APPENDIX E: UPPER LEWIS EDT ANALYSIS

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Prepared for
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Submitted by
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1.1 DRAFT UPPER LEWIS RIVER EDT ANALYSIS

1.1.1 Study Objectives

The Aquatic resources Group (ARG) for the Lewis River requested that PacifiCorp determine the potential of the stream habitat upstream of Merwin Dam to support anadromous salmonids. To achieve this objective PacifiCorp in consultation with the ARG modeled habitat potential using the Ecosystem Diagnosis and Treatment (EDT) methodology and modeling tools. The following report provides an overview of the EDT Model, a description of methods used to conduct the EDT Analysis and reports the results of modeling runs.

1.1.2 Study Area

The study area includes all streams assumed accessible to anadromous salmonids upstream of Merwin Dam and mainstem reaches of the Lewis River below Merwin Dam, and Columbia River.

1.1.3 Methods

In this section of the report we describe the methods used to complete the EDT analysis for the Upper Lewis River basin.

1.1.3.1 EDT Overview

EDT is an analytical tool used to relate habitat features and biological performance to support fish and wildlife planning. The model has been developed over a number of years primarily by state, tribal, local, and private interests in the Pacific Northwest involved with watershed restoration and salmon recovery[2]. The model captures a wide range of environmental information and makes it accessible to planners, decision-makers and scientists as a working hypothesis of the ecosystem. EDT acts as an analytical framework that brings together information from empirical observation, local experts, other models and analysis.

EDT is as much a planning methodology as it is a model, hence the name Ecosystem Diagnosis and Treatment method. It has three basic components, 1) a conceptual framework, 2) a six-step process based on a Patient/Template analysis, and 3) a set of tools (both a database and population model) that allow biologists to organize and analyze large amounts of environmental and biological data. The ultimate output of the EDT model is a Beverton-Holt spawner-recruit function for both the historic (Template[3]) and current (Patient) conditions. Model outputs are presented in terms of salmonid productivity, capacity, and life history diversity. Estimates of these parameters can be developed for specific fish population, by reach, subbasin or for an

[2] The Northwest Power Planning Council is currently in the process of web-enabling the EDT Model and data entry tools. The model is currently available at WWW.Mobrand.com/edt.
[3] Template or historic condition is defined as the mid 1800's, i.e. a time period before extensive European development of the watershed.

entire basin. These three parameters are included in the parameter list the National Marine Fisheries Service says is key to defining salmonid population viability (McElhany et. al., 2000)[4].

EDT is often misunderstood because of confusion surrounding the term "model". Although EDT is indeed a model, it is a scientific model, not a statistical model. A "scientific model" explains the mechanisms behind phenomena to form an overall hypothesis; a "statistical model" provides correlation-based predictions without necessarily explaining the underlying mechanism. As a scientific model, EDT constructs a working hypothesis of a watershed and a population, which enables us to understand complex ecological systems well enough to design effective enhancement strategies. This working hypothesis also provides metrics to monitor progress and testable hypotheses to refine knowledge. A statistical model, on the other hand, seeks to reduce complexity to a small number of predictive or correlated variables.

EDT draws upon an environmental database of 46 habitat attributes, and a set of mathematical algorithms to compute productivity, capacity and diversity parameters for the targeted salmonid population. Because it is completely deterministic, issues such as statistical power, precision or "over parameterization" are not relevant. A detailed matrix of EDT habitat attributes is provided in Appendix 1 (Environmental Attributes).

At a more fundamental level, EDT is not inductive and predictive so much as it is deductive and explanatory. That is to say, it does not attempt to discover some fundamental property of population performance from other observations or relationships. Rather, it assumes all such relationships are known, states them explicitly, and then uses computer power to integrate many individually simple premises and deduce their combined implications. As mentioned above, the "combined implications" are reduced to just three important biological parameters, salmonid productivity, carrying capacity and life history diversity for the target salmon species.

A complete description of the EDT method, modeling tools and algorithms can be found in Lestelle et al., 1999[5] and at the following link: WWW.EDTHOME.org/sbp/default.htm

A paper describing the biological rules EDT uses to link habitat quality and quantity can also be found at this same link.

1.1.3.2 Enter Environmental Data

The approach used for assembling environmental data for the analysis used three basic steps:

Identify Geographic Scope
Define Stream Reaches
Rate Stream Habitat

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[4] McElhany, P., M.H. Ruckleshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce, Seattle, Washington.

[5] Lestelle, L.C., L.E. Mobrand, J.A. Lichatowich, and T.S. Vogel. 1996. Applied ecosystem analysis - a primer, EDT: the ecosystem diagnosis and treatment method. Project number 9404600. Report. Bonneville Power Administration, Portland, Oregon.

The methods used for completing all three steps of the analysis are discussed below.

Determine Geographic Scope

The first step in the environmental data entry process was to identify the geographic scope of the EDT analysis. The ARG determined that only stream reaches historically accessible to anadromous species above Merwin Dam would be modeled. Stream reaches above impassable waterfalls or other natural barriers were not modeled as part of this effort. However, stream reaches above man-made barriers such as dams were modeled

Define Stream Reaches

In this step, fish-bearing steams were broken into reaches that reflected the hydrography of the basin. Reaches were defined based on habitat surveys (AQU-4), topographic maps, location of man-made barriers, gradient, stream size and confinement, confluences with other streams and input from ARG members[6]. A list of all reaches included in the EDT database is presented in Appendix 2. It should be noted that some of the reaches in this appendix are located below Merwin Dam. These lower basin stream reaches were included in the data because they were needed to run the model (Lewis River reaches 1-7) or may be used for future modeling of habitat potential in the lower basin. Stream data for the lower Lewis River basin can be found on the web at WWW.Mobrand.com/edt.

Mobrand staff was responsible for coding the hydrography of the basin – viz., indicating the direction of water flow and the spatial relationship of tributaries so that it could be understood by the EDT program. This type of reach structure was needed to ensure that the confluences of all fish-bearing streams were identified, and to include coding by which the model could determine upstream from downstream, and thus possible migration routes for juveniles and adults.

Rate Stream Habitat Quality and Quantity

Staff from Cramer and Associates (Cramer) was responsible for developing the draft set of EDT habitat ratings for all stream reaches upstream of Merwin Dam. Cramer staff entered the habitat ratings directly into the EDT Model using the EDT Habitat Questionnaire (Figure 1.1-1)[7]. The Habitat Questionnaire allows the user to enter data along three axes. The first axis is spatial, reflecting the reach structure developed for the basin. The second is temporal, as some information will refer to the Template (the normative, historical circa 1850 watershed), some to the Patient (the contemporary, non-normative watershed), and some to a specific season (by month). The third axes, captures the justification or level of proof for a piece of information.

The habitat ratings were then reviewed and edited by ARG members (Table 1.1-1).

Table 1.1-1. Staff responsible for reviewing EDT habitat data.

[6] Additional streams and reaches for modeling were identified by Janne Kaje (Steward and Associates) and Kevin Malone (Mobrand) based on SSHIAP stream definitions, and topographic maps of the area.
[7] A copy of the EDT questionnaire can be obtained by contacting PacifiCorp or Lewis County PUD.

Staff	Affiliation
Dan Rawding	WDFW
Frank Shrier	PacifiCorp
Duane Bishop	USFS
Tom Backman	Yakama Tribe
George Gilmour	Meridian Environmental, Inc.
Kevin Malone	Mobrand

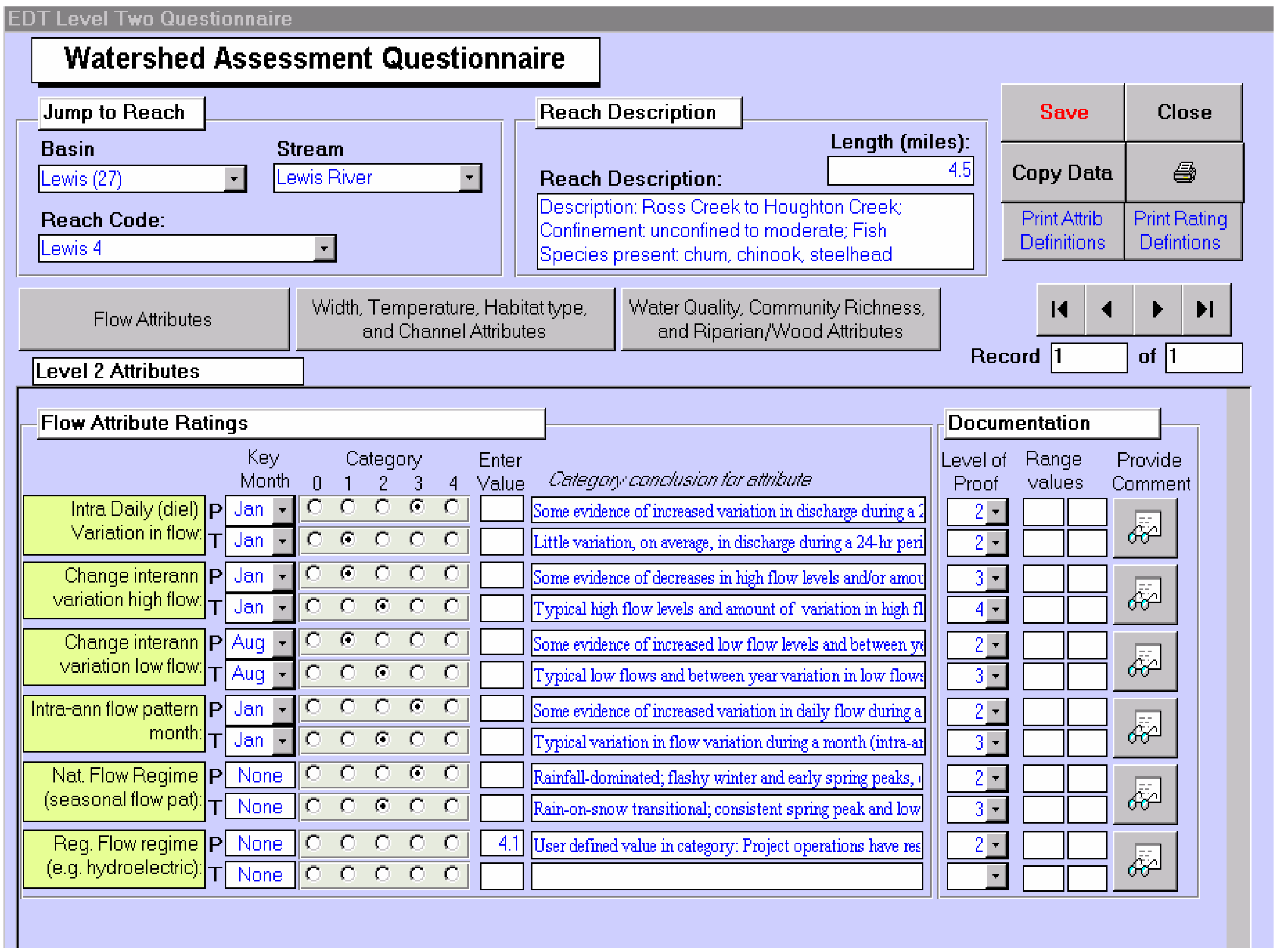

Figure 1.1-1. Screen capture of EDT Questionnaire habitat (flow) input screen.

The 46 attributes rated by the reviewers are listed in Appendix 1, and can be classified roughly into the following categories:

1. Hydrology
2. Water temperature
3. Channel/streambed
4. Biological community richness

5. Riparian conditions
6. Physical habitat (pools, rifles, glides)
7. Water Quality
8. Miscellaneous (pathogens, hatchery outplants, etc.)

The data used for rating each attribute came from a variety of sources and were documented in the Questionnaire in the comments box for each attribute. It should be noted that not every single attribute would have received a comment. Attributes that were rated using professional opinion or were inferred from other data sources would simply have a level of proof associated with them.

The habitat ratings for those stream reaches located below Merwin Dam (Lewis 1-7) was developed by WDFW and Mobrand staff (Dan Rawding, Kevin Malone) for another project. Habitat ratings for all Columbia River reaches were developed as part of the Northwest Power Planning Councils Framework process WWW.NWPPC.org.

Define Flow Patterns

The flow patterns used in the EDT analysis were based on the data presented in WTS-2. Flow patterns are used to expand stream widths by month and identify key high and low flow months.

1.1.3.3 Enter Biological Data

The EDT model requires a wide range of biological data including stock-specific information on fish fecundity, sex-specific age distributions, relative hatchery/wild fitness, hatchery program information, spawning sites and times, terminal harvest rates, and basic life history patterns. Specific parameters and information that were collected and entered by the FTT into the model are described in the following subsections of this report

Select Analysis Species

The ARG selected the following species for EDT Modeling; coho, spring and fall Chinook, and late winter steelhead. These species were selected by the ARG for analysis because they are native to the Lewis River basin and are the focus of management actions that may be undertaken as part of relicensing.

