A length frequency histogram was prepared to illustrate the size distribution of rainbow trout in the lower Hood River study area (Figure 3.1-2), the most common resident salmonid species in the study area. Although both adult and juvenile rainbow trout were captured in all 3 study reaches, most captured fish measured less than 130 mm in length. A size class mode was evident at about 100 mm, most likely corresponding to 0+ fish. Modes for larger size classes were not distinct.

Fulton-type condition factors were calculated for 27 of the 45 rainbow trout captured. In this analysis, condition factors were used as an overall indicator of "fitness" such that fish with high condition factors were relatively heavy per unit body length. Condition factors for 27 of the captured rainbow trout ranged from 1.2 to 2.2, with an average of 1.5. Generally salmonids with a condition factor of greater than 1.0 are considered to be in good condition or "fit." The rainbow trout captured in the study area were extremely fit and had above average condition factors for the state of Oregon (Carlander 1953). The high condition factors found in rainbow trout in the study area may be the result of relatively low salmonid densities, excellent habitat, or high food supply. Results of the macroinvertebrate study (Section 2.7) would suggest the former rather than the latter factors to be the cause of the high condition factors.

3.2 INSTREAM FLOW STUDY

The Powerdale Project provides minimum instream flows in the bypass reach for anadromous salmonid passage, spawning, and juvenile rearing. These flows were established based on results of instream flow studies using the Oregon Method, conducted between 1964 and 1966 (ODFW 1965 and 1968).

During First Stage Consultation, resource agencies expressed concern that minimum bypass flows established for the summer period may not provide sufficient passage depths at specific areas (described below) in the bypass reach, and may impede upstream migration of anadromous adult salmonids. Minimum flow requirements defined in the current project FERC license are:

Period	Minimum Flows
February 1 to April 30	270 cfs
May 1 to June 30	170 cfs
July 1 to July 31	130 cfs
August 1 to November 30	100 cfs
December 1 to January 31	170 cfs

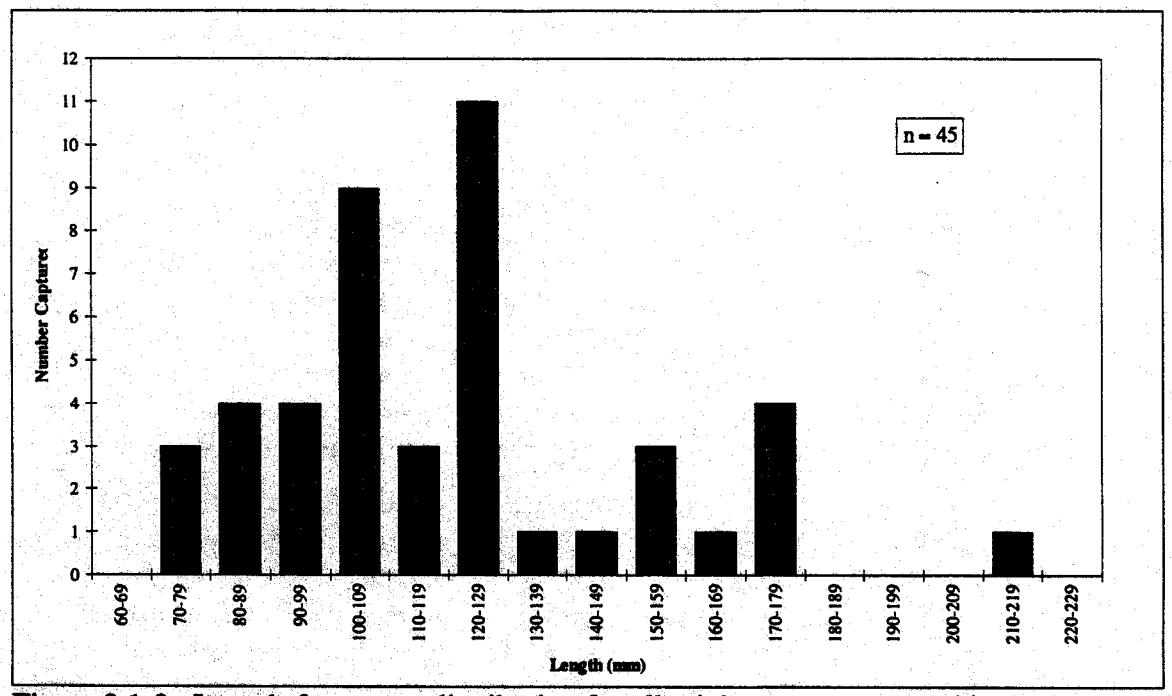

Figure 3.1-2. Length-frequency distribution for all rainbow trout captured in the lower Hood River during the resident fish population study.

Agencies and PacifiCorp agreed to evaluate minimum bypass flows for fish passage, as well as spawning and rearing lifestages, using the Oregon Method, since this was the original method used and the only method that defines fish passage depth and velocity criteria. It was further agreed that the Oregon Method would be combined with the IFG4 model (Bovee 1986) for simulating depth and velocity at flows other than the measured flows. The IFG4 is 1 component of the U.S. Fish and Wildlife Service's (USFWS) Instream Flow Incremental Methodology (IFIM). PacifiCorp agreed to evaluate flows for steelhead (*Oncorhynchus mykiss*), chinook, and coho for 3 different lifestages. PacifiCorp performed the study in 1995 and presented results of fish passage, rearing, and spawning in the Powerdale ITR.

