REVISED DRAFT HABITAT SUITABILITY CURVES
and COHO SALMON and STEELHEAD TROUT

Sawmill Creek Alaska

Blue Lake Hydroelectric Project, FERC No. 2230, Relicensing

Prepared by:

City and Borough of Sitka Electric Department ("City")

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INTRODUCTION

This document presents revised draft Habitat Suitability Curves (HSC's) for selected fish species and life stages in Sawmill Creek, near Sitka, Alaska. These curves are to be used in an analysis of instream flow needs in Sawmill Creek as part of the ongoing relicensing for the Blue Lake hydroelectric project (Project, FERC No. 2230) which is Sawmill Creek's primary source.

Throughout instream flow study planning, the City, consulting resource agencies and the Sitka Tribe of Alaska (STA) have addressed the instream flow issue. Collectively, these agencies and STA have been called the Instream Flow Team (IFT). The IFT has reviewed and approved instream flow study plans and reports and participated in site selection and field work. All meetings, documents other related material are in the Project Relicensing Website (relicense.cityofsitka.com), Table of Contents> Major Relicensing Milestones>Study Planning, Execution and Reporting, see Instream Flow.

The initial version of this document was distributed on January 10, 2005, for review prior to an IFT meeting on the curves (and other) topics held in Juneau on January 19, 2005. At that meeting, draft curves were reviewed and changes proposed. Also at that meeting, attendees discussed ways in which substrate data from the Sawmill Creek IFIM measurements could be incorporated. This documents presents revised velocity and depth curves, based on meeting comments, and initial draft substrate curves for limited life stages, as discussed at the meeting.

SAWMILL CREEK INSTREAM FLOW BACKGROUND

TARGET SPECIES/LIFE STAGE SELECTION

During instream flow study planning, the IFT developed a study plan based on the Instream Flow Incremental Methodology (IFIM). During this process, the IFT selected coho salmon *(Oncorhynchus kisutch*) and steelhead trout *(O. mykiss)* as target species for the instream flow analysis. Site selection and field measurements for the IFIM studies were completed in April, 2004 and a draft report documenting field measurements and initial computer processing was distributed in October, 2004.

HSC DATA SOURCES

Prior to preparing this paper, the City and its fisheries and instream flow contractors reviewed two primary data sources for HSC's for the Sawmill Creek target species. These papers, both prepared by R2 Resources Consultants of Redmond, Washington were:

- R2 Resources Consultants, 2001. Master Library of Habitat Suitability Curves, Falls Creek Hydroelectric Project, FERC Project no. 11659; and

- R2 Resources Consultants, 2002. Habitat Suitability Indices for Ward Creek (draft), Connell Hydroelectric Project, Ketchikan Public Utilities.

Both papers contain HSC information on coho salmon. Only the Ward Creek paper contains HSC information for steelhead trout. Our initial review indicates that coho salmon curves in both papers are identical, but we have not researched the curve development methods in both papers to the extent that we can say that development methods are also identical.

Curves for coho salmon were based partly on data from the Kizhuyak River on Kodiak island. Through personal communications, we have determined that the spawning/incubation habitats measured in that study had lower gradient and smaller particle sizes than those in which Sawmill Creek coho were seen to spawn. We feel, however, that it is appropriate to use the Kizhuyak study because researchers accounted for habitat availability in the study design. This reduces dependency on strict comparability of channel characteristics and produces a more "universal" preference curve.

RATIONALE and METHODS for HSC DEVELOPMENT

RATIONALE and PARAMETERS

Having reviewed the R2 Resources papers, our initial proposal is to use the data for coho salmon in both papers without the need for further literature review. For steelhead we propose to use the information from the Ward Creek paper, but with further evaluation based on observation data from Sawmill Creek, as described below. We do not propose to conduct further field work prior to finalizing curves for either species.

Based on discussions at the January 19, 2005, meeting, we have developed substrate curves for steelhead and coho spawning/incubation only, using methods described below.

METHODS

Coho Salmon Depth and Velocity

In this paper, we present draft HSC for coho salmon spawning/incubation, fry rearing, and juvenile rearing. While the Ward and Falls Creek papers contain information on other life stages, we believe that these are sufficient to describe the relevant life stages of Sawmill Creek coho salmon.

Literature sources for coho are presented relative to their respective life stages. Once curves from the various sources were digitized, we usually developed a proposed curve which reflected consistencies among the literature-based curves. In most cases, our objective was to "stay within the data" and not to develop curves reflecting preferences beyond the depth and velocity ranges shown in the literature-based curves.

Steelhead Trout Depth and Velocity

For steelhead, (presented only in the Ward Creek paper) we were concerned about applicability of lower-48 curves to Sawmill Creek. Lower-48 steelhead, either summer or winter strains, generally exhibit life history patterns very different from Sawmill Creek steelhead. We therefore used steelhead observations from Karl Wolfe's Sawmill Creek fish surveys, in association with velocity and depth information from the IFIM cross-sections, to augment curves from the Ward Creek paper.

Generally, to use Sawmill Creek velocity and depth data in steelhead curve development, we employed the following method:

1. Map locations of steelhead spawning, fry and juvenile rearing observations;

2. Select those observations which are nearest to IFIM cross-sections;

3. Locate, to the extent possible, the point at which fish were observed on or near the cross section relative to the depth and velocity measurement locations;

4. Find the discharge for the date on which the observation was made from the continuous gage record near the Blue Lake powerhouse;

5. From the appropriate tables in the MEC data report, determine the velocity and depth for the cross-section/vertical at the appropriate discharge for each fish observation, and list these velocities and depths in tables;

6. Develop velocity and depth vs. frequency distributions for each location and observation date;

7. Combine data from all dates and locations into composite velocity and depth "utilization" curves for each steelhead life-stage;

8. Compare the utilization curves with their respective curves derived from Ward Creek paper literature sources to develop proposed steelhead HSC's.

We are aware that certain factors limit the usefulness of this method. First, measurements were not taken at the exact locations of the fish, and fish locations may have been recalled many months after observations. Second, IFIM velocities are in most cases simulated, and not those actually measured in the field (in some cases, velocities were measured at about the same flow as that at which the fish were observed, however). Nonetheless, we believe that these data have the advantage of having been collected using observations of undisturbed fish, either by foot survey or snorkeling. Further, we believe that, based on the hydraulic evaluations of the model, the predicted velocities are probably quite accurate, particularly in the low flow range in which most observations were made.

Detailed descriptions of how Sawmill Creek steelhead observations were used in association with IFIM depth and velocity data are presented in Appendix I.

Descriptions of how we selected the literature sources for use in the steelhead depth and velocity HSC development are presented in Appendix II.

Substrate Curves

Substrate curves for both coho and steelhead were developed in different ways, as described below. The substrate code was the same for both species, and is shown in Table 1.

Table 1. Substrate Coding for Sawmill Creek IFIM Analysis

Substrate Description	Substrate Code
duff	0.00
silt/clay	1.00
	1.50
sand	2.00
	2.50
fine gravel	3.00
	3.40
	3.90
gravel	4.00
	4.50
	4.80
coarse gravel	5.00
	5.50
	5.60
	5.80

small cobble	6.00
cobble	6.50
large cobble	6.60
small boulder	6.80
boulder	7.00
large boulder	7.20
bedrock	8.0

Coho Salmon Substrate

Coho substrate curves for spawning/incubation were developed from the Kizhuyak River and Wilson and Tunnel River literature sources, in much the same fashion as these and other sources were used to develop coho velocity and depth curves.

Steelhead Trout Substrate

Steelhead substrate curves for spawning/incubation were developed in a fashion similar to that used for velocity and depth for this species. Utilization curves were first developed from observations of redds and spawning steelhead in Sawmill Creek. Generally, these observations were the same as those from which the steelhead depth and velocity utilization curves were derived.

Next, we reviewed available literature from the Ward and Falls Creek curves papers to find available substrate data. We used all available substrate data for comparison to the utilization data from Sawmill Creek. As with coho, the substrate coding was done according to codes in Table 1.

