Appendix C: Model Analysis and Supporting Data

1.1 Overview

The Ecosystem and Diagnostic Treatment (EDT) model was used to estimate the natural production potential of the habitat for species indigenous to the Klickitat River including Spring Chinook and Steelhead. The EDT model (Lestelle, Mobrand and McConnaha 2004[1]) is a scientific application that represents the relationship between anadromous fish habitat quality and population performance. The model provides the user with a means to diagnose a basin's current environmental limiting factors in time (i.e. by month) and space (i.e. by stream reach or subbasin) specific to anadromous Salmonid populations within a watershed. A diagnosis of current conditions is based on the rating (i.e., good to poor) of 40+ measurable environmental attributes that are rated for each stream reach in the watershed, and for each month of the year. These 40+ attributes consist of both quantitative and qualitative abiotic (physical) and biotic (biological) attributes. An assortment of data types are used to populate the attributes including empirical data, extrapolation of empirical data, and for cases where empirical data is unavailable, professional judgment.

Each anadromous Salmonid population experiences the landscape in a unique way due to variations in its freshwater life cycle (i.e. how a fish moves in time and space throughout the river system). As a result of this, each population has a unique suite of limiting factors, though there are often commonalities across populations. Examination of a population's limiting factors (Figures 2, 4) provides the basis for identifying productive and degraded stream reaches specific to a salmon or steelhead population. The level or magnitude of degradation within a specified geographic area is expressed in the changes to the overall biological performance of the population (Figure 1, 3). The biological performance is estimated using a suite of parameters including intrinsic productivity, capacity, equilibrium abundance, and life history diversity. With the exception of the life history diversity parameter, the remaining performance parameters estimated from EDT are based on Beverton-Holt stock recruitment dynamics. The type of recruitment dynamics is an important consideration when interpreting the biological performance, particularly for intrinsic productivity and equilibrium abundance estimates. Intrinsic productivity represents the productivity of a population when spawner numbers are low and/or below threshold values where density dependent effects have a significant role in reducing the number of recruits per spawner. As a result, the intrinsic productivity is often difficult to measure, and may differ significantly from an observed recruit per spawner estimate. The Beverton-Holt based equilibrium abundance estimate represents

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[1] Lestelle, Lawrence C., Lars E. Mobrand and Willis E. McConnaha. 2004. Information Structure of Ecosystem Diagnosis and Treatment (EDT) and Habitat Rating Rules for Chinook Salmon, Coho Salmon, and Steelhead Trout. Mobrand Biometrics, Inc., Vashon Island, Washington.

the abundance when the ratio of recruits per spawner is equivalent to 1. Generally speaking, this number may be comparative to an observed mean abundance estimate for a given time series, but likely differs from an observed mean, particularly if the observed recruit per spawner is greater than, or less than 1.

The EDT results represent the raw production potential of the natural environment and does not account for the influence of hatchery production, harvest, and out-of-basin effects. In order to adequately capture the synergistic effects of these major factors affecting the entire lifecycle, the All H Analyzer (AHA) model was used in conjunction with the EDT results to derive an integrated wild and hatchery population performance. Additional information on the All_H_Analyzer can be found at the following website: http://www.fws.gov/pacific/Fisheries/Hatcheryreview/documents/All-HAnalyzerDraftUsersGuideAug05.pdf

1.2 Scenario Descriptions

Several scenarios were included in the analysis for estimating the historic, current, and future natural production of Klickitat spring Chinook and steelhead. The future natural production estimates are based on two restoration scenarios including passage into the upper basin (blocked for ~40 years), and habitat restoration across the entire Klickitat subbasin. The second scenario includes both passage and watershed restoration. The scenario results for spring Chinook and Steelhead can be viewed in Tables 1 and 2 below.

Historic Conditions

Historical habitat conditions are representative of the pre-Anglo settlement era or time period when a pristine environment existed in the Subbasin. EDT uses an historical estimate of habitat conditions as a basis of comparison to determine the health and degradation of the current state of habitat. The restoration potential of a given stream reach or watershed represents the difference in environmental conditions between historic and current conditions. So in a sense, historical habitat conditions can also be viewed as an "upper bound" restoration potential of the Subbasin for naturally produced stocks.

Current Conditions

“Current conditions” represents the natural production potential for the current state of the habitat in the absence of harvest. "Current Conditions" is defined as a baseline model run representing natural production potential prior to basin wide habitat restoration activities and passage improvements at Castile Falls completed as of 2005. The current conditions scenario serves as a reference point for natural production potential prior to re-colonization of the upper basin above Castile Falls, and future habitat restoration activities.

Improved Castile Fishway Passage Only

This scenario consists of current conditions plus the natural production potential of the upper basin above Castile Falls. The scenario provides 100% passage to areas above

Castile Falls for both spring Chinook and steelhead. The fishway improvements have recently opened up 43 miles of previously blocked habitat that was historically occupied by spring Chinook and steelhead. The results from this scenario assume the habitat above Castile falls has been sufficiently re-colonized by both spring Chinook and Steelhead with no specified timeframe. The purpose of this scenario is to demonstrate the natural production potential of the upper basin after the two indigenous stocks successfully re-colonize historically occupied habitat.