During the first Annual Agency Meeting (following the ITR submittal), there was discussion regarding PacifiCorp's application of the Oregon Method to passage and rearing evaluation. ODFW's concerns with the passage analysis stemmed from the fact that IFG4 simulations used to simulate passage depths did not always match the field-measured results. PacifiCorp noted several reasons for the discrepancy:

1. ODFW binary passage criteria. Typically, IFG4 analysis relies on criteria that describe degrees of habitat suitability, ranging from no suitability to optimum suitability. With the Oregon Method, passage suitability is described by an "on-off" function: the depth of a cell is either completely suitable or completely unsuitable. This makes the passage function discontinuous, and tends to magnify any small errors that might occur in other steps. A difference of a few hundredths of a foot between measured and simulated values can result in a major change in calculated passage width.

2. Differences in IFG4 simulated vs. measured water surface elevations (WSELs). In the IFG4 program, measured WSELs are normally used to develop a regression equation. In some cases, the WSELs predicted by the regression model can differ by up to 0.05 foot from the input values. The effect is significant for all cells close to the threshold for passage suitability.

3. Random measurement error. Only 1 set of bed elevations is entered in IFG4, but 3 sets of depths were measured. The bed elevations used in the IFG4 simulations generally come from the measured low flow. The IFG4 simulated depth at high flow is roughly equal to the depth at low flow, plus the change in WSEL. In a perfect simulation, this would always equal the measured depth at high flow. But field measurements in the steep, cobble-strewn streambed were less than perfect. Thus, small differences existed between simulated and measured depths.

4. Differences in the way cell depth is calculated. For the measured data, each depth is considered the center (centroid) of a cell. The depth from the field data sheet is usually recorded to the nearest 0.1 foot; in the IFG4 program, the depth is simulated to the nearest 0.01 foot, because it equals the WSEL minus the bed elevation. Further, all depths are calculated as averages of 2 adjacent cells. The differences between the centroid and averaging methods were discussed in detail in a memo to ODFW from PacifiCorp (letter from T. Hardin, Hardin-Davis, for PacifiCorp, Portland, Oregon to R. Kruger, ODFW, Portland, Oregon, August 19, 1996).

After considering the differences in the measured vs. simulated passage depths, PacifiCorp and ODFW decided that an alternative analysis, using Excel spreadsheets, would allow more accurate evaluation of measured data. Methods used to reevaluate passage transect data are presented in Section 3.2.2 below.

The agencies also had concerns with the evaluation of rearing habitat. ODFW was concerned that the rearing lifestage evaluation only evaluated pool habitat rearing and requested that riffle and other habitat be included in the evaluation of steelhead rearing. Based on ODFW's comments, pool rearing habitat was evaluated only for juvenile chinook and coho, while rearing habitat for juvenile steelhead trout was evaluated using data from the passage transects (riffle habitat) as well as the 2 spawning transects (run habitat).

There was also discussion of the validity of using the 1995 data in light of the February 1996 flood, which changed considerably the stream channel of the Hood River. PacifiCorp staff and agency personnel agreed at the meeting that they would convene at the Hood River in August to walk the bypass reach and evaluate passage transects with respect to flood changes.

Between the time that the first Annual Agency Meeting was held and the August site visit at Hood River, several technical meetings were held with PacifiCorp and ODFW staff to discuss aspects of the fish passage evaluation methods; from these meetings, analytical techniques were refined and modified.

The August site visit was well attended by agency personnel; after examining the fish passage transects that were modeled in 1995 and several other passage areas in the bypass reach, it was agreed that the 1995 data could be used to complete the analysis.

3.2.1 Study Area

PacifiCorp's instream flow study focused on the bypass reach between the diversion dam and powerhouse, a distance of approximately 3 miles. In August 1995, PacifiCorp biologists, accompanied by ODFW and Confederated Tribes of the Warm Springs (CTWS), walked the bypass reach and selected the 2 areas that appeared to be the most difficult for upstream passage. Each of these areas had a divided flow. A single transect was placed across each main channel, and 2 transects placed across each side channel. The locations of passage sites are given in Figure 3.2-1.

Two spawning transects were selected in a run/glide habitat immediately downstream of the sand settling basin. Two large pools just upstream of the powerhouse were selected for the pool rearing evaluation.

3.2.2 Methods

The Oregon Method is essentially a precursor of the Physical Habitat Simulation (PHABSIM). It uses pre-established depth and velocity criteria to model habitat conditions for each lifestage. For example, the minimum flow requirement for adult chinook passage is defined as that flow resulting in at least 25 percent of the stream width (at a specific transect) being at least 0.8 foot deep, and at least 10 percent of the width being continuous (ODFW 1989). All criteria used in this study are shown in Table 3.2-1.