RESULTS AND REVISED DRAFT HSC CURVES

In the following sections, curves from the January 19 paper which have not been revised are labeled "Proposed 1". Those curves revised relative to comment at the January 19 meeting are labeled "Proposed 2". Curve graphics showing only "Proposed 1" labels indicate that no changes were proposed at the meeting. Life stages for which curves were revised are denoted by an asterisk next to the life-stage subtitle.

COHO SALMON VELOCITY

Spawning/Incubation*

Our proposed curve for spawning/incubation coho salmon is an amalgam of the Tunnel River and Kizhuyak River, Oregon 1963, and Bovee 1978 curves from the Ward and Falls Creek papers, (Figure 1, Table 2). The proposed curve shows narrower velocity preference than the Kizhuyak River curve, but wider preference than all others in the literature set. Minimum and maximum velocity preference points are the same as all other curves, except Kizhuyak.

Figure 1. SMC Coho Salmon Spawning/Incubation Velocity Preference Curves

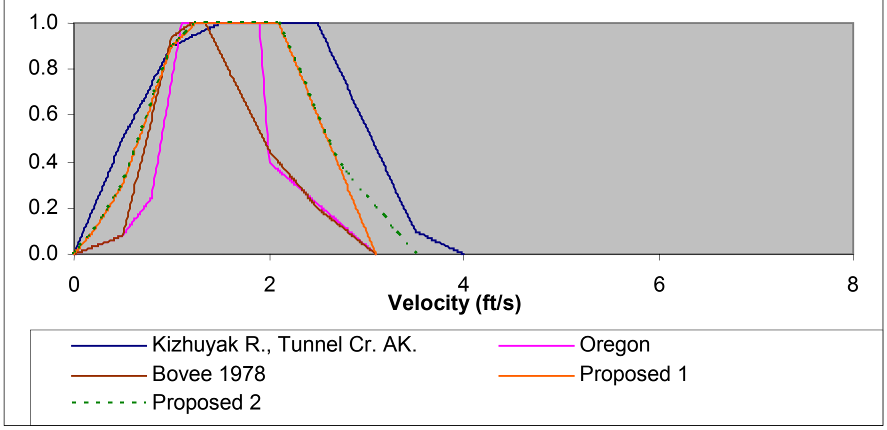

Table 2. Coordinate Data For Coho Salmon Spawning /Incubation Velocity Curves

X	Y	Y	Y	Y	Y
0.00	0.00	0.00	0.00	0.00	0
0.10	0.10				
0.20				0.10	0.10
.50	0.50	0.08	0.08	0.30	0.30
1.00	0.90		0.94	0.90	0.90
1.10		1.00			
1.20			1.00		
1.25				1.00	1.00
1.35			1.00		
1.50	1.00				
1.90		1.00			
2.00		0.40	0.45		
2.50	1.00		0.20		
2.70					0.40
3.00	0.50				
3.10		0.00	0.00	0.00	0.00
3.50	0.10				
4.00	0.00				

Fry Rearing*

For fry rearing, we propose a curve based on melded data from the Indian River and Kizhuyak River data from the Ward and Falls Creek papers (Figure 2, Table 3). In the original proposal, our proposed curve more closely followed the Indian River curve because of the similarities between this stream and Sawmill Creek, both in terms of stream characteristics and salmon life stage periodicities.

Figure 2. SMC Coho Salmon Fry Rearing Velocity Preference Curves

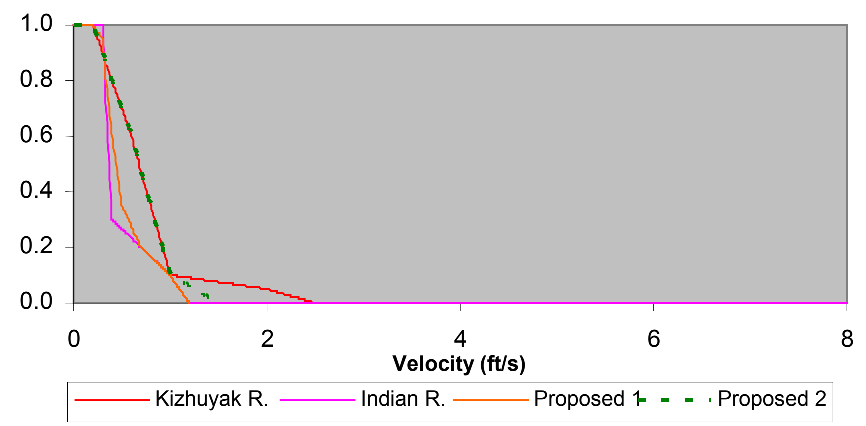

Table 3. Coordinate Data for Coho Salmon Fry Rearing Velocity Preference Curves

X	Y	Y	Y	Y
0.00	1.00	1.00	1.00	1.00
0.20	1.00		1.00	1.00
0.30	0.90	1.00		0.90
0.40		.030		
0.50			.35	0.60
0.60	.060			
0.70		0.20		
1.00	0.10	0.10	0.10	0.10
1.20		0.00	0.00	
1.50				1.00
2.00	0.05			
2.50	0.00			

Juvenile Rearing*

As with the fry rearing curve above, we propose a juvenile rearing curve based on melded data from the Indian River and Kizhuyak River studies from the Ward and Falls Creek papers (Figure 3, Table 4). Again, our originally proposed curve more closely followed the Indian River curve, for the reasons given above for the fry curves.

Figure 3. SMC Coho Salmon Juvenile Rearing Velocity Preference Curves

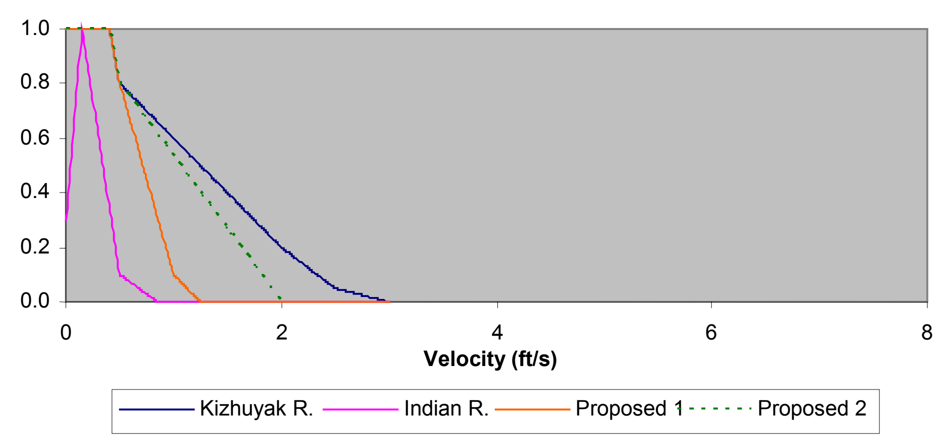

Table 4. Coordinate Data for Coho Salmon Juvenile Rearing Velocity Preference Curves.

X	Y	Y	Y	Y
0.00	1.00	0.30	1.00	1.00
0.15		1.00		
0.30		1.00		
0.40	1.00		1.00	1.00
0.45			0.90	
0.50	0.80	0.10	0.80	0.80
0.60			0.66	
0.80			0.38	
0.85		0.00		
1.00	0.60		0.10	
1.10				
1.25			0.00	
1.50	0.40			
2.00	0.05			0.00
2.50				
3.00	0.00			

STEELHEAD TROUT VELOCITY

Spawning/Incubation

For spawning/incubation of steelhead trout, we have used the Sams and Pearson (Oregon 1963) and White River (Hosey 1986) curves from the Ward Creek paper, and augmented them with observations from the Sawmill Creek IFIM study (See Appendix I).

A velocity vs. frequency distribution derived from observations of Sawmill Creek spawning steelhead for the 2004 season at three transects resulted in the frequency distribution and velocity utilization curves shown in Figures 4 and 5 and Table 5. This distribution shows fish utilization at velocities somewhat lower than those from the Ward Creek curves. We have therefore adjusted our proposed spawning/incubation curve upward to reflect the higher velocities in the literature-based curves, resulting in the proposed curve in Figure 6 (Table 6).