Castile Fishway Passage + Watershed Restoration

This scenario modeled re-colonization of the upper basin above Castile Falls in addition to habitat restoration actions targeting mainstem and tributary locations across the entire Klickitat subbasin (i.e. in all areas accessible for spring Chinook and Steelhead). Restoration actions targeted abiotic and biotic attributes contributing to major limiting factors identified for individual geographic areas in the EDT strategic priority summary tables for spring Chinook and steelhead (Figures 2, 4). The restoration actions were also guided by strategies outlined in the "Recovery Plan for the Klickitat River Population of the Middle Columbia River Steelhead Distinct Population Segment"[2].

The magnitude and intensity of a restoration action is perhaps the most difficult aspect to modeling restoration effectiveness. The restoration potential of a watershed as defined by EDT, is represented by the relative difference between historic and current conditions. The "Percent effectiveness" of a restoration scenario is therefore, bound by the relative difference between the current and historic condition where 0% effectiveness is equivalent to no restoration (current state of habitat conditions) and 100% effectiveness fully restores the habitat back to its pristine/historical state. While historic conditions represent the upper bound for restoration potential, the actual restoration potential of any given stream reach or watershed may be less than this due to other constraints such as cities, roads, miscellaneous infrastructure, land management practices, and societal values.

Primary restoration actions focus on restoring ecological functions in the watershed. These actions include: increasing floodplain channel and roughness, reconnecting side-channels, improving floodplain connectivity, relocating floodplain infrastructure and roads, improving maintenance, rehabilitating and decommissioning roads as appropriate, re-establishing and/or enhancing native vegetation within floodplain, implementing practices that leaves naturally occurring sources of large woody debris instream, and/or artificially introduce large debris or other structures.

For this restoration scenario, we assumed an arbitrary value of 40% effectiveness for attributes that comprised the major limiting factors (Figure 2, 4) to production for spring Chinook and steelhead. Forty percent effectiveness was used as an attempt to model the

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[2] NOAA-Fisheries. 2009. Recovery Plan for the Klickitat River Population of the Middle Columbia River Steelhead Distinct Population Segment. Appendix B in Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan. National Marine Fisheries Service, Northwest Region. Portland, OR. See: http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Interior-Columbia/Mid-Columbia/Mid-Col-Plan.cfm

restoration potential of the Klickitat Basin while acknowledging existing constraints that may hinder our ability to fully restore the watershed back to its pristine state. The true effectiveness or restoration potential of a given attribute or stream reach may differ from the 40% used for this modeling exercise. This scenario is the first attempt at modeling the true restoration potential of the entire subbasin with guidance from major limiting factors identified by EDT, in addition to the strategic guidance provided by the Klickitat Klickitat Lead Entity Region Salmon Recovery Strategy (Chapter 5.2). Therefore, this restoration scenario should be considered a preliminary model run that will likely change with refined, and more detailed modeling work in the future.

1.3 EDT Results and Discussion

Spring Chinook

Modeling results suggest the current state of habitat has the potential to produce about 500 adults on average (i.e., at equilibrium abundance), with a capacity of about 607. The "Improved Castile Falls Fishway" scenario suggests that providing access to the upper Basin above Castile Falls has the potential to increase the capacity from 607 to 1271 for spring Chinook (Table 1). Once fully seeded, the adult equilibrium abundance may also increase from about 500, to as much as 1,075. While not a huge increase in productivity (6.2 to 6.5), the slight increase supports the notion that quality spawning and rearing habitat exists above Castile Falls. In support of this notion, the upper basin is characterized by moderately confined to unconfined floodplains with large amounts of wood recruitment and gravel retention that shape the channel and habitat complexity within the mainstem areas. Contrary to the upper basin, the immediate section of river below Castile Falls that is currently utilized for spawning and rearing is confined by natural canyons resulting in high gradient reaches, little wood recruitment and simplified channel and habitat complexity.

Adding the 40% effectiveness habitat restoration scenario to the "improved Castile Falls Fishway passage only" scenario bolsters the capacity and abundance from 1271 and 1075 to 1360 and 1183 respectively. Though this slight increase is much less than the increase from passage alone, the largest benefit from restoration actions are the intrinsic productivity increases from 6.5 to 7.7. The habitat restoration scenario suggests that much of the restoration work will benefit the quality of habitat more so than the quantity. In particular, much of the beneficial restoration actions observed for spring Chinook are within mainstem areas where spawning and rearing take place.

Steelhead

Modeling results suggest the current state of habitat has the potential to produce about 1,233 adults on average (i.e., at equilibrium abundance), with a capacity of about 1,621. The "Improved Castile Falls Fishway" scenario suggests that providing access to the upper Basin above Castile Falls has the potential to increase the capacity from 1,621 to 2,597 for steelhead (Table 2). Once fully seeded, the adult equilibrium abundance may also increase from about 1,233, to as much as 2,020. These results, which imply a rather large production potential for the upper basin above Castile Falls, should be viewed and interpreted with the caveat that EDT does not model sympatric population dynamics that exist in many *O.mykiss* populations. That is to say, the results represent an allopatric population of *O.mykiss* where 100% of the individuals are assumed to express the anadromous life history. Realistically, the upper basin will likely produce both resident and anadromous forms of *O.mykiss* so the model results are likely biased high in terms of the true potential of the upper basin once fully seeded.

