.1   2.4
VEL3    2.0     2.1   2.4   2.2   2.1 2.0   1.3       1.6   0.8    0.0
VEL3    2.0                 0.0   0.0 0.0   0.0       0.0   0.0    0.0   0.0   0.0   0.0
VEL3    2.0     0.0   0.0   0.0   0.2       0.0
XSEC    3.0       270.0000.50         89.50
        3.0     0.0 98.2    5.0 90.9    10.0 89.9    15.0 89.8    20.0 89.6  25.0 89.7
        3.0    30.0 89.8   35.0 89.6    40.0 89.5    45.0 89.8    50.0 89.7  55.0 89.7
        3.0    60.0 89.8   65.0 89.9    70.0 90.1    75.0 90.2    80.0 90.5  85.0 90.7
        3.0    90.0 91.1   95.0 91.4   100.0 91.6   105.0 91.8   110.0 92.0 115.0 92.2
        3.0   120.0 92.2  125.0 92.6   130.0 92.6   140.0 93.0   160.0 92.6 180.0 93.0
        3.0   200.0 93.0  250.0 93.0   300.0 92.9   354.0 92.5
NS      3.0     0.0 42.5    0.0 46.5     0.0 56.6     0.0 46.5     0.0 46.5    0.0 57.8
NS      3.0     0.0 57.8    0.0 57.8     0.0 57.8     0.0 65.5     0.0 56.8    0.0 56.8
NS      3.0     0.0 52.9    0.0 52.9     0.0 52.9     0.0 52.9     0.0 62.8    0.0 62.8
NS      3.0     0.0 52.9    0.0 52.9     0.0 45.8     0.0 45.8     0.0 45.8    0.0 45.8
NS      3.0     0.0 45.8    0.0 45.8     0.0 45.8     0.0 45.8     0.0 45.8    0.0 45.8
NS      3.0     0.0 45.8    0.0 65.8     0.0 65.8     0.0 65.8     0.0         0.0
CAL1    3.0        92.73    1048.00
VEL1    3.0           2.8   3.6   4.0    4.3   4.1    4.3   4.2    4.1   4.6   4.4   4.3
VEL1    3.0     4.2   3.9   3.7   3.3    3.2   2.8    2.8   2.4    2.1   1.9   1.3   1.6
VEL1    3.0     1.4   0.0   0.0
CAL2    3.0        91.97      410.00
VEL2    3.0           1.0   2.2   2.2    2.3   2.2    2.1   2.4    2.5   2.3   2.8   2.5
VEL2    3.0     2.5   2.5   2.1   1.8    1.8   1.5    1.5   1.2    0.7   0.0
VEL2    3.0
CAL3    3.0        91.57      234.00
VEL3    3.0           0.5   1.6   1.3    1.8   1.7    1.6   1.8    2.0   2.1   2.0   2.1
VEL3    3.0     1.8   1.8   1.8   1.5    1.2   1.0    0.9   0.5
VEL3    3.0
XSEC    4.0       238.0000.50         89.50
```

	4.0	0.0	101.4	3.0	99.4	5.0	91.6	10.0	90.1	15.0	89.5	20.0	89.1
	4.0	25.0	89.0	30.0	88.6	32.5	88.5	35.0	88.2	37.5	88.2	40.0	88.2
	4.0	42.5	88.3	45.0	88.5	50.0	88.7	55.0	89.0	60.0	89.4	65.0	89.8
	4.0	70.0	90.2	75.0	90.4	80.0	90.6	85.0	90.9	90.0	91.1	95.0	91.5
	4.0	100.0	91.5	105.0	91.6	110.0	91.7	115.0	92.0	120.0	92.2	125.0	92.7
	4.0	130.0	92.7	135.0	92.9	140.0	93.0	145.0	93.1	147.0	93.2	160.0	93.4
	4.0	200.0	94.0	250.0	93.2	99.0	93.4						
NS	4.0	0.0	0.8	0.0	0.8	0.0	22.5	0.0	42.5	0.0	52.5	0.0	52.5
NS	4.0	0.0	52.5	0.0	52.5	0.0	52.5	0.0	52.5	0.0	52.5	0.0	52.5
NS	4.0	0.0	62.5	0.0	62.5	0.0	72.5	0.0	72.5	0.0	62.5	0.0	62.5
NS	4.0	0.0	62.5	0.0	62.5	0.0	52.5	0.0	52.5	0.0	42.5	0.0	42.5
NS	4.0	0.0	64.5	0.0	61.7	0.0	62.8	0.0	62.8	0.0	62.8	0.0	62.8
NS	4.0	0.0	62.8	0.0	62.8	0.0	62.8	0.0	62.8	0.0	62.8	0.0	42.8
NS	4.0	0.0	52.8	0.0	52.8	0.0	52.8	0.0		0.0		0.0	
CAL1	4.0		93.27		1048.00								
VEL1	4.0				1.9	2.6	3.0	3.1	3.2	3.2	3.2	3.5	3.5
VEL1	4.0	3.7	3.5	3.2	3.0	3.2	2.6	2.5	2.8	2.4	2.4	2.1	1.9
VEL1	4.0	2.1	1.8	1.8	1.6	1.5	1.0	0.9	0.8	0.5	0.0	0.0	
VEL1	4.0												
CAL2	4.0		92.29		410.00								
VEL2	4.0				0.4	1.3	1.4	2.0	2.1	2.2	1.8	2.1	2.0
VEL2	4.0	2.1	2.2	1.9	1.8	1.8	1.6	1.5	1.5	1.4	1.6	1.5	1.2
VEL2	4.0	1.2	1.0	0.7	0.0	0.0							
VEL2	4.0												
CAL3	4.0		91.78		234.00								
VEL3	4.0				0.3	0.9	1.2	1.1	1.2	1.3	1.3	1.4	1.2
VEL3	4.0	1.4	1.4	1.4	1.2	1.2	1.0	0.9	1.0	0.9	0.8	0.8	0.4
VEL3	4.0	0.3	0.3	0.0									
VEL3	4.0												
XSEC	5.0			321.0000.50		89.50							
	5.0	-3.0	99.4	0.0	96.0	5.0	95.4	10.0	92.3	15.0	91.7	20.0	90.5
	5.0	25.0	89.6	30.0	88.8	35.0	88.4	37.5	88.0	40.0	87.6	42.5	87.3
	5.0	45.0	86.9	47.5	86.7	50.0	86.6	52.5	86.8	55.0	7.1	57.5	87.7
	5.0	60.0	88.0	65.0	88.5	70.0	89.1	75.0	89.4	80.0	90.0	85.0	90.4
	5.0	90.0	91.0	95.0	91.6	100.0	92.0	105.0	92.3	110.0	92.6	115.0	93.2
	5.0	120.0	93.4	140.0	94.6	160.0	95.3	180.0	95.2	210.0	95.4		
NS	5.0	0.0	22.5	0.0	22.5	0.0	22.5	0.0	65.7	0.0	65.7	0.0	25.6
NS	5.0	0.0	74.5	0.0	76.5	0.0	76.5	0.0	76.5	0.0	76.5	0.0	64.5
NS	5.0	0.0	26.6	0.0	54.6	0.0	52.6	0.0	42.8	0.0	42.8	0.0	26.6
NS	5.0	0.0	62.6	0.0	76.5	0.0	76.5	0.0	62.6	0.0	75.6	0.0	62.5
NS	5.0	0.0	46.5	0.0	57.5	0.0	57.6	0.0	57.6	0.0	57.6	0.0	75.8
NS	5.0	0.0	75.6	0.0	74.5	0.0	74.5	0.0	46.6	0.0	54.5	0.0	
CAL1	5.0		93.39		1048.00								
VEL1	5.0				0.1	1.1	2.3	4.0	4.4	4.9	4.6	3.9	3.6
VEL1	5.0	3.5	3.4	3.4	3.1	2.6	2.8	2.9	2.5	2.2	1.9	1.5	0.9
VEL1	5.0	0.7	0.4	0.3	0.1	0.0	0.0						
CAL2	5.0		92.36		410.00								
VEL2	5.0				0.0	0.3	0.6	1.6	1.8	3.2	3.0	3.1	2.6

VEL2	5.0	2.1	2.0	1.8	2.0	1.5	1.7	1.5	1.1	0.8	0.3	0.3	0.2
VEL2	5.0	0.1	0.0	0.0	0.0								
CAL3	5.0		91.79		234.00								
VEL3	5.0					0.0	0.0	0.0	1.1	1.8	1.4	1.9	1.9
VEL3	5.0	2.2	1.6	1.3	1.2	1.4	1.2	1.5	1.1	0.5	0.2	0.1	0.0
VEL3	5.0	0.0	0.1										
XSEC	6.0		412.0000.50		91.00								
	6.0	-20.0	98.8	0.0	96.1	10.0	95.6	20.0	96.0	30.0	96.5	40.0	96.8
	6.0	50.0	96.8	60.0	96.3	70.0	95.8	80.0	94.9	85.0	94.5	90.0	93.8
	6.0	95.0	93.3	100.0	92.5	110.0	91.3	112.5	91.0	115.0	91.0	117.5	91.0
	6.0	120.0	91.2	122.5	91.5	125.0	91.6	130.0	92.0	135.0	92.0	140.0	91.9
	6.0	145.0	91.9	150.0	91.9	155.0	92.0	160.0	92.0	165.0	92.0	170.0	92.1
	6.0	175.0	92.0	180.0	92.0	185.0	92.3	190.0	92.2	195.0	92.3	200.0	92.1
	6.0	205.0	92.1	210.0	92.3	215.0	93.1	218.0	94.6	221.0	96.9	226.0	97.5
	6.0	236.0	97.6										
NS	6.0	0.0	0.8	0.0	0.8	0.0	22.5	0.0	34.6	0.0	34.6	0.0	34.6
NS	6.0	0.0	34.6	0.0	34.6	0.0	34.6	0.0	34.6	0.0	45.7	0.0	45.7
NS	6.0	0.0	56.5	0.0	56.6	0.0	54.5	0.0	62.8	0.0	62.8	0.0	62.8
NS	6.0	0.0	62.8	0.0	62.8	0.0	52.8	0.0	52.8	0.0	62.8	0.0	62.8
NS	6.0	0.0	57.5	0.0	57.5	0.0	76.7	0.0	76.7	0.0	76.7	0.0	67.8
NS	6.0	0.0	76.7	0.0	67.5	0.0	65.5	0.0	65.5	0.0	65.5	0.0	65.5
NS	6.0	0.0	65.5	0.0	65.5	0.0	62.8	0.0	46.8	0.0	0.8	0.0	0.8
NS	6.0	0.0	0.8	0.0		0.0		0.0		0.0		0.0	
CAL1	6.0		94.61		1048.00								
VEL1	6.0											0.1	1.2
VEL1	6.0	2.0	2.6	3.3	3.4	4.0	3.8	3.6	3.5	3.7	3.7	3.9	3.6
VEL1	6.0	3.8	3.8	3.2	3.5	3.4	2.8	3.3	3.0	2.8	2.3	2.3	2.3
VEL1	6.0	1.9	2.1	0.5									
CAL2	6.0		93.69		410.00								
VEL2	6.0												
VEL2	6.0	0.9	1.3	2.4	2.4	2.5	2.9	2.6	2.7	2.3	2.8	2.9	2.4
VEL2	6.0	2.6	2.2	2.3	1.9	1.8	2.0	1.8	1.4	1.6	1.4	1.1	1.0
VEL2	6.0	1.1	1.0	0.1									
CAL3	6.0		93.27		234.00								
VEL3	6.0												
VEL3	6.0		1.1	1.6	1.9	1.7	1.8	1.8	1.9	1.7	1.8	2.0	1.7
VEL3	6.0	1.9	1.6	1.4	1.4	1.3	1.2	1.2	0.9	0.8	0.8	0.8	0.7
VEL3	6.0	0.7	0.5	0.1									
XSEC	7.0		128.0000.50		91.00								
	7.0	-20.0	97.8	0.0	97.3	5.0	96.3	10.0	95.3	15.0	95.3	20.0	95.2
	7.0	25.0	94.6	30.0	94.5	35.0	94.1	40.0	93.7	45.0	93.6	50.0	93.7
	7.0	55.0	93.7	60.0	93.5	65.0	93.5	70.0	93.4	75.0	93.6	80.0	94.1
	7.0	90.0	95.6	100.0	95.3	110.0	94.8	115.0	94.3	120.0	93.7	125.0	93.3
	7.0	130.0	92.9	135.0	92.5	140.0	92.2	145.0	92.0	150.0	91.8	157.5	91.5
	7.0	160.0	91.3	162.5	91.3	165.0	91.1	167.5	90.8	170.0	90.8	172.5	90.5
	7.0	175.0	90.4	177.5	90.5	180.0	90.4	182.5	90.3	185.0	90.3	187.5	90.2
	7.0	190.0	90.2	192.5	91.2	195.0	91.6	200.5	96.2	206.0	96.4	226.0	96.5
NS	7.0	0.0	22.5	0.0	26.8	0.0	65.5	0.0	64.8	0.0	64.8	0.0	64.8

Appendix D1 IFG4 Input File Car Body Site Continued

NS	7.0	0.0 64.8	0.0 64.8	0.0 64.8	0.0 64.8	0.0 64.8	0.0 74.6
NS	7.0	0.0 74.6	0.0 74.6	0.0 74.6	0.0 56.8	0.0 56.8	0.0 56.8
NS	7.0	0.0 64.9	0.0 22.5	0.0 26.9	0.0 26.9	0.0 26.9	0.0 22.5
NS	7.0	0.0 22.5	0.0 12.5	0.0 26.7	0.0 26.6	0.0 26.6	0.0 64.7
NS	7.0	0.0 74.6	0.0 74.6	0.0 74.6	0.0 74.6	0.0 64.8	0.0 64.8
NS	7.0	0.0 64.8	0.0 64.8	0.0 65.7	0.0 65.7	0.0 65.7	0.0 65.7
NS	7.0	0.0 65.7	0.0 65.7	0.0 65.7	0.0 66.5	0.0 0.8	0.0 0.8
CAL1	7.0	94.74	1048.00				
VEL1	7.0				0.0 0.7	1.1 2.1	2.1 2.8
VEL1	7.0	2.8 3.3	3.0 2.9	2.5 2.2		0.0	0.0 0.3
VEL1	7.0	0.3 0.7	1.9 3.8	4.4 5.8	5.1 5.6	5.3 5.1	5.5 5.8
VEL1	7.0	5.8 6.3	5.8 6.0	5.7 4.1	3.2 2.4	2.2	
CAL2	7.0	93.78	410.00				
VEL2	7.0					0.00	0.2 0.0
VEL2	7.0	0.4 0.5	0.6 0.7	0.5			
VEL2	7.0	0.1 0.2	0.1 1.0	1.9 2.2	2.0 2.8	2.8 2.7	3.6 3.6
VEL2	7.0	3.4 3.5	3.1 3.1	3.4 3.3	2.8 2.3	1.4	
CAL3	7.0	93.39	234.00				
VEL3	7.0						
VEL3	7.0						0.0
VEL3	7.0	0.0 0.0	0.2 0.0	0.0 0.9.	1.1 1.3	1.6 2.5	2.0 2.9
VEL3	7.0	2.8 3.0	3.1 3.0	2.9 2.9	2.6 2.3	0.9	
ENDJ							

Appendix D2 Summary of Calibration Details Car Body Site

Car Body Site Calibration Information for Calculated Discharges

Transect Number

	1	2	3	4	5	6	7
Discharge							
	1093	1052	989	1031	1039	988	1142
	422	397	389	424	427	405	403
	236	235	234	221	249	211	251
Stage							
	89.05	89.22	92.73	93.27	93.39	94.61	94.74
	88.03	88.23	91.97	92.29	92.36	93.69	93.78
	87.60	87.88	91.57	91.78	91.79	93.27	93.39
Plotting Stage							
	5.65	5.22	3.23	3.77	3.89	3.61	3.74
	4.63	4.23	2.47	2.79	2.86	2.69	2.78
	4.20	3.88	2.07	2.28	2.29	2.27	2.39
Ratio of measured versus predicted discharge							
	0.98	0.98	1.02	0.99	1.02	0.98	1.01
	1.05	1.06	0.96	1.02	0.96	1.06	0.98
	0.97	0.96	1.03	0.99	1.02	0.96	1.02
Mean error of stage/discharge relationship for calculated Q							
	3.34	3.59	2.87	1.50	2.64	3.79	1.59
Mean error of stage/discharge relationship for given Q							
	2.90	5.18	1.52	1.81	3.02	0.53	2.34
Stage/discharge relationship (S vs Q) S=A*QB+SZF**							
A =	1.434	1.282	0.389	0.387	0.301	0.443	0.473
B =	0.195	0.201	0.307	0.327	0.368	0.303	0.293
SZF=	83.4	84.0	89.5	89.5	89.5	91.0	91.0
B coefficient log/log discharge/stage relationship							
	5.12	4.97	3.25	3.05	2.72	3.30	3.40

Appendix D3 Data Changes Car Body Site

Cell velocities changed for calibration

Transect 1	Vertical 8	VEL2	Changed	0.4	to	0.6
Transect 1	Vertical 10	VEL3	Changed	0.4	to	0.6
Transect 1	Specified Mannings N of 0.8 at Vertical 6					
Transect 1	Specified Mannings N of 0.7 at Vertical 36					
Transect 3	Vertical 2	VEL3	Changed	0.3	to	0.5
Transect 3	Vertical 22	VEL2	Changed	0.2	to	0.0
Transect 4	Vertical 28	VEL2	Changed	0.2	to	0.0
Transect 5	Vertical 6	VEL2	Changed	0.2	to	0.6
Transect 5	Vertical 7	VEL3	Changed	0.2	to	0.0
Transect 7	Vertical 12	VEL2	Changed	0.2	to	0.0
Transect 7	Vertical 28	VEL3	Changed	0.1	to	0.0
Transect 7	Vertical 29	VEL3	Changed	0.2	to	0.0
Transect 7	Vertical 30	VEL3	Changed	0.7	to	0.9

Appendix D4 Velocity Adjustment Factors Car Body Site

Transect	Flow	VAF
1.00	100.0	.844
1.00	234.0	.991
1.00	410.0	1.015
1.00	1048.0	.983
1.00	2500.0	.904
2.00	100.0	.942
2.00	234.0	.951
2.00	410.0	.962
2.00	1048.0	.974
2.00	2500.0	.996
3.00	100.0	.985
3.00	234.0	.999
3.00	410.0	1.006
3.00	1048.0	.994
3.00	2500.0	.843
4.00	100.0	.939
4.00	234.0	.996
4.00	410.0	1.012
4.00	1048.0	.990
4.00	2500.0	.863
5.00	100.0	.819
5.00	234.0	.954
5.00	410.0	1.010
5.00	1048.0	.998
5.00	2500.0	.838
6.00	100.0	1.052
6.00	234.0	1.005
6.00	410.0	.996
6.00	1048.0	1.003
6.00	2500.0	1.020
7.00	100.0	.735
7.00	234.0	.926
7.00	410.0	1.020
7.00	1048.0	.995
7.00	2500.0	.761

Appendix E

FLAMING GEYSER SITE CALIBRATION INFORMATION

Appendix E1   IFG4 Input File Flaming Geyser Site

```
Green River at Flaming Geyser   RM 43.6
Q/DATE MEASURED  966 cfs on 11-10-86, 301 on 06-24-86, 220 on 08-06-86
IOC             0000000200000000000
QARD     80.0
QARD     220.
QARD     301.
QARD     966.
QARD    2000.