Figure 4. SMC Frequency Distribution of Steelhead Spawning/Incubation at Velocities

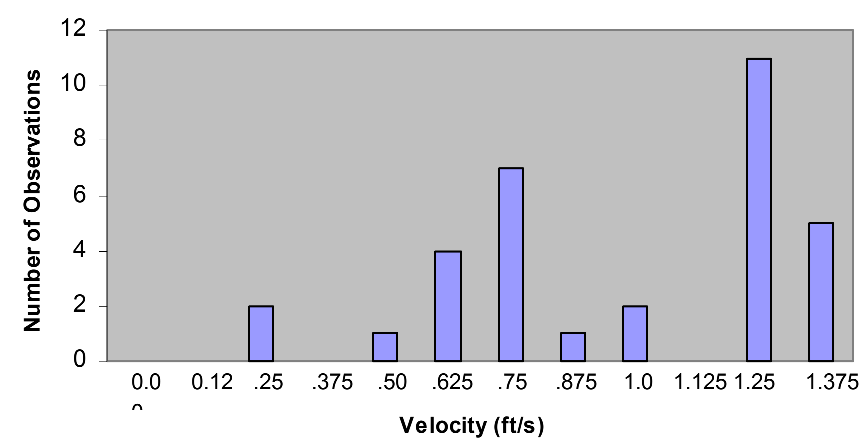

Figure 5. SMC Steelhead Spawning/Incubation Velocity Utilization Curve

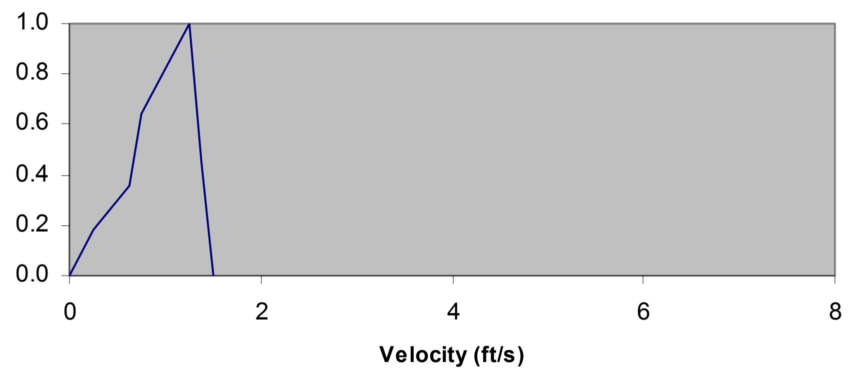

Table 5 Coordinate Data For SMC Spawning/Incubation Velocity Utilization Curve

X	Y
0.0	0.0
.25	0.18
.50	
.63	.36
.75	.64
1.10	
1.20	
1.25	1.0
1.38	.45
1.50	0.00

Figure 6. SMC Steelhead Spawning/Incubation Velocity Preference Curves

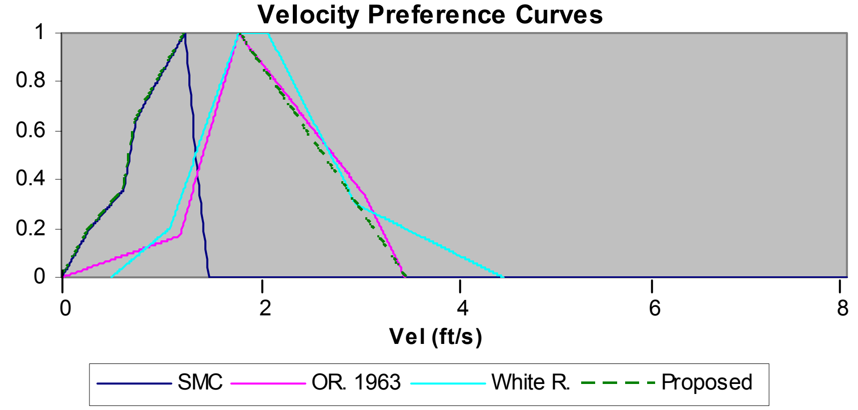

Table 6. Coordinate Data for Steelhead Spawning/Incubation Velocity Curves .

X	Y	Y	Y	Y
0.0	0.0	0.00		0.00
.25	0.18			0.18
.50			0.00	
.63	.36			.36
.75	.64			.64
1.10			0.20	
1.20		0.17		
1.25	1.0			1.00
1.38	.45			
1.50	0.00			
1.80		1.00	1.00	
2.10			1.00	
3.00		1.00	0.30	.30
3.10				
3.50		0.00		0.00
4.50			0.00	

Fry Rearing*

As with spawning/incubation, we first derived a steelhead rearing velocity frequency distribution based on Sawmill Creek observations and IFIM velocity values (Figure 7). The resulting utilization curve (Figure 8, Table 7) indicates a lower velocity preference than those for curves from the Ward Creek fry rearing data. We therefore adjusted the fry rearing curve upward to result in the proposed curve in Figure 9 (Table 8).