Changes in productivity across the scenarios are very similar to those observed for spring Chinook, relatively speaking. Accessibility alone to the habitat above Castile Falls may result in a slight increase in productivity from 4.2 to 4.5 but with additional habitat restoration across the watershed, the productivity jumps to 5.3. Unlike spring Chinook, steelhead will benefit from restoration actions targeting both mainstem and tributary areas.

Table 1. Habitat potential as modeled by EDT for Klickitat River spring Chinook.

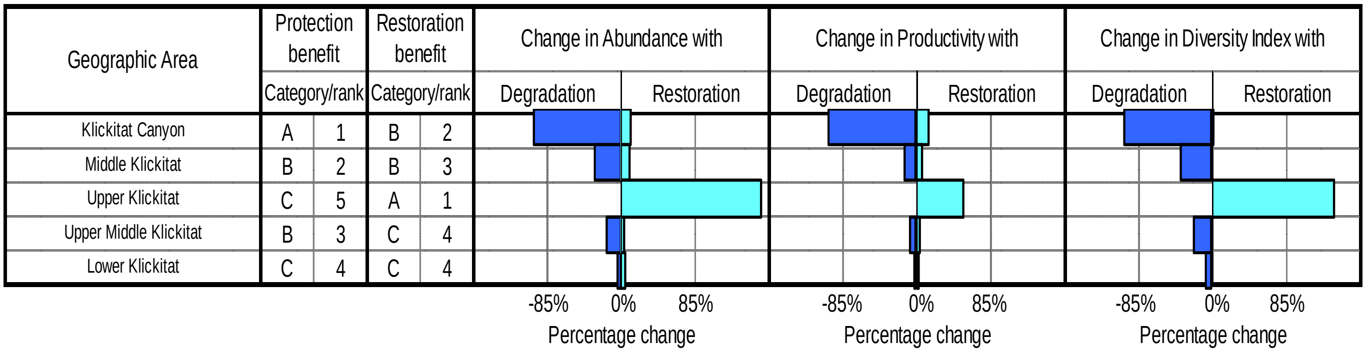
Klickitat River Spring Chinook				
Scenario	**Diversity index**	**Productivity**	**Capacity**	**Abundance**
Current Without harvest	41%	6.2	607	509
Improved Castile Falls Fishway passage only	97%	6.5	1,271	1,075
Castile Falls Fishway passage with watershed restoration	98%	7.7	1,360	1,183
Historic Potential	99%	10.2	1,677	1,513

Table 2. Habitat potential as modeled by EDT for Klickitat River steelhead.

Klickitat River Steelhead				
Scenario	**Diversity index**	**Productivity**	**Capacity**	**Abundance**
Current Without harvest	34%	4.2	1,621	1,233
Improved Castile Falls Fishway passage only	51%	4.5	2,597	2,020
Castile Falls Fishway passage with watershed restoration	59%	5.3	2,823	2,286
Historic Potential	75%	7.3	3,529	3,044