XSEC      1.0          0.0001.00        93.20
          1.0    -10.0 99.0     0.0 98.8      2.0 98.1      4.0 96.0      5.0 95.1   10.0 94.1
          1.0     15.0 94.1    20.0 93.9     25.0 93.7     30.0 93.6     35.0 93.6   40.0 93.3
          1.0     45.0 93.4    50.0 93.3     55.0 93.4     60.0 93.4     65.0 93.3   70.0 93.5
          1.0     75.0 93.2    80.0 93.5     85.0 93.6     90.0 93.5     95.0 93.7  100.0 93.8
          1.0    105.0 94.1   110.0 94.2    115.0 94.2    120.0 94.1    125.0 94.5  130.0 94.8
          1.0    135.0 94.7   140.0 94.7    145.0 95.0    150.0 95.1    155.0 95.1  160.0 95.0
          1.0    165.0 95.2   170.0 95.3    175.0 95.9    180.0 96.4    185.0 98.3186.0 100.5
NS        1.0      0.0  0.8     0.0  0.8      0.0  0.2      0.0  0.2      0.0  0.2    0.0 41.8
NS        1.0      0.0 41.8     0.0 51.8      0.0 56.7      0.0 57.8      0.0 75.5    0.0 75.6
NS        1.0      0.0 75.7     0.0 75.7      0.0 75.7      0.0 75.7      0.0 75.7    0.0 75.7
NS        1.0      0.0 72.8     0.0 73.8      0.0 75.7      0.0 75.7      0.0 75.7    0.0 73.8
NS        1.0      0.0 73.8     0.0 76.9      0.0 76.9      0.0 76.9      0.0 76.8    0.0 76.8
NS        1.0      0.0 76.7     0.0 76.7      0.0 76.7      0.0 76.5      0.0 76.5    0.0 76.5
NS        1.0      0.0 55.5     0.0 33.5      0.0 33.5      0.0  0.8      0.0  0.8    0.0  0.8
CAL1      1.0        95.90       966.00
VEL1      1.0                                 0.3  2.1      3.1  4.2      4.8  3.9    3.6  3.2
VEL1      1.0      3.5  3.5     3.3  3.43     3.7  4.0      3.8  4.0      3.5  3.5    3.1  3.3
VEL1      1.0      3.1  2.9      28  2.2      2.5  2.2      1.5  1.9      2.1  1.2    1.4  0.9
VEL1      1.0      0.7  0.4
CAL2      1.0        95.13       301.00
VEL2      1.0                                 0.0  1.4      2.2  2.4      2.6  2.2    2.6  2.3
VEL2      1.0      2.0  1.9     2.0  2.1      1.8  1.9      2.4  2.1      2.0  2.1    1.6  1.8
VEL2      1.0      1.3  1.5     1.5  1.1      0.7  1.0      0.9  0.1      0.6  0.3    0.0  0.0
VEL2      1.0
CAL3      1.0        95.01       220.00
VEL3      1.0                                      0.8      1.4  1.4      1.6  2.3    2.1  1.9
VEL3      1.0      1.5  0.6     0.7  0.7      0.5  0.9      0.5  0.7      0.0
VEL3      1.0
XSEC      2.0        15.0001.00        93.90
          2.0    -10.0 102.7    0.0 100.7     4.0 99.2      9.0 96.8     12.5 95.1   15.0 94.7
          2.0     17.5 94.5    20.0 94.5     22.5 94.2     25.0 94.1     27.5 94.3   30.0 94.1
          2.0     32.5 94.1    35.0 94.4     40.0 94.4     45.0 94.4     50.0 94.8   55.0 94.8
          2.0     60.0 94.7    65.0 95.0     70.0 94.5     75.0 94.4     80.0 94.4   85.0 94.2
          2.0     87.5 93.9    90.0 94.2     92.5 94.2     95.0 94.3     97.5 94.5  100.0 94.2
          2.0    102.5 94.4   105.0 94.3    110.0 94.1    115.0 94.5    120.0 94.4  125.0 94.7
          2.0    130.0 94.8   135.0 95.3    140.0 94.9    145.0 95.1    150.0 95.3  155.0 95.2
          2.0    160.0 95.2   170.0 96.0    180.0 96.4    201.0 97.7  205.0 100.6
NS        2.0      0.0  0.8     0.0  0.8      0.0  0.8      0.0  0.2      0.0  0.2    0.0 66.5
```

NS	2.0	0.0 65.9	0.0 65.9	0.0 65.9	0.0 67.8	0.0 65.9	0.0 65.8
NS	2.0	0.0 67.7	0.0 65.6	0.0 65.6	0.0 75.7	0.0 57.6	0.0 57.6
NS	2.0	0.0 56.7	0.0 65.9	0.0 75.5	0.0 75.7	0.0 75.8	0.0 75.8
NS	2.0	0.0 75.8	0.0 65.9	0.0 65.9	0.0 67.8	0.0 67.8	0.0 65.8
NS	2.0	0.0 65.8	0.0 65.9	0.0 66.5	0.0 66.5	0.0 66.5	0.0 65.9
NS	2.0	0.0 76.8	0.0 65.9	0.0 56.9	0.0 53.9	0.0 67.7	0.0 67.7
NS	2.0	0.0 67.7	0.0 56.7	0.0 56.8	0.0 0.8	0.0 0.8	0.0
CAL1	2.0	96.22	966.00				
VEL1	2.0			0.5 2.5	3.8 4.4	5.9 3.9	4.8 4.7
VEL1	2.0	4.3 4.9	3.5 3.1	3.8 3.1	3.3 3.1	3.5 3.6	4.2 4.0
VEL1	2.0	5.1 4.9	4.6 3.9	5.3 5.2	4.8 4.7	4.4 3.3	4.4 3.8
VEL1	2.0	4.4 3.0	2.4 2.7	3.5 3.6	1.0 0.0		
CAL2	2.0	95.46	301.00				
VEL2	2.0			0.1 1.9	3.3 4.4	4.3 3.8	4.0 3.5
VEL2	2.0	3.3 3.6	2.2 2.1	0.8 2.2	1.9 1.8	2.2 3.1	3.3 3.1
VEL2	2.0	3.3 3.6	4.1 2.6	3.8 3.0	3.0 2.0	1.3 2.0	1.9 1.9
VEL2	2.0	2.5 1.4	0.9 1.8	1.0 0.7	0.0		
CAL3	2.0	95.26	220.00				
VEL3	2.0			0.0 0.4	2.0 3.0	4.2 3.5	3.7 3.4
VEL3	2.0	3.2 2.9	2.4 1.9	0.7 1.4	2.8 1.6	1.8 3.0	2.8 3.1
VEL3	2.0	3.1 3.3	2.8 3.3	3.6 3.3	3.5 2.7	1.4 0.9	1.1 0.9
VEL3	2.0	1.6	0.5 0.0	0.6	0.0		
XSEC	3.0	15.0001.00		92.60			
	3.0	-25.0 96.6	0.0 96.5	5.0 96.3	10.0 94.4	15.0 94.1	20.0 93.7
	3.0	25.0 93.36	30.0 93.3	35.0 93.0	40.0 93.0	45.0 93.4	50.0 92.8
	3.0	55.0 93.0	60.0 93.0	65.0 93.7	70.0 93.0	75.0 92.8	80.0 92.6
	3.0	85.0 92.7	90.0 93.2	95.0 93.6	100.0 93.2	105.0 93.7	100.0 93.8
	3.0	115.0 94.2	120.0 95.3	125.0 94.5	129.0 95.4		
NS	3.0	0.0 0.8	0.0 0.8	0.0 0.8	0.0 0.8	0.0 65.6	0.0 65.5
NS	3.0	0.0 65.5	0.0 65.8	0.0 65.8	0.0 65.8	0.0 86.8	0.0 76.7
NS	3.0	0.0 76.7	0.0 76.8	0.0 86.6	0.0 86.6	0.0 68.5	0.0 76.7
NS	3.0	0.0 76.8	0.0 76.8	0.0 76.5	0.0 67.7	0.0 75.8	0.0 72.9
NS	3.0	0.0 27.8	0.0 0.8	0.0 0.8	0.0 0.8	0.0	0.0
CAL1	3.0	95.29	966.00				
VEL1	3.0		0.3	2.0 2.9	3.2 4.2	4.3 6.0	6.1 4.0
VEL1	3.0	4.6 5.8	3.7 7.5	6.5 5.4	5.3 3.6	4.1 1.9	1.4 0.9
EL1	3.0	0.6					
CAL2	3.0	94.49	301.00				
VEL2	3.0			0.0 0.9	1.5 2.9	2.6 3.2	4.4 3.1
VEL2	3.0	3.4 1.5	1.9 3.3	3.4 3.3	3.6 3.3	2.4 0.7	0.3 0.2
VEL2	3.0	0.0					
CAL3	3.0	94.35	220.00				
VEL3	3.0			0.0 0.4	1.1 1.4	2.6 2.7	3.3 3.3
VEL3	3.0	1.8 2.3	1.9 2.6	2.5 2.1	2.7 2.5	2.3 0.5	0.6 0.7
VEL3	3.0	0.3					
XSEC	4.0	10.0000.50		93.40			
	4.0	0.0 99.0	10.0 98.2	13.7 97.0	15.0 96.8	20.0 96.2	25.0 95.7
	4.0	30.0 95.3	35.0 95.0	40.0 94.8	45.0 94.8	50.0 94.5	55.0 94.4

	4.0	60.0	94.3	65.0	94.3	70.0	93.9	75.0	94.2	80.0	93.9	85.0	94.2
	4.0	90.0	94.0	95.0	93.6	100.0	93.7	105.0	93.4	110.0	93.4	115.0	93.5
	4.0	120.0	93.5	125.0	93.5	130.0	93.8	135.0	93.6	140.0	93.7	145.0	96.4
	4.0	146.1	97.0	147.0	97.0	149.0	97.7	151.0	99.6	155.0	102.6		
NS	4.0	0.0	22.5	0.0	22.5	0.0	22.5	0.0	22.5	0.0	22.5	0.0	68.6
NS	4.0	0.0	76.5	0.0	76.6	0.0	68.7	0.0	74.6	0.0	47.5	0.0	75.5
NS	4.0	0.0	74.5	0.0	57.6	0.0	56.6	0.0	75.6	0.0	58.7	0.0	75.6
NS	4.0	0.0	45.5	0.0	76.5	0.0	57.6	0.0	57.5	0.0	75.6	0.0	57.6
NS	4.0	0.0	74.6	0.0	62.7	0.0	67.6	0.0	62.7	0.0	62.8	0.0	0.2
NS	4.0	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.8	0.0	
CAL1	4.0		97.01		966.00								
VEL1	4.0				0.3	0.4	1.5	2.1	2.7	2.2	1.6	2.3	2.2
VEL1	4.0	2.5	3.3	2.9	3.1	3.4	3.1	3.4	3.3	3.7	3.8	4.4	4.0
VEL1	4.0	4.0	3.5	3.1	2.7	0.9	0.0						
CAL2	4.0		95.70		301.00								
VEL2	4.0							0.2	0.2	0.3	0.6	0.7	1.0
VEL2	4.0	1.0	1.1	1.1	1.4	1.5	1.6	1.6	1.2	1.6	1.6	1.7	2.1
VEL2	4.0	1.7	2.2	2.1	1.3	0.1							
CAL3	4.0		95.51		220.00								
VEL3	4.0							0.2	0.3	0.2	0.4	0.5	0.6
VEL3	4.0	0.8	0.9	0.9	1.0	1.2	0.9	1.3	0.9	1.1	1.6	1.9	1.7
VEL3	4.0	1.4	1.3	1.7	1.3	0.4							
XSEC	5.0		60.0000.50			93.40							
	5.0	-25.0	100.9	0.0	98.0	5.0	97.8	10.0	97.4	15.0	96.7	20.0	95.6
	5.0	25.0	95.4	30.0	94.7	35.0	93.6	40.0	93.1	45.0	93.2	50.0	93.3
	5.0	55.0	93.8	60.0	93.6	65.0	93.4	70.0	93.5	75.0	93.6	80.0	93.7
	5.0	85.0	93.8	90.0	93.7	95.0	94.4	100.0	94.8	105.0	95.0	110.0	95.6
	5.0	115.0	95.6	120.0	96.4	125.0	96.1	130.0	96.0	135.0	95.6	140.0	96.6
	5.0		141.2		97.2	145.0	98.1	149.0	99.9	153.0	101.3		
NS	5.0	0.0	0.8	0.0	22.5	0.0	22.5	0.0	22.5	0.0	22.5	0.0	67.7
NS	5.0	0.0	67.8	0.0	67.9	0.0	67.9	0.0	63.9	0.0	63.9	0.0	75.5
NS	5.0	0.0	76.6	0.0	57.6	0.0	56.6	0.0	57.8	0.0	74.5	0.0	58.8
NS	5.0	0.0	58.8	0.0	68.8	0.0	68.6	0.0	68.6	0.0	86.7	0.0	98.7
NS	5.0	0.0	86.7	0.0	68.6	0.0	68.6	0.0	68.6	0.0	68.6	0.0	0.8
NS	5.0	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.8	0.0		0.0	
CAL1	5.0		97.17		966.00								
VEL1	5.0					0.2	1.1	1.0	2.1	1.9	2.5	3.2	3.5
VEL1	5.0	4.7	4.7	4.2	4.4	3.8	3.8	3.8	2.8	3.0	2.6	2.2	2.6
VEL1	5.0	2.5	1.3	0.8	1.8	1.6	0.0						
CAL2	5.0		95.80		301.00								
VEL2	5.0						0.0	0.0	0.3	0.8	0.8	1.3	1.7
VEL2	5.0	2.3	2.5	2.7	2.3	2.4	2.1	1.6	1.2	1.3	0.6	0.5	0.0
VEL2	5.0	0.0				0.0							
CAL3	5.0		95.63		220.00								
VEL3	5.0						0.0	0.0	0.2	0.6	1.0	1.1	1.7
VEL3	5.0	1.7	1.6	1.9	2.3	2.1	1.9	1.6	1.0	0.9	0.7	0.3	0.0
VEL3	5.0	0.0				0.0							
ENDJ													

Appendix E2 Summary of Calibration Details Flaming Geyser Site

Flaming Geyser Site Calibration Information for Calculated Discharges

Transect Number	1	2	3	4	5
Discharge					
	958	944	894	1044	994
	339	332	320	257	259
	249	234	230	187	202
Stage					
	95.90	96.22	95.29	97.01	97.17
	95.13	95.46	94.49	95.70	95.80
	95.01	95.26	94.35	95.51	95.63
Plotting Stage					
	2.70	2.32	2.69	3.61	3.77
	1.93	1.56	1.89	2.30	2.40
	1.81	1.36	1.75	2.11	2.23
Ratio of measured versus predicted discharge					
	0.99	1.00	0.99	1.00	1.00
	1.05	1.00	1.05	1.02	1.01
	0.96	1.00	0.96	0.98	0.99
Mean error of stage/discharge relationship for calculated Q					
	3.48	0.29	3.36	1.59	0.87
Mean error of stage/discharge relationship for given Q					
	2.92	2.75	1.90	2.92	4.02
Stage/discharge relationship (S vs Q) S=A*Q**B+SZF					
	A = .3321	.1693	.2960	.4026	.3816
	B = .3049	.3822	.3243	.3154	.3318
	SZF= 93.2	93.9	92.6	93.4	93.4
B coefficient log/log discharge/stage relationship					
	3.28	2.62	3.08	3.17	3.01

Appendix E3 Data Changes Flaming Geyser Site

Cell velocities changed for calibration

Transect 1	Vertical 33	VEL2	Changed	0.4	to	0.6
Transect 1	Vertical 35	VEL2	Changed	0.1	to	0.0
Transect 1	Vertical 36	VEL2	Changed	0.1	to	0.0
Transect 2	Vertical 40	VEL3	Changed	0.2	to	0.0
Transect 2	Vertical 41	VEL2	Changed	0.8	to	1.0
Transect 2	Vertical 42	VEL3	Changed	0.4	to	0.6
Transect 3	Vertical 5	VEL2	Changed	0.1	to	0.0
Transect 3	Vertical 16	VEL3	Changed	0.6	to	2.6
Transect 5	Vertical 24	VEL2	Changed	0.2	to	0.0

Appendix E4 Velocity Adjustment Factors Flaming Geyser Site

Transect	Flow	VAF
1.00	80.0	.978
1.00	220.0	1.005
1.00	301.0	1.008
1.00	966.0	.998
1.00	2000.0	.976
2.00	80.0	1.003
2.00	220.0	1.006
2.00	301.0	1.003
2.00	966.0	.998
2.00	2000.0	.950
3.00	80.0	1.009
3.00	220.0	1.004
3.00	301.0	1.004
3.00	966.0	.999
3.00	2000.0	.982
4.00	80.0	.968
4.00	220.0	1.002
4.00	301.0	1.011
4.00	966.0	1.001
4.00	2000.0	.946
5.00	80.0	.893
5.00	220.0	.989
5.00	301.0	1.005
5.00	966.0	.997
5.00	2000.0	.973

Appendix F

HOSEY SITE CALIBRATION INFORMATION

Appendix F1   IFG4 Input File for Three-Flow Model   Hosey site

```
Green River at Hosey Site  RM 60.6
Q/DATE MEASURED  768 cfs on 11-13-86, 194 on 06-25-86, 140 on 08-04-86
IOC            0000000200000000000
QARD      60.0
QARD     140.0
QARD     194.0
QARD     768.0
QARD    2000.0
XSEC      1.0    0.0000.40      93.10
          1.0  -10.0 104.8   0.0 101.8    2.5 96.8    5.0 96.9   10.0 94.9   15.0 94.2
          1.0   20.0 94.0   25.0 94.1   30.0 94.2   35.0 94.3   40.0 94.9   45.0 95.2
          1.0   50.0 95.4   55.0 95.2   60.0 95.3   65.0 95.4   70.0 95.4   75.0 95.3
          1.0   80.0 95.2   85.0 95.0   90.0 94.7   95.0 94.8  100.0 94.6 105.0 94.4
          1.0  110.0 94.5  115.0 94.4  120.0 93.8  125.0 93.5  130.0 93.1 135.0 93.6
          1.0  140.0 93.8  145.0 93.7  150.0 94.3  155.0 95.9  158.0 97.0 160.0 97.9
          1.0  162.0 99.2
NS        1.0    0.0   0.8    0.0   0.8    0.0   0.8    0.0   0.8    0.0 42.6    0.0 65.5
NS        1.0    0.0 65.5    0.0 64.6    0.0 64.6    0.0 46.6    0.0 54.5    0.0 46.5
NS        1.0    0.0 45.5    0.0 45.7    0.0 55.5    0.0 75.5    0.0 45.5    0.0 64.5
NS        1.0    0.0 65.7    0.0 56.6    0.0 56.8    0.0 65.9    0.0 65.9    0.0 56.5
NS        1.0    0.0 76.6    0.0 56.5    0.0 56.6    0.0 76.5    0.0 56.5    0.0 65.5
NS        1.0    0.0 65.5    0.0 45.7    0.0 88.5    0.0   0.8    0.0   0.8    0.0   0.8
NS        1.0    0.0   0.8    0.0          0.0          0.0          0.0          0.0
CAL1      1.0        96.88        768.00
VEL1      1.0                               0.2   1.4    2.9   3.8    3.5   3.6    3.6   3.4
VEL1      1.0    2.8   2.3    2.1   2.2    1.4   1.4    1.6   2.6    3.0   3.4    3.6   3.8
VEL1      1.0    3.5   3.8    3.9   4.3    1.9   1.1    0.1   0.2    0.3   0.0
VEL1      1.0
CAL2      1.0        95.86        194.00
VEL2      1.0                               0.4   1.7    2.0   1.9    2.0   1.5    1.6   1.5
VEL2      1.0    0.9   1.2    1.8   1.7    1.2   1.0    0.9   1.1    1.3   1.2    1.2   1.5
VEL2      1.0    1.2   1.3    1.3   1.0    0.3   0.0    0.1   0.0    0.1
VEL2      1.0
CAL3      1.0        95.61        140.00
VEL3      1.0                               0.5   1.5    2.6   2.7    2.1   2.4    1.8   1.6
VEL3      1.0    0.8   0.0    0.5   0.6    0.8   0.4    0.5   0.9    0.8   1.1    1.3   0.9
VEL3      1.0    1.1   0.9    0.8   1.0    0.4   0.0    0.0   0.0    0.0
VEL3      1.0
XSEC      2.0       29.4000.40         93.10
          2.0   -7.0 101.2  -6.0 100.3    0.0 97.3    2.5 95.6    5.0 95.7    7.5 95.5
          2.0   10.0 93.4   15.0 91.7   20.0 90.4   25.0 89.7   30.0 89.3   35.0 89.1
          2.0   40.0 88.6   45.0 88.5   47.5 88.1   50.0 88.1   52.5 88.3   55.0 88.4
          2.0   57.5 88.7   60.0 88.8   65.0 88.7   70.0 89.1   75.0 90.0   80.0 90.8
          2.0   85.0 92.2   90.0 93.9   95.0 95.7   96.0 97.2  100.3 97.5105.0 100.5
NS        2.0    0.0   0.8    0.0   0.8    0.0   0.8    0.0 22.5    0.0 88.5    0.0 88.5
NS        2.0    0.0 22.5    0.0 26.6    0.0 62.8    0.0 62.6    0.0 62.6    0.0 78.5
NS        2.0    0.0 76.5    0.0 86.6    0.0 75.6    0.0 76.5    0.0 57.6    0.0 57.6
NS        2.0    0.0 57.6    0.0 57.6    0.0 78.5    0.0 27.6    0.0 24.7    0.0 21.9
```

```
NS      2.0    0.0 82.5    0.0  0.8    0.0  0.8    0.0  0.8    0.0  0.8    0.0  0.8
CAL1    2.0      97.21      768.00
VEL1    2.0                      0.0    0.0  0.1    0.3  0.8    1.4  0.9    1.0  2.2
VEL1    2.0    2.4  1.4    1.4  0.9    1.2  0.8    0.8  0.9    0.8  0.5    0.5  0.3
VEL1    2.0    0.1  0.1    0.1
CAL2    2.0      95.86      194.00
VEL2    2.0                      0.0    0.0  0.0    0.1  0.2    0.2  0.3    0.2  0.3
VEL2    2.0    0.3  0.5    0.5  0.7    0.5  0.7    0.7  0.6    0.2  0.4    0.3  0.1
VEL2    2.0    0.0  0.2
CAL3    2.0      95.71      140.00
VEL3    2.0                      0.0         0.0    0.0  0.1    0.6  0.2    0.1  0.6
VEL3    2.0    0.0  0.3    0.2  0.4    0.4  0.6    0.7  0.5    0.4  0.3    0.3  0.1
VEL3    2.0    0.1  0.1
XSEC    3.0      29.4001.00        93.10
        3.0   -7.0 102.1   0.0 99.3   10.0 97.4   15.0 95.9   20.0 95.8   22.5 95.1
        3.0   25.0 94.5   27.5 94.0   30.0 93.2   32.5 92.6   35.0 92.7   40.0 92.4
        3.0   42.5 92.1   45.0 91.9   50.0 91.5   52.5 91.2   55.0 90.9   60.0 90.7
        3.0   62.5 90.5   65.0 90.3   67.5 90.4   70.0 90.2   72.5 90.0   75.0 89.8
        3.0   77.5 89.7   80.0 89.3   82.5 93.4   85.0 94.7   90.0 95.7   95.0 96.5
        3.0   98.0 98.4  108.0 98.5  110.0 99.2
NS      3.0    0.0  0.8    0.0  0.8    0.0  0.8    0.0 99.5    0.0 99.5    0.0 99.5
NS      3.0    0.0 99.5    0.0 99.5    0.0 99.5    0.0 52.6    0.0 52.6    0.0 52.6
NS      3.0    0.0 47.7    0.0 74.5    0.0 67.7    0.0 67.7    0.0 82.8    0.0 82.7
NS      3.0    0.0 82.7    0.0 82.8    0.0 82.7    0.0 82.6    0.0 82.5    0.0 75.6
NS      3.0    0.0 75.6    0.0 75.7    0.0 99.5    0.0 99.5    0.0 99.5    0.0 99.5
NS      3.0    0.0  0.8    0.0  0.8   0.0  0.08    0.0         0.0         0.0
CAL1    3.0      97.31      768.00
VEL1    3.0                      0.9    1.1  1.7    1.5  1.6    1.7  1.9    1.9  2.0
VEL1    3.0    2.0  2.0    2.0  2.1    2.0  2.1    2.1  2.1    2.1  2.1    2.0  2.1
VEL1    3.0    2.3  2.4    2.2  2.2    0.9  0.0
CAL2    3.0      95.88      194.00
VEL2    3.0                      0.0    0.0  0.3    0.4  0.4    0.6  0.5    0.5  0.6
VEL2    3.0    0.6  0.7    0.7  0.6    0.6  0.7    0.7  0.7    0.7  0.8    0.5  0.7
VEL2    3.0    0.7  0.7    0.6  0.5    0.0
CAL3    3.0      95.74      140.00
VEL3    3.0                             0.0  0.4    0.4  0.3    0.5  0.5    0.6  0.6
VEL3    3.0    0.6  0.5    0.5  0.6    0.5  0.5    0.5  0.5    0.5  0.5    0.5  0.4
VEL3    3.0    0.5  0.6    0.5  0.4    0.0
XSEC    5.0      11.7600.40        88.20
        5.0   -1.0 103.6   0.0 93.2    1.0 91.5    2.5 91.2    5.0 91.7    7.5 91.5
        5.0   10.0 91.6   12.5 91.7   15.0 91.8   17.5 91.3   20.0 91.5   22.5 91.7
        5.0   25.0 91.1   27.5 90.6   30.0 90.1   32.5 90.4   35.0 90.2   37.5 90.3
        5.0   40.0 90.4   42.5 90.5   45.0 90.3   47.5 90.1   50.0 89.9   52.5 89.8
        5.0   55.0 89.5   57.5 89.4   60.0 89.2   62.5 89.2   65.0 89.2   57.5 89.1
        5.0   70.0 88.9   72.5 88.3   75.0 88.5   77.5 88.3   80.0 88.2   82.5 88.2
        5.0   85.0 88.3   87.5 89.2   90.0 89.6   92.5 90.8   95.0 91.8  100.0 94.0
        5.0  105.0 96.8  110.0 99.0
NS      5.0    0.0 99.5    0.0 99.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5
```

Appendix F1   IFG4 Input File for Three-Flow Model Hosey Site   Continued

```
NS      5.0     0.0 88.5    0.0 88.5    0.0 88.5    0.0 87.5    0.0 84.6    0.0 88.5
NS      5.0     0.0 88.5    0.0 99.5    0.0 86.6    0.0 76.5    0.0 76.7    0.0 76.8
NS      5.0     0.0 67.6    0.0 65.9    0.0 54.7    0.0 54.7    0.0 54.7    0.0 56.5
NS      5.0     0.0 57.6    0.0 76.7    0.0 76.7    0.0 78.8    0.0 78.8    0.0 67.5
NS      5.0     0.0 67.5    0.0 78.8    0.0 78.5    0.0 78.5    0.0 87.8    0.0 87.8
NS      5.0     0.0 87.8    0.0 83.8    0.0 82.8    0.0  828    0.0 86.5    0.0 86.5
NS      5.0     0.0 86.6    0.0  0.8    0.0          0.0        0.0         0.0
CAL1    5.0       93.28      768.00
VEL1    5.0                 3.3  1.4    0.3  0.3    0.6  0.3    0.8  4.3    2.5  4.8
VEL1    5.0     2.0  4.7    4.1  4.4    3.7  4.2    4.6  4.1    3.4  2.3    1.0  0.9
VEL1    5.0     0.3  0.7    2.1  3.4    3.7  3.9    3.4  3.5    3.7  3.7    4.2  3.3
VEL1    5.0     1.9  0.9    0.7  0.3    0.3
CAL2    5.0       91.88      194.00
VEL2    5.0                 0.3  0.4    0.1  0.1    0.1  0.7    0.5  0.0    0.2  0.6
VEL2    5.0     1.0  0.4    0.8  1.3    2.2  1.8    1.6  1.4    1.5  2.2    2.2  2.2
VEL2    5.0     1.9  1.3    0.6  0.6    0.9  1.2    1.7  1.5    1.8  2.0    2.0  1.1
VEL2    5.0     0.9  0.3    0.2  0.2    0.1
CAL3    5.0       91.64      140.00
VEL3    5.0                 1.0  1.0         1.0    0.0              0.0    0.0
VEL3    5.0     0.7  0.5    0.6  1.0    1.5  0.9    1.1  0.8    0.8  1.3    1.4  1.6
VEL3    5.0     1.6  0.9    0.7  0.6    0.6  1.1    1.2  1.3    1.2  1.2    1.3  1.2
VEL3    5.0     0.6  0.3    0.2  0.2
XSEC    6.0      29.4000.00       88.20
        6.0    -1.0 103.6   0.0 91.9    0.1 83.2    5.0 83.1    7.5 83.2   10.0 83.4
        6.0    12.5 83.6   15.0 84.1   17.5 84.8   20.0 85.7   22.5 86.3   25.0 86.9
        6.0    27.5 87.9   30.0 88.2   32.5 88.7   35.0 89.4   37.5 89.4   40.0 89.5
        6.0    42.5 89.9   45.0 90.0   47.5 89.8   50.0 89.7   52.5 89.9   55.0 90.4
        6.0    57.5 91.4   60.0 91.9   65.0 93.6   67.5 93.4   70.0 93.5   80.0 96.0
        6.0    87.5 98.9
NS      6.0     0.0 99.5    0.0 99.5    0.0 26.8    0.0 62.6    0.0 62.5    0.0 62.8
NS      6.0     0.0 62.8    0.0 62.7    0.0 63.7    0.0 63.6    0.0 64.5    0.0 46.5
NS      6.0     0.0 46.6    0.0 46.6    0.0 46.7    0.0 46.9    0.0 54.9    0.0 54.9
NS      6.0     0.0 46.8    0.0 46.6    0.0 46.5    0.0 36.5    0.0 36.6    0.0 99.5
NS      6.0     0.0 99.5    0.0 99.5    0.0 99.5    0.3 99.5    0.0 99.5    0.0  0.8
NS      6.0     0.0  0.8    0.0         0.0         0.0         0.0         0.0
CAL1    6.0       93.54      768.00
VEL1    6.0                 2.1  2.2    2.1  2.2    2.2  2.2    2.3  2.0    1.9  1.9
VEL1    6.0     1.9  2.0    2.2  2.1    2.2  2.5    2.6  2.4    2.4  2.2    2.0  2.2
VEL1    6.0     2.2  3.9         2.2    0.0
CAL2    6.0       91.98      194.00
VEL2    6.0                 0.3  0.4    0.8  0.7    0.7  0.8    0.8  0.8    0.8  0.7
VEL2    6.0     0.7  0.8    0.7  1.0    1.0  1.2    1.1  1.3    1.2  1.0    1.2  1.2
VEL2    6.0     1.3  0.0
CAL3    6.0       91.69      140.00
VEL3    6.0                 0.3  0.4    0.4  0.5    0.4  0.5    0.4  0.4    0.4  0.4
VEL3    6.0     0.4  0.4    0.5  0.6    0.8  1.0    0.9  1.0    0.9  0.7    0.8  0.9
VEL3    6.0     0.9
ENDJ
```

Appendix F2   IFG4 Input File for One-flow Model   Hosey Site

```
Green River at Hosey Site  Transect 4  RM 60.6
Q/date measured   190 cfs on 06-25-86
IOC       0000000200000000000
QARD      60.