Define Populations and Spawning Distribution

Fish populations were defined and modeled based on geographic distribution in the basin. The populations were defined as inhabiting stream reaches extending from Merwin Dam to the base of Yale Dam (Merwin), Yale Dam to the base of Swift Dam (Yale) and all stream reaches upstream of Swift Dam (Swift).

A complete list of the reaches in which each natural population was known or assumed to spawn either currently or historically was developed by WDFW staff based on professional experience and input from other ARG members. A complete list of the populations modeled and their spawning reaches are presented in Appendix 3 (Fish Populations).

Quantify Adult SpawnTiming

The weeks in which spawning typically begins and ends for each species was based on literature values for each species and input from WDFW fisheries biologist familiar with the basin. The spawn timing used for modeling is presented in Table 1.1-2.

Identify Species Specific Life History Patterns

In EDT modeling, a "life history pattern" consists of a distinct combination of juvenile and adult age distributions for different components of the same population. More specifically, it consists of a set of proportions (summing to 1.0) describing the prevalence of a number of such alternative patterns. Dan Rawding (WDFW) provided the life history patterns used in this analysis for steelhead; Mobrand staff provided the data for the remaining species. Patterns were assigned by species based on the biology of the species and size of stream. For example, it was assumed that late winter steelhead would use small feeder streams for spawning, but on a reduced basis for juvenile rearing as these streams likely dry-up during the summer. The EDT model allows the user to set the proportion of the life histories that remain in the spawning stream during the juvenile rearing period, thus better mimicking how fish actually use different types of stream habitat. The life histories modeled by species and stream size are listed in Table 1.1-3.

Table 1.1-2. Spawn timing for coho, spring Chinook, fall Chinook and winter steelhead.

Species	Start Date	End Date
Coho	November 1	January 29
Spring Chinook	August 20	October 7
Fall Chinook	October 15	January 29
Late Winter Steelhead	April 9	May 20

Table 1.1-3. Life history types modeled for Upper Lewis River basin fish species by stream size.

Species	Stream Size	Pattern
Coho	All	50% Resident/50% Migrant
Spring Chinook	All	50% Stream Type Resident/50% Stream Type Transient
Fall Chinook	All	100% Ocean-Type Transient
Late Winter Steelhead	Small Tributaries	10% Resident/90% Transient
	Midsize Tributaries (Rush, Big Creek, Pine and Muddy Fork)	40% Resident/60% Transient
	Large River (Mainstem Lewis)	95% Resident/5% Transient

In general, resident life histories spend more time in the spawning reach or stream than migrant or transient type.

Note that spring Chinook were modeled using only stream-type life histories while fall Chinook were modeled as having only ocean-type. It is recognized that both spring and fall Chinook will exhibit both types of life histories. Because the EDT Model does not account for competition between the two races, the model was run using the different life histories so that resulting Chinook production was not counted twice. Thus, the number of adults and juveniles produced by the model reflects potential "Chinook" production from the upper basin. The actual ratio of fall and spring Chinook produced in the upper basin will be dependent on the overlap in spawn timing, competition for spawning and rearing space and other environmental and biological factors.

Quantify Sex-specific Age Distribution

Age-specific sex ratios and age-specific fecundity values were obtained from WDFW staff and are listed in Table 1.1-4.

Table 1.1-4. Age, sex and fecundity data for fall Chinook, spring Chinook late winter steelhead and coho.

Fall Chinook Ocean Type

OceanAge	OceanAgeIndex	Fecundity	% Females	Eggs
0.00	0.00	500.00	0.00	0.00
1.00	0.11	500.00	0.01	5.00
2.00	0.15	4,500.00	0.12	540.00
3.00	0.47	5,000.00	0.65	3,250.00
4.00	0.27	5,500.00	0.76	4,180.00
5.00	0.01	5,750.00	0.76	4,370.00

Spring Stream Type

OceanAge	OceanAgeIndex	Fecundity	% Females	Eggs
0.00	0.00		0.00	
1.00	0.05	500.00	0.00	0.00
2.00	0.13	4,600.00	0.19	874.00
3.00	0.68	5,700.00	0.59	3,363.00
4.00	0.14	6,600.00	0.68	4,488.00

Steelhead

OceanAge	OceanAgeIndex	Fecundity	% Females	Eggs
0.00	0.03	1,691.00	0.00	0.00
1.00	0.64	3,848.00	0.50	1,913.00
2.00	0.33	4,893.00	0.62	3,029.00
3.00	0.00	4,893.00	0.00	0.00

Coho

OceanAge	OceanAgeIndex	Fecundity	% Females	Eggs
0.00	0.00	0.00	0.00	
1.00	1.00	3,000.00	0.50	1,500.00
2.00	0.00	3,000.00	0.00	

Quantify Harvest Rates by Species

Because the focus of the Lewis River analysis was to determine habitat potential, harvest rates were not incorporated into the modeling effort. Thus, all results presented in the report are based on the assumption that harvest impacts due not occur to the populations.

Develop Data on Hatchery Operations in the Basin

The number of hatchery fish released in the lower basin and their impact on upper basin fish was not modeled as part of this analysis. However, the habitat attribute ratings due reflect the fact that hatchery fish are present in the basin.

Smolt-to-Adult Return Rates

To account for the range of adult survival that would be observed over time, the model was run under both low and high SARs. The smolt-to-adult return rates (SAR) used in the EDT analysis are presented in Table 1.1-5. Values used by species were obtained based on input from WDFW staff and work products of the ARG.

Table 1.1-5. Smolt-to-Adult return rates (SAR) for coho, spring Chinook, fall Chinook and late winter steelhead.

Species	Low	High
Coho	5%	10%
Fall Chinook (Subyearling)	0.75%	1.5%
Spring Chinook (Yearling)	3%	6%
LW Steelhead	6%	12%

Genetic Fitness

For this analysis each population was modeled at 100% genetic fitness. In other words, it was assumed that the fish population using any stream habitat upstream of Merwin Dam are native to the Lewis River basin and their fitness has not been compromised from the effects of hatchery operations or inter-breeding with hatchery fish.

Additional Assumptions Affecting EDT Inputs or Results

As is the case with any model, results are can be heavily influenced by assumptions that may not be easily gleaned from a review of modeling inputs or results. Some of these assumptions have been discussed in the methods section of this report but are repeated here for emphasis. For this analysis the reader should be aware of the following assumptions:

1) It was assumed that salmon carcass abundance in stream reaches upstream of Merwin Dam is quite high. This assumption was made by the ARG in order to estimate the fish production that would occur with the re-establishment of marine derived nutrients to the system. In

EDT, an increase in salmon carcass abundance results in an increase in the food attribute, which results in an increase in system productivity and thus juvenile production.

2) The SARs used in the analysis has a direct bearing on resulting fish production from the basin. The higher the SAR the higher the number of adults returning to the basin. In interpreting EDT estimates of adult returns to the basin the reviewer should keep in mind that this is simply the Beverton-Holt equilibrium run size given the SAR and habitat ratings entered into the model. In reality, we would observe adult returns over time that would vary dramatically above and below the adult abundance value as a result of changing marine conditions and freshwater habitat variability etc. This is why the model was run using both a low and high SAR. This same point holds true for estimates of juvenile abundance values produced by the model. Thus, it is important that when comparing EDT numbers to any historical estimates of fish production that the assumptions behind the historical value be clearly stated for comparison purposes.

3) Adult and juvenile mortality associated with passage through dams and reservoirs was not specifically included in the model. Thus, the fish production numbers assume > 95% survival through the hydrosystem. For this analysis, the model treated the reservoirs as if they were simply a large pool. Although some mortality does occur at the smolt/migrant life stage, it was generally less than 2% for all reservoir reaches modeled.

4) It was assumed that coho juveniles survive at a higher rate than other species modeled in a reservoir environment. For this analysis, it was assumed that no more than 40% of the coho subyearlings that enter the reservoirs survive to the smolt stage. The 40% value was developed based on professional opinion in consultation with ARG members who reviewed the initial model runs. It was recognized that data to support such an assumption was lacking and would likely be highly affected by presence of other species, reservoir size, reservoir operations and the physical parameters (water temperature etc.) of the reservoirs and thus would not be known until fish were actually stocked in the upper basin. For comparison purposes, it should be noted that in the 1960's researchers estimated that less than 3% of the fry planted in Merwin Lake survived to the smolt smolt stage[8]. However, the authors of the study recognized that fry and subyearling coho could have migrated from the reservoir prior to the installation of traps the following spring. In this analysis the combined fry-to-smolt survival for coho entering the reservoirs vary from ~10-20%.

5) Reservoir survival values for all other life-stages and species were calculated directly by the biological rules imbedded in the model for reservoir habitat.

6) In EDT, each species is modeled independently. Thus, the model does not account for an increase or decrease in competition as fish abundance varies between species.

7) Because habitat data were not available for low gradient tributaries inundated by the reservoirs, most habitat ratings for these types of streams were based on the USFS stream habitat data for Clear Creek. Clear Creek is a low gradient tributary of the Muddy Fork. The exception to this rule was that the widths entered in the model for these low gradient tributaries were taken, if available, from non-inundated portions of the stream just upstream of the reservoir.

8) The model assumes that fish had access to all tributaries inundated by the reservoirs, and that barriers did not prevent them from using those areas above the inundation zone. Given the

[8] Hamilton J., L.O. Rothfus, M.W. Erho, J.D. Remington. Use of a Hydroelectric Reservoir for the rearing of Coho Salmon. Washington Department of Fisheries.

topographic maps of the area it is possible that historically some small tributaries currently accessible to anadromous salmonids were inaccessible.

9) Speelyai Creek has been routed into its historic location, i.e. into Merwin Lake. Therefore, all fish numbers presented for the Merwin populations include fish production from Speelyai Creek.

10) The Swift bypass reach was designated as Lewis 12. The habitat was rated as if Swift No. 2 was still in operation.

1.1.3.4 Run EDT Model

After the biological and environmental data were entered into EDT; Mobrand staff ran the model to produce the following analysis:

1. Population
2. Restoration and Preservation
3. Reach

A description and methods for each type of analysis are presented below.

Population Analysis

The population analysis results in estimates of current and historical fish performance. Data are presented for productivity (adult recruits per spawner and smolts per spawner), carrying capacity (adults and smolts), life history diversity (percent life histories with productivity greater than 1.0) and equilibrium abundance (adults and smolts). Model runs were completed for spring and fall Chinook, late winter steelhead and coho. The model was run to produce fish production results for all populations combined (Merwin, Yale, and Swift), as well as individual populations. The results of this analysis are discussed in detail below.

In addition to the standard current and historic the model was run a second time to estimate resulting fish production from the upper basin if habitat under the reservoir were set at historic condition, and tributaries were set at what is referred to by the NMFS as Properly Functioning Conditions (PFC). This information was developed to assist the ARG in developing and setting mitigation obligations for the Project. The results of this analysis are presented in Appendix 4 (PFC Template Analysis). It should be that this model run was not used for conducting the Restoration or Preservation analyses for the basin.

Finally, the EDT model results developed by others for the lower Lewis River and E.F. Lewis River are included in Appendix 5. This data was included to allow the reader to compare fish production currently occurring in the lower river with forecasted production from the upper. It should be noted that this data is currently being updated by WDFW for inclusion in the Web based system at WWW.Mobrand.com/edt .

Restoration Analysis

The restoration analysis is used to examine the effect restoring historical habitat conditions in each stream reach would have on fish performance in the basin. The reach analysis is conducted by substituting Template habitat values into the Patient condition one reach at a time. The EDT Model is then re-run, and the change in fish productivity, diversity and abundance determined.

Reaches are prioritized for restoration actions based on the combined score for all three parameters. The higher the score, the higher the reach is ranked for restoration. This analysis can be used to prioritize streams or reaches for habitat improvement actions.

Preservation Analysis

A preservation (or maintenance) analysis is undertaken to examine the relative benefit to fish performance if individual reaches were selected and protected in their current state against further habitat degradation. This analysis asks the question: Which reaches are the most important to protect to maintain or secure the fish population against further loss in performance? Analysis results are used to identify stream reaches and lands to acquire for protection.

The preservation analysis is conducted by decreasing habitat quality in each reach by changing (degrading) the values for key environmental attributes such as fine-sediment, stream temperature and bed scour to a set level. The attribute changes result in a situation where habitat quality is reduced sufficiently to eliminate most, but not all fish production from the reach. Preservation analysis results are presented as percent change in total basin fish abundance, productivity and diversity.

It should be noted that the preservation analysis conducted for the Lewis River does not incorporate the cumulative effects that would occur downstream as a result of a change in habitat quality in a given reach. For example, if stream temperature is increased in Reach 2 (upstream), no change in temperature is assumed for Reach 1 (located downstream).

Reach Analysis

The reach analysis compares current to historic habitat conditions on a reach-by-reach basis for the target species. The reach analysis is used to identify those stream reaches in the basin having the greatest affect on fish performance. The greater the affect the reach has on fish production, the greater the benefits that will accrue to the target species from the restoration of the reach.