Klickitat River Spring Chinook

Relative Importance Of Geographic Areas For Protection and Restoration Measures

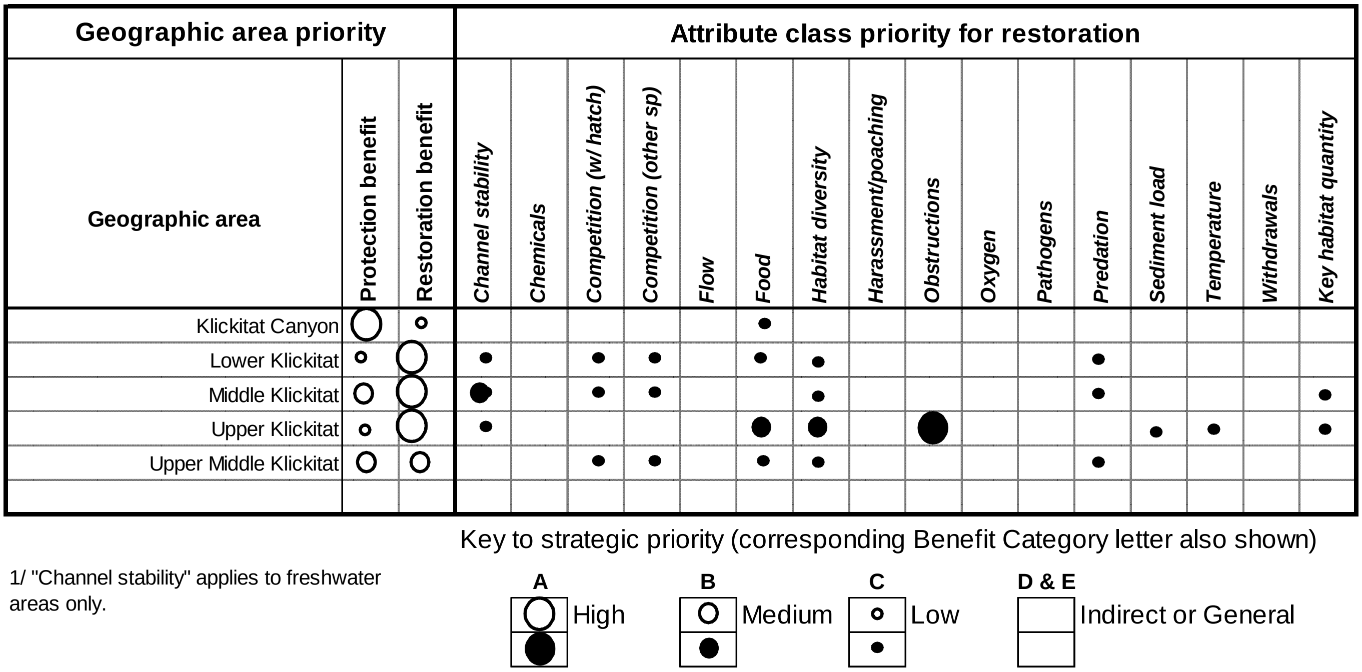


Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
Klickitat Canyon	A	1	B	2
Middle Klickitat	B	2	B	3
Upper Klickitat	C	5	A	1
Upper Middle Klickitat	B	3	C	4
Lower Klickitat	C	4	C	4

Figure 1. Diagram illustrating the relative preservation and restoration importance of geographic areas for spring Chinook.

Klickitat River Spring Chinook

Protection and Restoration Strategic Priority Summary



Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	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
Klickitat Canyon	○	○						●										
Lower Klickitat	○	○	●		●	●		●	●					●				
Middle Klickitat	○	○	●		●	●			●					●				●
Upper Klickitat	○	○	●					●	●		●				●	●		●
Upper Middle Klickitat	○	○			●	●		●	●					●				

Key to strategic priority (corresponding Benefit Category letter also shown)

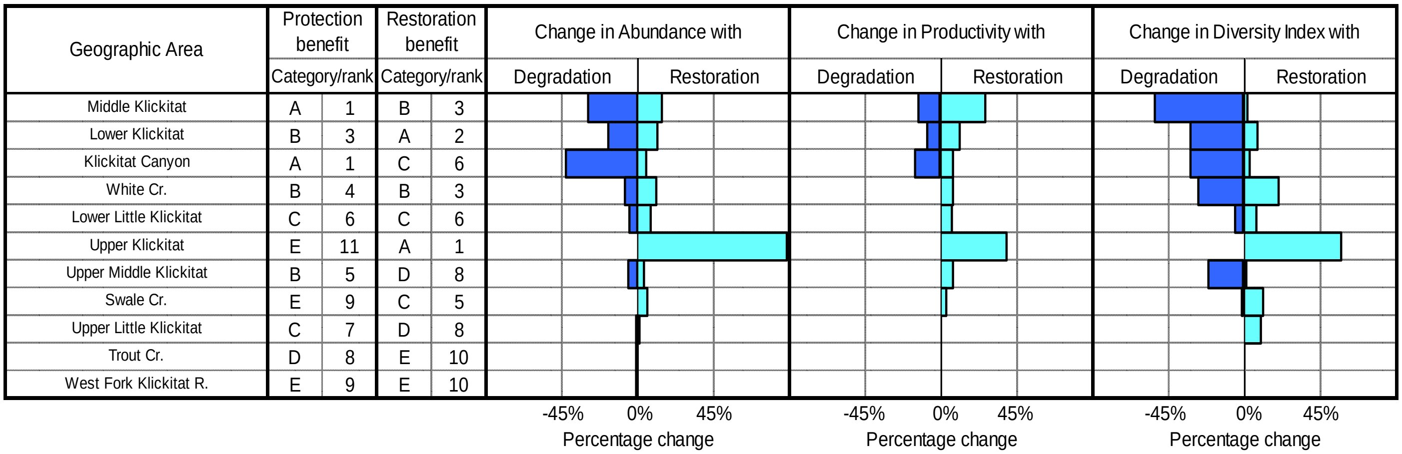
A		B		C		D & E	
○ ●	High	○ ●	Medium	○ ●	Low		Indirect or General

1/ "Channel stability" applies to freshwater areas only.

Figure 2. Diagram illustrating major limiting factors by geographic area for spring Chinook.

Klickitat River Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures



Geographic Area	Protection benefit Category	Protection benefit rank	Restoration benefit Category	Restoration benefit rank
Middle Klickitat	A	1	B	3
Lower Klickitat	B	3	A	2
Klickitat Canyon	A	1	C	6
White Cr.	B	4	B	3
Lower Little Klickitat	C	6	C	6
Upper Klickitat	E	11	A	1
Upper Middle Klickitat	B	5	D	8
Swale Cr.	E	9	C	5
Upper Little Klickitat	C	7	D	8
Trout Cr.	D	8	E	10
West Fork Klickitat R.	E	9	E	10

Figure 3. Diagram illustrating the relative preservation and restoration importance of geographic areas for steelhead.

Klickitat River Steelhead

Protection and Restoration Strategic Priority Summary

Geographic area	Protection benefit	Restoration benefit	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
Klickitat Canyon	◯	∘						•							•			
Lower Klickitat	○	◯			•		•	•	●	•				•	•	•		•
Lower Little Klickitat	∘	∘			•		•						•	•	●	●		
Middle Klickitat	◯	○	•		•		•		•	•				•	●			•
Swale Cr.		∘					•	●	•				●	•	●	⬤		●
Trout Cr.							•	●	•						⬤	•		•
Upper Klickitat		◯	•					•	•		⬤				●	•		•
Upper Little Klickitat	∘		•		•		•	•	•		⬤		•	•	●	●		•
Upper Middle Klickitat	○		•		•		•		•					•	•			
West Fork Klickitat R.																		
White Cr.	○	○					•	•	•						●	●		●

Geographic area priority — Attribute class priority for restoration

Key to strategic priority (corresponding Benefit Category letter also shown)

A		B		C		D & E	
◯	High	○	Medium	∘	Low		Indirect or General
⬤		●		•			

1/ "Channel stability" applies to freshwater areas only.