QARD     140.
QARD     190.
QARD     768.
QARD    2000.
XSEC      4.0        0.0001.00        89.50
          4.0      0.0 96.7    5.0 94.2   10.0 92.9   15.0 92.6   20.0 91.7   25.0 91.5
          4.0     30.0 91.3   35.0 89.5   40.0 89.8   45.0 89.9   50.0 89.8   55.0 90.6
          4.0     57.5 90.2   60.0 90.2   62.5 90.8   65.0 90.3   67.5 91.0   70.0 91.3
          4.0     72.5 90.8   75.0 90.3   77.5 90.5   80.0 90.4   82.5 90.6   85.0 91.0
          4.0     90.0 90.8   95.0 90.5  100.0 90.8  105.0 91.0  110.0 91.8 120.0 93.1
          4.0    131.0 93.8  140.0 97.4  145.0 102.4
NS        4.0      0.0   0.8    0.0   0.8    0.0 82.9    0.0 82.9.    0.0 82.9    0.0 82.9
NS        4.0      0.0 87.9    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5
NS        4.0      0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5
NS        4.0      0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5
NS        4.0      0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5
NS        4.0      0.0 88.5    0.0   0.8    0.0   0.8    0.0         0.0         0.0
CAL1      4.0        92.54      762.00      762.00
VEL1      4.0
VEL1      4.0
VEL1      4.0
CAL2      4.0        91.70      190.00      171.00
VEL2      4.0                               0.0   0.3    1.0   1.6    1.4   2.1    2.5   1.8
VEL2      4.0      2.8   1.1    2.0   28     4.4   1.2    0.7   4.0    2.4   0.6    1.6   2.1
VEL2      4.0      1.3   1.1    0.5   1.5
CAL3      4.0        91.59      144.00      160.00
VEL3      4.0
VEL3      4.0
VEL3      4.0
XSEC      4.5       10.0000.50        89.50
          4.5      0.0 96.7    5.0 94.2   10.0 92.9   15.0 92.6   20.0 91.7   25.0 91.5
          4.5     30.0 91.3   35.0 89.5   40.0 89.8   45.0 89.9   50.0 89.8   55.0 90.6
          4.5     57.5 90.2   60.0 90.2   62.5 90.8   65.0 90.3   67.5 91.0   70.0 91.3
          4.5     72.5 90.8   75.0 90.3   77.5 90.5   80.0 90.4   82.5 90.6   85.0 91.0
          4.5     90.0 90.8   95.0 90.5  100.0 90.8  105.0 91.0  110.0 91.8 120.0 93.1
          4.5    131.0 93.8  140.0 97.4  145.0 102.4
NS        4.5      0.0   0.8    0.0   0.8    0.0 82.9    0.0 82.9    0.0 82.9    0.0 82.9
NS        4.5      0.0 87.9    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5
NS        4.5      0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5
NS        4.5      0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5
NS        4.5      0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5    0.0 88.5
NS        4.5      0.0 88.5    0.0   0.8    0.0   0.8    0.0         0.0         0.0
CAL1      4.5        92.54      762.00      762.00
VEL1      4.5
```

Appendix F2 IFG4 Input File for One-Flow Model Hosey Site

VEL1	4.5														
VEL1	4.5														
CAL2	4.5	91.70		190.00		171.00									
VEL2	4.5					0.0	0.3	1.0	1.6	1.4	2.1	2.5	1.8		
VEL2	4.5	2.8	1.1	2.0	28	4.4	1.2	0.7	4.5	2.4	0.6	1.6	2.1		
VEL2	4.5	1.3	1.1	0.5	1.5										
CAL3	4.5	91.59		144.00		160.00									
VEL3	4.5														
VEL3	4.5														
VEL3	4.5														
ENDJ															

Appendix F3 Summary of Calibration Details Hosey Site

Hosey Site Calibration Information for Calculated Discharges

Transect Number					
1	2	3	4 *	5	6
Discharge					
843	612	757	762	812	813
200	169	170	171	219	208
154	147	131	160	143	126
Stage					
96.88	97.21	97.31	92.54	93.28	93.54
95.86	95.86	95.88	91.70	91.88	91.98
95.61	95.71	95.74	91.59	91.64	91.69
Plotting Stage					
3.78	4.11	4.12	3.04	5.08	5.34
2.76	2.76	2.78	2.20	3.68	3.78
2.51	2.61	2;64	2.09	3.44	3.49
Ratio of measured versus predicted discharge					
1.02	1.00	1.00	1.00	0.99	0.98
0.92	0.98	1.04	0.92	1.08	1.09
1.06	1.09	0.97	1.07	0.94	0.93
Mean error of stage/discharge relationship for calculated Q					
5.44	1.43	2.46	5.51	4.83	5.86
Mean error of stage/discharge relationship for given Q					
2.79	4.35	5.08	1.85	1.23	0.27
Stage/discharge relationship (S vs Q) S=A*QB+SZF**					
A = .7818	.5461	.6983	.6570	1.075	1.100
B = .2346	.3147	.2709	.2312	.2313	.2351
SZF= 93.1	93.1	93.1	89.5	88.2	88.2
B coefficient log/log discharge/stage relationship					
4.26	3.18	3.69	4.35	4.32	4.24

*Transect Four was run as a one-flow model.

Appendix F4 Data Changes Hosey Site

Cell velocities changed for calibration

Transect 1	Vertical 14	VEL3	Changed	0.2 to 0.0
Transect 2	Vertical 13	VEL3	Changed	0.1 to 0.0
Transect 5	Vertical 10	VEL2	Changed	0.1 to 0.0
Transect 5	Vertical 12	VEL2	Changed	0.4 to 0.6
Transect 5	Vertical 14	VEL3	Changed	0.3 to 0.5
Transect 6	Vertical 26	VEL2	Changed	0.2 to 0.0
Transect 6	Vertical 28	Specified Mannings N of 0.3		

Appendix F5 Velocity Adjustment Factors Hosey Site

Transect	Flow	VAF
1.00	60.0	.939
1.00	140.0	.949
1.00	194.0	.953
1.00	768.0	.995
1.00	2000.0	1.018
2.00	60.0	.790
2.00	140.0	.971
2.00	194.0	1.017
2.00	768.0	1.004
2.00	2000.0	.821
3.00	60.0	.960
3.00	140.0	.999
3.00	194.0	1.005
3.00	768.0	.998
3.00	2000.0	.978
4.00	60.0	.822 *
4.00	140.0	1.000 *
4.00	194.0	1.096 *
4.00	768.0	1.744 *
4.00	2000.0	2.556 *
5.00	60.0	.735
5.00	140.0	.980
5.00	194.0	1.020
5.00	768.0	1.008
5.00	2000.0	.857
6.00	60.0	1.011
6.00	140.0	1.006
6.00	194.0	1.007
6.00	768.0	1.003
6.00	2000.0	.989

* A one-flow IFG4 model was used for transect 4.

Appendix G

TRANSECT WEIGHTING

Appendix G TRANSECT WEIGHTING

Transect weight as a percent of each site.

Site	1	2	3	4	5	6	7
Kent	15.84	16.85	16.85	16.85	16.85	16.85	
Nealy Bridge	8.34	15.34	15.34	20.82	18.19	13.82	8.11
Car Body	7.89	16.26	15.59	17.15	22.49	16.57	3.92
Flaming Geyser	15.00	15.00	10.00	30.00	30.00		
Hosey	10.00	25.00	25.00	15.00	10.00	15.00	

Appendix H

FISH HABITAT USE

Appendix H1 Snorkel Surveys of Fish Distribution and Use

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River DATE: April 23, 1986

DISCHARGE OF RIVER: 895 cfs at Purification Plant gage
1280 cfs at Auburn gage

REACH OF RIVER SURVEYED: at RM 60.9, 100 ft. downstream of footbridge

VISIBILITY: 8-10 ft.

SPAWNING STEELHEAD OBSERVATIONS

Depth	Velocity	Substrate
3.7 ft.	2.07 fps	large gravel 60%, small cobble 40%
3.5 ft.	3.4 fps	large gravel 50%, small cobble 30%, and large cobble 20%

GENERAL COMMENTS: The redds were in the center of the channel. Though there were many redds we saw active fish on only two redds.

OBSERVATIONS BY: Brad Caldwell and Jim Farley (WDF)

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River DATE: May 9, 1986

DISCHARGE OF RIVER: 450 cfs at Purification Plant gage
833 cfs at Auburn gage

REACH OF RIVER SNORKELED: RM 60.3 to 60.9. Snorkeled from the footbridge just below diversion (RM 60.9) to the pipe bridge upstream of the control station (RM 60.3). The COE had reduced the river flow to 450 cfs about a week ago. No redds were observed in the 3 to 15 foot depths. Redds were observed at three sites: just below the footbridge, at gravel bar on roadside; ¾ of the way down from the footbridge to the pipe bridge (below largest tributary on north side); and immediately underneath and slightly downstream from the pipe bridge. Two redds were observed on the north edge of the river on transect two. Six dark steelhead were near two large, fresh redds at the footbridge spawning bar.

VISIBILITY: 15 feet

SPECIES OBSERVED	NUMBER OBSERVED
Steelhead adults (by foot bridge)	6
Steelhead adults (dark, by pipebridge)	20
Whitefish (12-15 in.)	12
Trout juvenile (5 in.)	1

SPAWNING STEELHEAD OBSERVATIONS

Depth	Velocity	Substrate
1.6 ft.	4.02 fps	small cobble 60%, large gravel 40%
2.0 ft.	3.32 fps	small cobble 50%, large gravel 50%
2.0 ft.	2.59 fps	small cobble 50%, large gravel 50%
2.6 ft.	1.97 fps	large gravel 60%, small cobble 40%
1.8 ft.	2.40 fps	large gravel 70%, small cobble 30%

GENERAL COMMENTS: Good-quality spawning gravel was observed in the pools, but there was no evidence of the dark, brown algae having been being disturbed by fish. Heavy concentrations of caddis larvae were observed at densities of 12 to 25 per square foot on cobble and bedrock in water 1 to 3 feet deep by the pipebridge. Steelhead redds on the gravel bar 100 yards upstream of the pipe bridge had only 1 to 3 inches of water at 450 cfs. These fresh redds were probably created last week while the flow was 2000 cfs. Because of spring reservoir filling, the steelhead redds at this bar probably have chronic dewatering problems.

OBSERVATIONS BY: Brad Caldwell

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River   DATE: August 12, 1986

DISCHARGE OF RIVER: 197 cfs at Purification Plant gage
403 cfs at Auburn gage

REACH OF RIVER SNORKELED: RM 60.6 to 60.9, the Hosey Site. We snorkeled from just below the footbridge (RM 60.9) downstream to transect 4 (FM 60.6).

VISIBILITY: 10 ft.

SPECIES OBSERVED	NUMBER OBSERVED
Steelhead adults (15-20 lbs.)	2 (1 was dark)
Sockeye adults (8-10 lbs.)	6 (dark red)
Sockeye adult (dead)	1
Trout (10-12 in.)	3
Trout juvenile (6-7 in.)	8
Trout juvenile (3-4 in.)	12
Whitefish (1 lb.)	18

GENERAL COMMENTS: The sockeye were spawning in a pool just below the riffles below transects 5 and 6. The redds were in 8 to 10 feet of water and the substrate was small cobble with a small amount of large gravel and large cobble. The sockeye were apparently the same as were observed here on August 5, 1986.

REACH OF RIVER SNORKELED: RM 38.9 to 39.9 at the Car Body site. Snorkeled from upstream end of the Car Body site (RM 39.9) to one mile downstream.

VISIBILITY: 6-8 ft.

SPECIES OBSERVED	NUMBER OBSERVED
Suckers (8 lbs.)	50
Whitefish (1 lb.)	10
Coho juveniles (2.5-4 in.)	80
Chinook juveniles (5-6 in.)	25
Trout juveniles (2.5-6)	100

GENERAL COMMENTS: The thousands of chinook juveniles seen last week were gone. There were about the same number of coho juveniles and trout juveniles as seen last month. Last month 95% of the all the salmonid juveniles observed were chinook. The car body was gone and a freshet occurred two days ago.

OBSERVATIONS BY: Brad Caldwell and Stephen Hirschey

Appendix H1 Snorkel Surveys of Fish Distribution and Use Continued

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River DATE: October 10, 1986

DISCHARGE OF RIVER: 228 cfs at Purification Plant gage
352 cfs at Auburn gage

REACH OF RIVER SNORKELED: RM 27.2 to 27.8 at downstream Kent site. We snorkeled from 0.5 mile upstream of transect 3 Kent site (RM 27.8) downstream to transect 1 (RM 27.2).

VISIBILITY: 50 feet

SPECIES OBSERVED	NUMBER OBSERVED
Coho adults (6-12 lbs.)	10
Chinook adults (15-20 lbs.)	4
Whitefish	20
Trout juveniles (5-6 in.)	6
Steelhead adult (7 lbs.)	1

GENERAL COMMENTS: most of the fish were observed in the pool upstream of transect 3.

REACH OF RIVER SNORKELED: RM 32.7 to 33.7. We started at Highway 18 bridge (RM 33.7) and went downstream for 1 mile.

SPECIES OBSERVED	NUMBER OBSERVED
Coho adults (1/2 were dark)	2000
Chinook adults	500
Chinook adults (dead)	5
Chinook juveniles (5-6 in.)	50
Trout juveniles (4-5 in.)	40
Whitefish (10-15 in.)	80
Suckers (large)	20

GENERAL COMMENTS: Many redds were observed in 6 to 10 feet of water with substrate of small cobble and large gravel. Many redds were also observed in 1.5 to 2 feet of water with substrate of small cobble and large gravel. Not many chinook were on the redds. The peak spawning time for chinook was over.

OBSERVATIONS BY: Brad Caldwell & Stephen Hirschey

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River DATE: October 14, 1986

DISCHARGE OF RIVER: 208 cfs at Purification Plant gage
340 cfs at Auburn gage

REACH OF RIVER SNORKELED: RM 60.3, transect 1, at the Hosey site.

VISIBILITY: 8 feet

SPAWNING CHINOOK OBSERVATIONS

Depth	Velocity	Substrate
1.4 ft.	2.4 fps	small cobble 70%, large gravel 30%
1.7 ft.	1.82 fps	small cobble 70%, large gravel 30%
1.0 ft.	2.92 fps	small cobble 80%, large gravel 20%

GENERAL COMMENTS: The spawning observations were taken at 35 and 120 feet downstream of transect 1 on active redds. Twenty to 30 chinook were observed over the spawning bar. Parts of the cobble bar were exposed in the center of the channel.

REACH OF RIVER SNORKELED: RM 60.4 at the gravel bar 100 yards upstream of the pipe bridge and 100 yards downstream of transect 2 of the Hosey site.

SPAWNING CHINOOK OBSERVATIONS

Depth	Velocity	Substrate
2.3 ft.	1.26 fps	small cobble 50%, large gravel 50%
1.5 ft.	1.09 fps	large cobble 50%, large gravel 50%
1.2 ft.	0.45 fps	large cobble 50%, large gravel 50%

GENERAL COMMENTS: Twenty feet of the channel against the south shore of the gravel bar where steelhead spawned last May was out of the water.

REACH OF RIVER SNORKELED: RM 60.6. This was 100 feet upstream of transect 4 at the head of the cascade. The chinook were actively spawning on two redds.

SPAWNING CHINOOK OBSERVATIONS

Depth	Velocity	Substrate
1.9 ft.	1.24 fps	small cobble 60%, boulder 40%
1.6 ft.	1.75 fps	large gravel 40%, small cobble, 30%, boulder 30%

SPECIES OBSERVED	NUMBER OBSERVED
Trout juveniles (6 in.)	18
Trout adult (12 in.)	1
Whitefish	12

ECOLOGY SNORKELING OBSERVATIONS ON GREEN RIVER, OCT. 14, 1988 Continued

REACH OF RIVER SNORKELED: RM 60.8, transect 5 at the Hosey site.

SPAWNING CHINOOK OBSERVATIONS

Depth	Velocity	Substrate
1.0 ft.	2.27 fps	small cobble 60%, large gravel 40%
1.1 ft.	2.91 fps	large cobble 40%, small cobble 30% large gravel 30%

GENERAL COMMENTS: Chinook redds were in the center of the channel. Redds were observed in six feet of water downstream of transect five, but could not be measured.

REACH OF RIVER SNORKELED: RM 60.8, transect 6 at the Hosey site.

SPAWNING CHINOOK OBSERVATIONS

Depth	Velocity	Substrate
1.9 ft.	1.48 fps	large cobble 40%, small cobble 40%, large gravel 20%
1.4 ft.	1.71 fps	small cobble 50%, large 50%

GENERAL COMMENTS: There were fresh redds, but we did not see fish on the redds. The redds were in the center of the channel.

SPECIES OBSERVED	NUMBER OBSERVED
Chinook adults	20
Chinook adults (dead)	3
Whitefish	6
Trout juveniles (6 in.)	10

GENERAL COMMENTS: These fish were observed in the pool upstream of transect six.

ECOLOGY SNORKELING OBSERVATIONS ON THE GREEN RIVER OCT. 14, 1988
Continued

REACH OF RIVER SNORKELED: At RM 35.5. Just upstream of transect 7 at the Nealy bridge site is a 40 yard long riffle on the right side of the river looking downstream.