An example of a Reach Analysis report is shown in Figure 1.1-2

A detailed explanation of the information contained in this type of table is presented below based on the analysis completed for the stream reach designated Sandy1.

Species/Component – This line in the table identifies the species to which the reach analysis applies. In this case, the species being examined is spring Chinook.

Restoration Potential- Identifies the comparison being used to determine the restoration potential of the reach. For the Sandy River the comparison is between current (Patient) and historic (Template) habitat conditions.

Restoration Emphasis- This line is used to identify the emphasis of the restoration approach. Typical restoration approaches could include increasing salmon productivity, re-establishing lost life-history patterns or improving habitat quality through active restoration.

Stream(s) Water(s)- Used to identify basin, river, ocean reach etc.

Species/Component:	Spring Chinook
Restoration Potential:	Current conditions versus Historic Potential
Restoration Emphasis:	0

Stream(s) / Water(s):	Sandy River	**Sub-Watershed:**	
Reach:	Sandy1 extends from confluence with Columbia River upstream 5.4 miles (near Dabney Park)	**Reach Length (mi):**	5.4
		Reach Code:	Sandy1

Restoration Benefit Category:	A	**Life History Diversity Rank:**	4	**Potential % change in diversity:1/**	5.6%
Combined Performance Rank:	2	**Productivity Rank:**	9	**Potential % change in productivity:1/**	7.6%
% of Total Life History Trajectories Affected:	100%	**Average Abundance (Neq) Rank:**	2	**Potential % change in Neq:1/**	28.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatc	Competition (other sp	Flow	Habitat diversity	Harvest	Nutrient load	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	% Key habitat (quan
Spawning	Sep	2.6%	-89.9%	3							•							●		
Egg incubation	Sep-Apr	2.6%	-100.0%	1													●	●		
Fry colonization	Mar-May	5.3%	-7.3%	10						•										
0-age resident rearing	Mar-Oct	12.9%	-10.7%	5					•	•					•	•		•		
0-age transient rearing	Mar-Aug	14.8%	-2.2%	11						•										
0-age migrant	Oct-Nov	13.8%	-3.2%	9						•					•	•				
0,1-age inactive	Oct-Mar	6.4%	-35.4%	4,2	•				•	•					•	•	●			
1-age migrant	Mar-Jun	68.9%	-0.7%	8						•						•				
1-age resident rearing	Mar-May	6.4%	-3.7%	12						•										
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	100.0%	-0.9%	6						•	•							•		
Prespawning holding	May-Sep	2.6%	-24.3%	7					•	•	•							•		

1/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

<HP> indicates highest priority given due to fragmentation of habitat by dam or reservoir.

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	•	○
High	●	○
Extreme	●	○

Figure 1.1-2. Reach Analysis output for Sandy River Spring Chinook.

Reach- Provides a brief description of the reach location.

Sub-watershed- Line provided to allow modelers to break the basin into subbasins for analysis purposes.

Reach Length- The length of the reach in either miles or kilometers.

Reach Code- Identifies the specific reach the data in the table applies to and its EDT modeling designation.

Restoration Benefit Category – Reach category is an arbitrary grouping of reaches based on a visual examination of the change in diversity index, productivity, and abundance for the reach if fully restored to the historic condition (Template). In this example, Sandy1 was assigned to the "A" category as its restoration has great potential for improving spring Chinook diversity, productivity, and abundance.

Life History Diversity, Productivity and Average Abundance (NEQ) Rank– Ranking of reach relative to all others in effect on these performance measures. For this example, Sandy1 was the 4th best candidate reach for improving spring Chinook life history diversity, 9th for productivity and 2nd for increasing abundance.

% of Total Life History Trajectories Affected- Calculates the percent of all modeled fish trajectories that this reach impacts. Sandy1 affects 100% of the prespawning trajectories, as it is the first reach in the basin. In general, the further upstream the each, the fewer trajectories the reach affects.

Combined Performance Rank- Combined reach ranking is the average rank among the three performance ranks in comparison to all reaches in the basin. In other words, the three ranks are averaged for each reach, the average scores for the reaches are then sorted lowest to highest, the lowest score is then converted to a 1 (reach with highest restoration potential) other reaches assigned ranks based on ascending order. In this example, Sandy1 was rated a 2, therefore there is only 1 reach with higher restoration benefit.

Potential % Change in Productivity, Abundance, and Diversity – These are the basic metrics for comparing the benefit category and ranking of the reaches. They show the potential for improvement in overall population performance if this reach were fully restored to historic conditions. The restoration of Sandy1 would result in a 5.6%, 7.6%, and 28.2% increase in Sandy River spring Chinook diversity, productivity and abundance (NEQ), respectively.

Life Stage – This column shows the life-stages examined in the model (may vary by species).

Relevant Months- The months or target month when the life-stage occurs.

% of Life History Trajectories Affected By Life Stage- This column shows how the reach is used by the entire spring Chinook population. Trajectories are computer-generated pathways through the landscape. Trajectories originate with spawning and end with pre-spawning holding (i.e., closed life history). Points to be aware of:

1) The % of the life history trajectories affected for pre-spawning holding, egg incubation and spawning are reach specific. For example, you will note that the % of life history trajectories is the same for all of these life stages (2.6%).
2) Note that the values for other life stages vary considerably as fish from different reaches in the basin use this reach differently. For example, 68.9% of the 1-age migrant trajectories pass through this reach, but only 5.3% of the fry colonization trajectories utilize the reach. The

fry trajectories are made up of fry produced in the reach and those migrating downstream from the next reach or two upstream.

Productivity change (%)- Is the change in life stage specific productivity resulting from the change in the attributes shown across the row (black dots). For Sandy1, the reach analysis shows that spawning productivity has decreased by 89.9% due primarily to a change in Temperature in this reach. Again, the comparison is based on Template conditions.

Life Stage Rank- Rank is combination of productivity loss and relative utilization of the reach by that life stage. A reach that is heavily used for a particular life stage and that has experienced a large loss will rank high. A reach may have experienced a large change in productivity for a life stage but if the reach is not used heavily by that life stage it will rank lower. In this example, egg incubation (1) was the life-stage most heavily affected by the change in the attributes, followed by 1-age inactive (2), and then spawning (3).

Change in attribute impact on survival- Provides for each life stage a consumer report style summary by attribute. Larger black circles indicate greater effect on survival, as a result of a decrease in habitat quality. Circles are scaled in comparison to all other circles presented for the reach. The reader should note that a lot of small black circles spread across multiple attributes could equal or exceed the effect of a single large circle. Thus, the reader should at look at both the life stage rank and the size of the circles to discern the conclusions presented in this table.

1.1.4 Results

Results of the EDT analysis are presented below under the following headings:

1. Population Analysis
2. Restoration and Preservation Analysis
3. Reach Analysis

Results for the population analysis are presented for all species modeled by geographic area. The results of the restoration, preservation and reach analyses are available on CD as there are over 400 pages of results. However, partial results are presented for spring Chinook to provide the reader the necessary information to interpret preservation and restoration results.

Population Analysis

Total Production

Results of the EDT population analysis for potential anadromous fish production upstream of Merwin Dam (upper basin) based on low SARs are presented in Table 1.1-6. Fish production data for the high SAR model runs are presented in the appendices.

The juvenile numbers in Table 1.1-6 reflect the number of juveniles leaving the Lewis River. Adult numbers denote the number of adults entering the mouth of the Lewis River.

Table 1.1-6. EDT estimates of juvenile and adult diversity, productivity, capacity and abundance for coho, late winter steelhead and spring and fall Chinook upstream of Merwin Dam for the current and historic condition. (Low SAR)

CURRENT							
Species	**Diversity**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**	**Adult Productivity**	**Adult Capacity**	**Adult Abundance**
Coho	48%	91.7	335,955	254,912	4.8	16,155	12,476
Late Winter Steelhead	42%	131.4	36,992	32,330	8.2	2,305	2,015
Spring Chinook	30%	176.5	86,072	66,195	5.4	2,615	2,013
Fall Chinook	35%	289.3	253,076	114,154	2.3	1,815	861
Total			**712,094**	**467,591**		**22,891**	**17,364**
% of Historic			54.5%	41.1%		46.2%	37.7%
HISTORIC							
Species	**Diversity**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**	**Adult Productivity**	**Adult Capacity**	**Adult Abundance**
Coho	97%	294.6	363,757	345,473	21.9	27,063	25,699
Late Winter Steelhead	98%	349.7	76,725	73,470	24.1	5,246	5,025
Spring Chinook	99%	424.1	362,497	335,351	16.4	12,643	11,781
Fall Chinook	100%	504.2	503,748	383,922	4.8	4,619	3,557
Total			**1,306,726**	**1,138,216**		**49,571**	**46,063**

The data in Table 1.1-6 indicate that streams above Merwin dam have the potential to produce upwards of 465,000 juvenile and 17,000 adult salmonids under current habitat conditions and modeling assumptions. For the historic condition, EDT estimates that the upper basin produced ~1.1 million juveniles and ~46,000 adults (at equilibrium). Overall, the upper basin has the potential to produce approximately 41% of historic juvenile production and ~38% of adult production if fish are allowed access to all streams and reaches modeled.

The EDT model estimates that both juvenile and adult productivity and capacity has decreased dramatically in comparison to the historic condition. For example, productivity values range from 2.3-8.2 for the current condition versus 4.8-24.1 for the historic. In addition, current adult and juvenile capacity has been decreased to ~40-60% of historic, while life history diversity has been reduced to about 30-50%.

Fish Production by Species and Geographic Area

The EDT model estimates that the upper basin can produce approximately ~250,000 coho juvenile and ~12,000 adults (Table 1.1-7)[9]. In contrast, the model shows that historic juvenile and adult production was 345,000 and 26,000, respectively. Based on these modeling results, it is estimated that the upper basin can produce ~72% of the historic juvenile production and 48% of the adult.

The vast majority of the adult coho production (~73%) comes from stream reaches upstream of Swift Dam. Coho production from the Yale and Merwin geographic areas produce approximately 20% and 8% of the coho, respectively.

The Swift population exhibits the highest juvenile and adult productivity, capacity and diversity values, Merwin the lowest, and Yale intermediate. Note that the combined juvenile capacity values for all three populations are actually very close to historic capacity. This is a direct result of the modeling assumption that reservoirs provide significant rearing habitat for coho salmon.

Estimates of current coho juvenile and adult productivity are greatly reduced from the historic condition (~14-34% of historic). A loss in productivity decreases the population’s ability to recover from losses due to harvest or extreme environmental events. Also note that life history diversity has decreased to about ~30-60% of its historic level. A loss in diversity results in a decrease in a populations resilience to environmental change.

For late winter steelhead (Table 1.1-8), the model forecasts that the upper basin can produce approximately 32,000 juveniles and 2,000 adults given the assumptions inherent in the model. For the historic condition the model estimated that the upper basin produced ~73,000 juvenile steelhead and ~5,000 adults. Based on these modeling results, it is estimated that the upper basin can produce ~44% of the historic juvenile steelhead production and ~40% of the adult.

[9] The fish numbers shown in Table 1-1.6 and Table 1.1-7 vary as a result of the way the numbers were generated. Combining individual populations into a single population was the process used to generate the numbers presented in Table 1.1-6. In contrast, the numbers presented in Table 1.1-7 to Table 1.1-10 are based on model runs of individual populations.

As was the case with coho, the vast majority of the steelhead production (~84%) comes from stream reaches upstream of Swift Dam. Steelhead production from the Yale and Merwin

Table 1.1-7. EDT estimates of juvenile and adult diversity, productivity, capacity and abundance for coho by geographic area and condition (Current and Historic). (Low SAR)

CURRENT

Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	56%	98.0	226,048	176,610	70.6%	5.2	11,203	8,866	72.4%
Yale	31%	75.6	80,004	54,650	21.8%	3.7	3,556	2,500	20.4%
Merwin	32%	62.9	29,903	18,927	7.6%	3.0	887	887	7.2%
Total			**335,955**	**250,187**			**15,646**	**12,253**	
% of Historic			92.4%	72.4%			57.8%	47.7%	
HISTORIC									
Species	**Diversity**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**	**% of Total Juvenile Production**	**Adult Productivity**	**Adult Capacity**	**Adult Abundance**	**% of Total Adult Production**
Swift	97%	289.6	253,139	240,103	69.5%	21.9	19,183	18,194	70.8%
Yale	100%	302.5	62,549	59,540	17.2%	21.7	4,487	4,271	16.6%
Merwin	95%	309.2	48,069	45,799	13.3%	21.7	3,393	3,232	12.6%
Total			**363,757**	**345,442**			**27,063**	**25,698**	

Table 1.1-8. EDT estimates of juvenile and adult diversity, productivity, capacity and abundance for late winter steelhead by geographic area and condition (Current and Historic). (Low SAR)

CURRENT

Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	60%	133.0	30,861	27,009	83.9%	8.3	1,920	1,680	83.8%
Yale	10%	90.2	2,901	2,373	7.4%	5.8	189	154	7.7%
Merwin	7%	125.3	3,230	2,794	8.7%	7.8	197	171	8.5%
Total			**36,992**	**32,176**			**2,305**	**2,005**	
% of Historic			48.2%	43.8%			43.9%	39.9%	
HISTORIC									
Species	**Diversity**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**	**% of Total Juvenile Production**	**Adult Productivity**	**Adult Capacity**	**Adult Abundance**	**% of Total Adult Production**
Swift	100%	340.5	52,235	49,935	68.0%	23.6	3,583	3,426	68.2%
Yale	97%	369.1	13,512	12,965	17.7%	25.3	912	875	17.4%
Merwin	90%	362.0	10,978	10,526	14.3%	24.8	751	720	14.3%
Total			**76,725**	**73,426**			**5,246**	**5,022**	

geographic areas produces the remaining 16% on a roughly equal basis. Juvenile and adult productivity is highest for the Swift population and lowest for Yale. The Swift population exhibits the highest life history diversity value (60%).