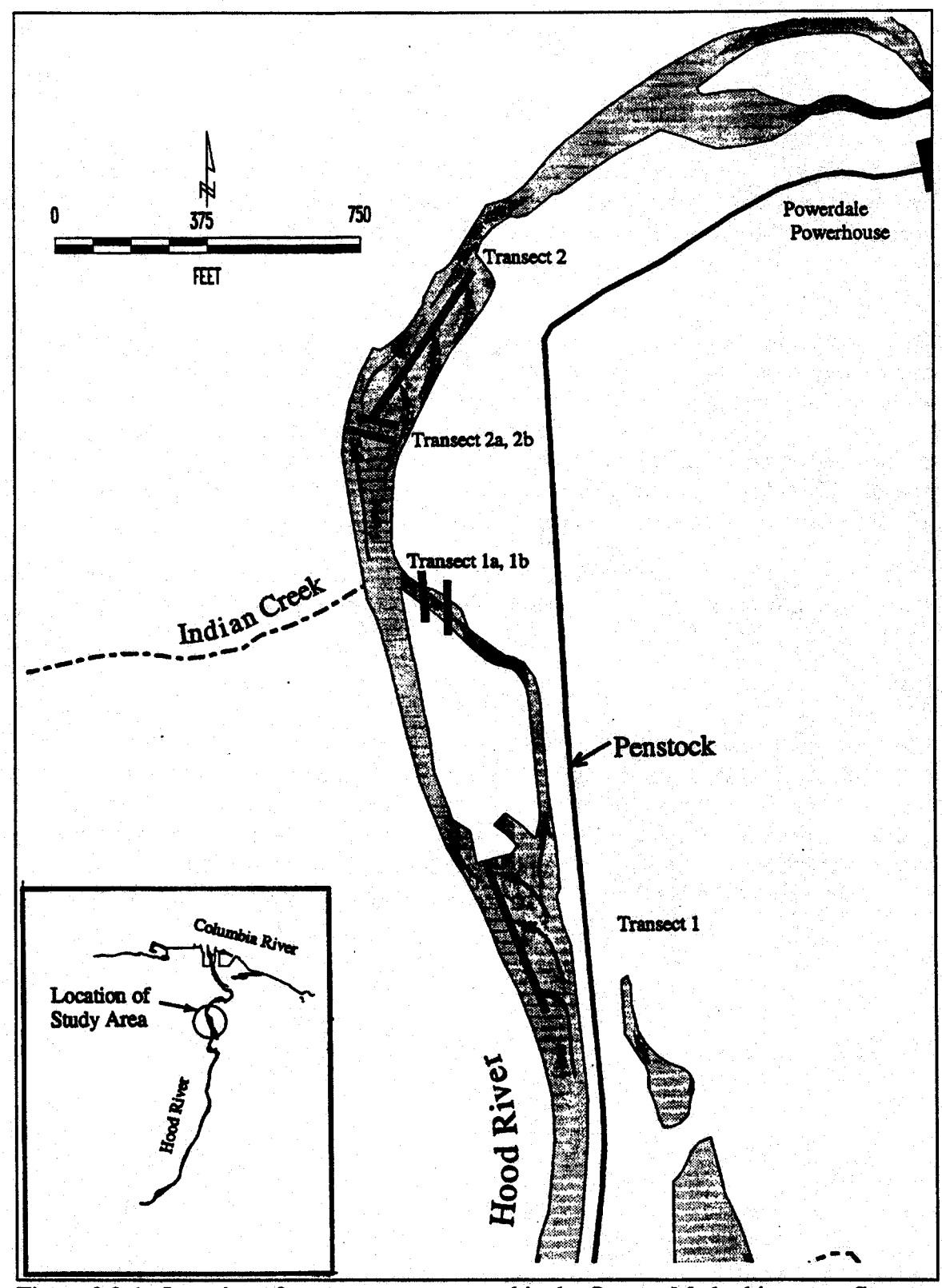

Figure 3.2-1. Location of passage transects used in the Oregon Method instream flow analysis, Hood River, Oregon.

Table 3.2-1. Depth and velocity criteria for use in the Oregon Method.

Biological Activity: Passage		
Species	**Minimum Depth (feet)**	**Velocity (fps)**
Adult chinook[1]	0.8	<8.0
Adult coho, steelhead, and large resident trout	0.6	<8.0
Biological Activity: Spawning		
Species	**Minimum Depth (feet)**	**Velocity (fps)**
Adult chinook[1]	0.8	1.0 to 3.0
Adult coho, steelhead, and large resident trout	0.6	1.0 to 3.0
Biological Activity: Rearing		
Species	**Preferred Depth (feet)**	**Preferred Velocity (fps)**
Juvenile chinook[1] and coho	1.0 to 4.0	0.2 to 0.8
Juvenile steelhead	0.6 to 2.2	0.2 to 1.6

Source: Oregon State Game Commission 1972.

[1] Includes both fall and spring chinook.