<u>SPAWNING CHINOOK OBSERVATIONS</u>

Depth	Velocity	Substrate
1.6 ft.	2.96 fps	large gravel 50%, small cobble 40%
2.8 ft.	3.03 fps	small cobble 50%, large gravel 50%
2.0 ft.	3.71 fps	large cobble 50%, large gravel 50%
1.0 ft.	1.74 fps	small cobble 70%, small gravel 30%
1.5 ft.	2.34 fps	small cobble 50%, large gravel 50%
1.3 ft.	3.00 fps	small cobble 50%, large gravel 50%
2.3 ft.	2.93 fps	large gravel 60%, large cobble 40%
2.1 ft.	3.78 fps	small cobble 60%, large gravel 40%
1.7 ft.	2.09 fps	large gravel 70%, small cobble 30%
1.4 ft.	1.75 fps	large cobble 50%, small gravel 30%, medium gravel 20%

SPECIES OBSERVED	NUMBER OBSERVED
Chinook adults	20
chinook adults (dead)	18
Whitefish	12
Trout juveniles (6 in.)	4
Trout juveniles (4 in.)	10

GENERAL COMMENTS: Upstream from transect 7 there were about 30 continuous redds in the deep, fast water about 4 feet from the bank. From transect 7 to below transect 5 no redds were observed due to slow velocities. Spawning was heavy in the riffle and head of riffle just downstream of transect 5.

REACH OF RIVER SNORKELED: At RM 35.3 at transect 4 of the Nealy Bridge site.

SPECIES OBSERVED	NUMBER OBSERVED
Chinook adults	9
Trout juveniles (4-5 in.)	10

SPAWNING CHINOOK OBSERVATIONS

Depth	Velocity	Substrate
1.4 ft.	1.76 fps	large gravel 80%, small cobble 20%
1.1 ft.	2.14 fps	large gravel 70%, small cobble 30%
1.4 ft.	1.53 fps	large gravel 50%, medium gravel 50%

GENERAL COMMENTS: Actively spawning salmon were on the three redds. There was evidence of mass spawning all the way across the channel with nine adult chinook in the area.

REACH OF RIVER SNORKELED: RM 35.3 to 35.0. We snorkeled the Nealy Bridge site from transect 4 (RM 35.3) down to Nealy bridge (RM 35.0).

SPECIES OBSERVED	NUMBER OBSERVED
Chinook adults	2
Chinook adults (dead)	9
Trout (12 in.)	4
Trout juveniles (6 in.)	10
Sucker adults	50

GENERAL COMMENTS: The chinook were spawning only in the riffles due to low flow and the resulting lack of velocity in the river. The water depth and substrate were adequate for spawning throughout the reach snorkeled but spawning areas were determined by the water velocities.

OBSERVATIONS BY: Brad Caldwell & Stephen Hirschey

Appendix H1 Snorkel Surveys of Fish Distribution and Use Continued

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River DATE: October 18, 1986

DISCHARGE OF RIVER: 183 cfs at Purification Plant gage
292 cfs at Auburn gage

REACH OF RIVER SNORKELED: RM 33.7 to RM 32.7. We snorkeled from the Highway 18 bridge (RM 33.7) downstream for 1 mile.

VISIBILITY: 15 feet

SPECIES OBSERVED	NUMBER OBSERVED
Coho adults (dark, holding)	25
Coho juveniles (5 in.)	2
Chinook adults spawning	15
Chinook adults (dead)	30
Chinook jacks spawning	8
Trout juveniles (4-7 in.)	70
Trout (7-12 in.)	6
Sucker adults	1000
Whitefish adults	40
Steelhead adults	1

GENERAL COMMENTS: Most of the chinook redds were observed at the head of the riffle, just upstream of the clay bluff. The suckers were in the large glide downstream of the bluff. Chinook jacks were on redds in water less than 1 foot deep adjacent to overhanging cover.

OBSERVATIONS BY: Brad Caldwell and Stephen Hirschey

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River DATE: October 21, 1986

DISCHARGE OF RIVER: 155 cfs at Purification Plant gage
286 cfs at Auburn gage

REACH OF RIVER SURVEYED: RM 35.0 to RM 34.8. We walked from Nealy Bridge (RM 35.0) downstream to 50 yards upstream of transect 1 (RM 34.8).

VISIBILITY: 15 feet

SPECIES OBSERVED	NUMBER OBSERVED
Chinook adults	3
Chinook adults (dead)	34

GENERAL COMMENTS: No active chinook spawning was observed.

REACH OF RIVER SURVEYED: At RM 40.6. We walked transects 1 and 2 of the Flaming Geyser site.

SPECIES OBSERVED	NUMBER OBSERVED
Chinook adults (dead)	5

GENERAL COMMENTS: Three redds were observed in the head of the riffle just downstream of transect 1.

REACH OF RIVER SURVEYED: At RM 43.6. We walked transects 3, 4 and 5 of the Flaming Geyser site.

SPECIES OBSERVED	NUMBER OBSERVED
Chinook adults (dead)	4

GENERAL COMMENTS: No live chinook were observed. Redds were observed in the riffle at transect 4.

OBSERVATIONS BY: Stephen Hirschey & Doug Weston (WCC)

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River   Date: October 24, 1986

DISCHARGE OF RIVER: 133 cfs at Purification Plant gage
234 cfs at Auburn gage

REACH OF RIVER SNORKELED: RM 35.5 to 35.0. We snorkeled the Nealy Bridge site from upstream of transect 7 (RM 35.5) down to Nealy bridge (RM 35.0).

VISIBILITY: 10-12 feet

SPECIES OBSERVED	NUMBER OBSERVED
Chinook adults	3
Chinook adults (dead)	18

COMMENTS: No chinook were actively spawning at the Nealy Bridge site.

REACH OF RIVER SNORKELED: RM 39.5 to 39.0. We snorkeled from transect 2 at the Car Body site (RM 39.5) downstream for 0.5 mile.

VISIBILITY: 10-12 FEET

SPECIES OBSERVED	NUMBER OBSERVED
Chinook adults	3
Chinook adults (dead)	4
Sucker adults	80
Whitefish	40
Trout adults (12 in.)	4
Trout juveniles (4 in.)	30
Trout juveniles (6 in.)	35
Searun Cutthroat trout (2-4 lbs.)	3
Steelhead adult (10 lbs.)	1

OBSERVATIONS BY: Stephen Hirschey & Doug Weston (WCC)

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River DATE: November 4, 1986

DISCHARGE OF RIVER: 157 cfs at Purification Plant gage
285 cfs at Auburn gage

REACH OF RIVER SNORKELED: RM 33.1 to RM 32.9. We snorkeled from an area of deep pools (RM 33.1) downstream of the Highway 18 bridge down for 0.2 mile.

VISIBILITY: 10 feet.

SPECIES OBSERVED	NUMBER OBSERVED
Coho adults	55
Coho adults (dead)	6
Trout juveniles (4-6 in.)	7
Whitefish adults	13
Sucker adults	45

GENERAL COMMENTS: The six dead coho were very bright and the mortality was probably not due to spawning. No fish were seen in the riffle. Adult coho were observed under logs and near overhanging vegetation.

REACH OF RIVER SNORKELED: RM 35.4 to 35.0. We snorkeled the Nealy Bridge site from transect 7 (RM 35.4) down to Nealy Bridge (RM 35.0).

VISIBILITY: 10 feet

SPECIES OBSERVED	NUMBER OBSERVED
Pink adult (in spawning colors)	1
Sockeye adult (in spawning colors)	1
Coho adults (dark)	60
Chum adults (dark)	3
Chum adults (dead)	2
Chinook (dead)	3
Whitefish	40
Sucker adults	80
Trout juvenile (6 in.)	1

GENERAL COMMENTS: Many fresh coho test redds were observed between transect 7 and Nealy Bridge. Heavy algae growth over chinook redds seen two weeks ago.

OBSERVATIONS BY: Brad Caldwell & Stephen Hirschey

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River   DATE: December 4, 1986

DISCHARGE OF RIVER: 1590 cfs at Purification Plant gage
2170 cfs at Auburn gage

REACH OF RIVER SURVEYED: Nealy Bridge site

VISIBILITY: poor, water was very turbid

GENERAL COMMENTS: The water was too turbid to observe any fish.

OBSERVATIONS BY: Stephen Hirschey and Jim Farley (WDF)

Appendix H1 Snorkel Surveys of Fish Distribution and Use Continued

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River DATE: December 12, 1986

DISCHARGE OF RIVER: 510 cfs at Purification Plant gage
970 cfs at Auburn gage

REACH OF RIVER SNORKELED: RM 35.4 to 35.2 and RM 34.9 to 34.4. Snorkeled the Nealy Bridge site from transect 7 (RM 35.4) to transect 4 (RM 35.2), and from transect 3 (RM 34.9) to the large pool downstream of transect one (RM 34.4).

VISIBILITY: 7 feet

SPECIES OBSERVED	NUMBER OBSERVED
Coho adults (dead)	1
Coho adults	2
Chum adults	2
Chum adults (dead)	2
Sucker adult (dead)	1

GENERAL COMMENTS: No juveniles were seen in any of the rootwads along the bank.

OBSERVATIONS BY: Stephen Hirschey

Appendix H1 Snorkel Surveys of Fish Distribution and Use Continued

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River DATE: December 18, 1986

DISCHARGE OF RIVER: 431 cfs at Purification Plant gage
793 cfs at Auburn gage

REACH OF RIVER SNORKELED: RM 61.0 to RM 60.3. We snorkeled from the Tacoma Diversion Dam (RM 61.0) to 100 feet downstream of transect one (RM 60.3).

VISIBILITY: 6 feet

SPECIES OBSERVED	NUMBER OBSERVED
Coho adults (dark)	4
Sockeye adult (dead)	1

GENERAL COMMENTS: According to Pat at the Headworks, large numbers of red-colored fish had congregated at the diversion within the last week and were also spawning downstream under the pipe bridge at the Headworks. No juvenile salmonids were seen.

OBSERVATIONS BY: Brad Caldwell & Stephen Hirschey

Appendix H1 Snorkel Surveys of Fish Distribution and Use Continued

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River DATE: January 6, 1987

DISCHARGE OF RIVER: 578 cfs at Purification Plant gage
1030 cfs at Auburn gage

REACH OF RIVER SNORKELED: RM 39.9 to 38.6. We snorkeled from transect 7 at the Car Body site (RM 39.9) downstream for 1.3 miles.

VISIBILITY: 8-10 feet

SPECIES OBSERVED	NUMBER OBSERVED
Chum adults (dead)	24
Chum adult	1
Steelhead adult	2
Trout juveniles (4-6 in.)	9
Trout (12 in.)	1
Sucker adults	60
Whitefish	30

REACH OF RIVER SNORKELED: RM 43.8 to RM 43.6. We snorkeled at the Flaming Geyser State Park upstream of our IFIM transects at RM 43.6.

SPECIES OBSERVED	NUMBER OBSERVED
Sockeye adults (spawning colors)	2
Chum adults	2

GENERAL COMMENTS: No steelhead adults were seen at Flaming Geyser State Park. The hatchery steelhead run had been expected to be present.

OBSERVATIONS BY: Brad Caldwell & Stephen Hirschey.

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River DATE: January 13, 1987

DISCHARGE OF RIVER: 444 at Purification Plant gage
996 cfs at Auburn gage

REACH OF RIVER SNORKELED: RM 32.8 to RM 32.7. We snorkeled from below Soos Creek at RM 32.8 downstream for 0.1 mile.

VISIBILITY: 4 feet

SPECIES OBSERVED	NUMBER OBSERVED
Steelhead adult	1

REACH OF RIVER SNORKELED: RM 42.9 to RM 42.8. We snorkeled from an area downstream of the entrance to Flaming Geyser State Park at RM 42.9 downstream for 0.1 mile.

VISIBILITY: 7 to 8 feet

SPECIES OBSERVED	NUMBER OBSERVED
Sucker adults	3
Whitefish	4

REACH OF RIVER SNORKELED: RM 43.6 to RM 43.4. We snorkeled starting at the restrooms in Flaming Geyser State Park (RM 43.6) and went downstream to the large bend in the river upstream of the bridge (RM 43.4).

VISIBILITY: 7 to 8 feet

SPECIES OBSERVED	NUMBER OBSERVED
Steelhead adults	1
Sucker adults	5
Whitefish	3

OBSERVATIONS BY: Brad Caldwell & Stephen Hirschey

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River DATE: April 10, 1987

DISCHARGE OF RIVER: 941 cfs at Purification Plant gage
1410 cfs at Auburn gage

REACH OF RIVER SURVEYED: River Mile 35.4 to RM 34.9. We walked the Nealy Bridge area from 100 yards upstream of transect seven (RM 35.4) to transect 3 (RM 34.9).

VISIBILITY: Less than 1 foot

SPECIES OBSERVED	NUMBER OBSERVED
Steelhead adult (dead)	1

REACH OF RIVER SNORKELED: RM 43.4 to RM 43.0. Snorkeled from the big bend in the river upstream of Flaming Geyser State Park bridge (RM 43.4) down to the bridge (RM 43.0). The current was fast, about 3.5 fps.

VISIBILITY: 7 feet

SPECIES OBSERVED	NUMBER OBSERVED
Whitefish (12 in.)	10
Sucker adults	30
Steelhead adults (8-10 lbs.)	10

OBSERVATIONS BY: Stephen Hirschey

ECOLOGY SNORKELING OBSERVATIONS

RIVER: Green River   DATE: ; April 18, 1987

DISCHARGE OF RIVER: 1370 cfs at Purification Plant gage
1860 cfs at Auburn gage

REACH OF RIVER SNORKELED: RM 35.4 to RM 34.9. We snorkeled the Nealy Bridge area from 100 yards upstream of Transect 7 (RM 35.4) to Transect 3 (RM 34.9).

VISIBILITY: 1.5 feet

SPECIES OBSERVED	NUMBER OBSERVED
Sucker adults (3 lbs.)	4

REACH OF RIVER SNORKELED: RM 43.7 to RM 43.0. We snorkeled from the pool upstream of the flaming geyser (RM 43.7) at Flaming Geyser State Park down to the park's bridge (RM 43.0).

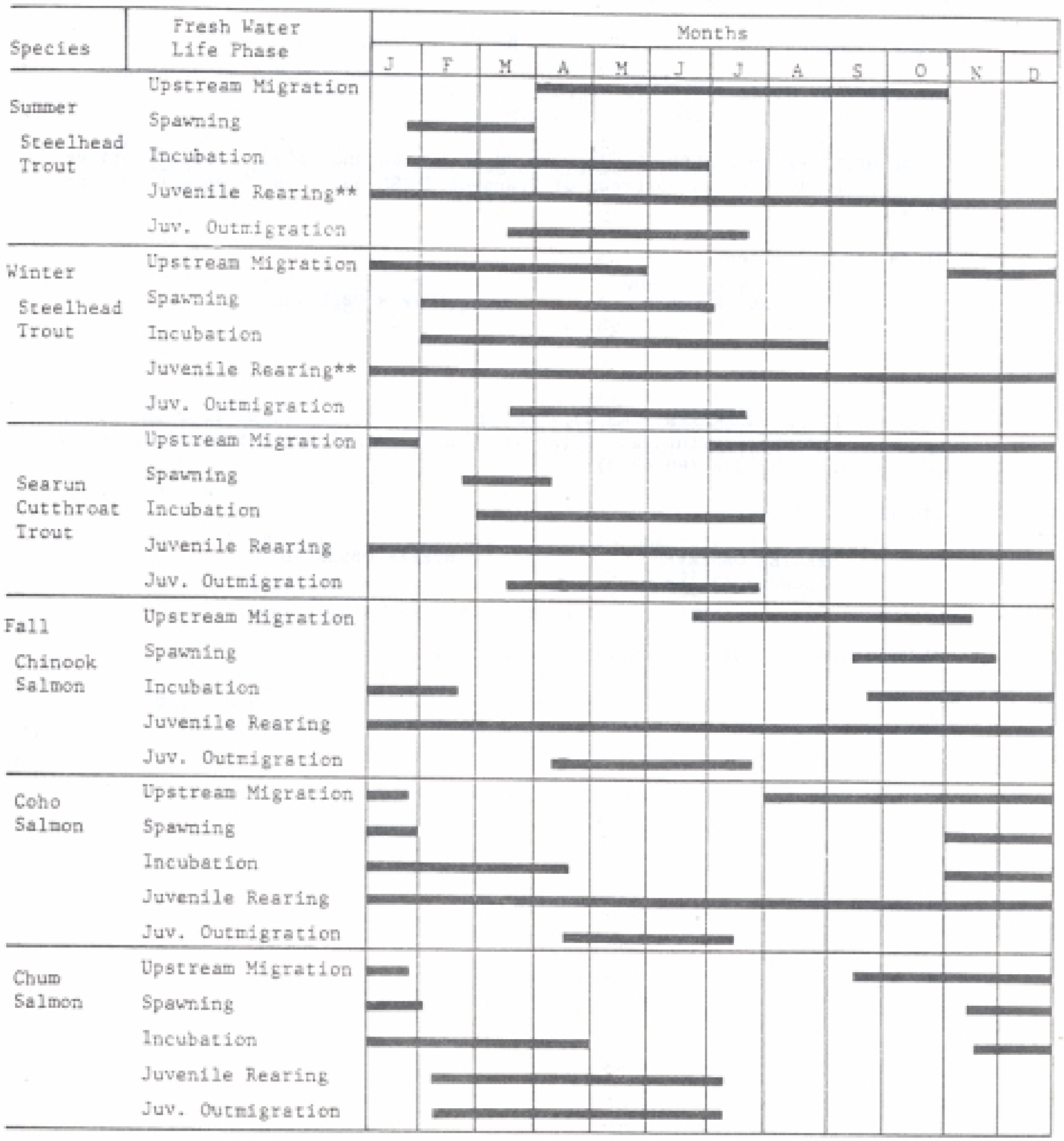
VISIBILITY: 6 feet

SPECIES OBSERVED	NUMBER OBSERVED
Suckers (3 lbs.)	3

OBSERVATIONS BY: Brad Caldwell & Stephen Hirschey

Appendix H2. Fish Periodicity Chart (DNR, 1981).