Figure 7. SMC Steelhead Fry <100mm Velocity Frequency Distribution

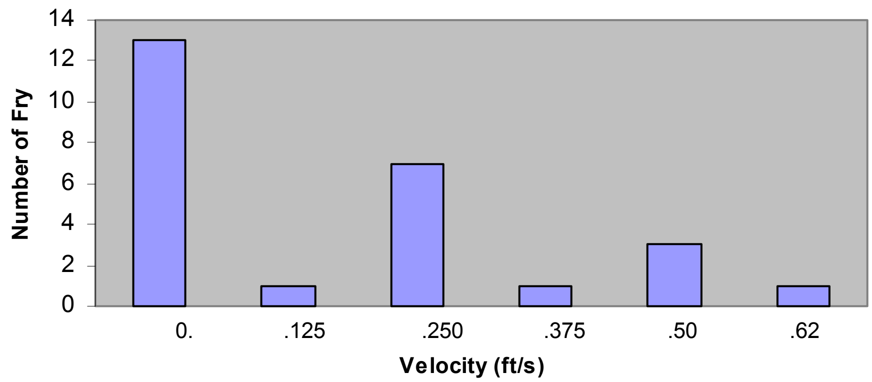

Figure 8. SMC Steelhead Fry <100mm Velocity Utilization Curve

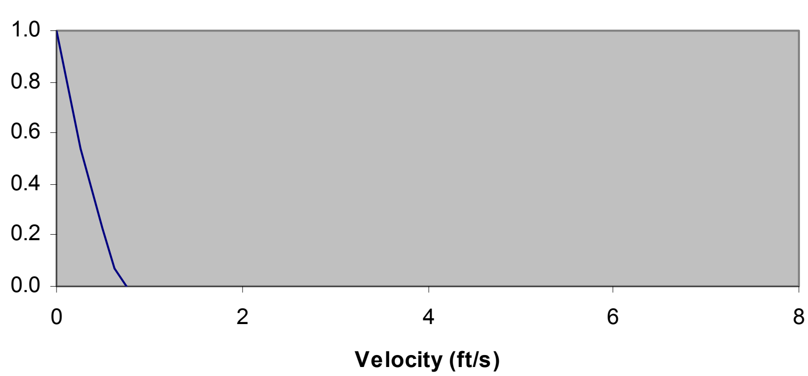

Table 7. Coordinate Data For Sawmill Cr. Observed Steelhead Fry

X	Y
0.00	1.00
0.25	0.54
0.50	0.23
0.63	0.07
0.75	0.00

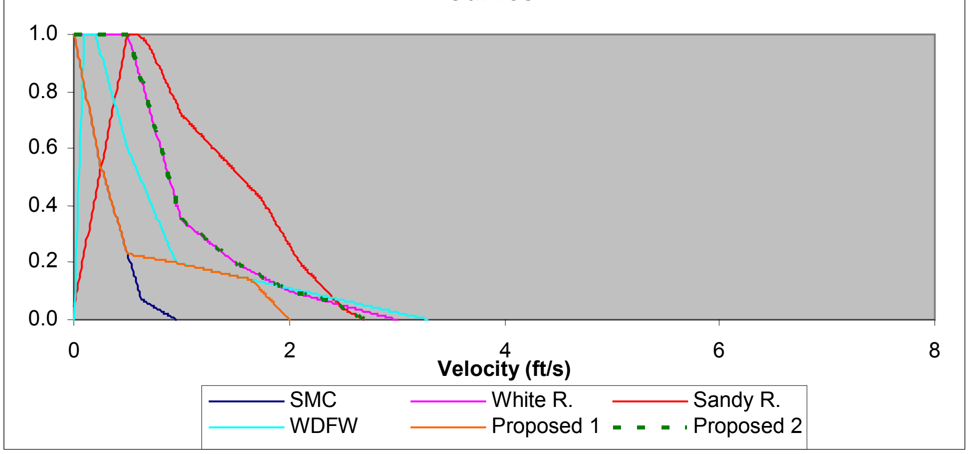

Figure 9. SMC Steelhead Fry Rearing Velocity Preference Curves

Table 8. Coordinate Data For Steelhead Fry Rearing Velocity Preference Curves

X	Y	Y	Y	Y	Y	Y
0.00	1.00	1.00	0.05		1.00	1.00
0.05				0.55		
0.10				1.00		
0.20				1.00		
0.25	0.54				0.54	
0.50	0.23	1.00	1.00	0.60	0.23	1.00
0.60			1.00			
0.63	0.07					
0.70			0.96			
0.75	0.00					
0.95				0.20	0.20	
1.00		0.35	0.72			0.35
1.50		0.20	0.42		0.15	0.20
1.75					0.10	
1.80					0.08	
2.00		0.10			0.00	0.10
2.10			0.20			
2.45						0.06
2.50			0.04			
2.70			0.00			0.00
3.00		0.00				
3.30				0.00		

Juvenile Rearing*

As with fry, juvenile velocity frequency distribution and utilization curves (Figures 10 and 11, Table 9) were developed. Comparison to the Ward Creek juvenile rearing curves again showed a lower velocity preference in our data. We therefore adjusted the our curve upward, and our proposed curves (Figure 12, Table 10) reflect this adjustment.

Figure 10. SMC Juvenile Steelhead 101mm-180mm Velocity Frequency Distribution

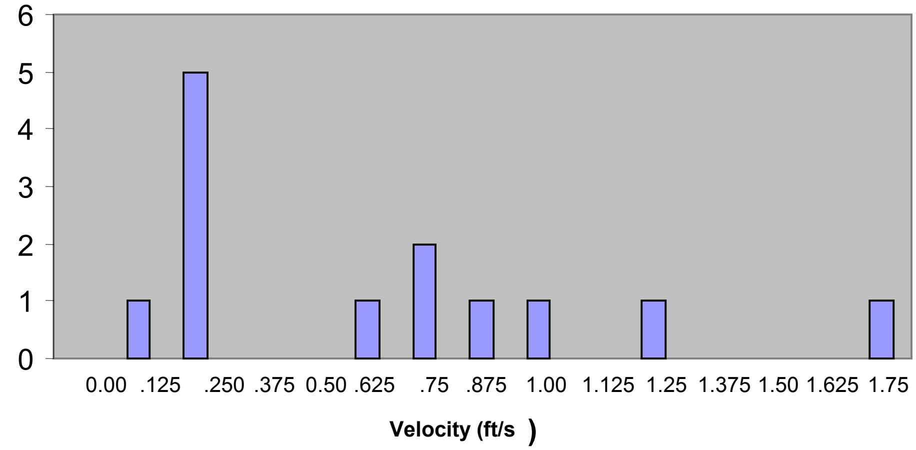

Figure 11. SMC Steelhead Juvenile (101-180mm) Velocity Utilization Curve

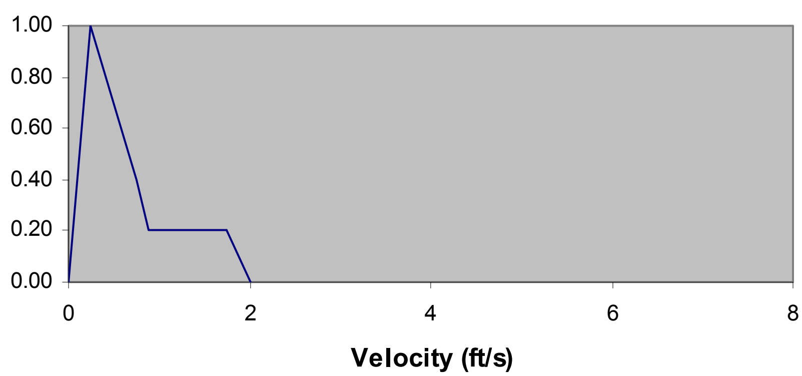

Table 9. Coordinate Data for Steelhead Juvenile Velocity Utilization Curve.

X	Y
0.00	0.00
0.25	1.00
0.75	0.40
0.88	0.20
1.00	0.20
2.00	0.0

Figure 12. SMC Steelhead Juvenile Rearing Velocity Preference Curves

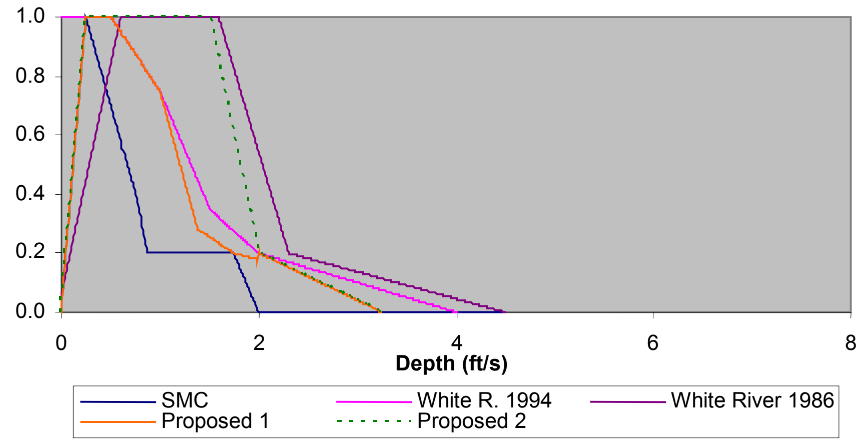

Table 10. Coordinate Data for Steelhead Juvenile Rearing Velocity Curves

X	Y	Y	Y	Y	Y
0.00	0.00	1.00	0.50	0.00	0.00
0.25	1.00			1.00	1.00
0.50		1.00		1.00	1.00
0.60			1.00	0.95	
0.75	0.40				
0.88	0.20				
1.00	0.20	0.75		0.75	
1.25					
1.50	0.35				1.00
1.60			1.00		
1.75					
2.00	0.0	0.20		0.20	0.20
2.30			0.20		
3.00				0.04	0.04
3.25				0.00	0.00
3.50					
4.00		0.00			0.00
4.50			0.00		

COHO SALMON DEPTH CURVES

Spawning/Incubation*

Our proposed curve for spawning/incubation coho salmon was an amalgam of the Wilson and Tunnel River, Terror and Kizhuyak River, Terror River , and Bovee 1978 curves from the Ward and Falls Creek papers, (Figure 13, Table 11; See Appendix I). All curves examined for this analysis were generally similar except for Bovee, 1978. We therefore constructed a proposed depth curve which followed the general trends of the majority of the curves.