3.2.2.1 Field Data Collection

Field procedures were analogous to an instream flow study using IFIM. At each of 3 flow levels (100, 200, and 400 cfs), PacifiCorp collected the following data for all transects:

Low flow:

- Benchmark elevations for reference in surveying
- Water surface elevations at each transect
- Depth and velocity data at 20 to 70 cells per transect
- Stage of zero flow (the point on or below a transect that controls water elevation)

Medium flow and high flow:

- Water surface elevations at each transect
- Depth and velocity data at the same locations used at low flow

3.2.2.2 Analysis of Passage Data: IFG4 Model vs. Excel Spreadsheet

The initial analyses performed by PacifiCorp (presented in the ITR) used the IFG4 model for simulating passage widths and depths. The alternative analysis that OFDW and PacifiCorp agreed to produced similar results as an IFG4 analysis, but the methods of calculation differed in several important ways. First, PacifiCorp abandoned the use of surveyed WSELs, substituting the average differences in measured depths between flows. Also, cell depths at each flow (which IFG4 calculates to the nearest 0.01 foot) were rounded to the nearest 0.1 foot. Finally, cell depths were calculated by the centroid method, as opposed to the averaging method used in IFG4.

The steps used in the analysis are listed below:

1. For each transect, depths were entered in columns for each of 3 measured flows. The average depth for each flow, and the average change in depth (Δ depth) between flows, were then calculated.

2. The WSEI4S program (a subprogram of the IFG4 Model) then calculated the Δ depth for all simulated (unmeasured) flows of interest. For each of these flows, depth at a given cell equaled depth measured at the higher flow, minus the Δ depth calculated by WSEI4S. For example, if the measured depth at a cell was 0.8 foot at 200 cfs, and the Δ depth between 200 and 160 cfs was 0.07, then the simulated depth at 160 cfs would equal 0.8 minus the 0.07, or 0.73 foot.

3. All simulated depths were rounded to the nearest 0.1 foot.

4. Passage flow was calculated at each flow according to ODFW criteria. Cell widths (continuous and total) meeting the criteria were summed for each flow. For each transect, this involved 4 sums: total width and continuous width for both the chinook (0.8 foot) and steelhead (0.6 foot) criteria.

5. Passage widths were graphed; measured and simulated data points are included on each graph (Appendix 3.2-1).

All input data, intermediate files, and graphs were provided by PacifiCorp for review by ODFW (letter from T. Hardin, Hardin-Davis, for PacifiCorp, Portland, Oregon to R. Kruger, ODFW, Portland, Oregon, August 19, 1996).

3.2.2.3 Analysis of Spawning and Rearing Habitat

Spawning flows were evaluated using Oregon Method criteria and the IFG4 model for the 3 measured flows and 15 (simulated) additional flows ranging between 100 and 400 cfs. The percentage of preferred spawning area was determined for each transect using spawning criteria listed in Table 3.2-1. For example, spawning transects 1 and 2 contained 31 and 39 percent, respectively, of spawning area for chinook at 100 cfs. These percentages were averaged and the resulting value plotted against streamflow. This was done for all streamflows (both measured and simulated) for both salmon and steelhead.

Juvenile chinook and coho rearing habitat was evaluated by measuring depth and velocity at 6 pool transects; juvenile steelhead/rainbow trout rearing habitat was evaluated using data collected at both fish passage transects (i.e., riffle habitat) and spawning transects (i.e., run/glide habitat). Data collection techniques at pool transects were similar to those used for fish passage and spawning transects. Hydraulic simulation and calibration was performed for 15 additional flows ranging between 100 and 500 cfs. The percentage of rearing area was determined using techniques described above for spawning habitat.

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Pool:riffle ratio (an indicator of rearing habitat) was also evaluated in the bypass reach per the Oregon Method. The ratio was determined using ODFW's stream habitat mapping information; the percentage of pool area was compared with the percentage of riffle area in the bypass reach.

3.2.3 Results and Discussion

Two passage sites, each containing 2 side channel and 1 main channel transect (Figure 3.2-1), were measured at flows of 100, 200, and 400 cfs. Fifteen intermediate flows were simulated, for a total of 18 flows. The analysis relied on depth only, since the velocity criteria were not exceeded even at the highest flow. Separate passage analyses were conducted for chinook salmon and steelhead. The passage criteria for coho are the same for steelhead.

In general, passage at individual transects resembled a stepwise, rather than a continuous function (Appendix 3.2-1). This was expected due to the binary passage function; large amounts of passable habitat were added or lost whenever a depth threshold was achieved. Passable flows at each individual transect ranged from 100 to 350 cfs, depending on the transect and the species (Table 3.2-2).

Table 3.2-2. Passage flows (cfs) for individual transects in the bypass reach.

	Chinook flow (cfs)		Steelhead flow (cfs)	
Transects	Continuous	Total	Continuous	Total
	Width	Width	Width	Width
1	250	225	170	110
1A	250	350	110	110
1B	100	225	100	100
2	300	170	120	110
2A	225	110	110	100
2B	100	110	100	100

3.2.3.1 Interpretation of Passage Results

To make a final passage recommendation from the Oregon Method, each transect had to be examined separately, followed by an analysis of the interaction of the transects. The analysis proceeded as follows.

1. For each transect, pick the flow that met the criteria for both continuous and total passage width (i.e., the higher of the 2 flows).

2. For a given passage site, the 2 side channel transects were compared, and the transect with the higher passage flow was selected. The reasoning is that once fish choose to ascend the side channel, they must be able to get through the most difficult part of it.

3. The passage flow in the main channel transect corresponding to the side channel was compared with the flow obtained above. The lower flow was selected. The logic is that fish will select either the main or the side channel, whichever is easier to ascend.