Timing of Freshwater Phases of Anadromous Fish in the Duwamish-Green Basin *

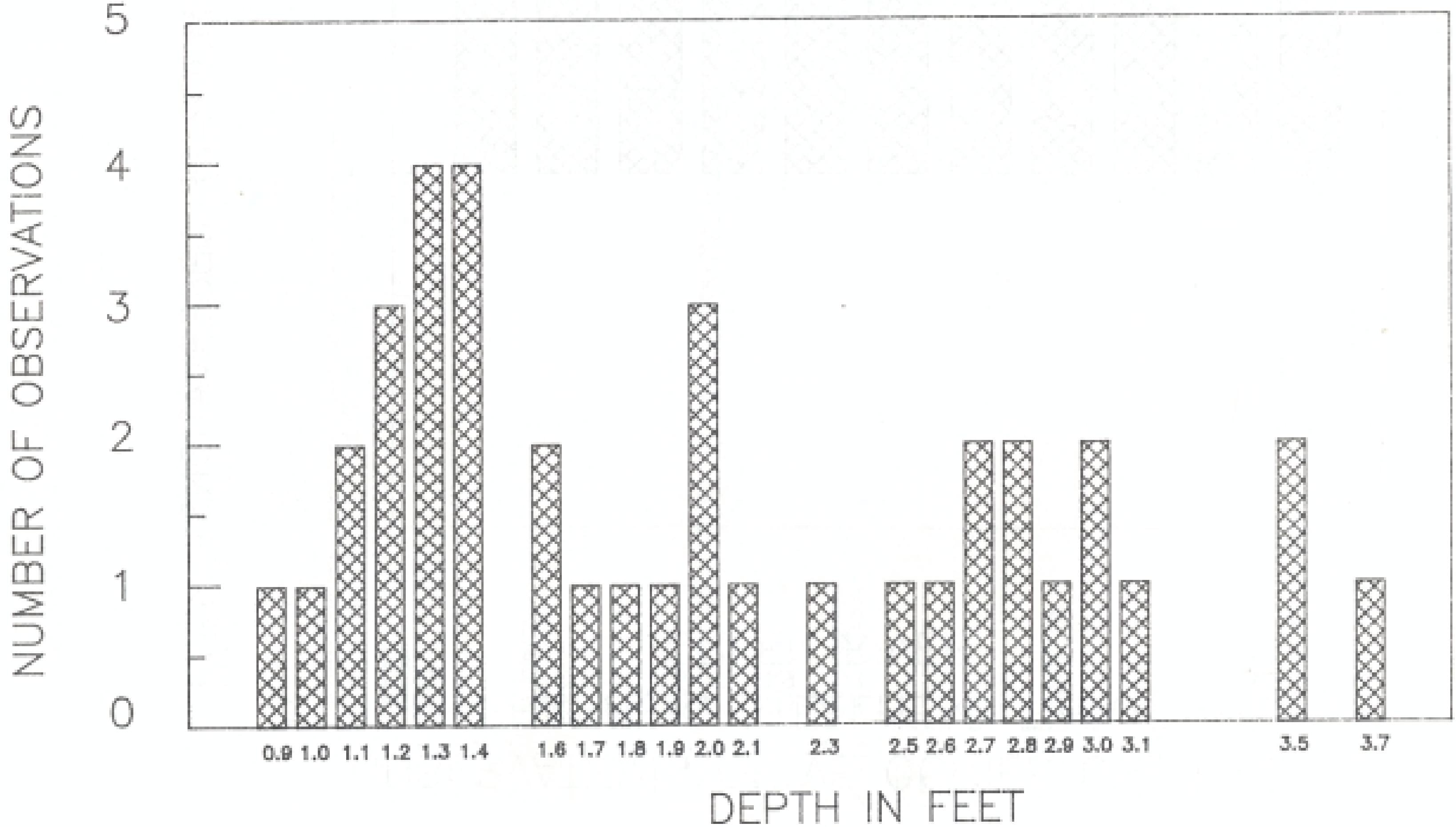


*Courtesy of Department of Fisheries and Game and Pacific Northwest River Basins Commission

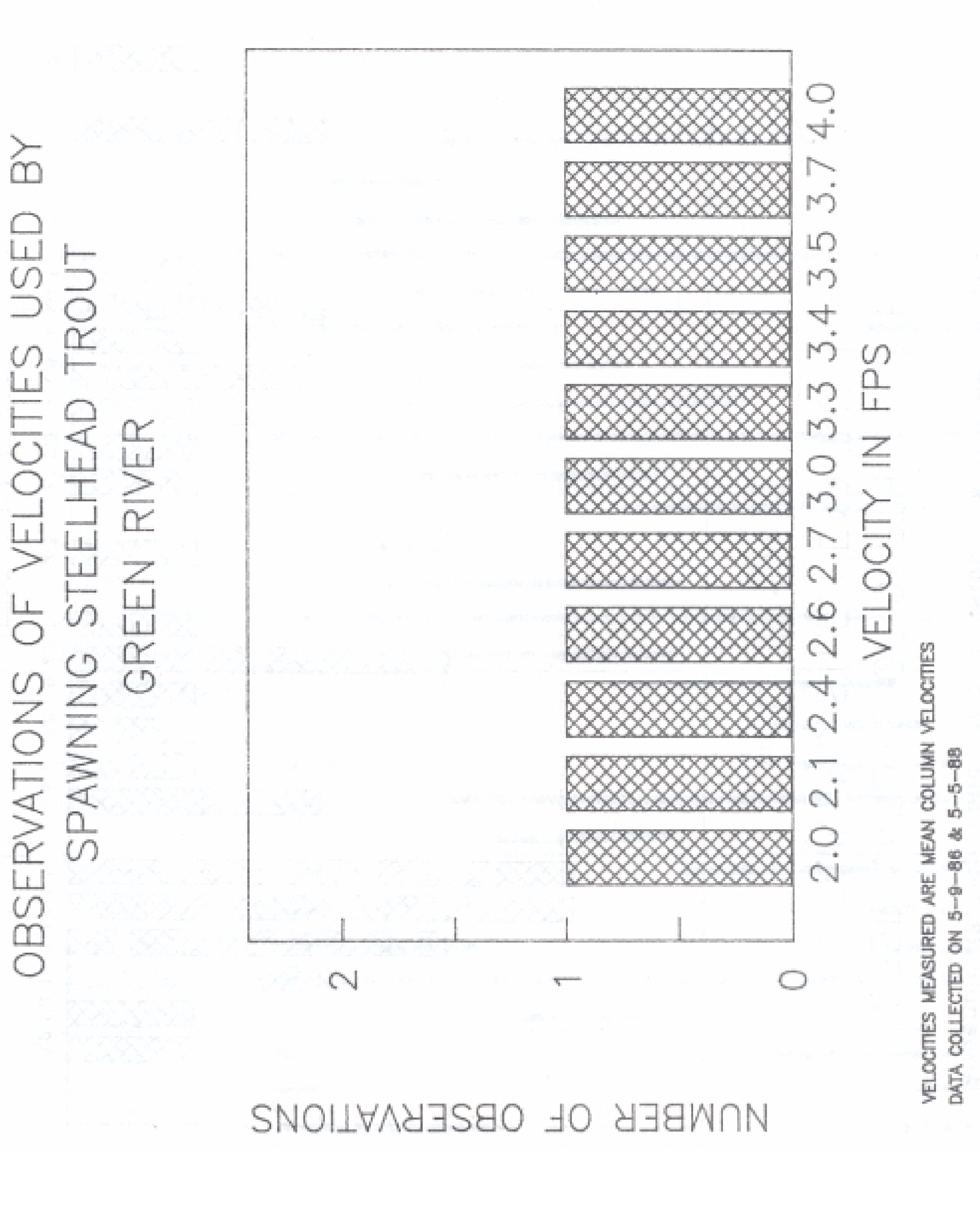
**Normally extends over two-year period

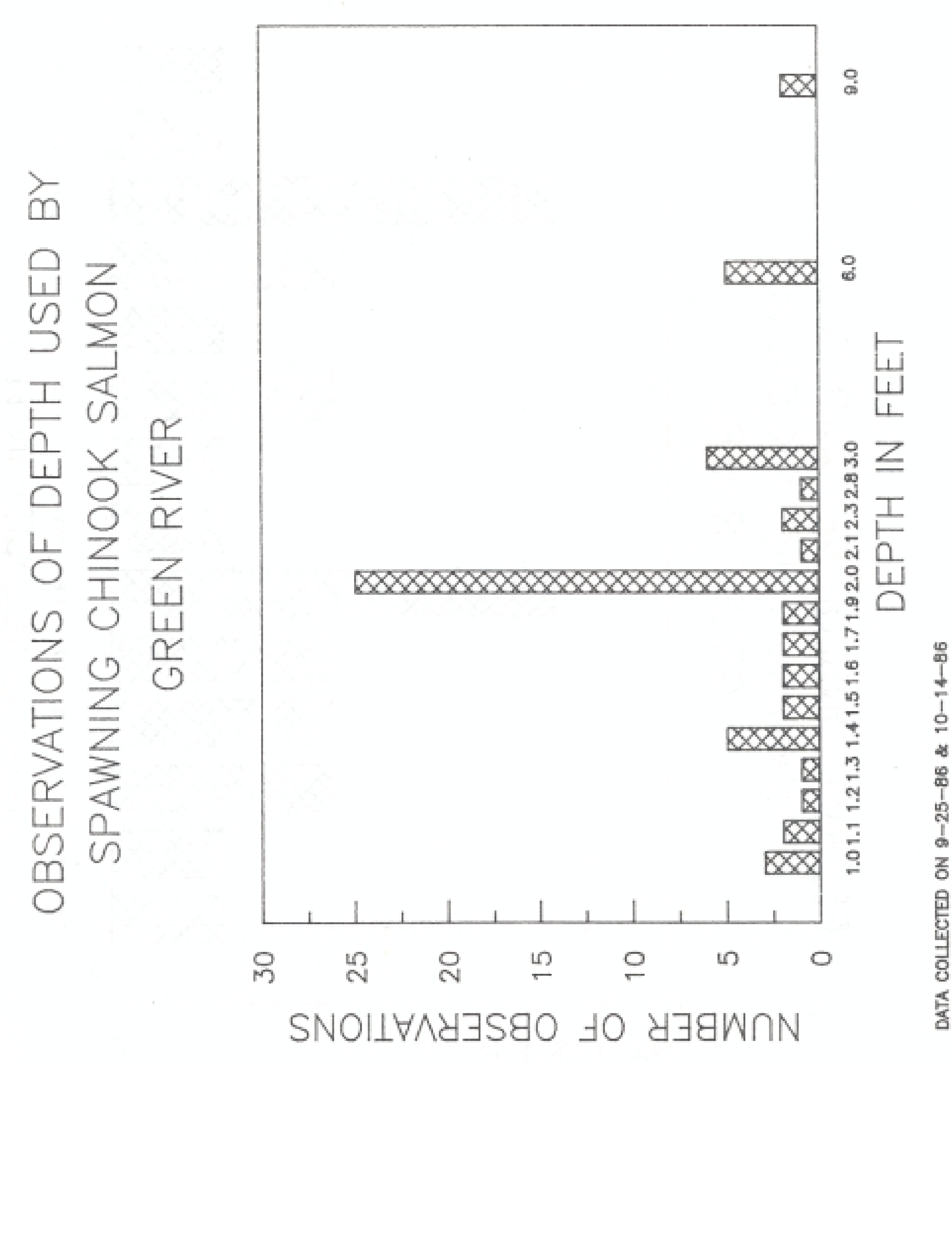
Appendix H3. Depth and Velocity Histograms of Spawning Salmonids

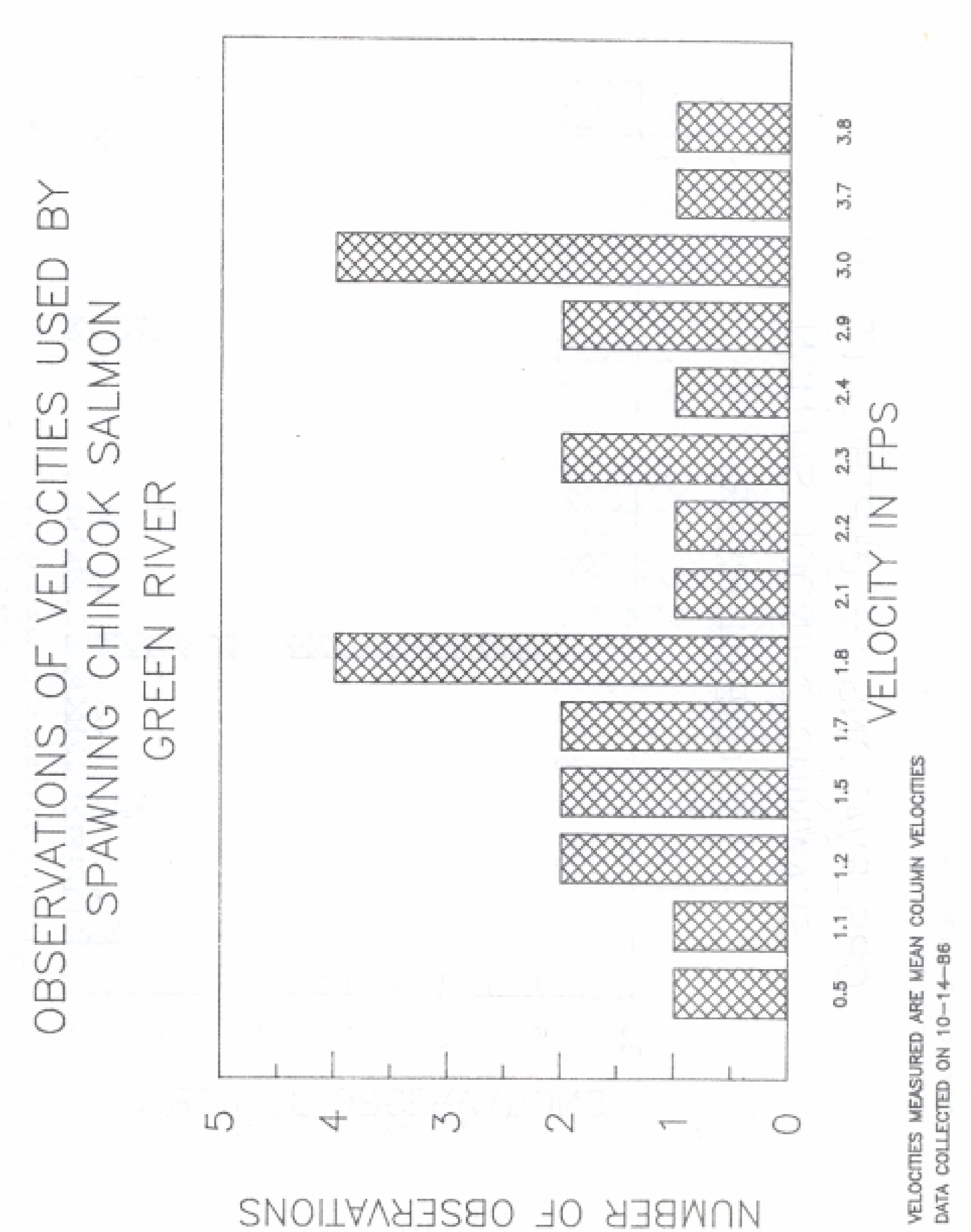
OBSERVATIONS OF DEPTH USED BY
SPAWNING STEELHEAD TROUT
GREEN RIVER



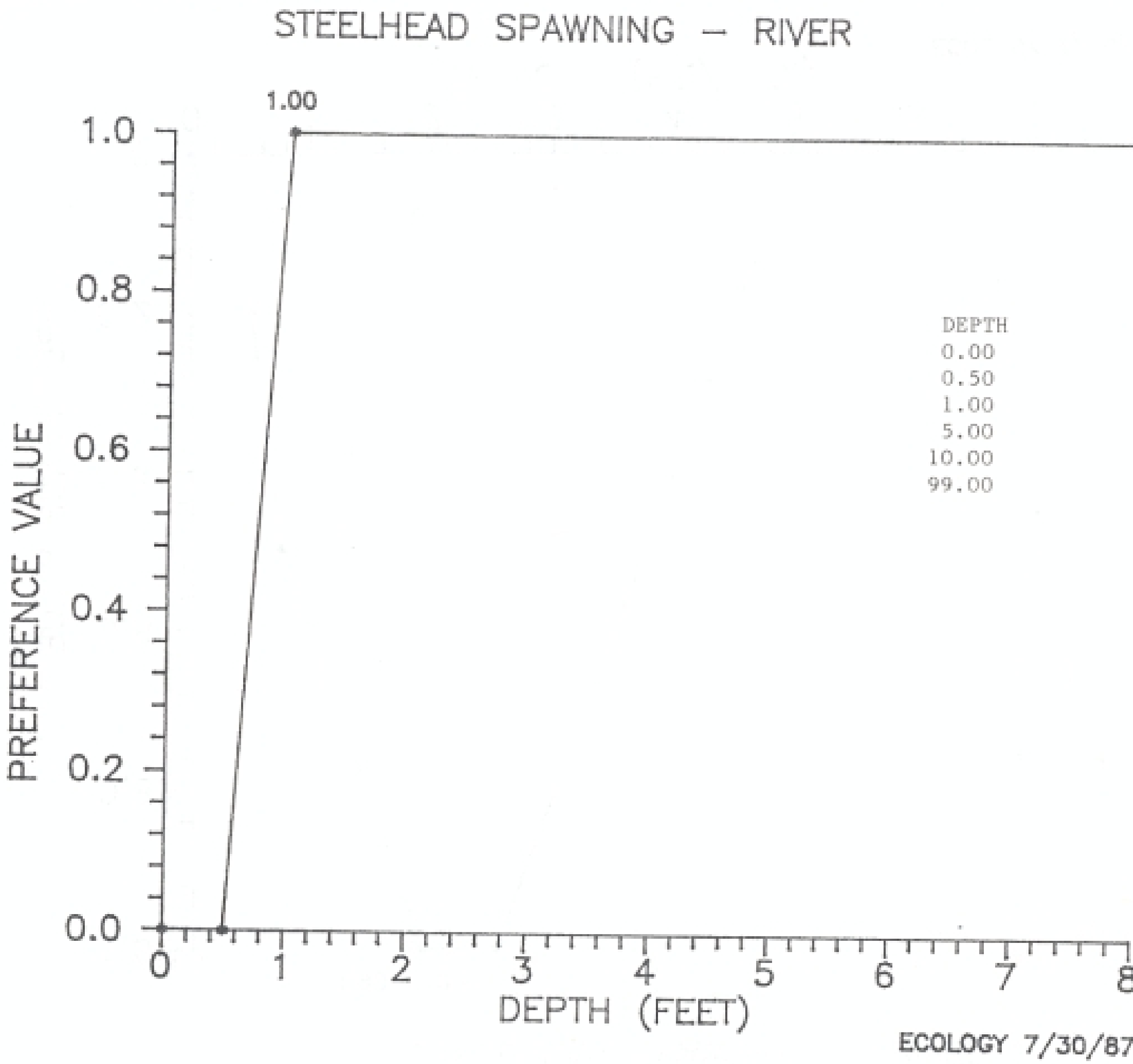
DATA COLLECTED ON 4-25-86, 5-9-86, & 5-5-88


OBSERVATIONS OF VELOCITIES USED BY
SPAWNING STEELHEAD TROUT
GREEN RIVER
NUMBER OF OBSERVATIONS
0
1
2
2.0 2.1 2.4 2.6 2.7 3.0 3.3 3.4 3.5 3.7 4.0
VELOCITY IN FPS
VELOCITIES MEASURED ARE MEAN COLUMN VELOCITIES
DATA COLLECTED ON 5-9-86 & 5-5-88

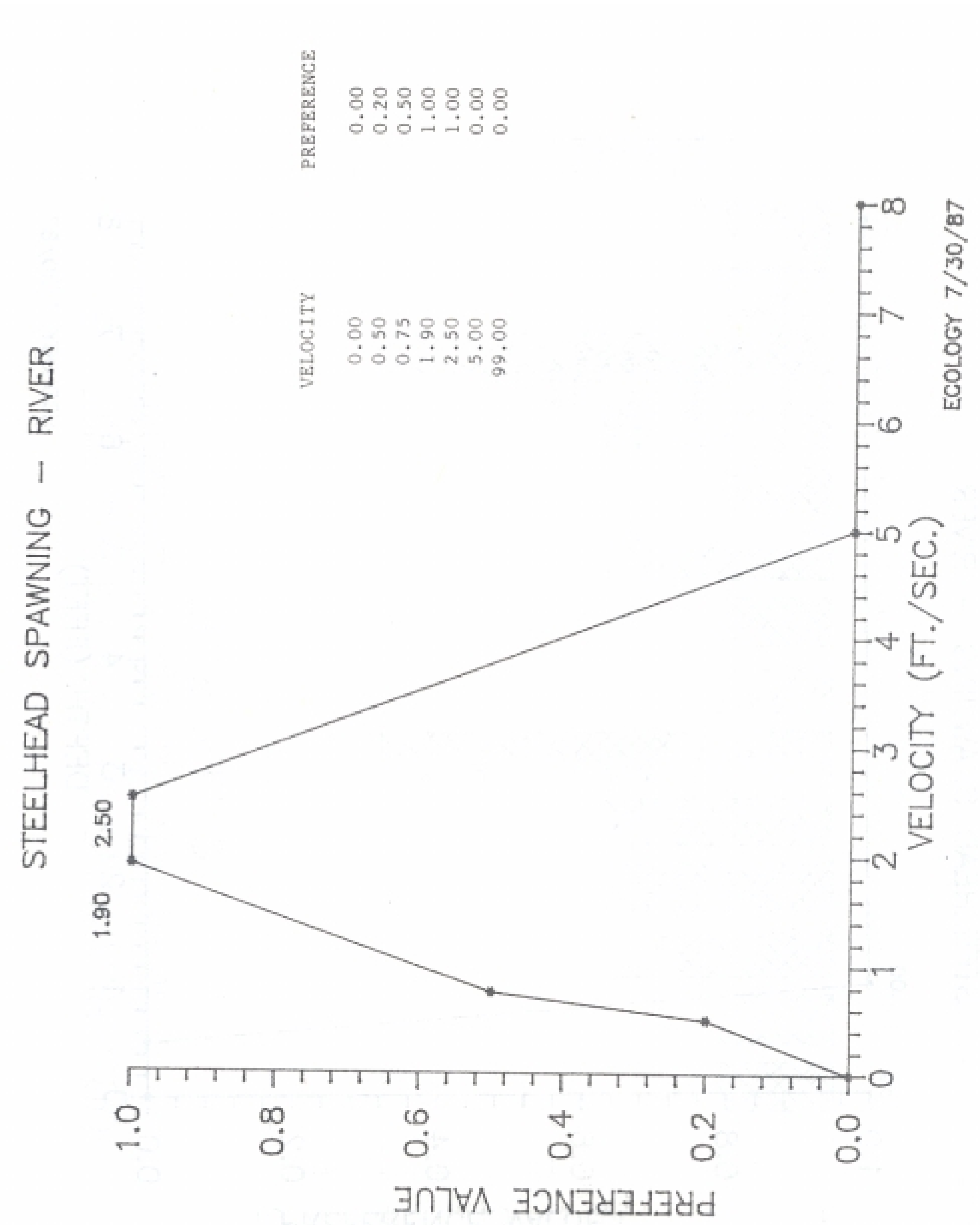

OBSERVATIONS OF DEPTH USED BY
SPAWNING CHINOOK SALMON
GREEN RIVER
NUMBER OF OBSERVATIONS
0
5
10
15
20
25
30
1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.9 2.0 2.1 2.3 2.8 3.0
6.0
9.0
DEPTH IN FEET
DATA COLLECTED ON 9-25-86 & 10-14-86

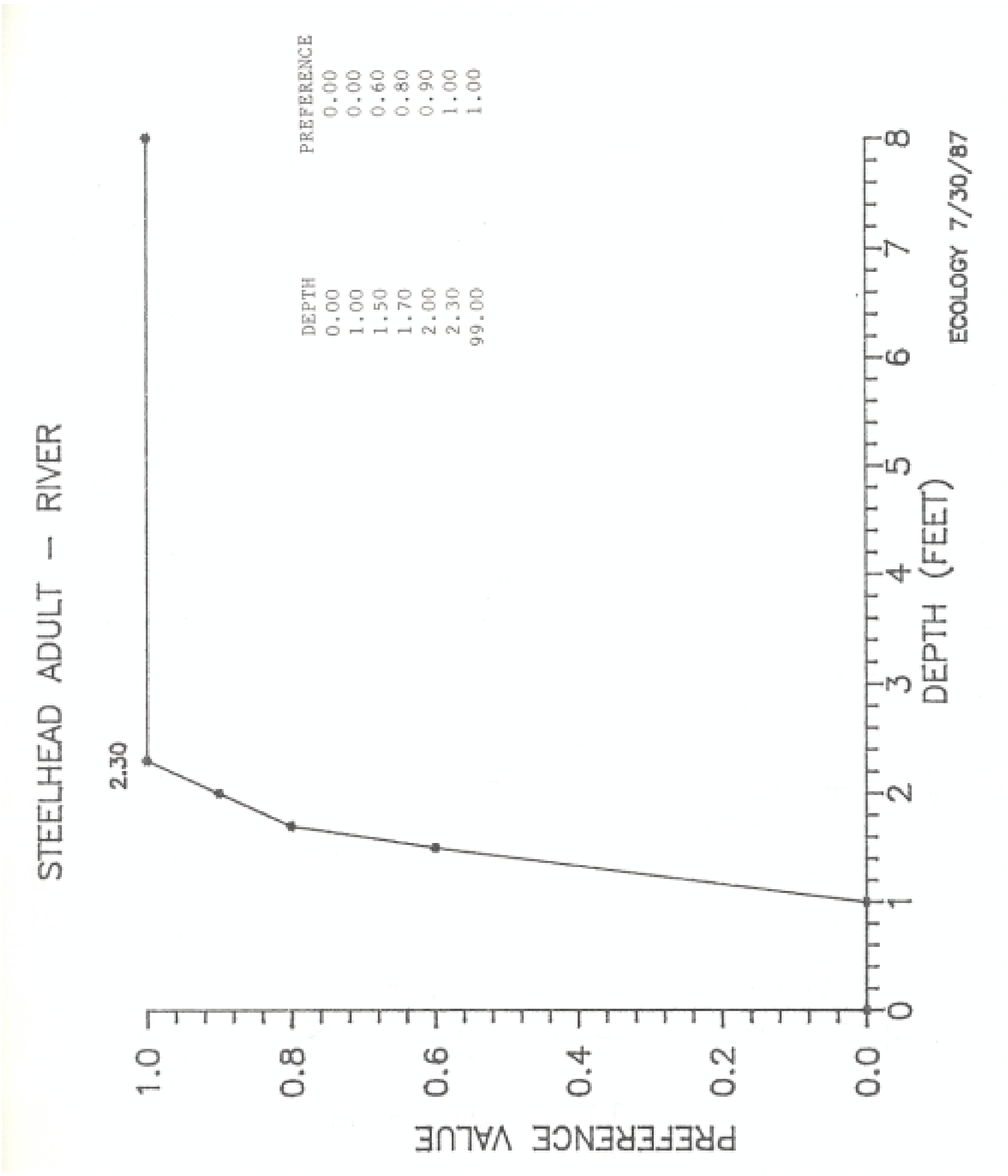

OBSERVATIONS OF VELOCITIES USED BY
SPAWNING CHINOOK SALMON
GREEN RIVER
NUMBER OF OBSERVATIONS
0
1
2
3
4
5
0.5
1.1
1.2
1.5
1.7
1.8
2.1
2.2
2.3
2.4
2.9
3.0
3.7
3.8
VELOCITY IN FPS
VELOCITIES MEASURED ARE MEAN COLUMN VELOCITIES
DATA COLLECTED ON 10-14-86

Appendix H4. Depth and Velocity Habitat-Use Curves

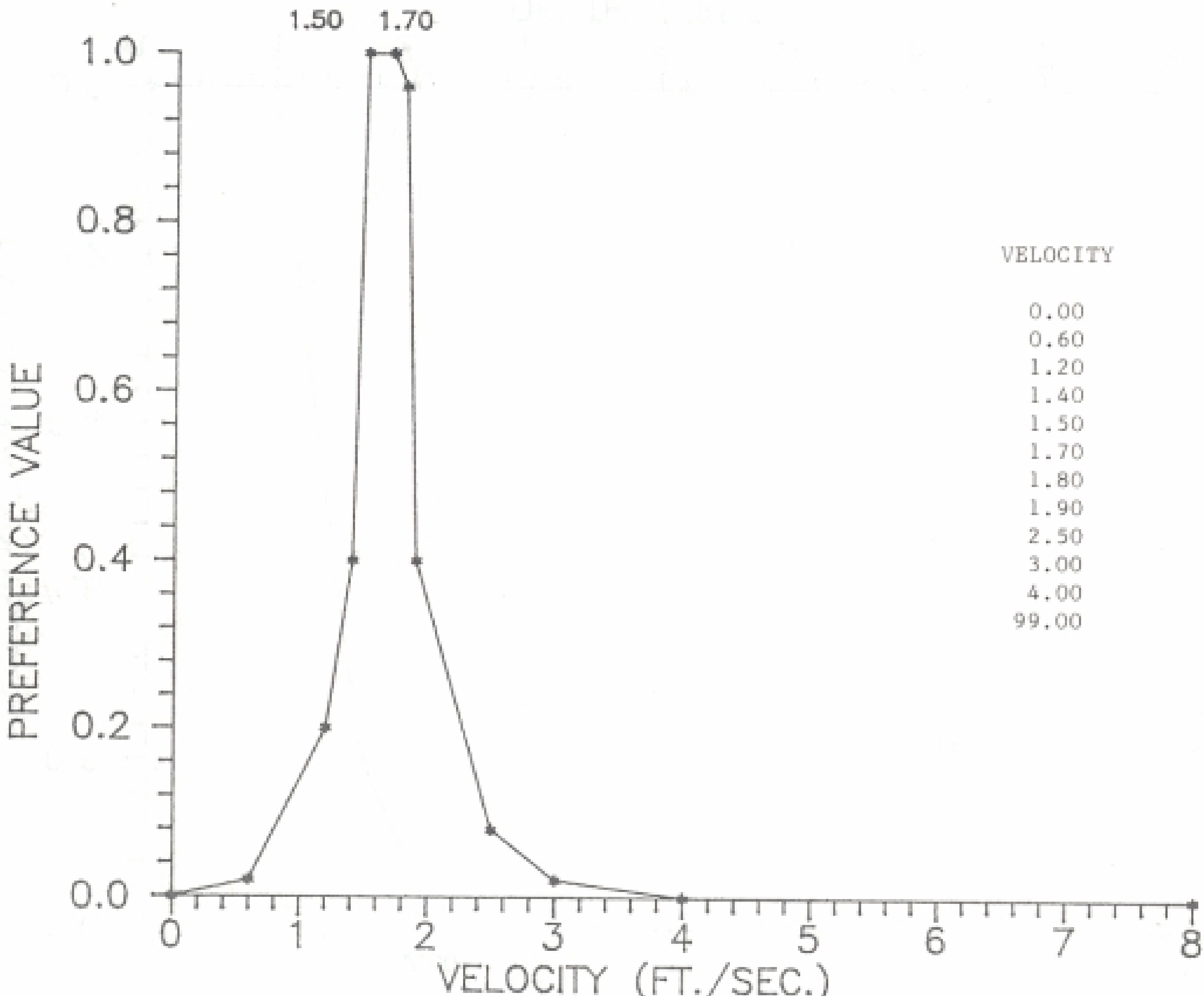


DEPTH	PREFERENCE
0.00	0.00
0.50	0.00
1.00	1.00
5.00	1.00
10.00	1.00
99.00	1.00


STEELHEAD SPAWNING — RIVER
1.90
2.50
PREFERENCE VALUE
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
8
VELOCITY (FT./SEC.)