Figure 4. Diagram illustrating major limiting factors by geographic area for steelhead.

1.4 AHA modeling and scenario descriptions

The EDT results for spring Chinook and steelhead were fed into the AHA model to account for the influence of hatchery production, harvest, and out-of-basin effects. Specifically, the model was used to analyze several hatchery production scenarios for varying habitat conditions (EDT scenarios listed above). These included the current hatchery programs in addition to the proposed future hatchery programs outlined in the masterplan. A scenario description by species is provided below. Results from these AHA scenarios are summarized in Tables 3 through 8.

Spring Chinook: Current hatchery program

The current spring Chinook hatchery program has released about 600,000 yearlings as an on-station release into the Klickitat River. Current and historic broodstock collection practices have relied on adult volunteers back into the hatchery. As a result, broodstock has primarily consisted of hatchery origin returns (HORs) as no attempt was made to intentionally collect natural origin returns (NORs).

For this scenario, it is assumed that 100% of spring Chinook broodstock is of hatchery origin, and that any adults escaping fisheries and failing to volunteer into the hatchery end up on the natural spawning grounds. We modeled a productivity rate of 0.5 relative to natural-origin spring Chinook. Current habitat conditions (Table 1) that disclude habitat above Castile Falls were also used for this scenario. The purpose of modeling the current hatchery program with existing habitat conditions is to provide a reference point and basis of comparison against the anticipated performance of the future hatchery programs under future habitat conditions. Tables 9 through13 provide additional information on other model parameters.

Spring Chinook: Future hatchery program

The future hatchery program will transition to a true integrated program by incorporating some proportion on NOR adults into the program. Initially, the proportion of NORs used for broodstock may be limited due to depressed run sizes and lack of production in the upper Basin above Castile Falls. With time, the proportion of NORs used for broodstock may increase if the natural run size allows. A sliding scale collection regime will be used to limit the proportion NORs taken for broodstock to 25%. The proportion of NORs comprising the broodstock will likely range from 25% to 50%, depending on this sliding scale for broodstock collection. For this modeling scenario, we assumed a 25% NOR contribution to the broodstock on average. For integrated hatchery-origin fish, we modeled a productivity rate of 0.85 relative to natural-origin spring Chinook.

Two habitat restoration scenarios were used with the future integrated production regime, one with passage into the upper basin alone, and the other with passage + the 40% restoration across the watershed. Results for the spring Chinook scenarios can be viewed in Table 3 below.

Steelhead: Current hatchery program

Current and historic hatchery releases of steelhead in the Klickitat have consisted of about 105,000 summer steelhead smolts derived from the Skamania-origin steelhead reared at both Skamania and Vancouver hatcheries. Hatchery smolts are 100% adipose-clipped for harvest retention and have historically been scatter-planted as direct stream releases at various locations ranging from as high as the Klickitat hatchery at Rkm 69 and as low as Rkm 0.8 near the river mouth. This type of release strategy lacks imprintment of juveniles on water sources located in terminal locations (i.e. hatchery ponds and/or acclimation ponds using unique water sources) which confounds the managers' ability to trap and remove surplus hatchery adults.

For this scenario, 105,000 Skamania steelhead smolts were used as the average release number without imprintment on terminal locations. Thus, surplus adults escaping fisheries were assumed to spawn in the wild with the natural-origin population. We modeled a productivity rate of 0.2 relative to natural-origin steelhead. Current habitat conditions (Table 1) that disclude habitat above Castile Falls were also used for this scenario. The purpose of modeling the current hatchery program with existing habitat conditions is to provide a reference point and basis of comparison against the anticipated performance of the future hatchery programs under future habitat conditions. Additional model parameters for this scenario can be viewed in Tables 9 through 13. The results for this scenario can be viewed in Table 4 below.

Steelhead: Future Segregated hatchery program

This scenario converts the use of out-of-basin releases of Skamania summer steelhead to a segregated hatchery program using Skamania summer steelhead returning to the Klickitat River basin for broodstock (i.e., developing a localized broodstock for the program) and assumes an average release of about 90,000 smolts. The broodstock consists of 100% HORs from both adults collected at Lyle Falls, and adults volunteering back to the Klickitat hatchery. What separates this future scenario from the "Current hatchery program" scenario is the ability to remove some proportion of surplus adults escaping fisheries due to juvenile imprintment at the hatchery. It is anticipated that anywhere from 50% to 90% of surplus adults will volunteer back into the hatchery. For this scenario, we assumed that approximately 70% of adult steelhead escaping fisheries volunteered back into the hatchery. Simulations were run for future habitat conditions including current conditions + habitat above Castile Falls, and current conditions + habitat above Castile Falls + 40% effectiveness habitat restoration. Additional model parameters for this scenario can be viewed in Tables 9 through 13. The results for this scenario can be viewed in Table 4 below.