The data in Table 1.1-9 provides an estimate of spring Chinook production for the upper basin. As was noted in the methods section, the results for spring Chinook are based on a stream-type (yearling) life history pattern. The EDT model estimates that the upper basin can produce approximately 66,000 juvenile spring Chinook and ~2,000 adults. In contrast, the model shows that historic juvenile and adult production was ~335,000 and ~12,000, respectively. Based on these modeling results, it is estimated that the upper basin can produce ~20% of the historic juvenile production and 17% of the adult.

The majority of the spring Chinook production, ~93% of the juvenile and 94% of the adult, comes from stream reaches upstream of Swift Dam. The remainder of the spring Chinook production comes from Yale. Because of a lack of spawning habitat in the Merwin reach, the model forecasts that spring Chinook cannot successfully reproduce in this area.

Spring Chinook productivity and diversity is also greatly reduced from the historic condition. Current juvenile and adult productivity is less than ~50% of the historic: while current juvenile and adult capacity is less than ~24% and ~21%, respectively.

The data in Table 1.1-10 provides an estimate of fall Chinook production for the upper basin. Again, as was noted in the methods section, the results for fall Chinook are based on an ocean-type (subyearling) life history pattern. The EDT model estimates that the upper basin can produce approximately 112,000 juvenile fall Chinook and ~847 adults. In contrast, the model shows that historic juvenile and adult production was ~385,000 and 4,000, respectively. Based on these modeling results, it is estimated that the upper basin can produce ~29% of the historic juvenile production and ~24% of the adult.

As was the case with spring Chinook, the vast majority of the juvenile production (~81%) and adult fall Chinook production (~85%) comes from above Swift with the remainder produced from Yale.

In comparison to the historic condition, life history diversity is approximately 50%-100% of historic, while juvenile and adult productivity has been decreased by more than 50%.

<u>Restoration and Preservation Analyses</u>

The restoration analysis is used to identify those stream reaches that would provide the greatest benefit to the target species if restored to their historic habitat conditions. The preservation analysis is used to identify reaches that should be protected through management actions as they are currently providing the bulk of the fish production in the basin.

In both analyses, the reaches are ranked based on their combined score for all three parameters (diversity, abundance, productivity). This approach emphasizes the fact that each parameter has equal importance to the population. Because the number of reaches (>100) and species (4) examined results in over 400 lines of output, the results are presented by species in an EXCEL driven program on the attached CD.

Table 1.1-9. EDT estimates of juvenile and adult diversity, productivity, capacity and abundance for spring Chinook by geographic area and condition (Current and Historic). (Low SAR)

CURRENT									
Species	**Diversity**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**	**% of Total Juvenile Production**	**Adult Productivity**	**Adult Capacity**	**Adult Abundance**	**% of Total Adult Production**
Swift	35%	174.7	79,580	61,324	92.7%	5.4	2,452	1,893	94.0%
Yale	27%	193.5	6,493	4,805	7.3%	4.9	164	121	6.0%
Merwin	0%	0.0	0	0	0.0%	0.0	0	0	0.0%
Total			**86,072**	**66,129**			**2,615**	**2,014**	
% of Historic			23.7%	19.7%			20.7%	17.1%	
HISTORIC									
Species	**Diversity**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**	**% of Total Juvenile Production**	**Adult Productivity**	**Adult Capacity**	**Adult Abundance**	**% of Total Adult Production**
Swift	100%	395.5	215,233	199,989	59.6%	16.3	8,733	8,121	68.9%
Yale	100%	421.8	55,922	52,086	15.5%	16.0	2,079	1,939	16.5%
Merwin	91%	576.1	91,342	83,201	24.8%	17.4	1,831	1,720	14.6%
Total			**362,497**	**335,277**			**12,643**	**11,780**	

Table 1.1-10. EDT estimates of juvenile and adult diversity, productivity, capacity and abundance for fall Chinook by geographic area and condition (Current and Historic).

CURRENT

Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	49%	265.4	210,047	90,635	81.3%	2.2	1,571	718	84.7%
Yale	20%	381.3	43,028	20,915	18.7%	2.6	245	129	15.3%
Merwin	0%	0.0	0	0	0.0%	0.0	0	0	0.0%
Total			**253,076**	**111,551**			**1,815**	**847**	
% of Historic			50.2%	29.0%			39.3%	23.8%	

HISTORIC

Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	100%	441.7	239,245	179,529	46.6%	4.7	2,440	1,848	51.9%
Yale	100%	560.3	124,488	96,129	25.0%	5.1	1,064	832	23.4%
Merwin	100%	615.1	140,015	109,623	28.5%	5.0	1,115	878	24.7%
Total			**503,748**	**385,280**			**4,619**	**3,558**	

To help the reader interpret the results from a typical EDT restoration and preservation analyses, a subset of the spring Chinook output is presented in Figure 1.1-3. Some key points from this analysis are:

1) The restoration of Clearwater Creek and the mainstem Lewis River reaches (Lewis 10-14) inundated by the reservoirs would provide some of the largest increases in spring Chinook production in the upper Lewis River basin. This can be seen by examining the length of the bars on the restoration side of the chart
2) Improvements in the lower Columbia River and estuary would also result in a large increase in spring Chinook production in the basin. These data point out the fact that factors outside of the basin have dramatic effects on resulting fish production in the Lewis River.
3) In regards to preservation, the model indicates that Clear Creek would be a major producer of spring Chinook if this species were restored to the Upper Lewis River, as evidenced by the bar under the Degradation column in the figure.

As was discussed in the methods section, the preservation analysis is performed by degrading the reach to a level where fish production is still possible but reduced significantly. Reaches that show a large change in fish production from degradation have the highest production under current conditions.

Reach Analysis

The reach analysis shows the effect the individual habitat attributes are having on fish production at the reach level. The reach analysis results for Clear Creek are presented in Figure 1.1-4 for illustration purposes. Data are available for all reaches modeled in this analysis on the accompanying CD.

The reach analysis is used for focusing actions on the habitat attributes having the greatest impact on fish performance. In the case of Clear Creek, the largest loss in productivity (-39.3%) is in the egg incubation stage, primarily due to impacts from sedimentation.

The reach analysis not only provides an easy way to identify habitat problems and their effect on fish populations, it can also be used to check the habitat ratings entered into the model. For example, if you have a report showing that sediment levels are low in a reach, yet the model shows a high sediment hit, then a check of the data is in order to confirm that data were entered correctly.

A point that should be emphasized is that the reach analysis looks at the difference in survival by life stage between the historic and current condition. Thus, in the sediment example above, there may still be a significant hit from sedimentation even if the sediment rating entered for the current condition was correct. It is important when diagnosing habitat problems that the values for both conditions be examined closely before running the model.

Columbia, Lower Spring Chinook

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
Clearwater Creek	A	4	B	7
Columbia R: Mouth - RM 49 (saltwater estuary)	B	8	B	8
Lewis 12	B	6	B	10
Clear Creek	A	3	C	14
Clear Creek Lower	A	2	D	17
Lewis 11	D	27	A	4
Lewis 14	D	25	B	6
Columbia R: Cowlitz R-Below Bonn	C	15	D	18
Columbia R: RM 49-Cowlitz R (upper estuary)	C	17	D	22
Lewis 10	E	40	A	3
Cougar Creek	C	18	E	51
Lewis 13	E	51	E	27
Drift Creek	E	38	E	41
Drift Creek Template	E	56	E	25
Cougar Creek Template	E	53	E	34
Lewis 1 tidal	E	39	E	50
Cussed Hollow	E	45	E	58
Canyon Creek	E	59	E	59
Coastal Zone North (100 mi): Col. R. Mouth	E	59	E	59
oastal Zone North (100 mi): Col. R. to Cape Flatter	E	59	E	59

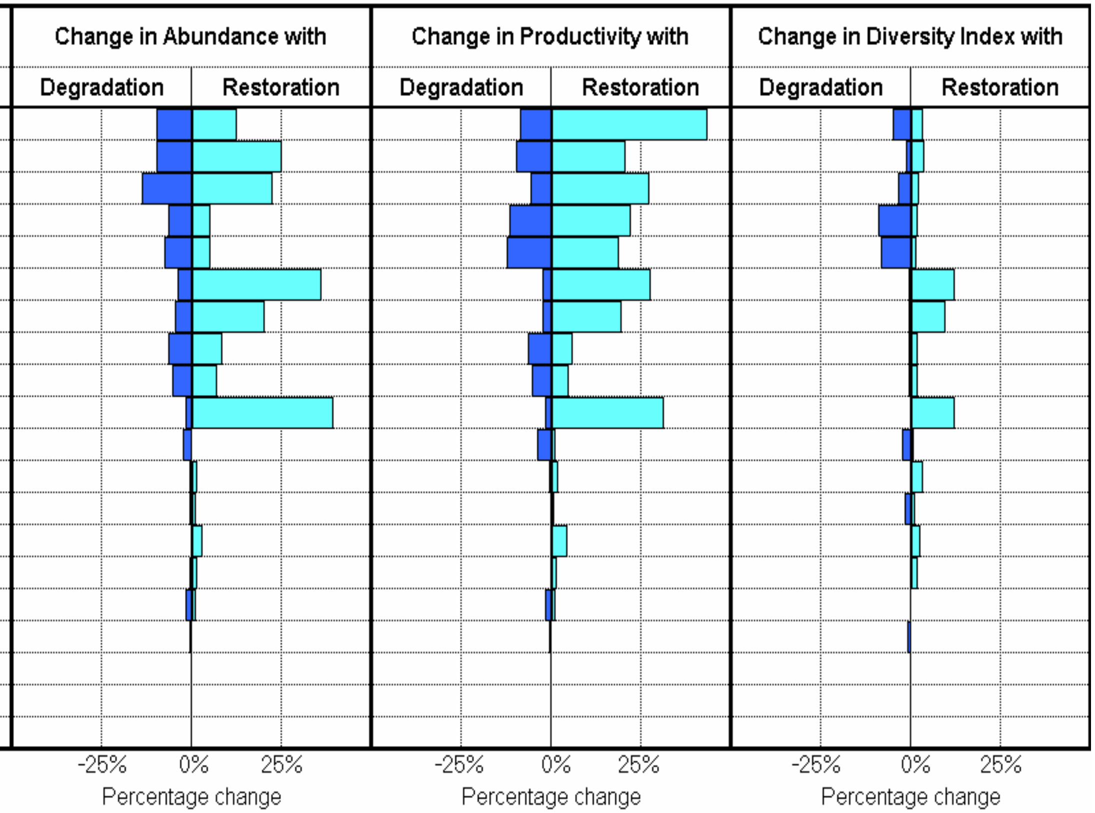

Figure 1.1.3. Preservation and restoration analysis for Upper Lewis River Spring Chinook

Species/Component:	Spring Chinook
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Upper Lewis - Spring Chinook

Geographic Area:	Clear Creek	**Stream:**	Clear Creek
Reach:	Description: mouth to RM 8.7; Confinement: confined; Fish Species present: WS, SS	**Reach Length (mi):**	6.15
		Reach Code:	Clear Creek

Restoration Benefit Category:1/	C	**Productivity Rank:1/**	9	**Potential % change in productivity:2/**	21.7%
Overall Restoration Potential Rank:1/	14	**Average Abundance (Neq) Rank:1/**	18	**Potential % change in Neq:2/**	4.8%
(lowest rank possible - with ties)1/	59	**Life History Diversity Rank:1/**	23	**Potential % change in diversity:2/**	1.6%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	4	**% loss in productivity with degradation:2/**	-11.5%
Overall Preservation Rank:1/	3	**Average Abundance (Neq) Rank:1/**	11	**% loss in Neq with degradation:2/**	-6.1%
(lowest rank possible - with ties)1/	59	**Life History Diversity Rank:1/**	2	**% loss in diversity with degradation:2/**	-8.8%

					Change in attribute impact on survival															
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Sep	3.2%	-1.0%	6							●									•
Egg incubation	Sep-Apr	3.2%	-39.3%	1													⬤			•
Fry colonization	Mar-May	6.4%	-7.4%	2					●	●	●									●
0-age active rearing	Mar-Oct	2.3%	-4.7%	3						•	•									⬤
0-age migrant	Oct-Nov	1.9%	-1.6%	7							•					•				
0-age inactive	Oct-Mar	1.0%	-10.0%	4					•	•	●									●
1-age active rearing	Mar-May	1.0%	-1.1%	8							•									●
1-age migrant	Mar-Jun	1.0%	-0.3%	10							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	3.2%	-0.1%	9							•									
Prespawning holding	May-Sep	3.2%	-2.6%	5					•		•									●
All Stages Combined		6.4%																		

Loss Gain

Figure 1.1-4. Spring Chinook reach analysis for Clear Creek.