VELOCITY
0.00
0.50
0.75
1.90
2.50
5.00
99.00
PREFERENCE
0.00
0.20
0.50
1.00
1.00
0.00
0.00
ECOLOGY 7/30/87

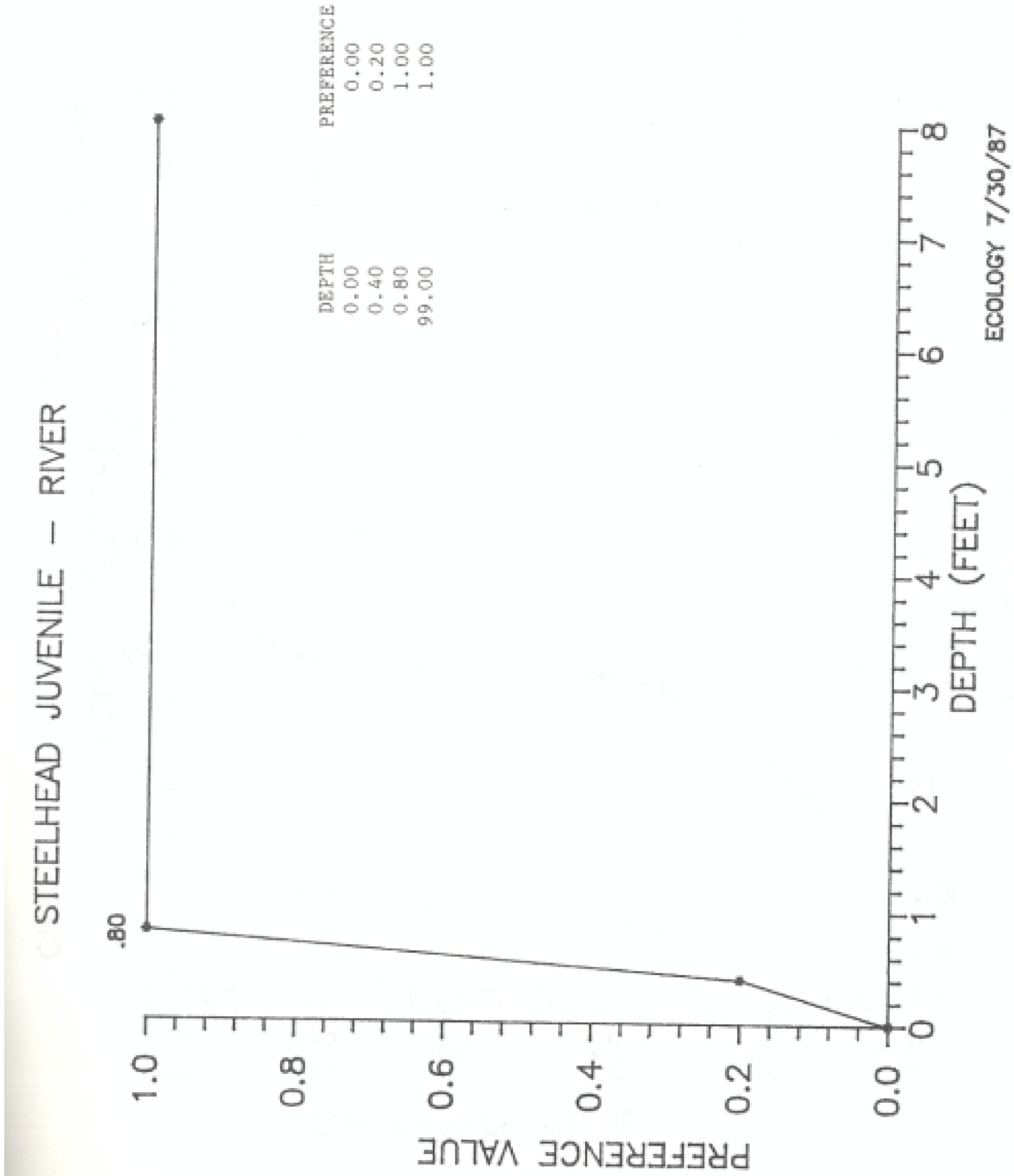

STEELHEAD ADULT — RIVER
2.30
PREFERENCE VALUE
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
8
DEPTH (FEET)
DEPTH PREFERENCE
0.00 0.00
1.00 0.00
1.50 0.60
1.70 0.80
2.00 0.90
2.30 1.00
99.00 1.00
ECOLOGY 7/30/87

STEELHEAD ADULT — RIVER

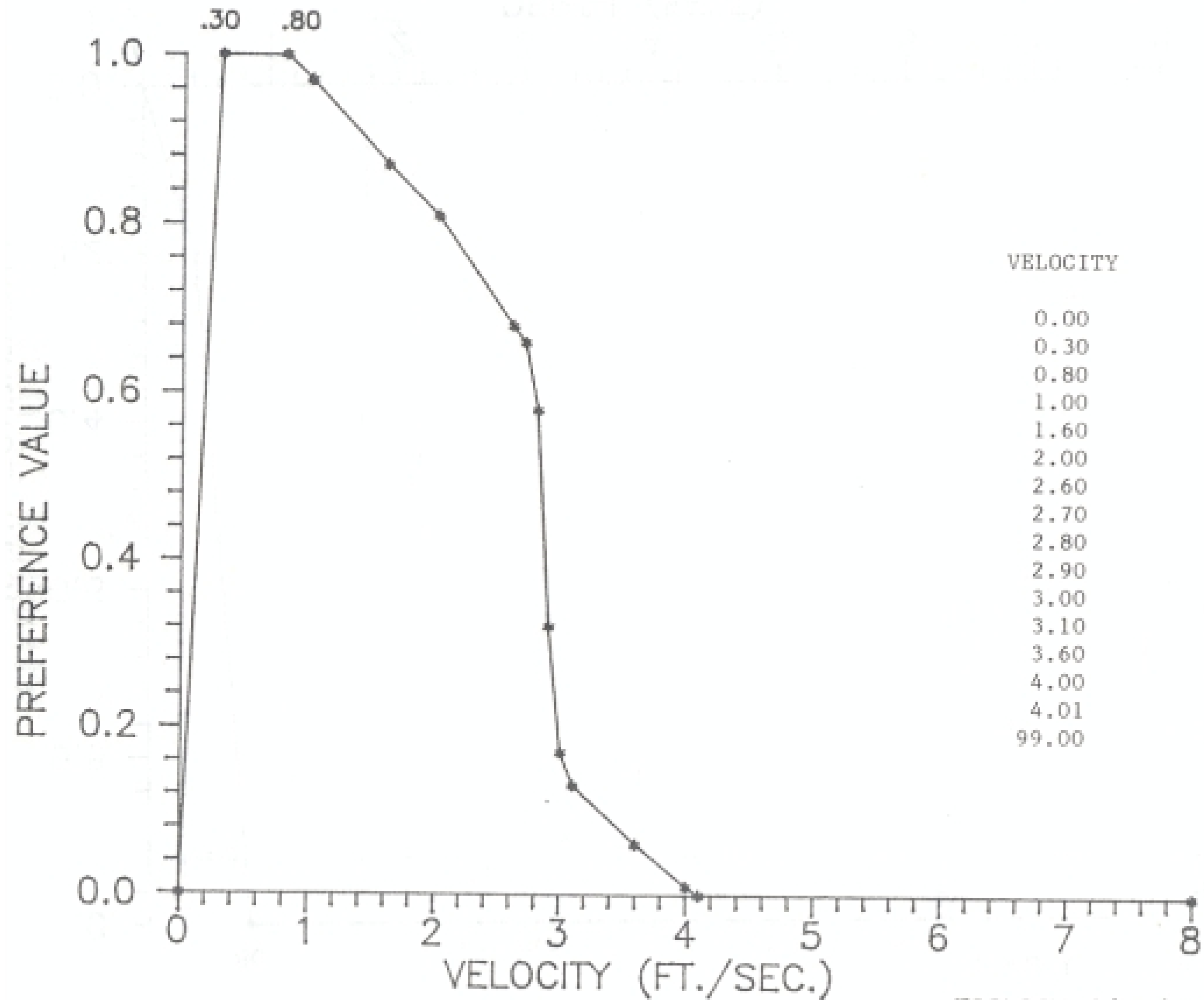


VELOCITY	PREFERENCE
0.00	0.00
0.60	0.02
1.20	0.20
1.40	0.40
1.50	1.00
1.70	1.00
1.80	0.96
1.90	0.40
2.50	0.08
3.00	0.02
4.00	0.00
99.00	0.00

ECOLOGY 7/30/87


STEELHEAD JUVENILE — RIVER
PREFERENCE VALUE
1.0
0.8
0.6
0.4
0.2
0.0
.80
0
1
2
3
4
5
6
7
8
DEPTH (FEET)
ECOLOGY 7/30/87
DEPTH PREFERENCE
0.00 0.00
0.40 0.20
0.80 1.00
99.00 1.00

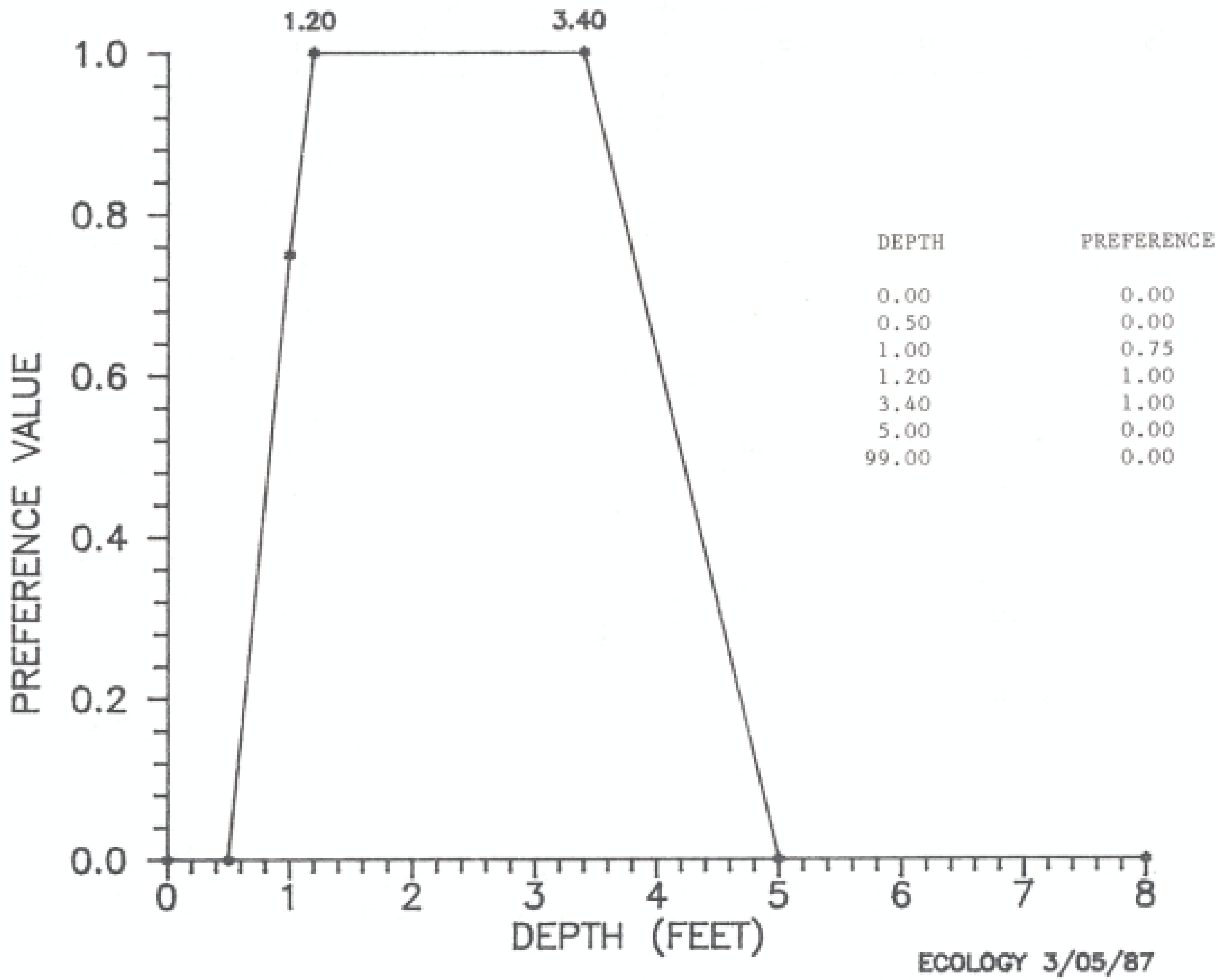
STEELHEAD JUVENILE — RIVER



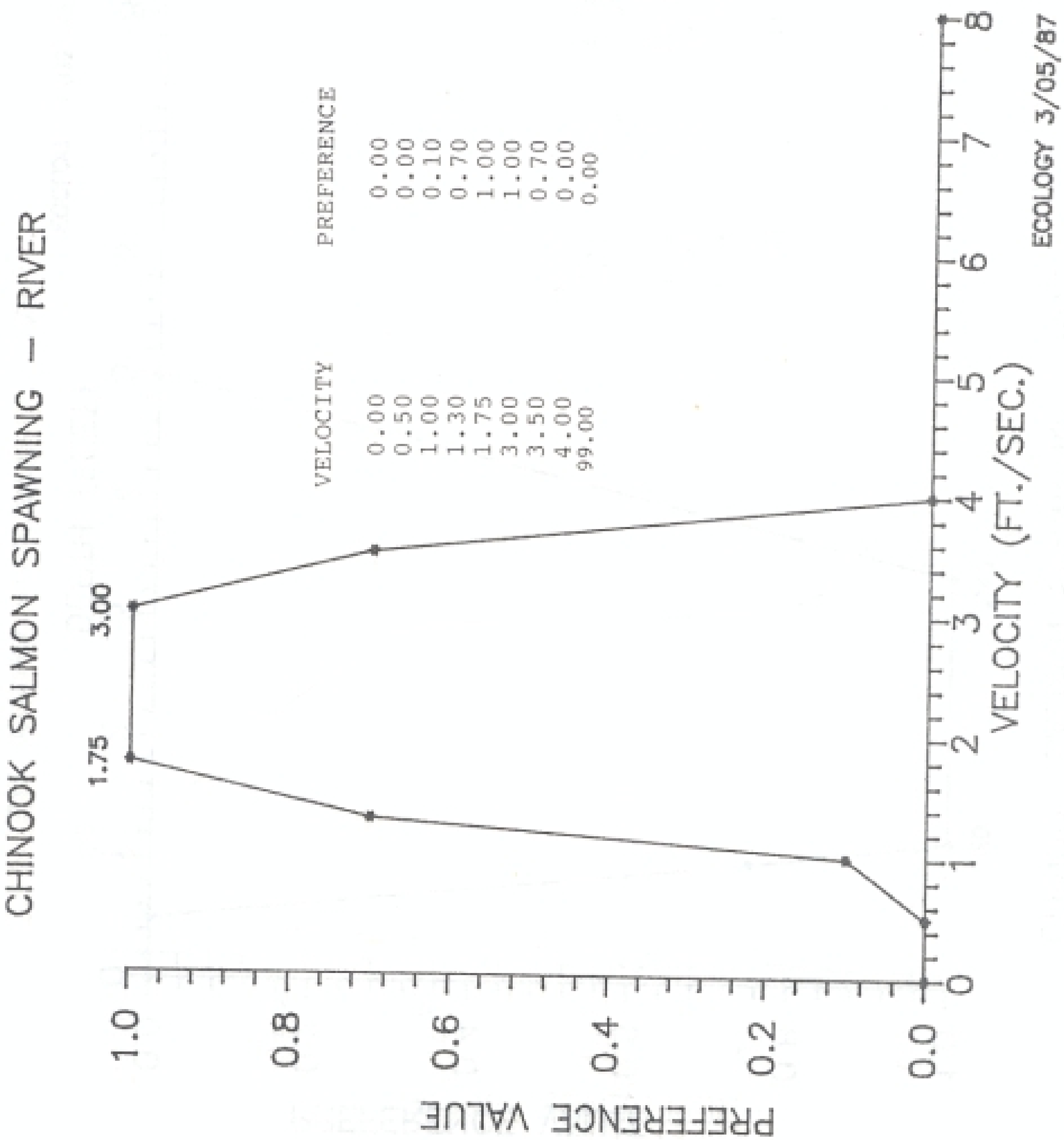
VELOCITY	PREFERENCE
0.00	0.00
0.30	1.00
0.80	1.00
1.00	0.97
1.60	0.87
2.00	0.81
2.60	0.68
2.70	0.66
2.80	0.58
2.90	0.32
3.00	0.17
3.10	0.13