Steelhead: Future Integrated hatchery program

This scenario converts the current Skamania summer steelhead program to an integrated hatchery program using NOR steelhead native to the Klickitat River for broodstock. The program would use 100% NORs for broodstock with a release of 90,000 smolts. For integrated hatchery-origin fish, we modeled a productivity rate of 0.85 relative to natural-origin steelhead.

For consistency with the other scenarios, we assumed an adult volunteer rate back into the hatchery of 70%. Simulations were run for future habitat conditions including current conditions + habitat above Castile Falls, and current conditions + habitat above Castile Falls + 40% effectiveness habitat restoration. Additional model parameters for this scenario can be viewed in Tables 9 through13. The results for this scenario can be viewed in Table 5 below.

Steelhead: Future with no hatchery program

A scenario without hatchery production was modeled under all three states of habitat conditions. These included the current conditions, the future with passage into the upper basin, and the future with passage into the upper basin + 40% effectiveness watershed restoration. The purpose of this scenario was to demonstrate the natural population's ability to meet the harvest objectives without the augmentation of artificial production. For both future scenarios, the model assumes the upper Basin had been fully seeded and occupied by the anadromous life history, meaning that, little to no production of the resident life history existed. In an attempt meet the harvest objectives for both treaty and non-treaty terminal fisheries as outlined in the plan (Chapter 6.1), the scenario assumed a harvest rate of 20% for current conditions, and 50% for the two future habitat conditions. These values were chosen for the scenario to represent a threshold value before NOR escapement experienced significant declines. The results for this scenario can be viewed in Table 6 below.

1.5 AHA Model results by Species

Table 3. AHA model runs for Klickitat River Spring Chinook current and proposed future programs.

	Current conditions with segregated program			Future Integrated Program: With habitat above Castile Falls			Future Integrated Program: With habitat above Castile Falls & Restoration		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
NOR Escapement	2,866	217	713	2,560	209	657	2,854	259	748
HoS Total Escapement	1,545	268	506	3,284	321	877	3,578	371	968
HoS Effective Escapement	309	54	101						
Total Natural Escapement (NoS & All HoS)	4,276	499	1,219						
Total Harvest	8,074	1,377	2,612	12,868	1,963	3,911	12,998	1,985	3,951
Hatchery Broodstock	73	73	73	138		138	138		138
Surplus at Hatchery	1	0	0	6,463	653		6,463	653	1,682
Total Runsize	12,215	1,868	3,809	23,148	3,487	7,022	23,578	3,560	7,153

Table 4. AHA model runs for Klickitat River Steelhead: Current and future conditions with proposed segregated program.

	Current Conditions W/Skamania hatchery imports scatter planted			Future Segregated Program: In-basin propagation & hatchery imprintment			Future Segregated Program: With habitat above Castile Falls			Future Segregated Program: With habitat above Castile Falls & Restoration		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
NOR Escapement	3,205	275	834	4,344	648	1,347	7,655	1,196	2,371	7,884	1,215	2,481
HoS Total Escapement	1,576	273	516	563	97	184	563	97	184	1,126	194	368
HoS Effective Escapement	315	55	103	113	19	37	113	19	37	225	39	74
Total Natural Escapement (NoS & All HoS)	4,643	562	1,349	4,907	750	1,531	8,218	1,298	2,555	9,010	1,419	2,849
Total Harvest	8,448	1,456	2,749	10,493	1,802	3,400	11,675	1,993	3,760	11,755	2,011	3,798
Hatchery Broodstock	73	73	73	87	87	87	87	87	87	87	87	87
Surplus at Hatchery	1	0	0	1,228	142	344	1,228	142	344	589	-	87
Total Runsize	12,993	2,017	4,073	16,659	2,818	5,320	21,113	3,534	6,674	21,414	3,569	6,817

Table 5. AHA model runs for Klickitat River Steelhead: Current and future conditions with proposed integrated program.

	Current Conditions W/Future Integrated program: Harvest augmentation			Future Integrated Program: W/Habitat above Castile Falls			Future Integrated Program: With habitat above Castile Falls & Restoration		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
NOR Escapement	**4,918**	**698**	**1,443**	**8,065**	**1,209**	**2,425**	**9,020**	**1,394**	**2,748**
HoS Total Escapement	**562**	**97**	**184**	**562**	**97**	**184**	**562**	**97**	**184**
HoS Effective Escapement	**450**	**78**	**147**	**450**	**78**	**147**	**450**	**78**	**147**
Total Natural Escapement (NoS & All HoS)	**5,480**	**800**	**1,627**	**8,627**	**1,311**	**2,608**	**9,582**	**1,496**	**2,931**
Total Harvest	**10,719**	**1,836**	**3,462**	**11,842**	**2,018**	**3,806**	**12,183**	**2,079**	**3,920**
Hatchery Broodstock	**87**	**87**	**87**	**87**	**87**	**87**	**87**	**87**	**87**
Surplus at Hatchery	**1,314**	**229**	**431**	**1,314**	**229**	**431**	**1,314**	**229**	**431**
Total Runsize	**17,538**	**2,950**	**5,562**	**21,767**	**3,635**	**6,857**	**23,052**	**3,863**	**7,287**

Table 6. AHA model runs for Klickitat River Steelhead: Current and future conditions with no hatchery program.