1.1.5 Discussion

The EDT Model is able to provide managers with a series of analysis that are directed at answering very specific management questions or objectives. The population analysis provides managers with an estimate of fish production potential at the basin; stream and reach levels for both the current and historic conditions. In contrast, the restoration analysis can be used by managers to identify those reaches that if restored to historic conditions would provide the largest benefits to target species. The preservation analysis may be used to identify those reaches that are currently providing the bulk of fish production in a basin and therefore should be considered for protection (preservation) from human activities that may degrade this critical habitat.

For the Lewis River, the EDT analysis has to date been more focused on the population component of the analysis. Participants in the relicensing process are interested in determining the anadromous fish production potential in stream reaches upstream of Merwin Dam. These data may be used for selecting the need for, and location of, fish passage facilities: mitigating for project impacts, and determining the relative benefits of proposed actions. Because of the production emphasis, the discussion presented below focuses on the major points the reader should come away with from the population analysis.

Estimates of Fish Population Size and Viability for the Current Condition

EDT Model estimates that the upper basin is currently capable of producing approximately ~40% of the historic coho, Chinook and late winter steelhead adult production (Table 1.1-6). However, this conclusion rests upon the assumption that fish passage survival through the hydrosystem is quite high (>95%). Therefore, to achieve the full production levels forecast by the model, effective fish passage facilities would need to be constructed at the three-mainstem hydroprojects (Swift No. 1, Yale and Merwin).

Of the three species modeled, coho produce the most returning adults (~12,000), followed by Chinook (~3,000) and late winter steelhead (~2,000) (Table 1.1-6). The adult numbers presented in the analysis represent the equilibrium (average) run size expected back to the basin over time as long as habitat conditions remain unchanged. As is the case with all natural anadromous fish populations, run size would vary yearly due to variability in freshwater survival, changing ocean conditions and interactions with other species etc. To illustrate this point, the habitat inputs used in EDT for current upper basin coho production were entered into the Lewis River Fish Passage Model developed by the ARG. Model outputs are shown in Figure 1.1-5.

The results of this illustration show that given the population parameter assumptions, average coho abundance is approximately 9,300 (EDT estimated ~12,000), and would vary from a low of ~1,000 to a high upwards of ~30,000, for all populations combined[10]. Note that in this example all reservoir, turbine, transport survival etc. included in the Lewis River Model were set at 100%. The data for the Swift Only columns reflect only fish production from above Swift Dam. The

[10] The difference in adult production between models is a result of the SAR values used in each. The Lewis River coho model selects from a range of SAR values ranging from 1%-13%, EDT uses a single value.

Summary Results for Inter-Annual Variation Analysis
Summary Of Spawner and Smolt Abundances Over 100 Generations

Model Run At: 2/20/03 1:55:01 PM
SAR - Variable; Smolts/Female - Variable

Spawners (on spawning grounds)		System					
		1 - Volitional		2 -Max Trap-and-haul		3 - Swift Only	
		No bypass effect	Bypass effect	No D effect	D effect	No D effect	D effect
Total	**Average**	9,343	9,343	9,343	9,343	5,942	5,942
	Max	30,376	30,376	30,376	30,376	19,313	19,313
	Min	1,099	1,099	1,099	1,099	699	699
	No < 50 fish [1/]	0	0	0	0	0	0
Swift	Average	5,942	5,942	5,942	5,942	5,942	5,942
	Max	19,313	19,313	19,313	19,313	19,313	19,313
	Min	699	699	699	699	699	699
	No < 50 fish [1/]	0	0	0	0	0	0
Yale	Average	2,119	2,119	2,119	2,119		
	Max	6,894	6,894	6,894	6,894		
	Min	250	250	250	250		
	No < 50 fish [1/]	0	0	0	0		
Merwin	Average	1,281	1,281	1,281	1,281		
	Max	4,168	4,168	4,168	4,168		
	Min	151	151	151	151		
	No < 50 fish [1/]	0	0	0	0		

1/ Number of generations when spawner abundance < 50 fish.

Figure 1.1-5. Lewis River Fish Passage Model results using EDT current population parameters for coho.

Max Trap-and-haul numbers assume no hydrosystem loss or loss due to transport. Again however, the point of Figure 1.1-5 is to simply show how fish abundance may vary over time.

Based on EDT model results, current juvenile production (all species) for the entire upper basin is estimated at ~467,000 fish. Coho juvenile make up the vast majority of upper basin production (~250,000). The majority of the coho production (72%) comes from stream reaches above Swift. Of interest is the fact that the model estimates Merwin coho juvenile production at ~19,000. In comparison, WDF researchers in the 1960's estimated that fry plantings in tributaries and in this reservoir produced between 9,000 and 26,000 smolts (Hamilton et al., 1970)[11].

In regards to productivity, the model forecasts that late winter steelhead would have the highest productivity, fall Chinook the lowest, followed closely by coho. These results indicate that late winter steelhead would be able to better withstand mortality associated with harvest or other events resulting in a large decrease in survival (e.g. loss due to fish passage through reservoirs and dams). Given the low productivity values of the other species, any significant loss from fish passage or harvest would decrease the probability that the runs could be maintained (without hatchery supplementation) over time.

[11] Hamilton J., L.O. Rothfus, M.W. Erho, J.D. Remington. Use of a Hydroelectric Reservoir for the rearing of Coho Salmon. Washington Department of Fisheries.

Each of the populations modeled show a decrease in life history diversity of up to 100%. Thus, significant portions of the life histories assumed present in the historic condition are no longer viable. This result should not be surprising given the conversion of large amounts of free flowing mainstem riverine habitat into slack water reservoirs as a result of dam construction. Whether this prediction is correct would not be known until these species are reintroduced back to the upper watershed. In addition, the presence of the reservoirs may result in a life history that is not possible in a riverine environment. If it is decided to reintroduce fish to the upper basin, monitoring should be focused on determining which life histories are successful, and whether or not unexpected life histories are being developed and protected.

As was the case with the results of earlier ARG model runs of the Lewis River Fish Passage Model for coho, the majority of the fish production for each species (72-94%) comes from stream reaches upstream of Swift Dam.

For all populations combined, approximately 77% of the adult production is produced above Swift, 17% in Yale, and 6% in Merwin. Note that no fall or spring Chinook are produced in the Merwin portion of the upper basin, and that less than 200 are produced in Yale; primarily from the bypass reach.

In regards to fish passage, the EDT results show that construction of highly effective fish juvenile collection or bypass facilities at Swift are critical to program success if reintroduction is undertaken in the upper basin. Approximately 77% of the juvenile production comes from stream reaches above this dam. If juveniles are allowed to migrate volitionally through the remaining two/three reservoirs and dams, similar facilities with high passage effectiveness will also be needed at these dams as well. However, it must be noted that regardless of the effectiveness of the fish collection facilities at locations downstream of Swift Dam, juveniles leaving Swift Dam would still have to pass through at least two reservoirs dams and bypass systems. A 40% loss fish passage loss to the Swift population would equal the total juvenile production from both Yale and Merwin for all species combined.

<u>Estimates of Fish Population Size for the Historic Condition</u>

The EDT model forecasts that historically the upper basin produced approximately 1.1 million anadromous juveniles and 46,000 adults. The habitat supported self-sustaining runs of coho, Chinook and late winter steelhead. These populations were highly productive and exhibited diverse life histories.

The reader should be aware that the estimate of adult production is the equilibrium value as defined using a Beverton-Holt production function. Actual fish run-sizes (as well as juvenile production) would vary dramatically around this population estimate due to the variability in freshwater habitat, the ocean, and due to interactions with other species.

The variability in run size that may occur due to environmental or biological variability can be shown through the use of a fish population model programmed to incorporate variability into the analysis. To illustrate this point, the EDT generated population parameters for historic upper basin coho production was entered into the Lewis River Fish Passage Model developed by the ARG. Model outputs are shown in Figure 1.1-6. The results of this illustration show that given

Summary Results for Inter-Annual Variation Analysis
Summary Of Spawner and Smolt Abundances Over 100 Generations

Model Run At: 2/20/03 1:19:17 PM
SAR - Variable; Smolts/Female - Variable

Spawners (on spawning grounds)		System					
		1 - Volitional		2 -Max Trap-and-haul		3 - Swift Only	
		No bypass effect	Bypass effect	No D effect	D effect	No D effect	D effect
Total	**Average**	23,026	23,026	23,026	23,026	16,232	16,232
	Max	48,149	48,149	48,149	48,149	33,943	33,943
	Min	5,056	5,056	5,056	5,056	3,564	3,564
	No < 50 fish [1/]	0	0	0	0	0	0
Swift	Average	16,232	16,232	16,232	16,232	16,232	16,232
	Max	33,943	33,943	33,943	33,943	33,943	33,943
	Min	3,564	3,564	3,564	3,564	3,564	3,564
	No < 50 fish [1/]	0	0	0	0	0	0
Yale	Average	3,844	3,844	3,844	3,844		
	Max	8,039	8,039	8,039	8,039		
	Min	844	844	844	844		
	No < 50 fish [1/]	0	0	0	0		
Merwin	Average	2,949	2,949	2,949	2,949		
	Max	6,167	6,167	6,167	6,167		
	Min	648	648	648	648		
	No < 50 fish [1/]	0	0	0	0		

1/ Number of generations when spawner abundance < 50 fish.

Figure 1.1-6. Lewis River Fish Passage Model results using EDT historic population parameters for coho.

the population parameter assumptions, average coho abundance is approximately 23,000 (EDT estimated 26,000), and would vary from a low of 5,000 to a high upwards of 48,000.

A major question that is always asked about the EDT estimate of fish historic production:

Is the estimate accurate?

The correct answer of course can never be known or determined, as there are no accurate estimates of coho returns to the Lewis River basin for the 1800's. Thus, EDT is providing one hypothesis about coho production given the assumptions about the quality and quantity of fish habitat in the basin and the scientists understanding of the biology of the species. Disagreements in run size estimates should therefore not be focused on the numbers produced by any model, but the assumptions that go into the model. As was noted in the methods section of this report, run size could be doubled by simply doubling the SAR value entered into the model.

A further point that should be emphasized is that before spending considerable time and resources arguing and fine-tuning historical estimates a second question should be asked.

What importance does this number have in regards to the management decisions that need to be made?

or

If the number were double or half, would this materially affect the decision process or final choice?

If importance is high, then effort may be well spent in an attempt to refine the value. In this case, an examination of historical fish counts at an earlier time may be in order.

The earliest "counts" of coho and Chinook production originating from the upper basin was collected in the 1930's with the closure of Merwin Dam (see Aqu-1). The min, max and average number of fish collected by species along with the EDT derived estimate of average historic conditions is shown in Table 1.1-11.

Table 1.1-11. The min, max and average number of adults collected at Merwin Dam in the 1930's: and EDT historic estimate of average adult production.

Species	Min	Average	Max	EDT (average)
Coho	643	11,000	24,595	25,699
Chinook	26	1,412	4,007	15,200
LW Steelhead*	300	NA	500	5,025

* Steelhead numbers based on 1930-50's dam counts.

A quick review of the data in this table show that average EDT adult production is near or well above the maximum number of adults captured at Merwin in the 1930's. However, even with actual fish counts, a comparison with EDT results is not straightforward as the number of fish available for collection or collected at Merwin in the 1930's was heavily affected by trap-efficiency, harvest rate, juvenile survival past Merwin Dam, and ocean conditions. Thus, even when using actual counts of real fish at a known time and place tremendous uncertainty still exists around the resulting numbers.

Although it may never be known if the EDT estimate reflects historic fish production potential of the basin, the difference between the historic potential of the basin is significantly higher than the current. This implies that severe degradation of habitat has occurred over the last 150-years which is consistent with observation. The model also shows that habitat conditions outside of the basin (lower Columbia and Estuary) are also having an impact on fish production in the Lewis River, which is also consistent with observations. And although the EDT estimate may not reflect 1800's conditions, the data collected in the 1930's do not challenge the reasonableness of this estimate.

1.1.6 Summary

Through EDT modeling, members of the ARG have documented one working hypothesis for how a change in habitat quality and quantity over time has impacted fish performance in the basin. If this working hypothesis is insufficient to help select and direct management actions then a second hypothesis should be developed and the assumptions driving the hypothesis clearly identified.