3.60	0.06
4.00	0.01
4.01	0.00
99.00	0.00

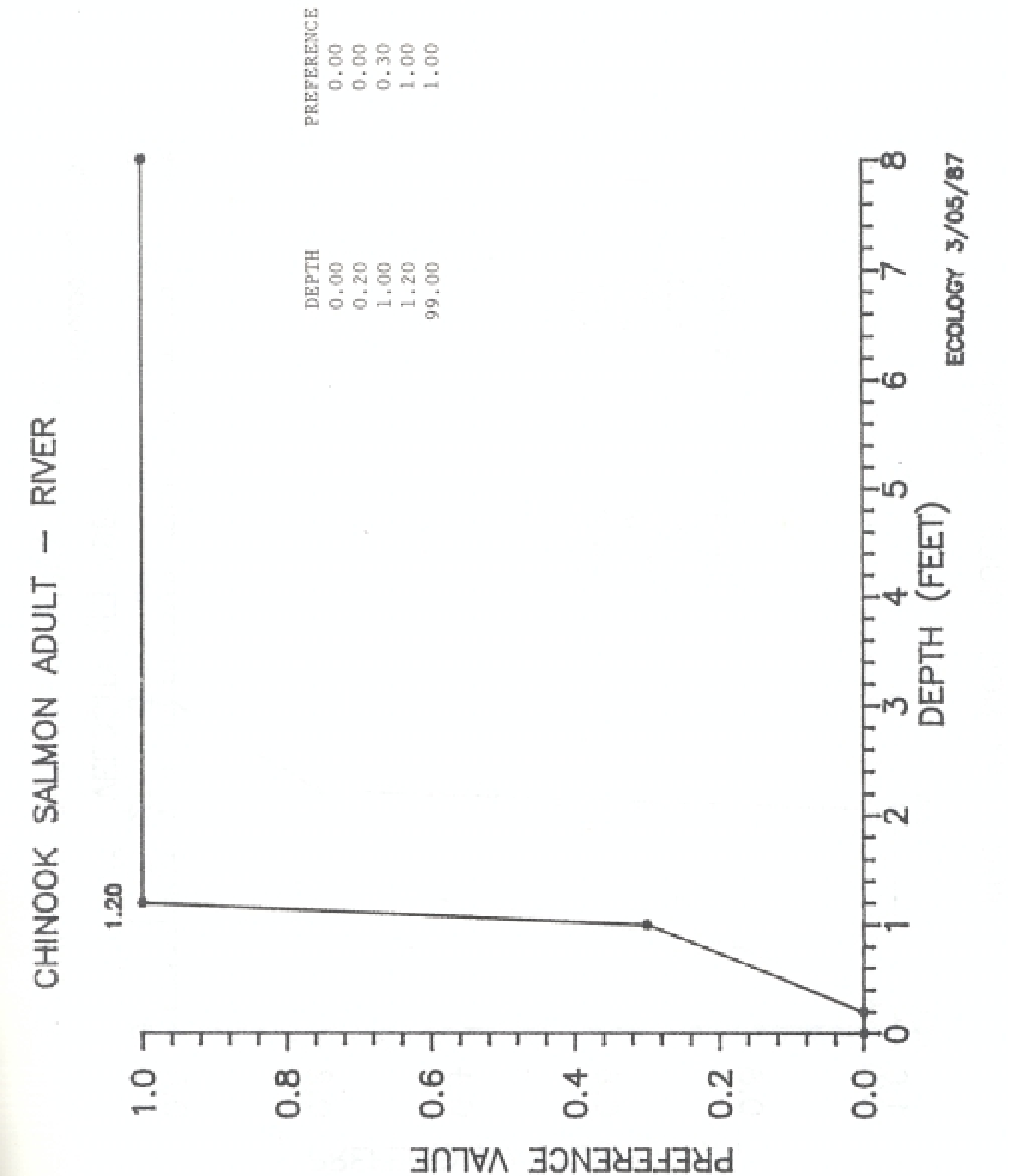
ECOLOGY 7/30/87

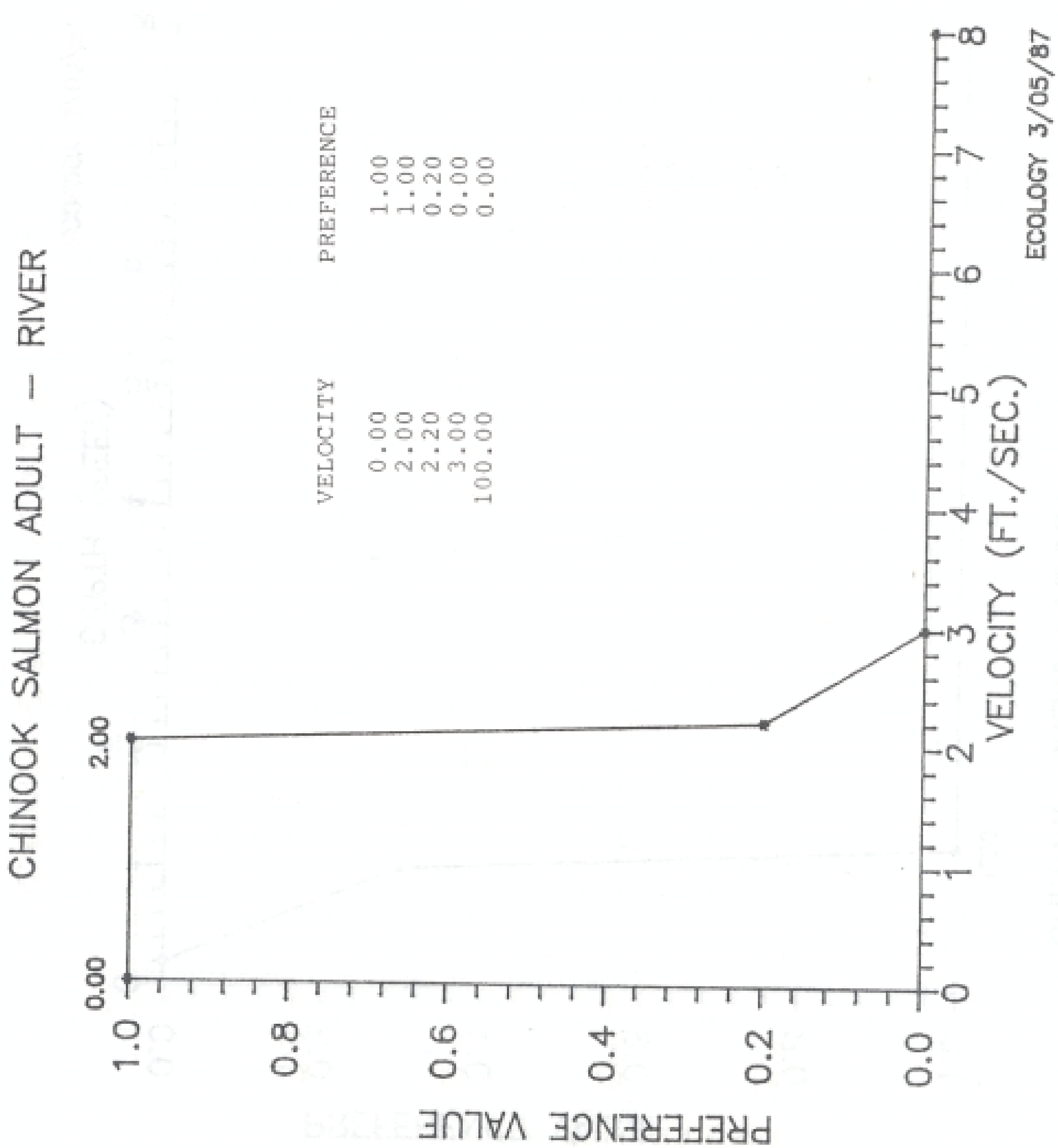
CHINOOK SALMON SPAWNING — RIVER



DEPTH	PREFERENCE
0.00	0.00
0.50	0.00
1.00	0.75
1.20	1.00
3.40	1.00
5.00	0.00
99.00	0.00

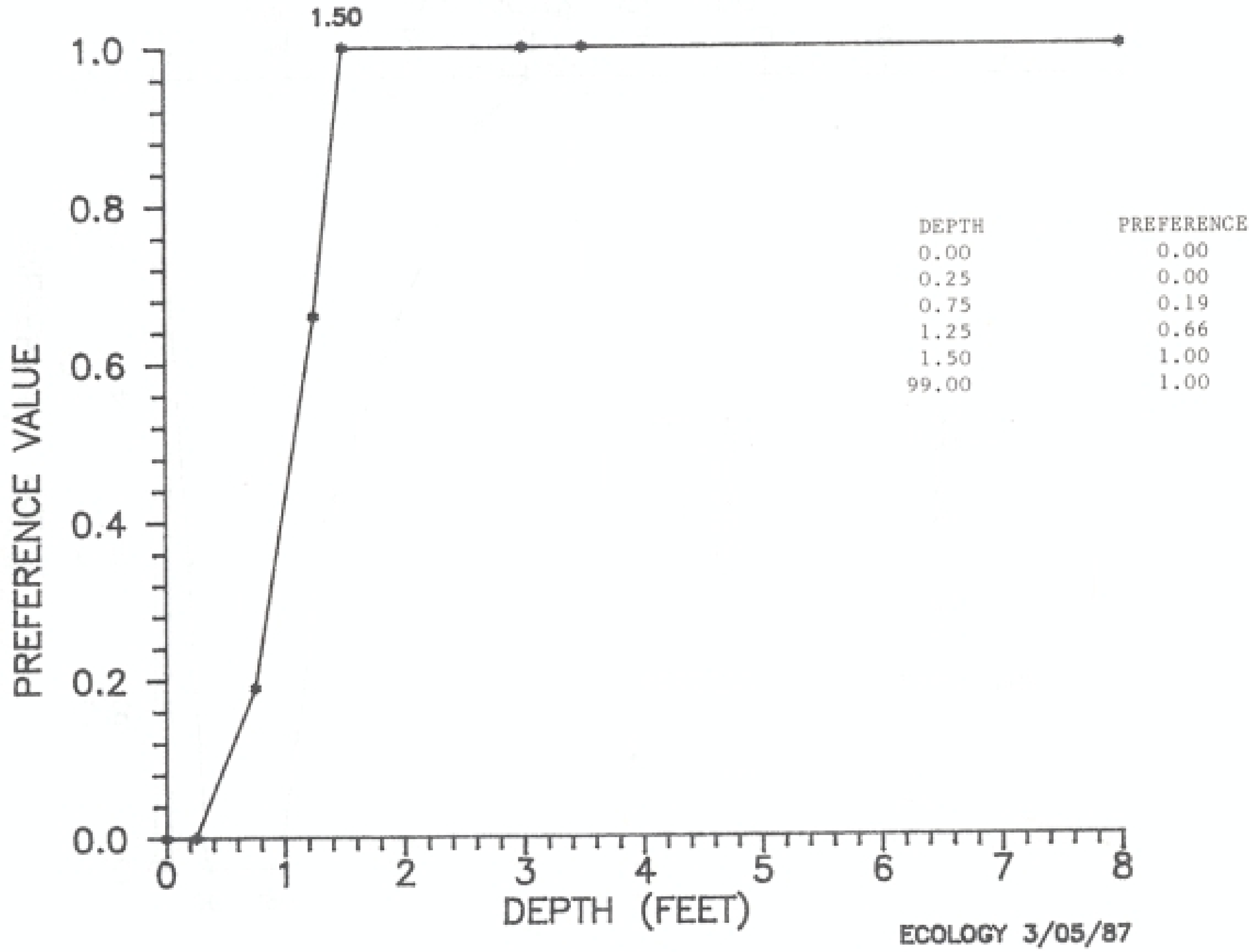

CHINOOK SALMON SPAWNING — RIVER
1.75
3.00
VELOCITY
0.00
0.50
1.00
1.30
1.75
3.00
3.50
4.00
99.00
PREFERENCE
0.00
0.00
0.10
0.70
1.00
1.00
0.70
0.00
0.00
PREFERENCE VALUE
VELOCITY (FT./SEC.)
ECOLOGY 3/05/87

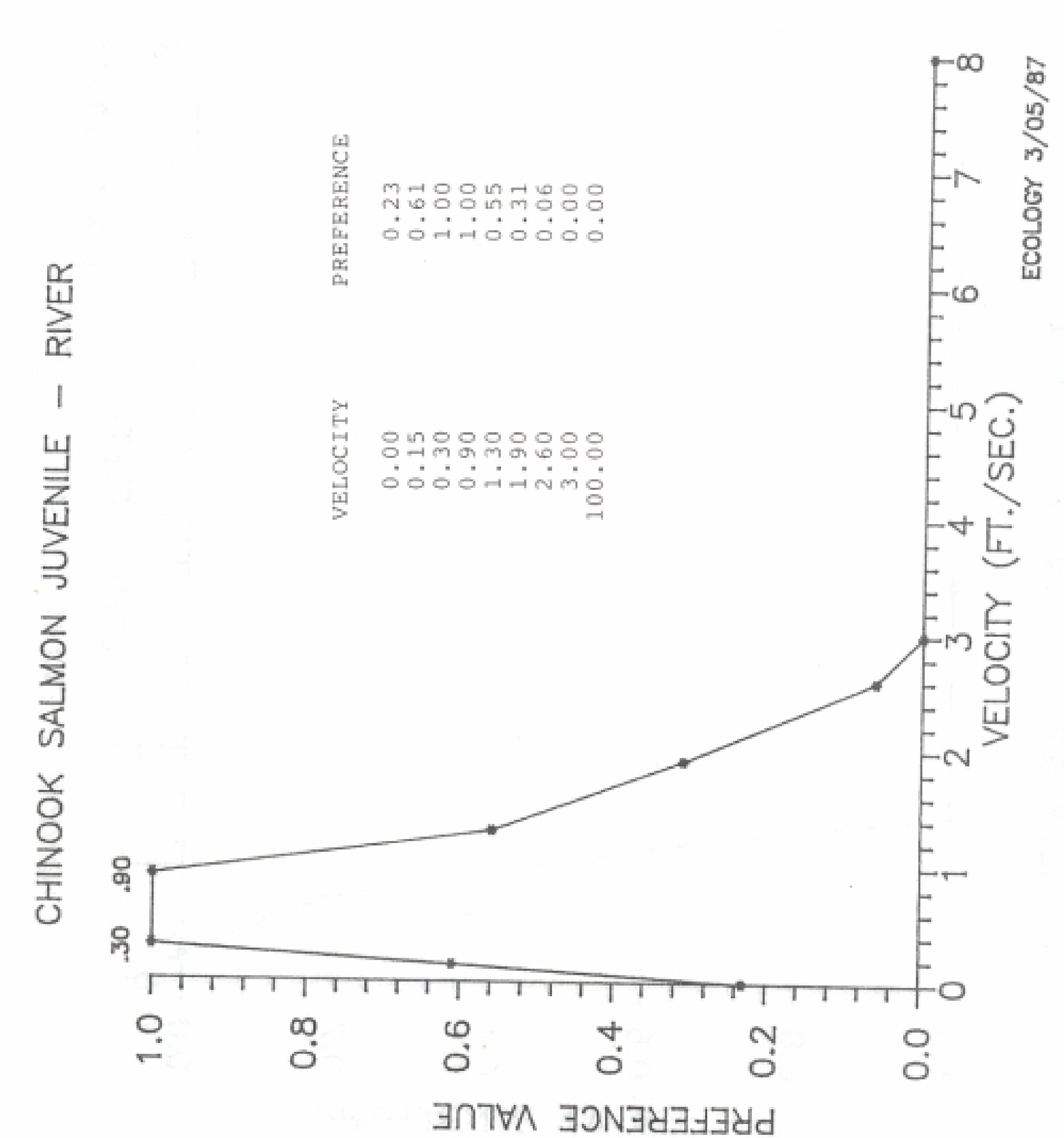

CHINOOK SALMON ADULT — RIVER
PREFERENCE VALUE
1.0
0.8
0.6
0.4
0.2
0.0
1.20
0
1
2
3
4
5
6
7
8
DEPTH (FEET)
DEPTH
0.00
0.20
1.00
1.20
99.00
PREFERENCE
0.00
0.00
0.30
1.00
1.00
ECOLOGY 3/05/87

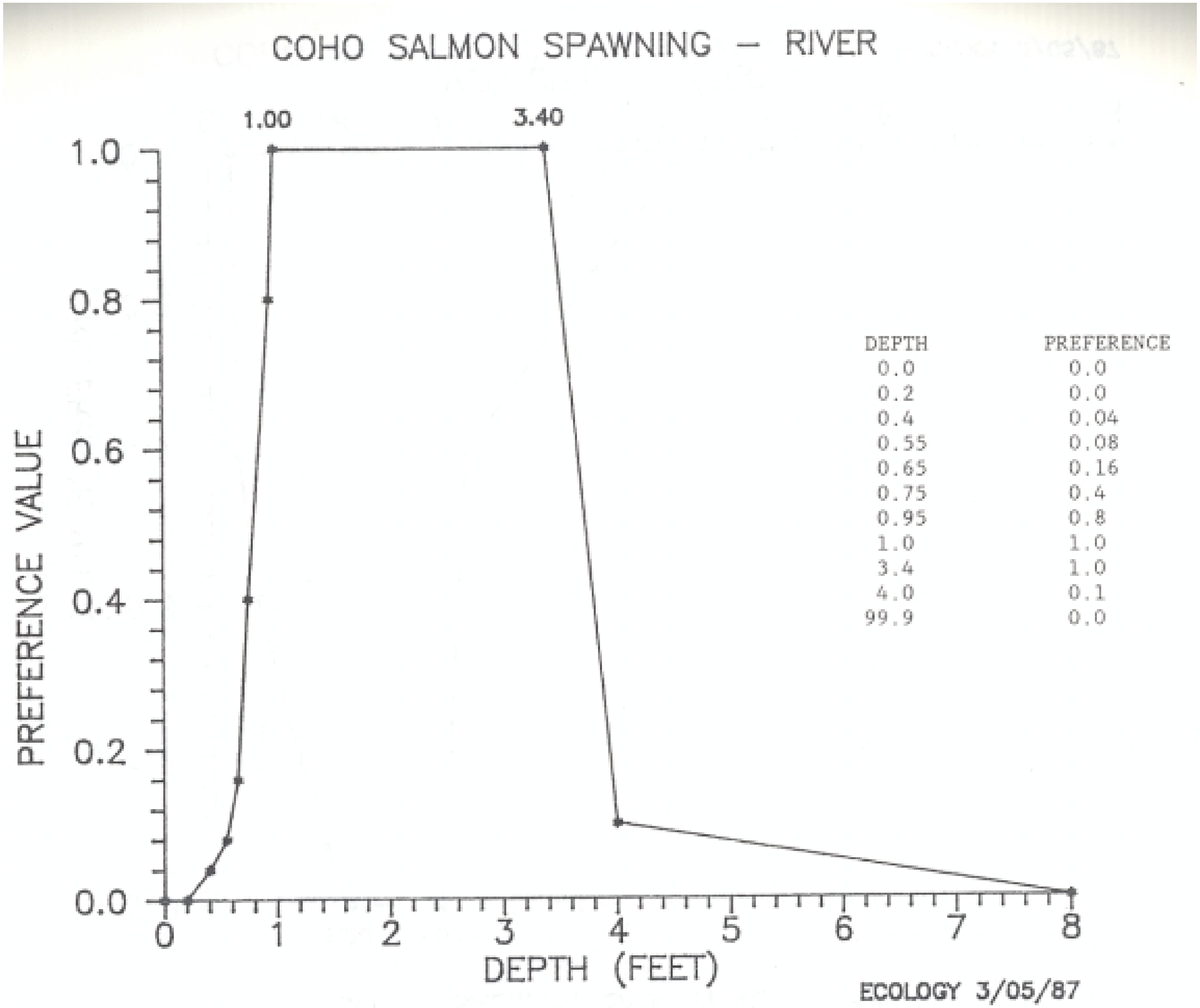


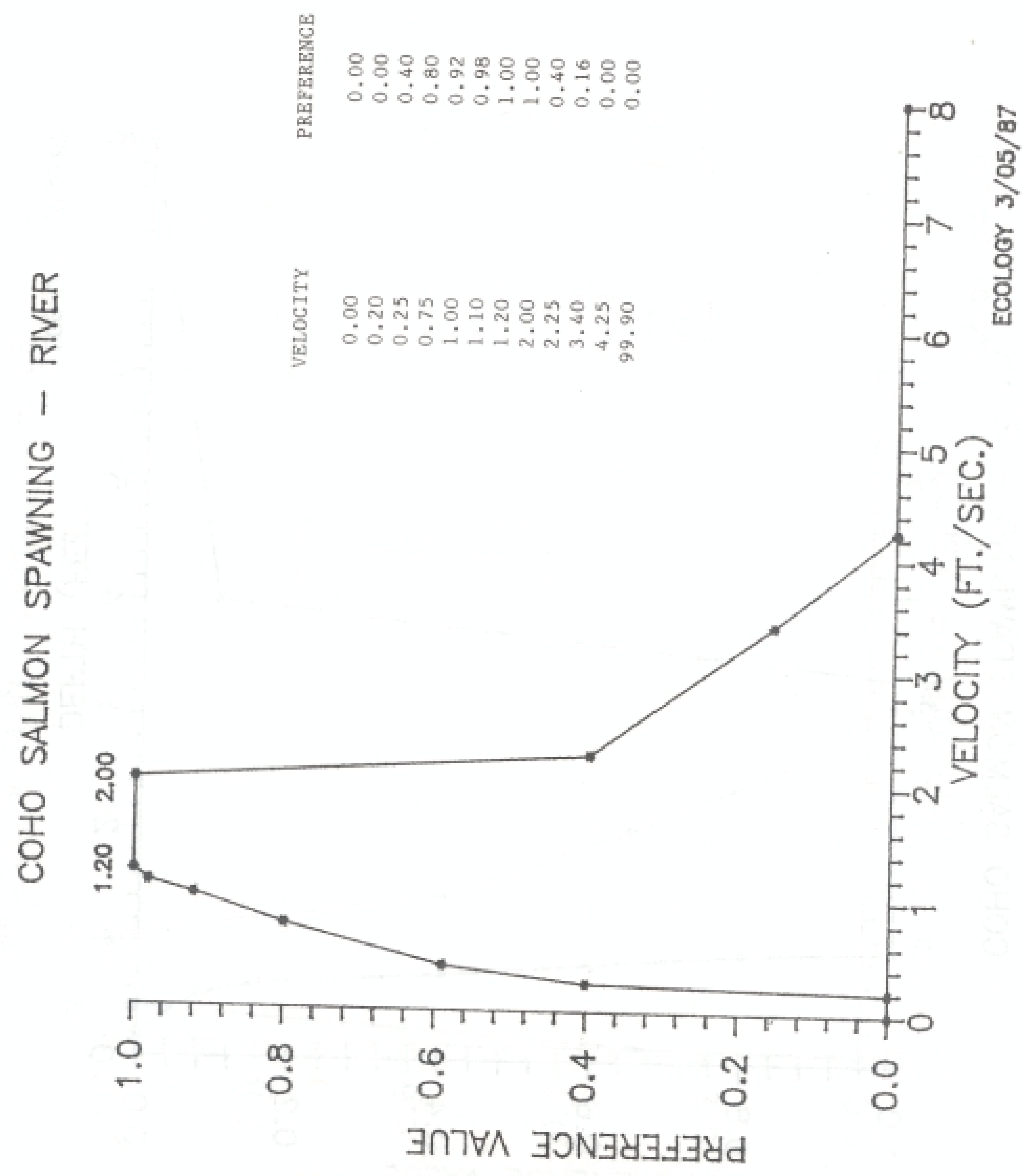
CHINOOK SALMON ADULT — RIVER
VELOCITY
0.00
2.00
2.20
3.00
100.00
PREFERENCE
1.00
1.00
0.20
0.00
0.00
0.00
2.00
PREFERENCE VALUE
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
8
VELOCITY (FT./SEC.)