	Current Conditions with no hatchery program (20% Terminal harvest)			Future conditions with Habitat above Castile Falls, no hatchery program (50% Terminal harvest)			Future conditions with habitat above Castile Falls, Restoration, and no hatchery program (50% Terminal harvest)		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
NOR Escapement	**5,021**	**794**	**1,547**	**4,447**	**653**	**1,332**	**5,133**	**780**	**1,553**
HoS Total Escapement	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
HoS Effective Escapement	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Total Natural Escapement (NoS & All HoS)	**5,021**	**794**	**1,547**	**4,447**	**653**	**1,332**	**5,133**	**780**	**1,553**
Total Harvest	**1,792**	**277**	**542**	**5,178**	**741**	**1,521**	**5,977**	**888**	**1,776**
Hatchery Broodstock	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Surplus at Hatchery	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Total Runsize	**6,748**	**1,041**	**2,041**	**9,572**	**1,370**	**2,811**	**11,048**	**1,641**	**3,283**

Table 7. AHA model runs for Klickitat River Fall Chinook Hatchery programs: Current and proposed future programs.

	Current hatchery program performance			Projected future program performance: Initial Phase								
				Initial Phase						Long-term Phase		
	Out-of-basin (4M)			Out-of-basin (2M)			In-basin (2M)			In-basin (4M)		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
NOR Escapement	3,889	571	1,158	8	1	3	2,378	1	331	4,121	1	623
HoS Total Escapement	19,351	3,361	6,337	10,006	1,738	3,277	9,724	1,260	2,918	14,817	2,573	4,792
HoS Effective Escapement	9,676	1,681	3,168	5,003	869	1,638	4,862	630	1,459	11,854	2,058	3,834
Total Natural Escapement (NoS & All HoS)	23,240	3,965	7,495	10,014	1,739	3,279	11,942	1,261	3,249	18,938	2,574	5,415
Total Harvest	62,422	10,651	20,131	26,900	4,672	8,809	44,836	5,784	13,491	63,165	10,746	20,074
Hatchery Broodstock	2,251	2,251	2,251	1,164	1,164	1,164	1,165	703	1,045	1,165	968	1,147
Surplus at Hatchery	1	0	1	1	0	1	3,586	189	728	3,414	383	912
Total Runsize	85,663	14,617	27,626	36,916	6,412	12,089	61,528	7,938	18,514	86,683	14,746	27,548

Table 8. AHA model runs for Klickitat River Coho Hatchery programs: Current and proposed future programs.

	Current performance of Hatchery programs						Future program performance goal		
	Current Conditions Hatch$_1$*			Current Conditions Hatch$_2$*			Future Hatchery program		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
NOR Escapement	226	27	63	1	0	0	427	2	79
HoS Total Escapement	2,739	475	897	1,794	311	587	1769	307	579
HoS Effective Escapement	2,191	380	717	1,435	249	470	1415	246	463
Total Natural Escapement (NoS & All HoS)	2,965	507	959	1,795	311	587	2196	322	658
							0	0	0
							0	0	0
Total Harvest	19,349	3,312	6,262	29,886	5,191	9,787	27115	11055	14018
							0	0	0
Hatchery Broodstock	2,345	2,345	2,345	1,177	1,177	1,177	952	952	952
Surplus at Hatchery	1	0	0	1	0	1	6442	593	1682
							0	0	0
Total Runsize	22,313	3,819	7,222	31,682	5,503	10,375	36705	12922	17310

* See Table 13 for description of Hatch$_1$ and Hatch$_2$.

1.6 Additional AHA Input parameters for Klickitat River Anadromous Species

Harvest

Table 9. Harvest Rates used for AHA models characterizing current programs and observed harvest rates by fishery.

Current Programs				
Species	Fishery	Natural Origin	Hatchery Origin	Comments
Spring Chinook	Ocean	-	-	
	Zones 1-6	8.3%	8.3%	1996-2005 estimated mean- 2006 WDFW & ODFW Joint Staff Report
	Terminal	34.6%	34.6%	1996-2005 estimated harvest- Tribal Spring Chinook Database
Steelhead	Ocean	-	-	
	Zones 1-6	8.2%	13.2%	2005 Harvest BiOp, page 95[1/]
	Terminal	20.0%	80.0%	YN Harvest Database[2/]
Fall Chinook	Ocean	38.3%	38.3%	1989-2005 Average harvest; YN Database[3/]
	Zones 1-5	17.9%	17.9%	
	Zone 6	20.3%	20.3%	
	Terminal	32.8%	32.8%	
Coho	Ocean	15.0%	53.7%	1987-2005 Average harvest; YN Database[4/]
	Zones 1-5	7.5%	27.6%	
	Zone 6	5.0%	5.0%	
	Terminal	83.1%	83.1%	

1/ Projected incidental harvest in Zones 1-6 post 2005. An additional 5% harvest of hatchery steelhead is expected in Columbia mainstem sport fishery.

2/ Based on a conservative NOR run size of ~750-800 fish, Tribal harvest of wild fish would have a maximum harvest rate of 15% (2000-2011), plus an additional 5% hook and release mortality in terminal sport fishery.