The model uses the difference in the historic and current habitat conditions to:

1. Determine the level of fish production that was lost over time and to estimate current Lewis River basin fish production potential. Managers can use this information to determine existing habitat quality, feasibility of reintroducing fish to specific areas, and estimating the likely resulting production and probable success of mitigation actions.
2. Identify the key environmental attributes having the largest effect on fish production in the Lewis River basin at the stream and reach levels. The manager can use this information to direct stream restoration actions to specific reaches in the basin.
3. Identify stream reaches currently providing the greatest level of fish production. This data will be useful for prioritizing streams for protection actions.

The results of the analysis show that the upper basin is still capable of producing significant numbers of adult and juvenile coho, Chinook and late winter steelhead. For all populations combined, the model estimates that 38% of historic adult production can still be achieved. The actual numbers of fish produced however, will be highly dependent on the effectiveness of fish passage facilities, their location, and fish response to reservoirs.

The majority of the fish production (>73%) will come from stream reaches upstream of Swift No.1 Dam, 19% in Yale and the remainder from Merwin. Coho will provide the majority of the production followed by Chinook and late winter steelhead.

As the hydrosystem is currently configured, modeling results show that Chinook production is not sustainable in the Merwin area and limited in Yale.

The EDT estimate of current adult abundance can be considered the average amount of production observed over time. However, the actual run size to the basin on any given year would vary dramatically due to variability in both the freshwater and ocean environments. The numbers do not reflect losses due to migration through the hydrosystem, impacts from harvest, or any genetic fitness loss due to domestication or influence of hatchery fish. The numbers presented were measured at the mouth of the Lewis River.

When comparing various model estimates of historic fish production it is important that the inherent assumptions behind the estimate be made clear. The EDT estimate of historic production is based on the habitat data entered for all stream reaches within and outside of the Lewis River basin that Lewis River fish use to complete their life cycle. The estimate represents the average amount of production that would be observed over time as measured at the mouth of the Lewis River absent harvest, 100% genetic fitness, and SARs reflective of values measured in the Lewis River and other basins since the late 1970's.

APPENDIX 1: ENVIRONMENTAL ATTRIBUTES

Table A1-1. Level 2 Environmental Attributes.

Code	Attribute	Definition
Alka	Alkalinity	Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/l of either HCO3 or CaCO3.
BdScour	Bed scour	Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et a. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).
BenComRch	Benthos diversity and production	Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of ORegon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).
ChLngth	Channel length	Length of the primary channel contained with the stream reach -- Note: this attribute will not be given by a categories but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.
WidthMx	Channel width - month maximum width (ft)	Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.
WidthMn	Channel width - month minimum width (ft)	Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.
ConfineHdro	Confinement - Hydromodifications	The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cutoff due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees--consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.

Code	Attribute	Definition
Confine	Confinement - natural	The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankful channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.
DisOxy	Dissolved oxygen	Average dissolved oxygen within the water column for the specified time interval.
Emb	Embeddedness	The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tailout habitat units and only where cobble or gravel substrates occur.
FnSedi	Fine sediment	Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.
FshComRch	Fish community richness	Measure of the richness of the fish community (no. of fish taxa, i.e., species).
FshPath	Fish pathogens	The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.
FSpIntro	Fish species introductions	Measure of the richness of the fish community (no. of fish taxa). Taxa here refers to species.
FlwHigh	Flow - change in average annual peak flow	The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).
FlwLow	Flow - change in average annual low flow	The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically-based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.

Code	Attribute	Definition
FlwDielVar	Flow - Intra daily (diel) variation	Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.
FlwIntraAnn	Flow - intra-annual flow pattern	The average extent of intra-annual flow variation during the wet season -- a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.
Grad	Gradient	Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.
HbBckPls	Habitat type - backwater pools	Percentage of the wetted channel surface area comprising backwater pools.
HbBvrPnds	Habitat type - beaver ponds	Percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat.
HbGlide	Habitat type - glide	Percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.
HbLrgCbl	Habitat type - large cobble/boulder riffles	Percentage of the wetted channel surface area comprising large cobble/boulder riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et a. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).
HbOfChFctr	Habitat type - off-channel habitat factor	A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.
HbPlTails	Habitat type - pool tailouts.	Percentage of the wetted channel surface area comprising pool tailouts.
HbPls	Habitat type - primary pools	Percentage of the wetted channel surface area comprising pools, excluding beaver ponds
HbSmlCbl	Habitat type - small cobble/gravel riffles	Percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et a. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).
Harass	Harassment	The relative extent of poaching and/or harassment of fish within the stream reach.

Code	Attribute	Definition
HatFOutp	Hatchery fish outplants	The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.
HydroRegimeNatural	Hydrologic regime - natural	The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.
HydroRegimeReg	Hydrologic regime - regulated	The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily variation attribute).
Icing	Icing	Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short-term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.
MetWatCol	Metals - in water column	The extent of dissolved heavy metals within the water column.
MetSedSls	Metals/Pollutants - in sediments/soils	The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.
MscToxWat	Miscellaneous toxic pollutants - water column	The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.
NutEnrch	Nutrient enrichment	The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.
Obstr	Obstructions to fish migration	Obstructions to fish passage by physical barriers (not dewatered channels or hinderances to migration caused by pollutants or lack of oxygen).
PredRisk	Predation risk	Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant). NOTE: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).
RipFunc	Riparian function	A measure of riparian function that has been altered within the reach.

Code	Attribute	Definition
SalmCarcass	Salmon Carcasses	Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs the upper mainstem, or in mainstem areas vs major tributary drainages.
TmpMonMx	Temperature - daily maximum (by month)	Maximum water temperatures within the stream reach during a month.
TmpMonMn	Temperature - daily minimum (by month)	Minimum water temperatures within the stream reach during a month.
TmpSptVar	Temperature - spatial variation	The extent of water temperature variation within the reach as influenced by inputs of groundwater.
Turb	Turbidity	The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids, hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/l. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a = 1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.
Wdrwl	Water withdrawals	The number and relative size of water withdrawals in the stream reach.
WdDeb	Wood	The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LWD pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard TFW definition as those > 50 cm diameter at midpoint.

APPENDIX 2: STREAM REACHES AND LENGTHS

Table A2-1. Stream reaches and lengths in meters and miles.

RName	Meters	Miles	Slope
Ape Canyon Creek	1,609.00	1.00	0.06
B1	804.50	0.50	0.07
Bean Creek	1,126.30	0.70	0.07
Big Creek	643.60	0.40	0.10
Big Creek Mid	482.70	0.30	0.15
Bitter Creek	2,252.60	1.40	0.01
Brezee Creek	9,814.90	6.10	0.02
Brooks Creek	1,769.90	1.10	0.04
Brush Creek	1,769.90	1.10	0.08
Buncombe Hollow Creek	1,287.20	0.80	0.04
Buncombe Hollow Creek Template	917.13	0.57	0.01
Canyon Creek	321.80	0.20	0.00
Cape Horn Creek	482.70	0.30	0.07
Cedar Cr. (trib Rock Cr)	7,240.50	4.50	0.02
Cedar Creek 1a	4,022.50	2.50	0.01
Cedar Creek 1b	2,413.50	1.50	0.01
Cedar Creek 2	5,470.60	3.40	0.00
Cedar Creek 3	2,574.40	1.60	0.00
Cedar Creek 4	1,930.80	1.20	0.00
Cedar Creek 5	965.40	0.60	0.01
Cedar Creek 6	10,941.20	6.80	0.01
Chelatchie Cr 1	643.60	0.40	0.00
Chelatchie Cr 2	7,079.60	4.40	0.01
Chickoom Creek	804.50	0.50	0.11
Clear Creek	9,895.35	6.15	0.01
Clear Creek Lower	9,895.35	6.15	0.01
Clear Creek Small Tribs	3,169.73	1.97	0.01
Clearwater Creek	8,366.80	5.20	0.01
Clearwater Tribs	1,287.20	0.80	0.01
Cold Creek	1,126.30	0.70	0.05
Copper Creek	643.60	0.40	0.03
Cougar Creek	2,735.30	1.70	0.03
Cougar Creek Template	643.60	0.40	0.01
Crab Creek	804.50	0.50	0.01
Curly Creek	804.50	0.50	0.01
Cussed Hollow	1,126.30	0.70	0.08
Dean Creek	3,700.70	2.30	0.01
Diamond Creek	160.90	0.10	0.10
Diamond Creek Template	1,126.30	0.70	0.01
Dog Creek	2,252.60	1.40	0.04
Dog Creek Template	804.50	0.50	0.01
Drift Creek	2,574.40	1.60	0.11
Drift Creek Template	2,477.86	1.54	0.01
EF Lewis 1	3,218.00	2.00	0.00

RName	Meters	Miles	Slope
EF Lewis 10	3,057.10	1.90	0.01
EF Lewis 11	4,827.00	3.00	0.01
EF Lewis 12	160.90	0.10	0.00
EF Lewis 13	2,413.50	1.50	0.01
EF Lewis 14	4,022.50	2.50	0.01
EF Lewis 15	804.50	0.50	0.01
EF Lewis 16	2,735.30	1.70	0.02
EF Lewis 17	1,448.10	0.90	0.02
EF Lewis 18	2,091.70	1.30	0.04
EF Lewis 19	5,470.60	3.40	0.01
EF Lewis 2	1,930.80	1.20	0.00
EF Lewis 20	4,505.20	2.80	0.03
EF Lewis 3	1,930.80	1.20	0.00
EF Lewis 4	1,930.80	1.20	0.01
EF Lewis 5	1,930.80	1.20	0.00
EF Lewis 6	482.70	0.30	0.00
EF Lewis 7	2,735.30	1.70	0.00
EF Lewis 8	10,780.30	6.70	0.00
EF Lewis 9	4,666.10	2.90	0.01
Green Fork	3,057.10	1.90	0.11
Houghton Cr	3,539.80	2.20	0.02
Indian George Creek	1,448.10	0.90	0.05
Jim Creek	965.40	0.60	0.03
John Creek	1,769.90	1.10	0.05
Johnson Cr	1,609.00	1.00	0.03
King Creek	3,700.70	2.30	0.06
Lewis 1 tidal	5,792.40	3.60	0.00
Lewis 10	2,574.40	1.60	0.01
Lewis 11	4,022.50	2.50	0.01
Lewis 12	4,344.30	2.70	0.01
Lewis 13	321.80	0.20	0.00
Lewis 14	4,183.40	2.60	0.00
Lewis 15	2,896.20	1.80	0.01
Lewis 16	2,091.70	1.30	0.01
Lewis 17	7,723.20	4.80	0.01
Lewis 18	1,126.30	0.70	0.01
Lewis 19	804.50	0.50	0.01
Lewis 2 tidal	8,849.50	5.50	0.00
Lewis 20	8,849.50	5.50	0.01
Lewis 21	1,609.00	1.00	0.00
Lewis 22	1,769.90	1.10	0.01
Lewis 23	5,631.50	3.50	0.01
Lewis 24	643.60	0.40	0.01
Lewis 25	482.70	0.30	0.01
Lewis 26	1,448.10	0.90	0.01
Lewis 27	321.80	0.20	0.01

RName	Meters	Miles	Slope
Lewis 3	1,609.00	1.00	0.00
Lewis 4	7,240.50	4.50	0.00
Lewis 5	4,344.30	2.70	0.00
Lewis 6	643.60	0.40	0.00
Lewis 7	5,953.30	3.70	0.00
Lewis 8	23,330.50	14.50	0.00
Lewis 9	9,975.80	6.20	0.01
Little Creek	1,126.30	0.70	0.01
Lockwood Creek	14,641.90	9.10	0.02
LW Rock Creek	3,539.80	2.20	0.02
M14	1,930.80	1.20	0.03
M14 Template	450.52	0.28	0.01
Manley Creek	2,896.20	1.80	0.02
Marble Creek	2,252.60	1.40	0.22
Marble Creek Template	804.50	0.50	0.01
Mason Creek	14,481.00	9.00	0.02
McCormick Creek	5,148.80	3.20	0.01
Merwin Dam	0.00	0.00	
Merwin Small Tribs	2,220.42	1.38	0.01
Mill Creek	4,022.50	2.50	0.01
Muddy R 1	7,079.60	4.40	0.01
Muddy R 1A	7,079.60	4.40	0.01
Muddy R 2	2,413.50	1.50	0.03
Muddy R 3	5,631.50	3.50	0.14
NF Chelatchie Cr	2,091.70	1.30	0.00
NF Siouxon	3,378.90	2.10	0.03
Ole Creek	1,287.20	0.80	0.01
P1	1,448.10	0.90	0.04
P10	482.70	0.30	0.06
P3	1,609.00	1.00	0.06
P7	1,769.90	1.10	0.04
P8	6,757.80	4.20	0.04
Panamaker Cr	482.70	0.30	0.06
Pepper Creek	643.60	0.40	0.07
Pine Creek 1	2,815.75	1.75	0.03
Pine Creek 2	804.50	0.50	0.03
Pine Creek 3	1,609.00	1.00	0.03
Pine Creek 4	1,609.00	1.00	0.03
Pine Creek 5	1,609.00	1.00	0.03
Pine Creek 6	4,424.75	2.75	0.03
Pup Creek	3,218.00	2.00	0.04
Rain Creek	1,432.01	0.89	0.01
Range Creek	1,061.94	0.66	0.09
Range Creek Template	1,609.00	1.00	0.01
Robinson Cr	1,448.10	0.90	0.03
Rock Creek 1	1,609.00	1.00	0.02