4. Steps 1 to 3 were repeated for the other site, and a passage flow obtained. Results of the 2 sites were compared, and the higher of the 2 flows selected. The reasoning is that fish must get through the entire bypass reach, and the lower of the 2 flows would be insufficient at 1 of the sites.

3.2.3.2 Chinook Salmon Passage

Transect 1: In the side channel, Transect 1A (T1A) required a higher flow - 350 vs. 225 cfs (Table 3.2-3). In the main channel, passage criteria were met with a flow of 250 cfs. Therefore, the overall flow for the site is 250 cfs, because this would allow passage through at least 1 channel (Table 3.2-3).

Table 3.2-3. Flows (cfs) needed to meet the continuous and total width criteria for chinook salmon at Transect 1.

Location	Transect	Continuous criteria	Total criteria	Both criteria
Side channel	T1A	250	350	350
	T1B	100	225	225
	Combined	-	-	350
Main channel	T1	250	225	250
Entire site	T1, 1A, 1B	-	-	250
The side channel recommendation is based on T1A, the more difficult transect. But the overall recommendation is based on the main channel results.				

Transect 2: In the side channel, T2A required the higher flow - 225 vs. 110 cfs (Table 3.2-4). In the main channel, passage criteria were met with a flow of 300 cfs. Therefore, the overall flow for the site is 225 cfs (Table 3.2-4).

Minimum Required Flow: The recommendation must be based on the higher of the flows for the 2 individual sites. Therefore, 250 cfs is the recommended flow for chinook passage.

Table 3.2-4. Flows (cfs) needed to meet the continuous and total width criteria for chinook salmon at Transect 2.

Location	Transect	Continuous criteria	Total criteria	Both criteria
Side channel	T2A	225	110	225
	T2B	100	110	110
	Combined	-	-	225
Main channel	T2	300	170	300
Entire site	T2, 2A, 2B	-	-	**225**
The side channel recommendation is based on T2A, the more difficult transect. The overall recommendation is also based on the side channel results.				

3.2.3.3 Steelhead Passage

Transect 1: In the side channel, T1A required a slightly higher flow - 110 vs. 100 cfs (Table 3.2-5). In the main channel, a flow of 170 cfs met passage criteria. Therefore, the overall flow level for the site is 110 cfs, because this would allow passage through at least 1 channel (Table 3.2-5).

Table 3.2-5. Flows (cfs) needed to meet the continuous and total width criteria for steelhead at Transect 1.

Location	Transect	Continuous criteria	Total criteria	Both criteria
Side channel	T1A	110	110	110
	T1B	100	100	100
	Combined	-	-	110
Main channel	T1	170	110	170
Entire site	T1, 1A, 1B	-	-	**110**
The side channel recommendation is based on T1A, the more difficult transect. The overall recommendation is also based on the side channel results.				

Transect 2: In the side channel, T2A required the higher flow - 110 vs. 100 cfs (Table 3.2-6). In the main channel, a flow of 120 cfs met passage criteria. Therefore, the overall flow level for the site is 110 cfs (Table 3.2-6).

Minimum Required Flow: The recommendation is based on the higher of the flows for each site. In this case, the site-specific flows are identical, and the flow recommendation is 110 cfs for steelhead passage.

Table 3.2-6. Flows (cfs) needed to meet the continuous and total width criteria for steelhead at Transect 2.

Location	Transect	Continuous criteria	Total criteria	Both criteria
Side channel	T2A	110	100	110
	T2B	100	100	100
	Combined	-	-	110
Main channel	T2	120	110	120
Entire site	T2, 2A, 2B	-	-	**110**
The side channel recommendation is based on T2B, the more difficult transect. The overall recommendation is 110, since the passage flow is identical for both channels.				

3.2.3.4 Passage Results Discussion

The results presented above follow directly from the Oregon Method. However, these results should not be used as the sole determinant for flows. PacifiCorp's other studies (e.g., radiotelemetry [see Section 3.6]) and the CTWS/ODFW fish trapping data need to be incorporated into the recommendations. The ODFW constructed a species life history periodicity table (Table 3.2-7) based on their knowledge of the Hood River fishery. PacifiCorp discussed this life history information and results of various relicensing studies with tribal and agency representatives to determine appropriate flows for anadromous fish passage.

3.2.3.5 Spawning and Rearing Results

The spawning transect analysis showed that salmon and steelhead had similar spawning depth and velocity requirements (Table 3.2-8, Figure 3.2-2). The percentage of usable spawning area of each species was nearly identical over the range of flows modeled. Preferred spawning area ranged from a low of 35 percent (both species at 100 cfs) to a high of 69 percent (both species at 350 cfs).

Preferred spawning habitat area increased 29 percent from a flow of 100 cfs to about 220 cfs (35 percent to 64 percent); however, from 220 cfs to 350 cfs, preferred spawning area increased only 5 percent (64 to 69 percent). Beyond 350 cfs, spawning area decreased. Thus, 220 cfs appears to be the inflection point at which minimal spawning habitat is gained with increased flow.