3/ RMIS database queried for Marine and Zones 1-5 Harvest. 1992 Discluded due to insufficient tag recoveries in marine fisheries. Zone 6 and terminal derived from YN Database.

4/ RMIS database queried for Marine and Zones 1-5 harvest. 1989-1990, 1995-1996 Discluded due to insufficient tag recoveries in marine fisheries. Zone 6 and terminal derived from YN Database.

Table 10. Harvest Rates used for AHA models characterizing future programs and observed harvest rates by fishery.

Future Programs					
Species	Fishery	Natural Origin	Hatchery Origin	Hatchery Origin	Comments
Spring Chinook	Ocean	-	-	-	
	Zones 1-6	11.0%	11.0%[5]	18.7%	Post 2005 Estimated Harvest zones 1-6[1/]
	Terminal	20.0%	20.0%[5]	65.0%	Post 2005 Estimated terminal Harvest[2/]
Steelhead	Ocean	-	-	-	
	Zones 1-6	8.2%	13.2%		2005 Harvest BiOp, page 95[3/]
	Terminal	20.0%	80.0%		Harvest rates not expected to change for indefinite future
Fall Chinook	Ocean	8.25%	38.3%		
	Zones 1-5		17.9%		Projected future harvest[4/]
	Zone 6	23.0%	20.3%		
	Terminal	17.2%	32.8%		
Coho	Ocean	15.0%	53.7%	-	
	Zones 1-5	7.5%	27.6%		Projected future harvest[4/]
	Zone 6	5.0%	5.0%		
	Terminal	83.1%	83.1%		

1/ Wild harvest based on US v Oregon schedule assuming a run size of 141,000 at Bon. Table 30, 2005 Biop. Hatchery harvest based 2001-2005 sport average plus estimated zone 6 hatchery harvest

2/ Estimated Tribal harvest of wild fish from 1996-2005 from YN Spring Chinook database. Hatchery harvest is the anticipated rate for combined fisheries under new program guidelines.

3/ Projected incidental harvest in Zones 1-6 post 2005. An additional 5% harvest of hatchery steelhead is expected in Columbia mainstem sport fishery.

4/ Maximum allowable harvest rates for marine and Zones 1-6 (2005-2007 Interim Management Agreement). Hatchery exploitation expected to remain the same as current in all fisheries.

5/Hatchery-origin fish for the future program will not be adipose-clipped until the current hatchery line (progeny of long-term hatchery-origin parents) has been completely phased out.

Smolt-to-Adult Survival for Klickitat River Anadromous Species (HORs & NORs)

Table 11. Estimated smolt-to-adult return rates for current hatchery-origin returns (HORs) and naturally origin returns (NORs).

Current Programs			
Species	Origin	SAR	Comments
Spring Chinook	NORs	0.053	EDT Estimated NOR survival back to mouth
	HORs	0.002	Klickitat Hatchery Stock Average Survival before Exploitation
Steelhead	NORs	0.058	Estimated NOR survival back to mouth[1]
	HORs	0.026	Estimated Skamania Survival[2]
Fall Chinook	NORs	0.017	EDT Estimate
	HORs	0.005	Klickitat hatchery releases average Survival before Exploitation[3]
Coho	NORs	0.030	EDT Estimated NOR survival back to mouth
	HORs$_1$	0.003	Average survival for out-of-basin imports[4]
	HORs$_2$	0.008	Average survival for in-basin releases[5]

1/ Extrapolation from average Hood River NOR survival for brood years 1994-2002.
2/ Estimate based on run reconstructions for release years 1994-2002.

3/ Average Survival prior to exploitation. Based on available Brood years in HGMP

4/ Estimated average Survival of 2.5M smolts reared at Washougal Hatchery and scatter planted in Klickitat. Estimate based on available HGMP data.

5/ Estimated average Survival of 1.2M smolts reared and released from Klickitat hatchery. Estimate based on available HGMP data.

Table 12. Estimated smolt-to-adult return rates for future hatchery-origin returns (HORs) and naturally origin returns (NORs).

Future Programs			
Species	Origin	SAR	Comments
Spring Chinook	NORs	0.053	EDT Estimated NOR survival back to mouth
	HORs	0.007	Projected Survival Prior to exploitation[/1]
Steelhead	NORs	0.058	Estimated NOR survival back to mouth[/2]
	HORs	0.018	Estimated NOR survival back to mouth[/3]
Fall Chinook	NORs	0.017	EDT Estimated NOR survival back to mouth
	HORs	0.008	Survival goal for initial future program
	HORs	0.010	Survival goal for long-term future program
Coho	NORs	0.030	EDT Estimated NOR survival back to mouth
	HORs	0.016	Survival goal for long-term future program

1/ Survival based on Yakima River CESRF hatchery recruitment rate of spring Chinook.

2/ Extrapolation from average Hood River NOR survival for brood years 1994-2002.

3/ Extrapolation from average Hood River NOR broodstock program brood years 1999-2002.

Hatchery Release Numbers

Table 13. Estimated number of hatchery-origin fish released by species for current and future programs used in EDT and AHA models.

Current Hatchery program release numbers			Future Hatchery program release numbers
Species	Hatchery$_1$	Hatchery$_2$	Hatchery$_1$
Spring Chinook	826595		800000
Steelhead	100505		100000
Coho	2467656	1238563	1000000
Fall Chinook	3867241		4000000