Figure 13. SMC Coho Salmon Spawning/Incubation Depth Preference Curves

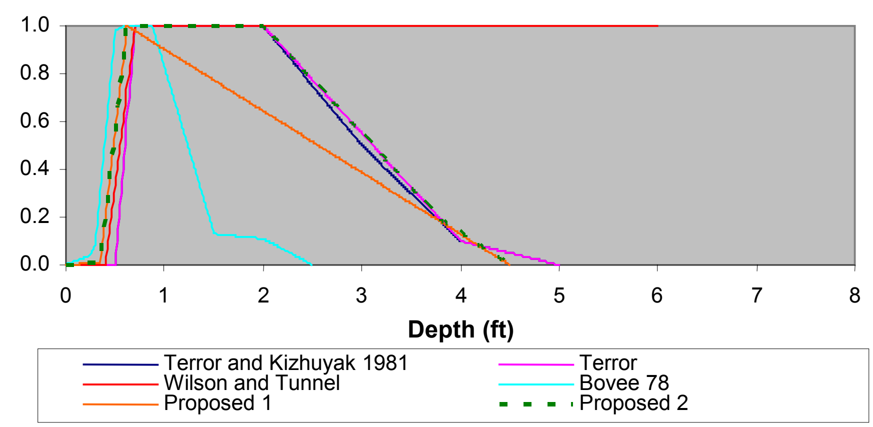

Table 11. Coordinate Data For Coho Salmon Spawning /Incubation Depth Preference Curves

X	Y	Y	Y	Y	Y	Y
0.00			0.00	0.00	0.00	0.00
0.25				0.04		
0.30				0.08		
0.35						
0.50	0.00	0.00	0.00	0.98	0.56	0.56
0.60				1.00		
0.62	0.60				1.00	1.00
0.70	1.00	1.00	1.00			
0.85				1.00		
1.00				0.88		
1.50				0.13		
1.60					0.75	
1.90						
2.00	1.00	1.00		0.11		1.00
2.50				0.00		
3.00	0.50	0.50				
3.10						
3.50		0.20				
4.00	0.10	0.10				
4.50					0.00	0.00
5.00	0.00	0.00				
6.00			1.00			
8.00						

Fry Rearing

As with the spawning/incubation curve above, we proposed a fry rearing curve based on melded data from the Indian River, Terror and Kizhuyak River, And Wilson and Tunnel River data from the Ward and Falls Creek papers (Figure 14, Table 12).

Figure 14. SMC Coho Salmon Fry Rearing Depth Preference Curves

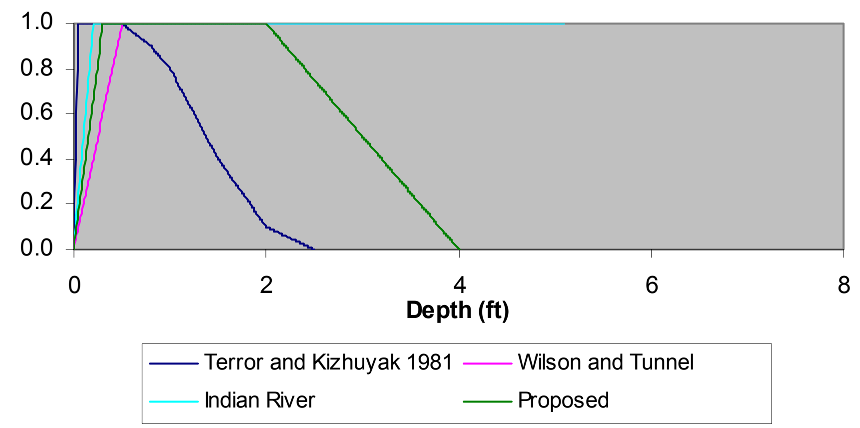

Table 12. Coordinates For Coho Salmon Fry Rearing Depth Curves.

X	Y	Y	Y	Y
0.00	0.00	0.00	0.00	0.00
0.05	1.00			
0.20			1.00	0.67
0.25				
0.30				1.00
0.35				
0.50	1.00	1.00		
0.80	0.90			
0.85				
1.00	0.80			
1.50	0.40			
2.00	0.10			1.00
2.10				0.95
2.50	0.00			0.75
3.00				0.50
4.00				0.00
5.10		1.00	1.00	
6.00				
8.00				

Juvenile Rearing*

As with the spawning/incubation curve above, we propose a juvenile rearing curve based on melded data from the Indian River, and Kizhuyak River data from the Ward and Falls Creek papers (Figure 15, Table 13).

Figure 15. SMC Coho Juvenile Rearing Depth Preference Curves

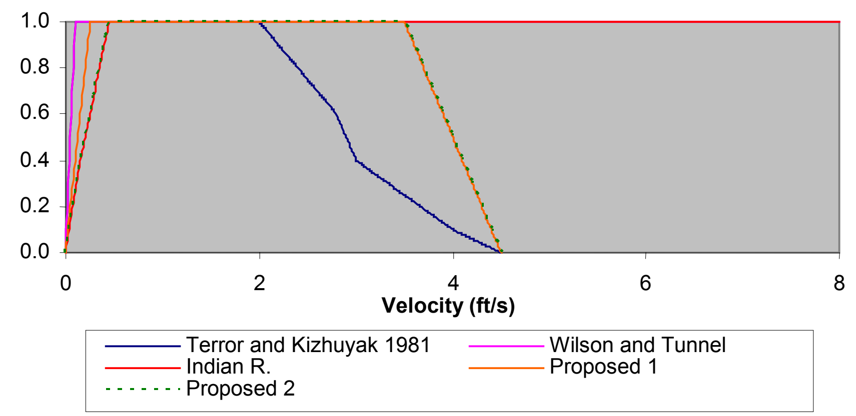

Table 13. Coordinate Data For Coho Juvenile Rearing Depth Preference Curves

X	Y	Y	Y	Y	Y
0.00	0.00	0.00	0.00	0.00	0.00
0.10	1.00	1.00		0.40	
0.15			0.40		0.40
0.20					
0.25				1.00	
0.40					
0.45			1.00		1.00
0.50					
1.90					
2.00	1.00				
2.20					
2.40	0.80				
2.80	0.60				
3.00	0.40				
3.10					
3.50				1.00	1.00
4.00	0.10			0.50	0.50
4.50	0.00			0.00	0.00
5.00					
5.10					
6.00					
8.00		1.00	1.00		

STEELHEAD TROUT DEPTH CURVES

Spawning/Incubation

A composite frequency distribution derived from observations of spawning steelhead for 2004 season at three transects resulted in the frequency distribution shown in Figure 16. This distribution shows fish utilization at depths somewhat deeper than those from the Ward Creek curves (Figure 17, Table 14). We have therefore adjusted our proposed spawning/incubation curve upward, resulting in the proposed curve in Figure 18 (Table 15).

Figure 16. SMC Steelhead Spawning/Incubation Depth Frequencies

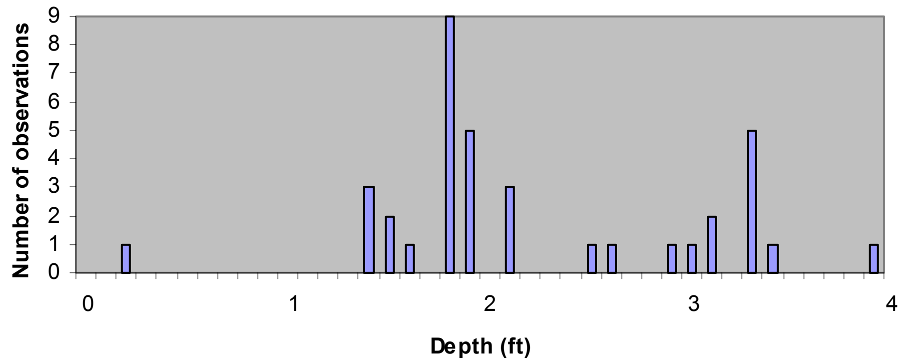

Figure 17. SMC Steelhead Spawning/Incubation Depth Utilization Curves

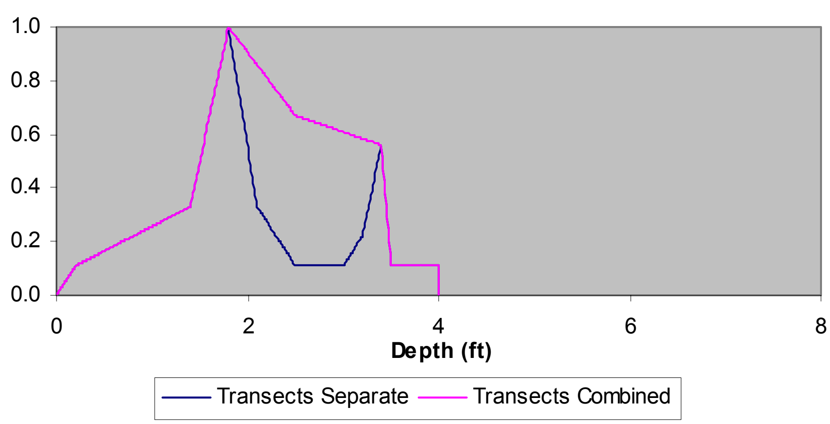

Table 14. Coordinate Data for Observed Steelhead Juvenile Velocity Utilization Curve.