Analysis of juvenile chinook and coho rearing habitat showed that pools provide the greatest amount of habitat at lower flows (Table 3.2-9, Figure 3.2-3). Pool habitat was maximized at flows of approximately 110 cfs, and decreased rapidly as flows increased to around 275 cfs. At this flow habitat continued to decrease at a gradual rate with increasing flow.

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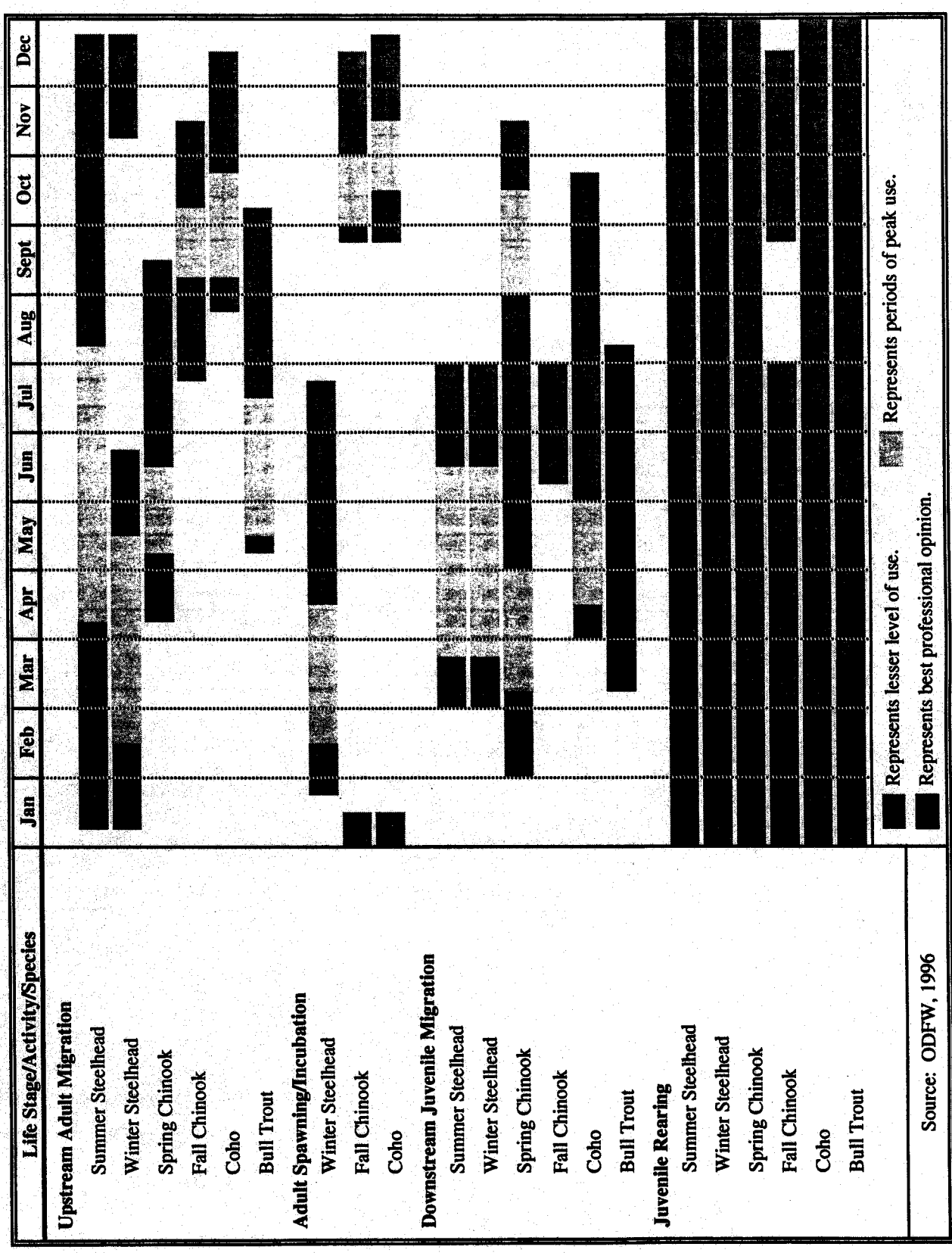

Table 3.2-7. Periodicity of salmonid use in the Hood River from mouth to Powerdale Dam, by species, life stage, and activity.

Table 3.2-8. Percent of preferred spawning area based on Oregon Method spawning criteria.

		Flow (cfs)																	
Species	Transects	100	110	120	130	140	150	160	179	180	190	200	225	250	275	300	350	390	400
Chinook	1	31	34	38	38	42	46	46	50	50	50	50	57	61	69	69	84	80	76
	2	39	39	39	43	52	52	52	49	53	53	58	71	63	63	63	54	50	50
	Average	35	37	38	41	47	49	49	49	51	51	54	64	62	66	66	69	65	63
Steelhead & Coho	1	31	34	38	38	42	46	46	50	50	50	50	57	61	69	69	84	80	76
	2	39	43	43	43	52	52	52	49	53	60	64	71	63	63	63	54	57	57
	Average	35	39	41	41	47	49	49	49	49	51	55	57	64	62	66	69	69	67

Table 3.2-9. Percent of preferred rearing area in pools and riffles based on Oregon Method rearing criteria.