RName	Meters	Miles	Slope
Rock Creek 2	1,609.00	1.00	0.01
Rock Creek 3	804.50	0.50	0.01
Rock Creek 4	3,700.70	2.30	0.01
Rock Creek 5	5,309.70	3.30	0.04
Ross Cr	3,700.70	2.30	0.05
Rush Creek	4,022.50	2.50	0.08
S10	643.60	0.40	0.07
S15	2,091.70	1.30	0.07
Siouxon 1	1,930.80	1.20	0.01
Siouxon 1 Template	1,609.00	1.00	0.01
Siouxon 2	3,700.70	2.30	0.02
Slide Creek	2,413.50	1.50	0.09
Smith Creek	9,171.30	5.70	0.01
Smith Creek Small Tribs	1,496.37	0.93	0.01
Speelyei (Canal)	482.70	0.30	0.04
Speelyei 1	5,148.80	3.20	0.04
Speelyei 1 Template	1,769.90	1.10	0.03
Speelyei 2	4,505.20	2.80	0.05
Spencer Creek	965.40	0.60	0.08
Swift Campground Creek	1,930.80	1.20	0.01
Swift Creek	482.70	0.30	0.08
Swift Creek Template	2,735.30	1.70	0.01
Swift Dam	160.90	0.00	
Swift Reservoir Tribs Template	2,912.29	1.81	0.01
U8	482.70	0.30	0.13
unnamed LB trib (27.0255?)	804.50	0.50	0.09
unnamed RB trib1 (27.0258)	643.60	0.40	0.04
unnamed RB trib2 (27.0265)	1,769.90	1.10	0.10
Upper Smith Creek	21,721.50	13.50	0.02
Y8	321.80	0.20	0.16
Yale Dam	0.00	0.00	0.00
Yale Small Tribs	6,275.10	3.90	0.01

APPENDIX 3: FISH SPAWNING POPULATIONS

Table A3-1. Spring Chinook Spawning Populations.

Pop_Name	RName	Length (miles)
Merwin Spr Yearling	Canyon Creek	0.2
Merwin Spr Yearling	Lewis 8	14.5
	Total	14.7
Swift Spr Yearling	Clear Creek	6.15
Swift Spr Yearling	Clear Creek Lower	6.15
Swift Spr Yearling	Clearwater Creek	5.2
Swift Spr Yearling	Cussed Hollow	0.7
Swift Spr Yearling	Drift Creek	1.6
Swift Spr Yearling	Drift Creek Template	1.54
Swift Spr Yearling	Lewis 13	0.2
Swift Spr Yearling	Lewis 14	2.6
Swift Spr Yearling	Lewis 15	1.8
Swift Spr Yearling	Lewis 16	1.3
Swift Spr Yearling	Lewis 17	4.8
Swift Spr Yearling	Lewis 18	0.7
Swift Spr Yearling	Lewis 19	0.5
Swift Spr Yearling	Lewis 20	5.5
Swift Spr Yearling	Lewis 21	1
Swift Spr Yearling	Lewis 22	1.1
Swift Spr Yearling	Lewis 23	3.5
Swift Spr Yearling	Lewis 24	0.4
Swift Spr Yearling	Lewis 25	0.3
Swift Spr Yearling	Lewis 26	0.9
Swift Spr Yearling	Lewis 27	0.2
Swift Spr Yearling	Muddy R 1	4.4
Swift Spr Yearling	Muddy R 1A	4.4
Swift Spr Yearling	Muddy R 2	1.5
Swift Spr Yearling	Muddy R 3	3.5
Swift Spr Yearling	Pepper Creek	0.4
Swift Spr Yearling	Pine Creek 1	1.75
Swift Spr Yearling	Pine Creek 2	0.5
Swift Spr Yearling	Pine Creek 3	1
Swift Spr Yearling	Pine Creek 4	1
Swift Spr Yearling	Pine Creek 5	1
Swift Spr Yearling	Pine Creek 6	2.75
Swift Spr Yearling	Range Creek	0.66
Swift Spr Yearling	Range Creek Template	1
Swift Spr Yearling	Rush Creek	2.5
Swift Spr Yearling	Smith Creek	5.7
Swift Spr Yearling	Swift Creek	0.3
Swift Spr Yearling	Swift Creek Template	1.7
Swift Spr Yearling	Upper Smith Creek	13.5
	Total	93.7

Table A3-1 continued. Spring Chinook Spawning Populations.

Yale Spr Yearling	Cougar Creek	1.7
Yale Spr Yearling	Cougar Creek Template	0.4
Yale Spr Yearling	Lewis 10	1.6
Yale Spr Yearling	Lewis 11	2.5
Yale Spr Yearling	Lewis 12 Bypass	2.7
Yale Spr Yearling	Lewis 9	6.2
Yale Spr Yearling	Siouxon 1	1.2
Yale Spr Yearling	Siouxon 1 Template	1
	Total	17.3

Table A3-2. Fall Chinook Spawning Populations.

Pop_Name	RName	Length (miles)
Merwin Fall Chinook	Lewis 8	14.5
	Total	14.5
Swift Fall Chinook	Muddy R 1	4.4
Swift Fall Chinook	Muddy R 1A	4.4
Swift Fall Chinook	Muddy R 2	1.5
Swift Fall Chinook	Pine Creek 1	1.75
Swift Fall Chinook	Lewis 13	0.2
Swift Fall Chinook	Lewis 14	2.6
Swift Fall Chinook	Lewis 15	1.8
Swift Fall Chinook	Lewis 16	1.3
Swift Fall Chinook	Lewis 17	4.8
Swift Fall Chinook	Lewis 18	0.7
Swift Fall Chinook	Lewis 19	0.5
Swift Fall Chinook	Lewis 20	5.5
Swift Fall Chinook	Lewis 21	1
Swift Fall Chinook	Lewis 22	1.1
Swift Fall Chinook	Lewis 23	3.5
Swift Fall Chinook	Lewis 24	0.4
Swift Fall Chinook	Lewis 25	0.3
Swift Fall Chinook	Lewis 26	0.9
Swift Fall Chinook	Lewis 27	0.2
Swift Fall Chinook	Pine Creek 2	0.5
	Total	37.35
Yale Fall Chinook	Lewis 10	1.6
Yale Fall Chinook	Lewis 11	2.5
Yale Fall Chinook	Lewis 12 Bypass	2.7
Yale Fall Chinook	Lewis 9	6.2
	Total	13

Table A3-3. Late Winter Steelhead Spawning Populations.

Pop_Name	RName	Length (miles)
Merwin LW main	Lewis 8	14.5
Merwin LW Tribs	Brooks Creek	1.1
Merwin LW Tribs	Buncombe Hollow Creek	0.8
Merwin LW Tribs	Buncombe Hollow Creek Template	0.57
Merwin LW Tribs	Canyon Creek	0.2
Merwin LW Tribs	Cape Horn Creek	0.3
Merwin LW Tribs	Indian George Creek	0.9
Merwin LW Tribs	Jim Creek	0.6
Merwin LW Tribs	M14	1.2
Merwin LW Tribs	M14 Template	0.28
Merwin LW Tribs	Merwin Small Tribs	1.38
Merwin LW Tribs	Speelyei 1	3.2
Merwin LW Tribs	Speelyei 1 Template	1.1
Merwin LW Tribs	Speelyei 2	2.8
	Total	28.93
Swift LW STHD Main	Lewis 13	0.2
Swift LW STHD Main	Lewis 14	2.6
Swift LW STHD Main	Lewis 15	1.8
Swift LW STHD Main	Lewis 16	1.3
Swift LW STHD Main	Lewis 17	4.8
Swift LW STHD Main	Lewis 18	0.7
Swift LW STHD Main	Lewis 19	0.5
Swift LW STHD Main	Lewis 20	5.5
Swift LW STHD Main	Lewis 21	1
Swift LW STHD Main	Lewis 22	1.1
Swift LW STHD Main	Lewis 23	3.5
Swift LW STHD Main	Lewis 24	0.4
Swift LW STHD Main	Lewis 25	0.3
Swift LW STHD Main	Lewis 26	0.9
Swift LW STHD Main	Lewis 27	0.2
Swift LW STHD Mid	Big Creek Mid	0.3
Swift LW STHD Mid	Muddy R 1	4.4
Swift LW STHD Mid	Muddy R 1A	4.4
Swift LW STHD Mid	Muddy R 2	1.5
Swift LW STHD Mid	Muddy R 3	3.5
Swift LW STHD Mid	Pine Creek 1	1.75
Swift LW STHD Mid	Pine Creek 2	0.5
Swift LW STHD Mid	Pine Creek 3	1
Swift LW STHD Mid	Pine Creek 4	1
Swift LW STHD Mid	Pine Creek 5	1
Swift LW STHD Mid	Pine Creek 6	2.75
Swift LW STHD Mid	Rush Creek	2.5
Swift LW STHD Strbs	Ape Canyon Creek	1

Table A3-3 continued. Late Winter Steelhead Spawning Populations.

Pop_Name	RName	Length (miles)
Swift LW STHD Strbs	Bean Creek	0.7
Swift LW STHD Strbs	Chickoom Creek	0.5
Swift LW STHD Strbs	Clear Creek	6.15
Swift LW STHD Strbs	Clear Creek Lower	6.15
Swift LW STHD Strbs	Clear Creek Small Tribs	1.97
Swift LW STHD Strbs	Clearwater Creek	5.2
Swift LW STHD Strbs	Clearwater Tribs	0.8
Swift LW STHD Strbs	Crab Creek	0.5
Swift LW STHD Strbs	Curly Creek	0.5
Swift LW STHD Strbs	Cussed Hollow	0.7
Swift LW STHD Strbs	Diamond Creek	0.1
Swift LW STHD Strbs	Diamond Creek Template	0.7
Swift LW STHD Strbs	Drift Creek	1.6
Swift LW STHD Strbs	Drift Creek Template	1.54
Swift LW STHD Strbs	Little Creek	0.7
Swift LW STHD Strbs	Marble Creek	1.4
Swift LW STHD Strbs	Marble Creek Template	0.5
Swift LW STHD Strbs	Pepper Creek	0.4
Swift LW STHD Strbs	Range Creek	0.66
Swift LW STHD Strbs	Range Creek Template	1
Swift LW STHD Strbs	Smith Creek	5.7
Swift LW STHD Strbs	Smith Creek Small Tribs	0.93
Swift LW STHD Strbs	Spencer Creek	0.6
Swift LW STHD Strbs	Swift Campground Creek	1.2
Swift LW STHD Strbs	Swift Creek	0.3
Swift LW STHD Strbs	Swift Creek Template	1.7
Swift LW STHD Strbs	Swift Reservoir Tribs Template	1.81
Swift LW STHD Strbs	Upper Smith Creek	13.5
	Total	107.91
Yale LW STHD Main	Lewis 10	1.6
Yale LW STHD Main	Lewis 11	2.5
Yale LW STHD Main	Lewis 12 Bypass	2.7
Yale LW STHD Main	Lewis 9	6.2
Yale LW STHD Tribs	Cougar Creek	1.7
Yale LW STHD Tribs	Cougar Creek Template	0.4
Yale LW STHD Tribs	Dog Creek	1.4
Yale LW STHD Tribs	Dog Creek Template	0.5
Yale LW STHD Tribs	NF Siouxon	2.1
Yale LW STHD Tribs	Ole Creek	0.8
Yale LW STHD Tribs	Panamaker Cr	0.3
Yale LW STHD Tribs	Rain Creek	0.89
Yale LW STHD Tribs	Siouxon 1	1.2

Table A3-3 continued. Late Winter Steelhead Spawning Populations.

Pop_Name	RName	Length (miles)
Yale LW STHD Tribs	Siouxon 1 Template	1
Yale LW STHD Tribs	Siouxon 2	2.3
Yale LW STHD Tribs	Yale Small Tribs	3.9
	Total	29.49

Table A3-4. Coho Spawning Populations.