X	Y	Y
0.00	0.00	0.00
0.20	0.11	0.11
1.40	0.33	0.33
1.80	1.00	1.00
1.90	0.56	0.56
2.10	0.33	
2.50	0.11	0.67
3.00	0.11	
3.20	0.22	
3.40	0.56	0.56
3.50	0.11	0.11
4.00	0.11	0.11
4.10	0.00	0.00

Figure 18. SMC Steelhead Spawning/Incubation Depth Preference Curves

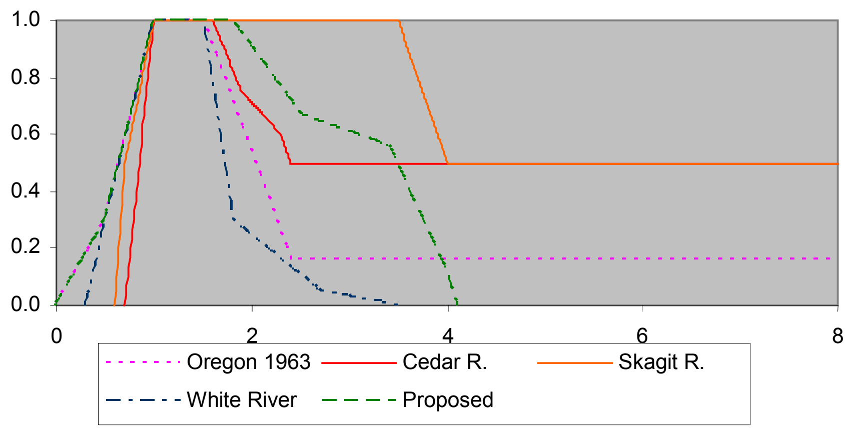

Table 15. Coordinate Data for Steelhead Spawning/Incubation Depth Curves

X	Y	Y	Y	Y	Y
0.00	0.00	0.00	0.00		0.00
0.20					
0.30				0.00	0.18
0.50	0.30				0.30
0.60			0.00		0.44
0.70		0.00	0.50		
1.00	1.00		1.00		1.00
1.10		1.00		1.00	
1.40					
1.50	1.00			1.00	
1.80				0.30	1.00
1.90					
2.40	0.16				
2.50					0.67
2.70				0.05	
3.00					
3.20					
3.40					0.56
3.50			1.00	0.00	
4.00			0.50		0.11
4.10			0.50		0.00
5.00			0.50		
6.00	0.16	1.00	0.50		
8.00	0.16	1.00	0.50		

Fry Rearing*

Composite frequency distributions and utilization curves for steelhead fry rearing depth, are shown in Figures 19 and 20 and Table 16. The utilization curve was bimodal because of differences in habitat availability among sampling sites. We therefore adjusted the fry rearing curve to account for greater depth availability, resulting in the proposed curve in Figure 21 (Table 17).

Figure 19. Steelhead Fry (<100mm) Depth Frequency

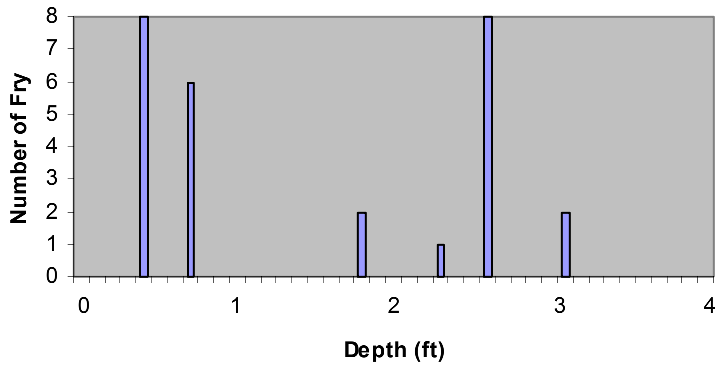

Figure 20. SMC Steelhead Fry <100mm Depth Utilization Curve

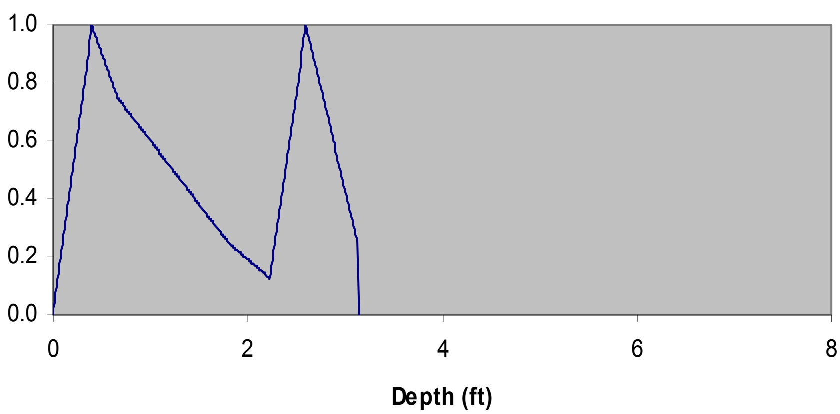

Table16. Coordinate Data For SMC Steelhead Depth Utilization Curve

X	Y
0.00	0.00
0.40	1.00
0.66	0..75
1.80	0.25
2.33	0.125
2.60	1.00
3.13	0.25
3.14	0.00

Figure 21. SMC Steehead Fry Rearing Depth Preference Curves

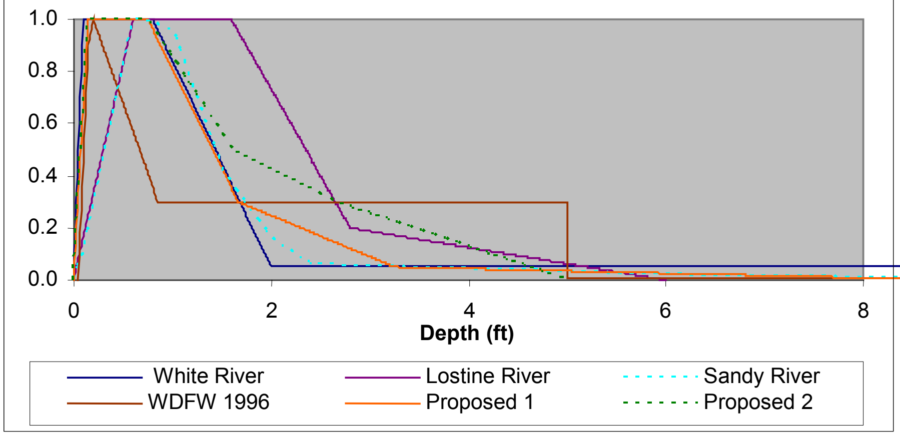

Table 17. Coordinate Data For Sawmill Cr. Steelhead Fry Depth Preference Curves

X	Y	Y	Y	Y	Y	Y
0.00	0.00	0.00	0.00		0.00	0.00
0.05				0.00		
0.10	1.00		0.10			
0.15				0.90	1.00	1.00
0.20				1.00		
0.30						
0.50						
0.60		1.00	1.00			
0.70			1.00	1.00		
0.75					1.00	1.00
0.80	1.00					
0.85				0.30		
1.00			0.96			
1.10						
1.40						
1.50			0.42			
1.60		1.00				0.50
1.67	0.31		0.29	0.30	0.30	
2.00	0.05		0.16			
2.40			0.06			
2.65		0.30				0.30
2.80		0.20				
3.00						
3.20						
3.25					0.05	
5.00				0.30		0.00
5.01				0.01		
6.00		0.00	0.20			
9.00					0.00	
10.00	0.05		0.00	0.01		

Juvenile Rearing

As with fry, a composite juvenile depth frequency distribution, composite depth frequency curve and observed depth utilization curve (Figure 22, Figure 23, Table 18, were developed. Comparison to the Ward Creek juvenile rearing curves again showed a greater depth preference, and our final proposed curve (Figure 24, Table 19) reflected this adjustment.