			Flow (cfs)																			
Species	Pool Transects		100	110	120	130	140	150	160	170	180	190	200	225	235	250	275	300	350	400	450	500
Chinook & Coho	1	1	75%	75%	67%	53%	46%	40%	40%	40%	33%	26%	26%	19%	19%	19%	19%	19%	19%	19%	12%	6%
	1	2	70%	70%	70%	70%	70%	59%	59%	54%	44%	39%	28%	28%	23%	23%	13%	13%	8%	0%	0%	3%
	1	3	66%	61%	54%	49%	49%	34%	34%	29%	24%	24%	29%	29%	29%	19%	13%	13%	13%	13%	16%	16%
	Average		70%	69%	64%	57%	55%	44%	44%	41%	33%	29%	28%	25%	24%	20%	15%	15%	13%	11%	9%	8%
	2	1	26%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	20%	20%	20%	7%	7%	7%	0%	0%	0%
	2	2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	5%	5%	5%	5%	5%
	2	3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Average		9%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	7%	7%	7%	4%	4%	4%	2%	2%	2%
	Combined		40%	40%	37%	34%	33%	28%	28%	26%	22%	20%	19%	16%	15%	13%	9%	9%	9%	6%	6%	5%
Species	Transects		100	110	120	130	140	150	160	170	180	190	200	225	235	250	275	300	350	400	450	500
Steel-head	Spawn-ing	1	18%	22%	22%	22%	29%	36%	36%	44%	43%	41%	41%	44%	48%	48%	41%	37%	37%	30%	25%	19%
		2	16%	22%	22%	22%	16%	19%	19%	24%	24%	24%	17%	14%	14%	8%	8%	8%	0%	3%	2%	0%
	Passage	1	18%	17%	15%	14%	14%	13%	11%	10%	10%	10%	11%	13%	11%	11%	12%	11%	10%	10%	8%	8%
		2	9%	11%	13%	13%	13%	11%	13%	16%	17%	16%	15%	14%	14%	16%	16%	16%	19%	23%	22%	26%
	Combined		15%	18%	18%	18%	18%	20%	20%	23%	23%	23%	21%	21%	22%	21%	19%	18%	16%	16%	14%	13%

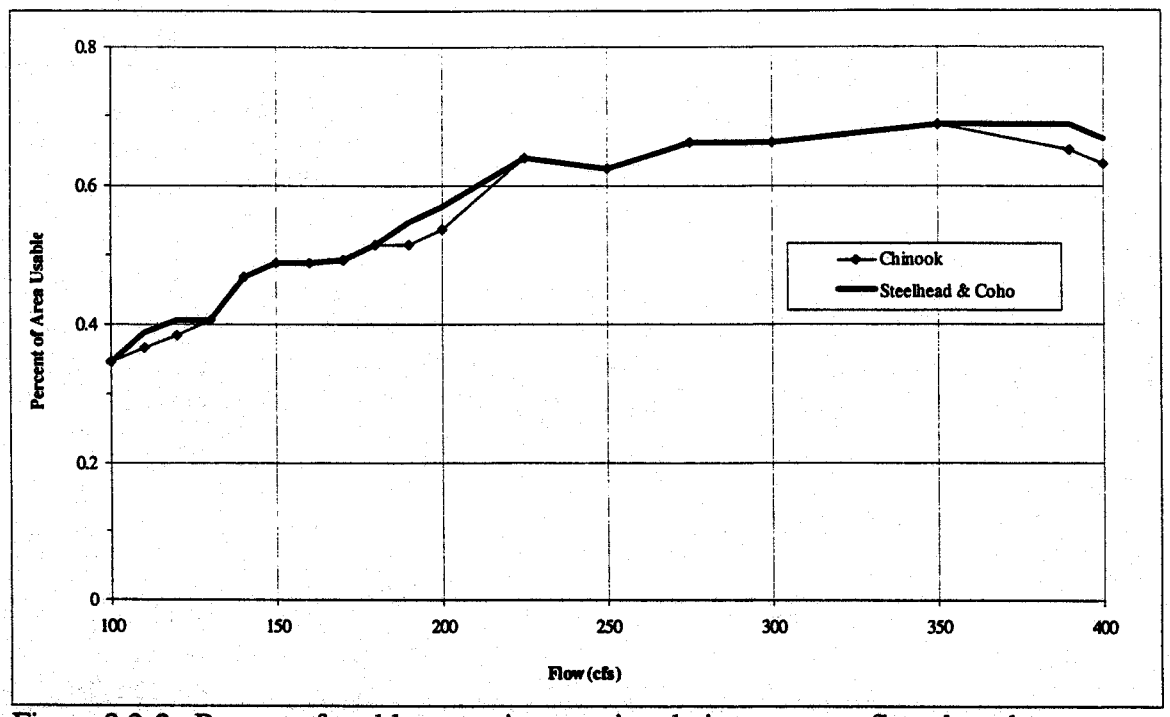

Figure 3.2-2. Percent of usable spawning area in relation to streamflow, based on an analysis of 2 spawning transects in the Powerdale Project bypass reach.