Pop_Name	RName	Length (miles)
Merwin Coho	B1	0.5
Merwin Coho	Brooks Creek	1.1
Merwin Coho	Buncombe Hollow Creek	0.8
Merwin Coho	Buncombe Hollow Creek Template	0.57
Merwin Coho	Canyon Creek	0.2
Merwin Coho	Cape Horn Creek	0.3
Merwin Coho	Indian George Creek	0.9
Merwin Coho	Jim Creek	0.6
Merwin Coho	Lewis 8	14.5
Merwin Coho	M14	1.2
Merwin Coho	M14 Template	0.28
Merwin Coho	Merwin Small Tribs	1.38
Merwin Coho	Speelyei 1	3.2
Merwin Coho	Speelyei 1 Template	1.1
Merwin Coho	Speelyei 2	2.8
	Total Miles	29.43
Swift Coho	Ape Canyon Creek	1
Swift Coho	Bean Creek	0.7
Swift Coho	Big Creek Mid	0.3
Swift Coho	Chickoom Creek	0.5
Swift Coho	Clear Creek	6.15
Swift Coho	Clear Creek Lower	6.15
Swift Coho	Clear Creek Small Tribs	1.97
Swift Coho	Clearwater Creek	5.2
Swift Coho	Clearwater Tribs	0.8
Swift Coho	Crab Creek	0.5
Swift Coho	Curly Creek	0.5
Swift Coho	Cussed Hollow	0.7
Swift Coho	Diamond Creek	0.1
Swift Coho	Diamond Creek Template	0.7
Swift Coho	Drift Creek	1.6
Swift Coho	Drift Creek Template	1.54
Swift Coho	Lewis 13	0.2
Swift Coho	Lewis 14	2.6
Swift Coho	Lewis 15	1.8
Swift Coho	Lewis 16	1.3
Swift Coho	Lewis 17	4.8
Swift Coho	Lewis 18	0.7
Swift Coho	Lewis 19	0.5
Swift Coho	Lewis 20	5.5
Swift Coho	Lewis 21	1
Swift Coho	Lewis 22	1.1
Swift Coho	Lewis 23	3.5
Swift Coho	Lewis 24	0.4

Table A3-4 continued. Coho Spawning Populations.

Pop_Name	RName	Length (miles)
Swift Coho	Lewis 25	0.3
Swift Coho	Lewis 26	0.9
Swift Coho	Lewis 27	0.2
Swift Coho	Little Creek	0.7
Swift Coho	Marble Creek	1.4
Swift Coho	Marble Creek Template	0.5
Swift Coho	Muddy R 1	4.4
Swift Coho	Muddy R 1A	4.4
Swift Coho	Muddy R 2	1.5
Swift Coho	Muddy R 3	3.5
Swift Coho	P1	0.9
Swift Coho	P10	0.3
Swift Coho	P3	1
Swift Coho	P7	1.1
Swift Coho	P8	4.2
Swift Coho	Pepper Creek	0.4
Swift Coho	Pine Creek 1	1.75
Swift Coho	Pine Creek 2	0.5
Swift Coho	Pine Creek 3	1
Swift Coho	Pine Creek 4	1
Swift Coho	Pine Creek 5	1
Swift Coho	Pine Creek 6	2.75
Swift Coho	Range Creek	0.66
Swift Coho	Range Creek Template	1
Swift Coho	Rush Creek	2.5
Swift Coho	S10	0.4
Swift Coho	S15	1.3
Swift Coho	Smith Creek	5.7
Swift Coho	Smith Creek Small Tribs	0.93
Swift Coho	Spencer Creek	0.6
Swift Coho	Swift Campground Creek	1.2
Swift Coho	Swift Creek	0.3
Swift Coho	Swift Creek Template	1.7
Swift Coho	Swift Reservoir Tribs Template	1.81
Swift Coho	Upper Smith Creek	13.5
	Total Miles	117.11
Yale Coho	Cougar Creek	1.7
Yale Coho	Cougar Creek Template	0.4
Yale Coho	Dog Creek	1.4
Yale Coho	Dog Creek Template	0.5
Yale Coho	Lewis 10	1.6
Yale Coho	Lewis 11	2.5
Yale Coho	Lewis 12 Bypass	2.7
Yale Coho	Lewis 9	6.2

Table A3-4 continued. Coho Spawning Populations.

Pop_Name	RName	Length (miles)
Yale Coho	NF Siouxon	2.1
Yale Coho	Ole Creek	0.8
Yale Coho	Panamaker Cr	0.3
Yale Coho	Rain Creek	0.89
Yale Coho	Siouxon 1	1.2
Yale Coho	Siouxon 1 Template	1
Yale Coho	Y8	0.2
Yale Coho	Yale Small Tribs	3.9
	Total Miles	27.39

APPENDIX 4: PFC TEMPLATE ANALYSIS

Table A4-1. EDT estimates of coho adult and juvenile production for the PFC template condition.

PFC Template- Coho Higlh SAR

Species	DDiversity	Juvenile Productivity	Juvenile Capacity	JAuvenile Abundance	% of Total Juvenile Production	Adult Productivity	AAdult Capacity	AAdult Abundance	%% of Total AAdult Production
Swift	8693%	2407.6	249,290	2327,2653	72.6%	14.5	2427,7605	231,5944	7734.7%
Yale	7680%	2863.3	51,026	4970,2381	15.0%	27.6	42,9694	42,7357	1449.7%
Merwin	7985%	2981.9	42,181	4385,9356	12.4%	23.7	3,1966	3,1748	111.76%
Total			342,496	3216,3269			3317,6474	3215,1328	

Table A4-2. EDT estimates of late winter steelhead adult and juvenile production for the PFC template condition.

PFC Template- Late Winter Steelhead High SAR

Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	100%	295.9	56,796.7	54,997.6	70.7%	34.5	6,524.9	6,320.1	71.0%
Yale	96%	336.1	13,278.7	12,909.0	16.6%	38.6	1,494.7	1,453.9	16.3%
Merwin	92%	321.2	10,216.1	9,911.3	12.7%	36.8	1,157.4	1,123.0	12.6%
Total			80,291	77,818			9,177	8,897	

PFC Template- Late Winter Steelhead Low SAR

Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	100%	298.3	50,454.6	47,455.4	70.5%	18.4	3,039.5	2,861.9	70.9%
Yale	96%	336.3	11,979.6	11,353.9	16.9%	20.3	706.6	670.6	16.6%
Merwin	92%	321.3	9,039.2	8,530.7	12.7%	19.4	533.1	503.6	12.5%
Total			71,473	67,340			4,279	4,036	

Table A4-3. EDT estimates of fall Chinook adult and juvenile production for the PFC template condition.

PFC Template- Fall Chinook High SAR

Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	0%	0.0	0	0	0.0%	0.0	0	0	0.0%
Yale	0%	0.0	0	0	0.0%	0.0	0	0	0.0%
Merwin *	100%	902.8	429,849	352,029	100.0%	0.0	2,768	2,349	100.0%
Total			429,849	352,029			2,768	2,349	

* Fall Chinook modeled only in Merwin

PFC Template- Fall Chinook Low SAR

Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	0%	0.0	0	0	0.0%	0.0	0	0	0.0%
Yale	0%	0.0	0	0	0.0%	0.0	0	0	0.0%
Merwin *	100%	901.3	429,849	258,073	100.0%	0.0	1,189	781	100.0%
Total			429,849	258,073			1,189	781	

* Fall Chinook modeled only in Merwin

Table A4-4. EDT estimates of fall Chinook adult and juvenile production for the PFC template condition.

PFC Template- Spring Chinook High SAR

Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	99%	331.5	214,008	200,848	64.0%	18.9	12,058	11,325	70.8%
Yale	100%	384.9	50,822	48,100	15.3%	20.8	2,694	2,552	16.0%
Merwin	91%	503.2	69,560	64,991	20.7%	22.1	2,224	2,116	13.2%
Total			334,391	313,940			16,976	15,993	

PFC Template- Spring Chinook Low SAR

Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	97%	332.7	177,285	156,179	66.1%	9.8	5,035	4,453	71.7%
Yale	100%	387.9	41,308	36,863	15.6%	10.7	1,078	967	15.6%
Merwin	91%	501.6	49,157	43,352	18.3%	11.3	873	790	12.7%
Total			267,751	236,393			6,986	6,210	

APPENDIX 5: LOWER LEWIS EDT RESULTS

Table A5-1. EDT estimates of anadromous fish production for the lower Lewis River (includes E.F. Lewis River).

Species	Alternative	Diversity Index	Adult Productivity	Adult Capacity	Adult Abundance
Chum	P	8%	1.6	5256	2051
Chum	PFC	43%	2.7	17875	11205
Chum	T	47%	4.2	96450	73594
Coho	P	29%	5.7	6004	4949
Coho	PFC	55%	10.0	11563	10403
Coho	T	99%	21.4	54670	52113
Winter Steelhead	P	18%	4.4	534	412
Winter Steelhead	PFC	57%	12.2	2975	2731
Winter Steelhead	T	72%	19.5	3741	3549
Fall Chinook	P	80%	2.3	5279	2974
Fall Chinook	PFC	89%	5.5	9331	7638
Fall Chinook	T	90%	8.0	19181	16780
Spring Chinook	P	56%	2.3	460	260
Spring Chinook	PFC	99%	9.8	1001	899
Spring Chinook	T	100%	16.4	1555	1460

P = Patient or Current

PFC = Properly Functioning Conditions

T = Template or Historic

Note: Includes harvest and genetic impacts.

APPENDIX 6: EDT HIGH SAR RESULTS

Table A6-1. EDT estimates of coho adult and juvenile production for current and historic conditions (high SAR).

CURRENT- Coho High SAR									
Species	**Diversity**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**	**% of Total Juvenile Production**	**Adult Productivity**	**Adult Capacity**	**Adult Abundance**	**% of Total Adult Production**
Swift	65%	90.9	226,048	197,206	68.9%	9.3	21,963	19,287	70.4%
Yale	33%	71.8	80,004	65,375	22.8%	7.0	7,105	5,897	21.5%
Merwin	33%	61.1	29,903	23,759	8.3%	5.7	2,215	2,215	8.1%
Total			335,955	286,341			31,282	27,399	
% of Historic			92.4%	80.9%			59.5%	53.6%	
HISTORIC									
Species	**Diversity**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**	**% of Total Juvenile Production**	**Adult Productivity**	**Adult Capacity**	**Adult Abundance**	**% of Total Adult Production**
Swift	100%	287.5	253,139	245,966	69.5%	42.1	37,035	35,986	70.3%
Yale	100%	301.3	62,549	60,968	17.2%	42.4	8,813	8,591	16.8%
Merwin	96%	307.5	48,069	46,894	13.3%	42.7	6,753	6,586	12.9%
Total			363,757	353,828			52,601	51,163	

Table A6-2. EDT estimates of late winter steelhead adult and juvenile production for current and historic conditions (high SAR).

CURRENT-Late Winter Steelhead High SAR									
Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	60%	128.7	30,861	28,728	83.7%	15.2	3,621	3,371	83.5%
Yale	10%	89.8	2,901	2,621	7.6%	11.0	360	325	8.1%
Merwin	7%	111.3	3,230	2,965	8.6%	13.0	370	340	8.4%
Total			36,992	34,315			4,351	4,036	
% of Historic			48.2%	45.8%			43.9%	41.7%	
HISTORIC									
Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	100%	338.6	52,235	50,994	68.0%	44.4	6,759	6,600	68.1%
Yale	99%	369.2	13,512	13,223	17.6%	48.0	1,732	1,696	17.5%
Merwin	92%	362.0	10,978	10,738	14.3%	47.2	1,425	1,394	14.4%
Total			76,725	74,955			9,916	9,690	

Table A6-3. EDT estimates of fall Chinook adult and juvenile production for current and historic conditions (high SAR).

CURRENT- Fall Chinook
High SAR

Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	70%	235.8	210,047	143,578	81.9%	3.9	3,354	2,315	85.6%
Yale	20%	374.7	43,028	31,692	18.1%	5.1	513	390	14.4%
Merwin	0%	0.0	0	0	0.0%	0.0	0	0	0.0%
Total			253,076	175,270			3,866	2,705	
% of Historic			50.2%	39.1%			39.2%	30.8%	
HISTORIC									
Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	100%	443.8	239,245	210,830	47.1%	9.6	5,182	4,566	52.0%
Yale	100%	564.6	124,488	111,252	24.8%	10.7	2,288	2,051	23.4%
Merwin	100%	616.0	140,015	125,811	28.1%	10.6	2,399	2,156	24.6%
Total			503,748	447,893			9,869	8,772	

Table A6-4. EDT estimates of spring Chinook adult and juvenile production for current and historic conditions (high SAR).

CURRENT- Spring Chinook High SAR

Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	40%	165.5	79,580	69,420	92.6%	10.0	4,752	4,150	93.7%
Yale	27%	181.5	6,493	5,573	7.4%	9.0	325	278	6.3%
Merwin	0%	0.0	0	0	0.0%	0.0	0	0	0.0%
Total			86,072	74,993			5,076	4,428	
% of Historic			23.7%	21.5%			20.8%	18.8%	
HISTORIC									
Species	Diversity	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance	% of Total Juvenile Production	Adult Productivity	Adult Capacity	Adult Abundance	% of Total Adult Production
Swift	100%	395.2	215,233	207,123	59.5%	31.3	16,796	16,172	68.8%
Yale	100%	420.4	55,922	53,927	15.5%	31.1	4,030	3,890	16.5%
Merwin	91%	579.4	91,342	87,119	25.0%	34.3	3,571	3,460	14.7%
Total			362,497	348,169			24,398	23,523	