Figure 22. SMC Steelhead Juveniles 101-180 mm Depth Frequency Distribution

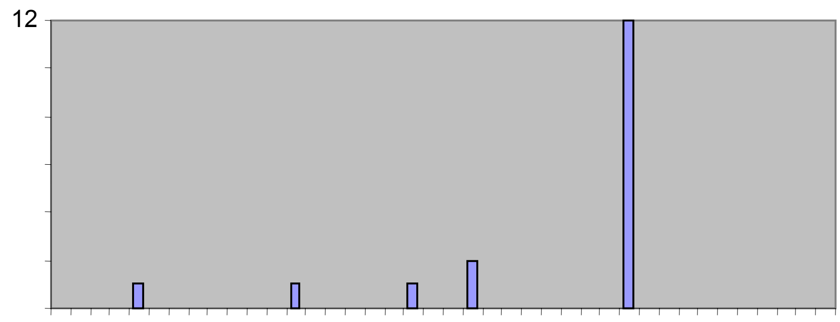

Figure 23. SMCJuvenile Steelhead 101-180mm Depth Utilization Curve

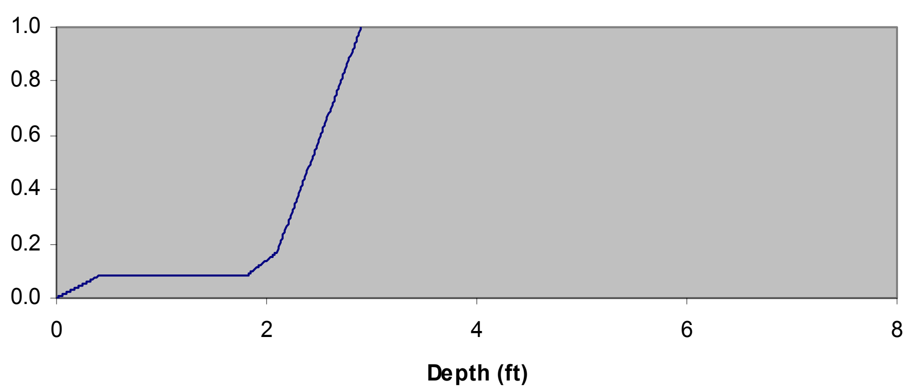

Table. 18 Coordinate Data for SMC Observed Juvenile Steelhead Depth Utilization Curve.

X	Y
0.00	0.08
0.40	0.08
1.20	0.08
1.80	0.08
2.10	0.17
2.90	1.00

Figure 24. SMC Steelhead Juvenile Depth Preference Curves

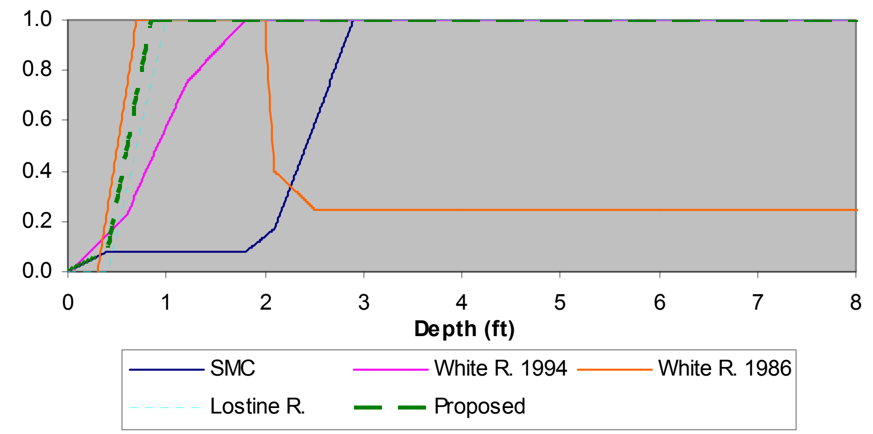

Table 19. Coordinate Data For Juvenile Steelhead Depth Curves.

X	Y	Y	Y	Y	Y
0.00	0.08	0.00		0.00	0.00
0.30			0.00		
0.40	0.08	0.00		0.00	.08
0.50	0.08				.29
0.60		0.23			.50
0.70			1.00		.70
0.85					1.00
1.00				1.00	
1.20	0.08	0.75			
1.50					
1.60					
1.80	0.08	1.00			
2.00			1.00		
2.10			0.40		
2.50			0.25		
2.90	1.00		0.40		
3.50					
9.00			0.25		
10.00		1.00		1.00	1.00

STEELHEAD SUBSTRATE

Spawning/Incubation

Steelhead spawning/incubation substrate utilization and preference curves (Figures 25 and 26, Table 20, Table 21) were developed according to previously described methods.

Figure 25. SMC Steelhead Spawning /Incubation Substrate Utilization Curves

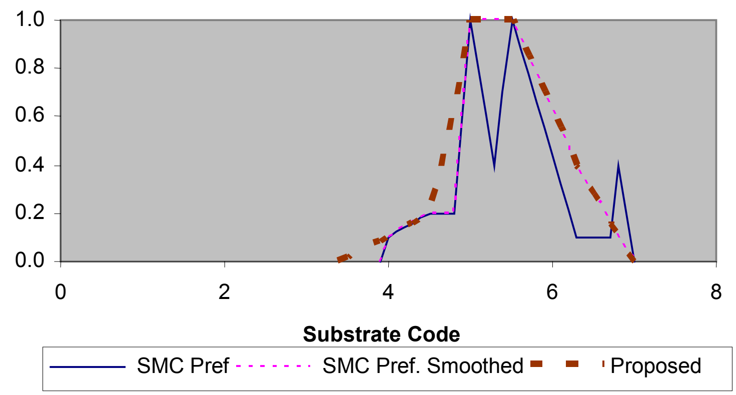

Table 20. Coordinate Data For Steelhead Spawning/Incubation Substrate Utilization Curves

Code	X	Y	Y	Y
Duff	0.00			
silt/clay	1.00			
	1.50			
sand	2.00			
	2.50			
f.gravel	3.00			
	3.40	0.00	0.00	0.00
	3.90	0.00	0.00	
m.gravel	4.00	0.10	0.10	0.10
	4.50	0.20	0.20	0.20
	4.80	0.20	0.20	0.62
c.gravel	5.00	1.00	1.00	1.00
	5.50	1.00	1.00	1.00
	5.60		0.93	0.93
	5.80		0.78	0.78
s.cobble	6.00		0.63	0.63
cobble	6.50	0.10	0.28	0.28
l.cobble	6.60	0.10	0.22	0.22
s.boulder	6.80	0.40	0.10	0.10
boulder	7.00	0.00	0.00	0.00
l.boulder	7.20			
bedrock	8.00			

Figure 26 SMC Steelhead Spawning/Incubation Substrate Preference Curves

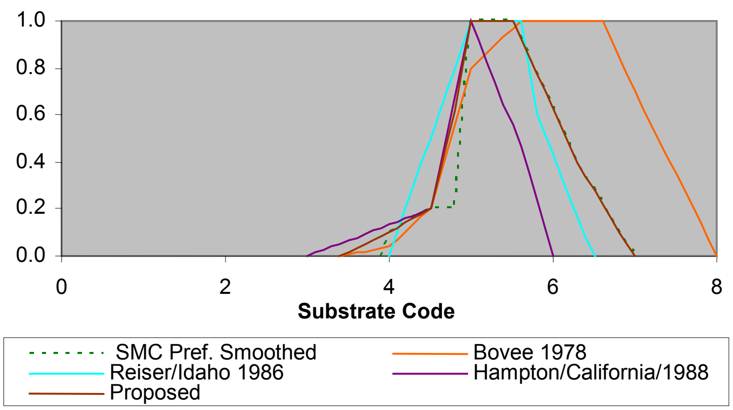

Table 21. Coordinate Data for Steelhead Spawning/Incubation Substrate Preference Curves.