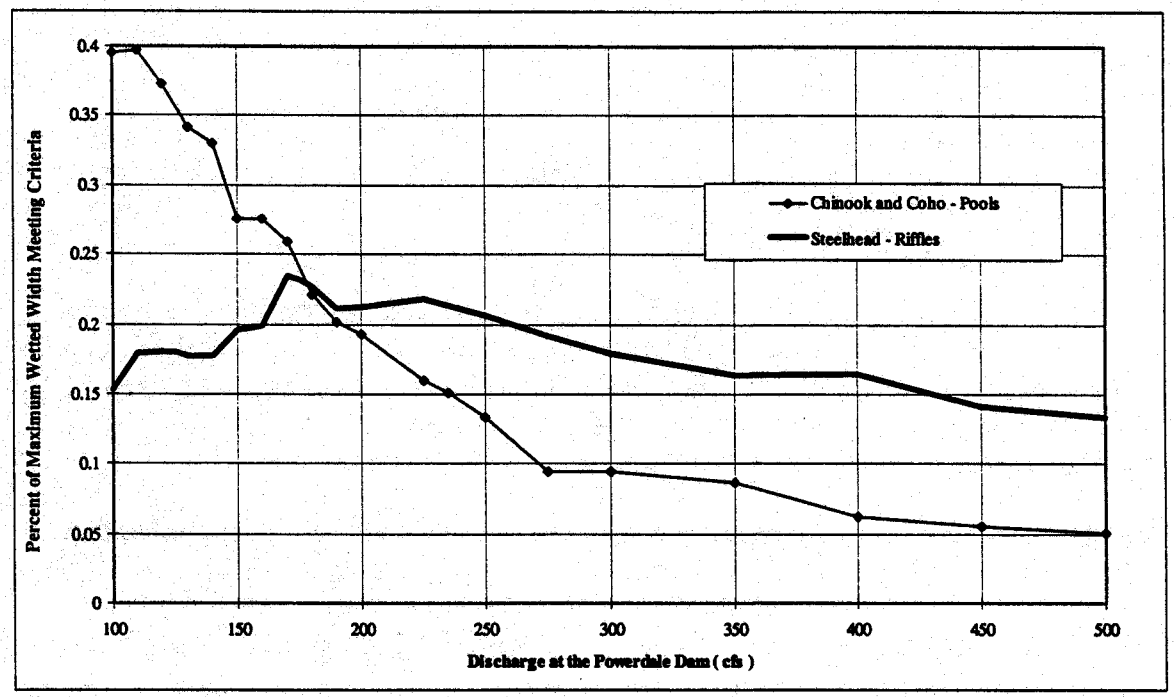

Figure 3.2-3. Suitable rearing habitat for chinook, coho, and steelhead in the Powerdale Project bypass reach.

The juvenile steelhead rearing analysis was performed by ODFW (pers. comm., R. Kruger, ODFW, Portland, Oregon, August 1, 1996) using data collected by PacifiCorp at passage and spawning transects. Rearing habitat values from each transect were summed and averaged to yield a single rearing curve (Figure 3.2-3). Juvenile steelhead rearing habitat ranged from 15 percent to 23 percent at flows from 100 to nearly 425 cfs (Table 3.2-9). Maximum habitat (23%) was achieved at flows of approximately 170 cfs.

Examination of ODFW's Hood River Physical Habitat/Fish Survey report (ODFW 1995) showed that the 3-mile-long bypass reach contains approximately 25,000 square feet of pool habitat and 35,000 square feet of riffle habitat, which equates to a pool:riffle ratio of 1 to 1.4. The Oregon Method guidelines for rearing suggest a pool:riffle ratio of approximately 1:1.

3.2.3.6 Spawning and Rearing Results Discussion

Based on the spawning analysis performed at the 2 transects in the bypass reach, spawning area was near maximum at approximately 220 cfs. This flow would also provide close to maximum habitat area (21% vs. 23%) for juvenile steelhead rearing in riffle habitat, but would limit chinook and coho rearing habitat in pools. Substantially lower flows would increase the amount of pool rearing habitat, but would have an adverse impact on spawning habitat.

Spawning flows should be evaluated with respect to timing of spawning activity in the Powerdale Project bypass reach, which occurs predominantly in late winter-early spring (steelhead), and in fall (fall chinook and coho) (see Table 3.2-7).

Rearing can occur year-round in the bypass reach, so it may be more appropriate to give greater consideration to spawning activities during the winter/spring and fall periods.

3.3 RAMPING RATE STUDY

Operation of the Powerdale Project can cause flow fluctuations in the Hood River between the diversion dam and the river's mouth (a distance of approximately 4 miles). Flow fluctuations that cause river level (stage) to decline rapidly may strand juvenile fish along the margins of the river. The rate at which the stage drops is called the "ramp rate," and is expressed in inches per hour.

During First Stage Consultation, several agencies (OFDW and NMFS) requested that ramp rates be measured for standard project operations (planned outages), as well as for forced (unplanned) outages. In addition, agencies requested an evaluation of effects to aquatic organisms during a forced outage event, which could cause a temporary but sudden decrease in river stage below the powerhouse.

During a forced outage, both the headgate at the canal intake, and penstock butterfly valve automatically close. When this happens, 2 events occur simultaneously: (1) flow to the powerhouse turbine is stopped, causing an immediate (but temporary) decrease in

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