ECOLOGY 3/05/87

CHINOOK SALMON JUVENILE — RIVER

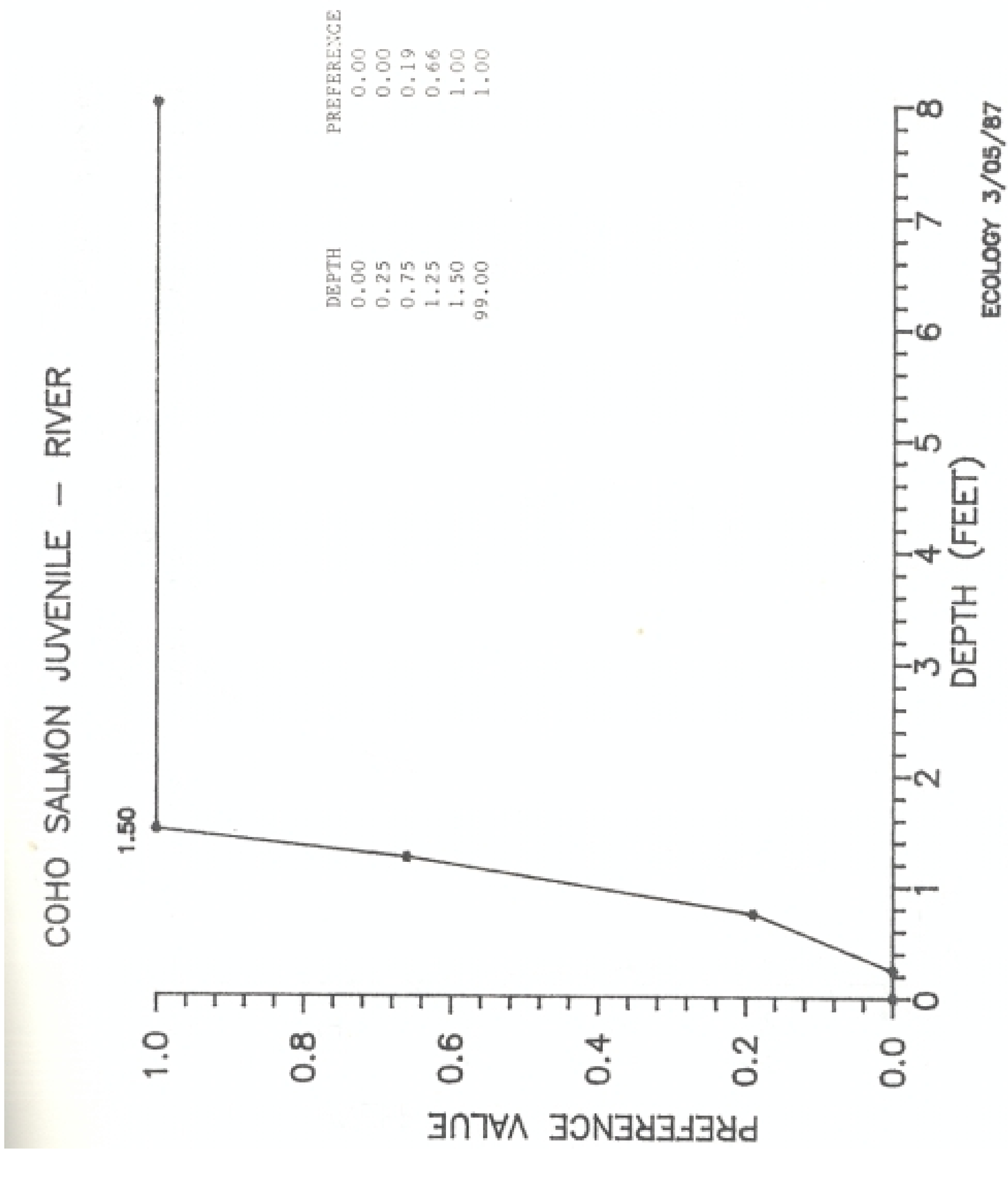



CHINOOK SALMON JUVENILE — RIVER
VELOCITY PREFERENCE
0.00 0.23
0.15 0.61
0.30 1.00
0.90 1.00
1.30 0.55
1.90 0.31
2.60 0.06
3.00 0.00
100.00 0.00
.30
.90
1.0
0.8
0.6
0.4
0.2
0.0
PREFERENCE VALUE
0 1 2 3 4 5 6 7 8
VELOCITY (FT./SEC.)
ECOLOGY 3/05/87

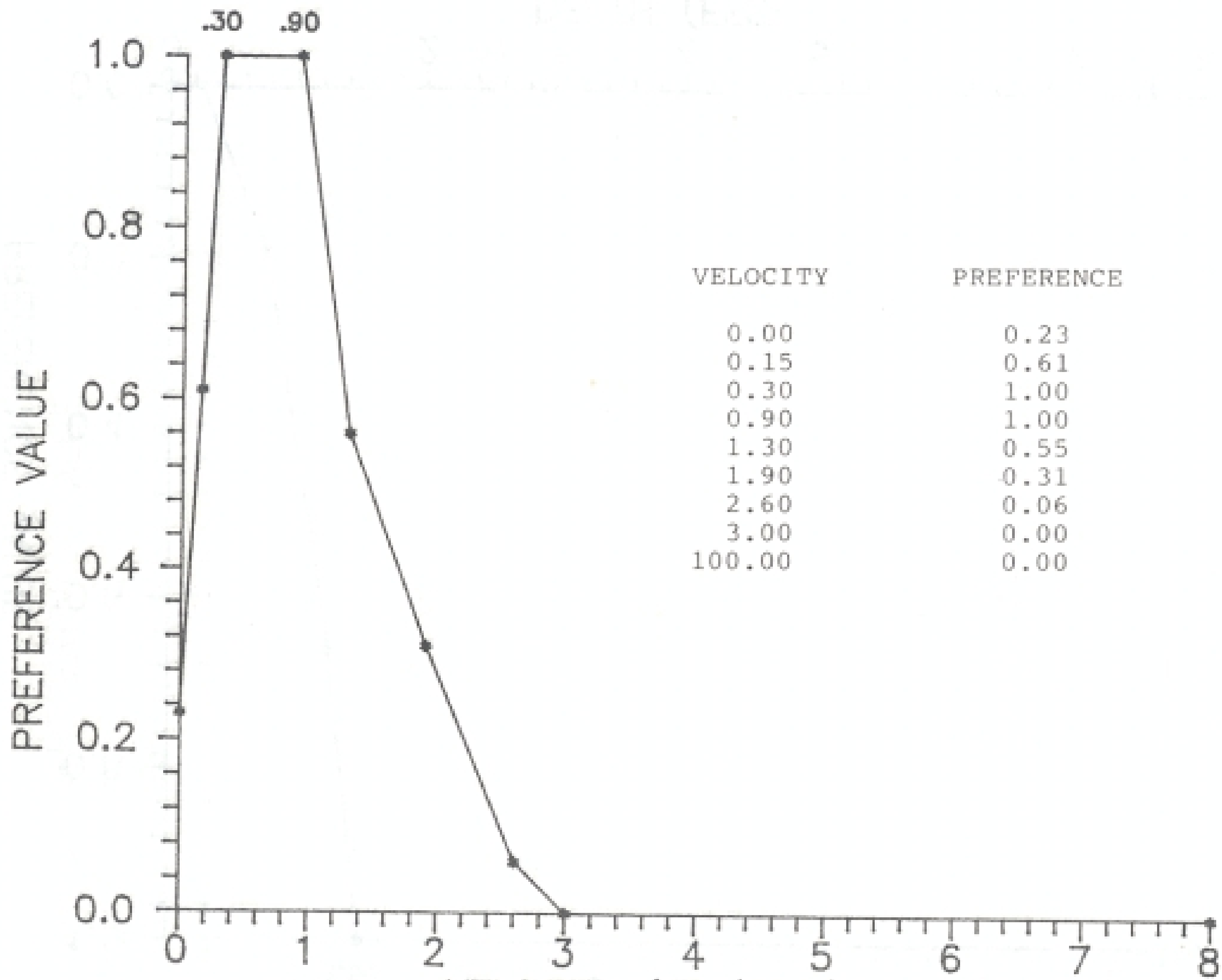

COHO SALMON SPAWNING – RIVER
1.00
3.40
PREFERENCE VALUE
1.0
0.8
0.6
0.4
0.2
0.0
DEPTH (FEET)
0
1
2
3
4
5
6
7
8
DEPTH PREFERENCE
0.0 0.0
0.2 0.0
0.4 0.04
0.55 0.08
0.65 0.16
0.75 0.4
0.95 0.8
1.0 1.0
3.4 1.0
4.0 0.1
99.9 0.0
ECOLOGY 3/05/87



VELOCITY	PREFERENCE
0.00	0.00
0.20	0.00
0.25	0.40
0.75	0.80
1.00	0.92
1.10	0.98
1.20	1.00
2.00	1.00
2.25	0.40
3.40	0.16
4.25	0.00
99.90	0.00

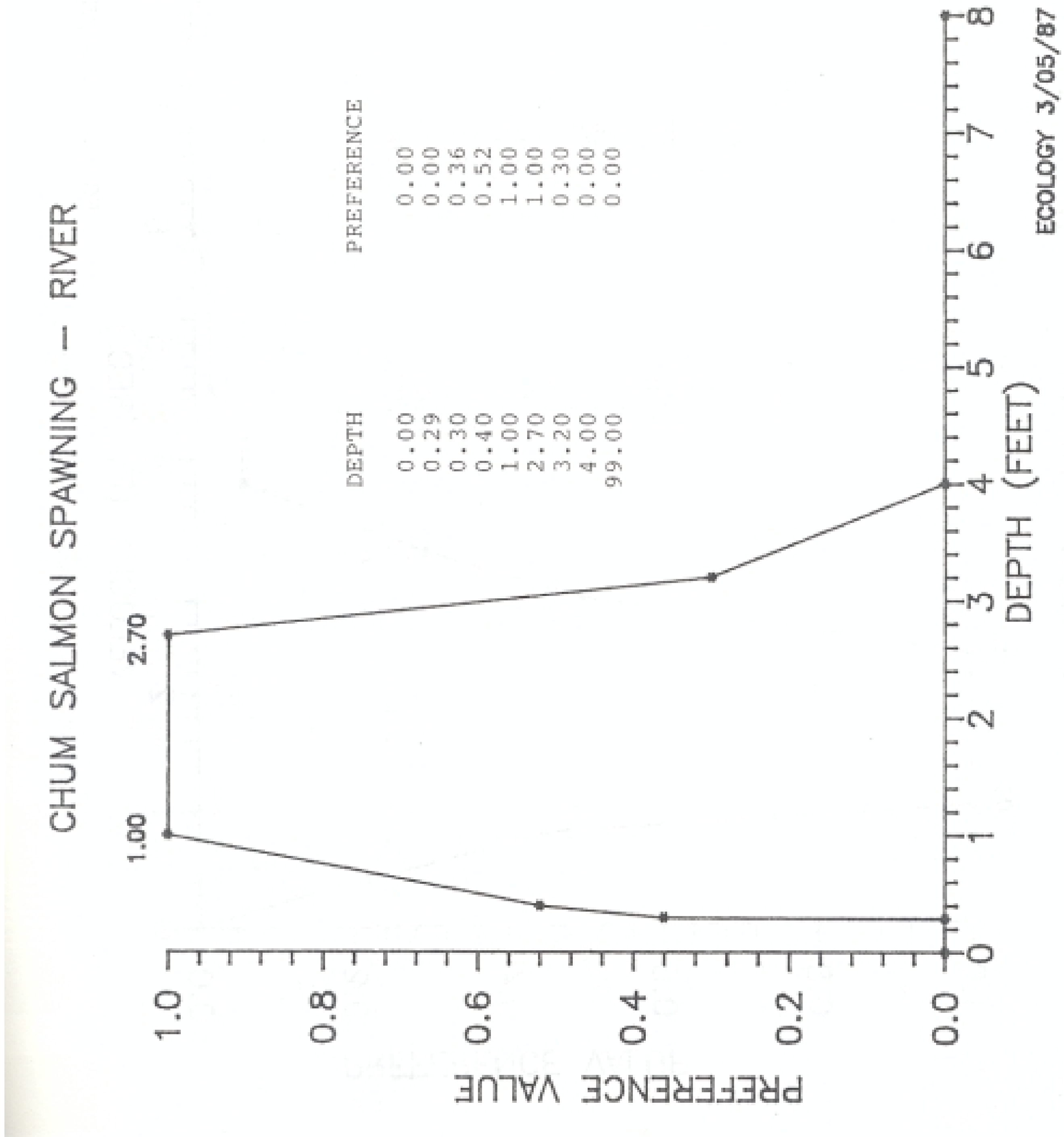

COHO SALMON JUVENILE — RIVER
1.50
PREFERENCE VALUE
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
8
DEPTH (FEET)
ECOLOGY 3/05/87
DEPTH PREFERENCE
0.00 0.00
0.25 0.00
0.75 0.19
1.25 0.66
1.50 1.00
99.00 1.00

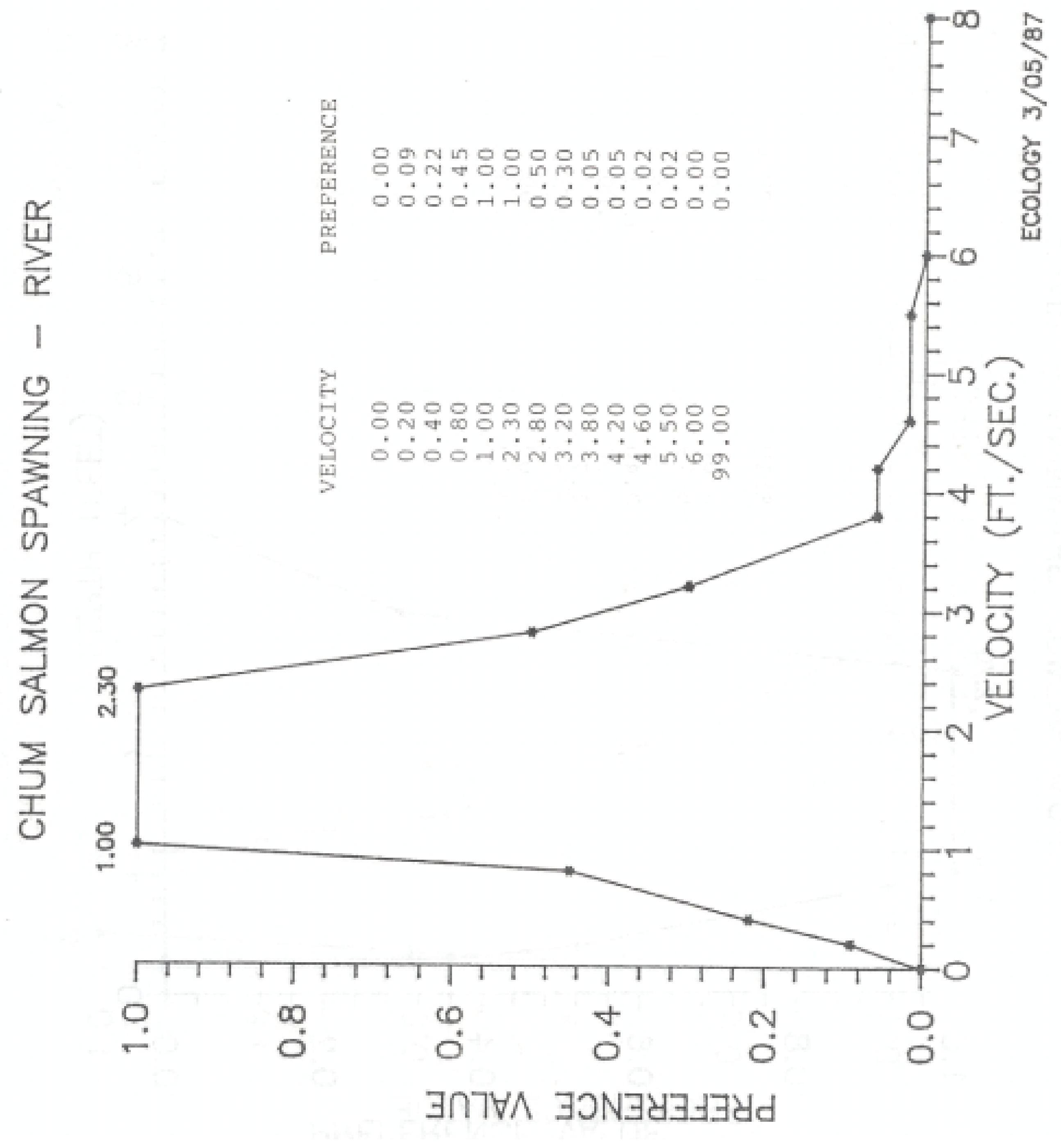
COHO SALMON JUVENILE — RIVER



VELOCITY	PREFERENCE
0.00	0.23
0.15	0.61
0.30	1.00
0.90	1.00
1.30	0.55
1.90	0.31
2.60	0.06
3.00	0.00
100.00	0.00

ECOLOGY 3/05/87


CHUM SALMON SPAWNING — RIVER
PREFERENCE VALUE
DEPTH (FEET)
1.00
2.70
DEPTH PREFERENCE
0.00 0.00
0.29 0.00
0.30 0.36
0.40 0.52
1.00 1.00
2.70 1.00
3.20 0.30
4.00 0.00
99.00 0.00
ECOLOGY 3/05/87


CHUM SALMON SPAWNING — RIVER
1.00
2.30
VELOCITY
0.00
0.20
0.40
0.80
1.00
2.30
2.80
3.20
3.80
4.20
4.60
5.50
6.00
99.00
PREFERENCE
0.00
0.09
0.22
0.45
1.00
1.00
0.50
0.30
0.05
0.05
0.02
0.02
0.00
0.00
PREFERENCE VALUE
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
8
VELOCITY (FT./SEC.)
ECOLOGY 3/05/87

Appendix H5. Substrate/Cover Code.

DEPARTMENTS OF FISHERIES & WILDLIFE
INSTREAM FLOW STUDIES SUBSTRATE AND COVER CODE APPLICATION 11/23/87

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 subdominant substrate can be determined by subtraction. Dominant substrate is determined by the largest quantity of a certain substrate, not by the size of the substrate. The sum of the percent dominant and the percent subdominant 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

CODE	Substrate Size In Inches	SALMON Juvenile Rearing	SALMON Spawning	SALMON Adult Holding	STEELHEAD & TROUT Spawning Steelhead	STEELHEAD & TROUT Spawning Trout	STEELHEAD & TROUT Rearing/Holding Juvenile & Adult	STEELHEAD & TROUT Rearing/Holding 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	.8
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 I

INFLOWS FOR THE KENT, NEALY BRIDGE, AND CAR BODY SITES

Appendix I. Inflows for the Kent, Nealy Bridge, and Car Body sites
(Ten-day, 50% exceedence flows).

Month		Kent Site Inflow in cfs	Nealy Bridge and Car Body Sites Inflow in cfs
January	1-10	767	541
	11-20	718	518
	21-31	746	520
February	1-10	735	511
	11-20	624	395
	21-28	638	428
March	1-10	555	367
	11-20	500	325
	21-31	431	261
April	1-10	521	365
	11-20	558	406
	21-30	379	239
May	1-10	271	155
	11-20	303	206
	21-31	286	201
June	1-10	295	220
	11-20	274	207
	21-30	254	197
July	1-10	235	184
	11-20	224	181
	21-31	178	140
August	1-10	158	126
	11-20	161	130
	21-31	158	127
September	1-10	157	126
	11-20	151	118
	21-30	161	129
October	1-10	148	112
	11-20	167	128
	21-31	118	75
November	1-10	148	95
	11-20	289	215
	21-30	355	226
December	1-10	436	270
	11-20	546	376
	21-31	700	505

These statistics are ten-day averages (Log Pearson) from 1962-1986 from USGS gage data. The Kent site inflow was calculated by subtracting the flows at the Purification Plant gage from the flows at the Auburn gage. The inflows at the Nealy Bridge and Car Body sites were calculated by adding flows at the Purification Plant gage and the Big Soos Creek gage and subtracting this total from the flows at the Auburn gage.

Appendix J

LITERATURE CITED

LITERATURE CITED

Bovee, K.D., 1982. A Guide to Stream Habitat Analysis using the Instream Flow Incremental Methodology. Instream Flow Paper 12. U.S. Fish and Wildlife Service, Fort Collins, Colorado. FWS/OBS-82/26.

Caldwell, B.A., and Caldwell, J., 1987. Documentation and Rationale for Preference Curves used 1983-1987 for IFIM Studies. Habitat Management Division, Washington Department of Fisheries, Olympia, Washington.

Chapman, D.W., 1984. Hydrographs and Instream Flow Requirements for Fish: Green, Cedar and White Rivers. Report to the Muckleshoot Indian Tribe, Auburn, Washington.

Grette, G.B., and Salo, E.O., 1986. The Status of Anadromous Fishes of the Green/Duwamish River System. Final Report to U.S. Army Corps of Engineers by Evans-Hamilto Inc., Seattle, Washington.

Milhous, R.T. et al. 1984. User's 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.

Swift III, C.H., 1979. Preferred Stream Discharges for Salmon Spawning and Rearing in Washington. Open-File Report 77-422. U.S. Geological Survey, Tacoma, Washington.

Washington Department of Natural Resources, 1981. Draft Aquatic Land Management Plan for the Duwamish-Green River. Division of Marine Land Management, Olympia, Washington.

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 K

ECOLOGY’S MISSION STATEMENT

OUR MISSION

WASHINGTON STATE DEPARTMENT OF ECOLOGY

The mission of the Department of Ecology is to protect, preserve and enhance Washington's environment and promote the wise management of our air, land and water for the benefit of current and future generations.

To accomplish this mission, Ecology will:

- Recognize its most valuable asset is its dedicated and committed employees and it will provide necessary support, training and professional development.
- Promote prevention and conservation as the most effective ways to preserve our natural resources and protect the environment.
- Enforce environmental laws and regulations in a fair and firm manner.
- Provide public education programs to promote wise use of our natural resources and encourage environmental protection.

[illegible]

- Offer information, technical and financial assistance to help the public, governments, businesses and industries comply with environmental laws and regulations.
- Promote the recognition that compliance with environmental laws and regulations is compatible with a sound economy.

WASHINGTON STATE DEPARTMENT OF ECOLOGY

- Promote meaningful public involvement in the development of rules, regulations and new initiatives.
- Provide leadership in addressing emerging problems and strive to bring public agencies and diverse interest groups together to address environmental issues.
- Use an integrated approach to resolve environmental issues.
- Place special emphasis on educating and working with youth to create a strong environmental ethic.
- Help state agencies set an example in environmental protection.
- Work with the executive and legislative branches to promote sound environmental policy.

Adopted [illegible]