Code	X	Y	Y	Y	Y	Y
Duff	0.00					
silt/clay	1.00		0.00		0.00	
	1.50					
sand	2.00					
	2.50					
f.gravel	3.00				0.00	
	3.40	0.00	0.00			0.00
	3.90	0.00				
m.gravel	4.00	0.10	0.04	0.00		0.10
	4.50	0.20	0.20	0.50	0.20	0.20
	4.80	0.20				0.62
c.gravel	5.00	1.00	0.80	1.00	1.00	1.00
	5.50	1.00				1.00
	5.60	0.93	1.00	1.00	0.47	0.93
	5.80	0.78		0.60		0.78
s.cobble	6.00	0.63			0.00	0.63
cobble	6.50	0.28		0.00		0.28
l.cobble	6.60	0.22	1.00			0.22
s.boulder	6.80	0.10	0.70			0.10
boulder	7.00	0.00	0.00	0.00	0.00	0.00
l.boulder	7.20					
bedrock	8.00					

COHO SALMON SUBSTRATE

Spawning/Incubation

As described in the methods section, coho substrate curves for spawning/incubation were developed from the Kizhuyak and Wilson and Tunnel River literature sources (Figure 27, Table 22).

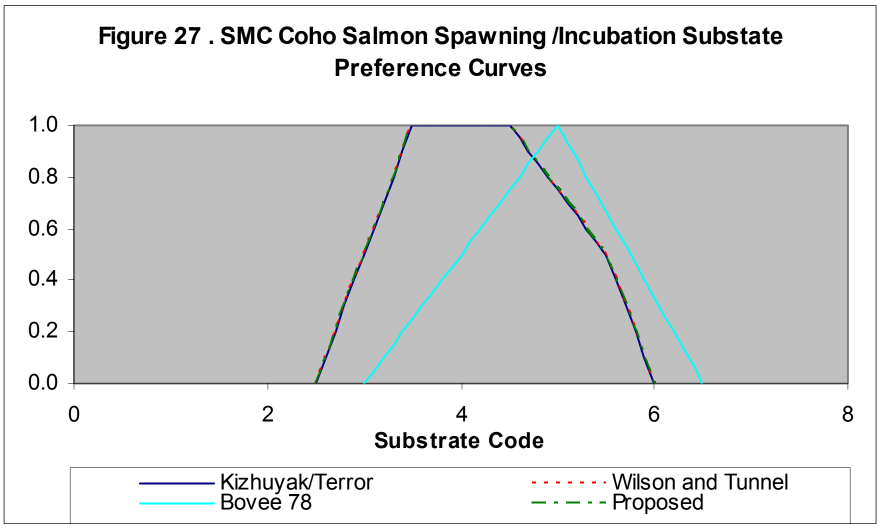

Table 22 . Coordinate Data for Coho Salmon Spawning/Incubaton Substrate Preference Curves.

Code	X	Y	Y	Y
Duff	0.00			
silt/clay	1.00			
	1.50			
sand	2.00			
	2.50	0.00	0.00	
f.gravel	3.00	0.50	0.50	0.00
	3.40	1.00	1.00	
m.gravel	4.00			
	4.50	1.00	1.00	
c.gravel	5.00			1.00
	5.50	0.50	0.50	
	5.60			
	5.80			
s.cobble	6.00	0.00	0.00	0.55
cobble	6.50			
l.cobble	6.60			0.05
s.boulder	6.80			
boulder	7.00			0.00
l.boulder	7.20			
bedrock	8.00			

REFERENCES

All referenced curve information was taken from Ward and Falls Creek papers:

Allan, D.J. 1995. Minimum Flow Requirements, in *Stream Ecology, Structure and Function of Running Waters,* Chapmen and Hall, Oxford pp. 317-320**.**

Baldridge, J.E. 1981. Appendix 3, Development of Habitat Suitability criteria. Artic Environ. Information and Data Center, Terror Lake Project, Alaska

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Conner, E. D., D. Reiser, and P. DeVries. 1995. Site specific habitat suitability curves for the White River, Washington: 1993-1994 study results. Prepared by R2 Resources Consultants for Perkins Coie, Bellevue, Washington.

Hosey and Associates. 1986. Unpublished White River Criteria Curves.

Nadeau, R.L. and S.M. Lyons. 1987. Instream flow investigation Indian River Sitka National Historic Park. Prepared by the USFWS Alaska Investigations for the National Park Service. Alaska Region.

Oregon, 1963. (See Sams and Pearson, 1963).

R2 Resources. 1994, White River. (See Conner, Reiser and DeVries, 1995).

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Sams, R.E. and R.L. Pearson. 1963. The Depth and Velocity of Water over redd sites selected by various salmonid species. Environmental Management section, Oregon Department of Fish and Wildlife, Portland.

WDFW. Washington State 1996. Instream Flow Study Guidelines. Washington Dept. of Fish and Wildlife.

APPENDIX I

Determination of depths and velocities associated with Sawmill Creek steelhead observations through linear interpolation .

Steelhead Depth Curve Development.

As with steelhead velocity curves, steelhead depth curves were developed using both literature-based and Sawmill Creek field survey-based data. Observations of steelhead spawning, fry and juveniles were made in Sawmill Creek over the course of relicensing surveys in 2003 and 2004. Observations which corresponded to IFIM transects were evaluated for depth, using the following process for associating transect depths with fish observations:

- Only fish observed within about 2 feet up- or downstream of an IFIM transect were included in the depth preference evaluation;

- If a fish was observed within one foot of an IFIM transect vertical, the depth at that vertical was assigned to the observation;

- If the fish was more than one foot from a vertical, the depth for that fish was determined through linear interpolation.

Similarly, differences in depths related to differing discharges at the times of the steelhead observations were accounted for by 1) determining the discharge at the time of observation from the Lower Staff Gage record; 2) noting the difference in depth due to discharge differences on the IFIM cross-sections; and 3) generally using linear interpolation, as above, to correct depth for discharge. After examining effects of these discharge differences, we concluded that depth differences due to discharge variation were so small as to be considered insignificant.

APPENDIX II

STEELHEAD TROUT LITERATURE SOURCES

Various sources from the Ward Creek paper were used to develop curves for different life stages. This is a general explanation of why the sources were selected for each life stage.

STEELHEAD VELOCITY

Spawning/Incubation

Oregon 1963 (Sams and Pearson 1963) was selected for use in spawning curve development due to the fact that 45% of the observed Saw Mill Creek data was taken from redds located on the transects. The Sams and Pearson data were also derived from redds.

White River (Hosey 1986) was chosen to help represent spawning in a system whose channel is affected yearly by flood conditions

Fry Rearing

White River (Hosey 1986) was chosen to represent the highly turbid conditions often seen in Sawmill Creek during spill.

Sandy River (Beak 1985) was chosen due to its medium size and the nature of the system which consists of lower gradient pools and riffles in its lower reaches and higher gradient habitat in its upper reaches.

The WDFW (1996) curves were chosen because they came from various sources including medium sized coastal streams in that state.

Juvenile Rearing

The White River study by Conner, Reiser and Devries, 1995, was chosen due to the use of snorkeling observations, to represent highly turbid Sawmill Creek conditions during spill, and to show a comparison between night time and day time preference on the same system.

The second White River curves (Hosey 1986) were chosen to help represent Fall conditions on Sawmill Creek, and as a daytime comparison.

STEELHEAD DEPTH

Spawning/Incubation

As with velocity, the Oregon 1963 (Sams and Pearson 1963) study was selected for use in spawning curve development due to similar data sources as 45% of the observed Sawmill Creek data were taken from redds located on the transects.

The White River (Hosey 1986) was chosen to represent spawning in a system whose channel is affected yearly by flood conditions.

The Skagit (DES 1999) was used due to the similar use of snorkeling observations.

Cedar River (WDFW 1996) curves were used due to the similarity of size after diversion and related human resource use activities.

Fry Rearing

The White River (Hosey 1986) was chosen to help represent rearing in a system with seasonally high turbidity.

The Lostine River (R2 Resources) was chosen due to the similar methods of using previous studies along with field observations.

Sandy River (Beak 1985) was chosen due to its medium size and the nature of the system which consists of lower gradient pools and riffles in its lower reaches and higher gradient habitat in its upper reaches.

Juvenile Rearing

The White River (1994) (Conner, Reiser, and Devries 1995) study was chosen due to the use of snorkeling observations, to help represent Fall conditions on Saw Mill Cr. that during spill consist of highly turbid conditions, and to show a comparison between night time and day time preference on the same system.

The White River (Hosey 1986) was chosen to help represent rearing in a system with seasonally high turbidity.

The Lostine River (R2 Resources) was chosen due to the similar methods of using previous studies along with field observations.