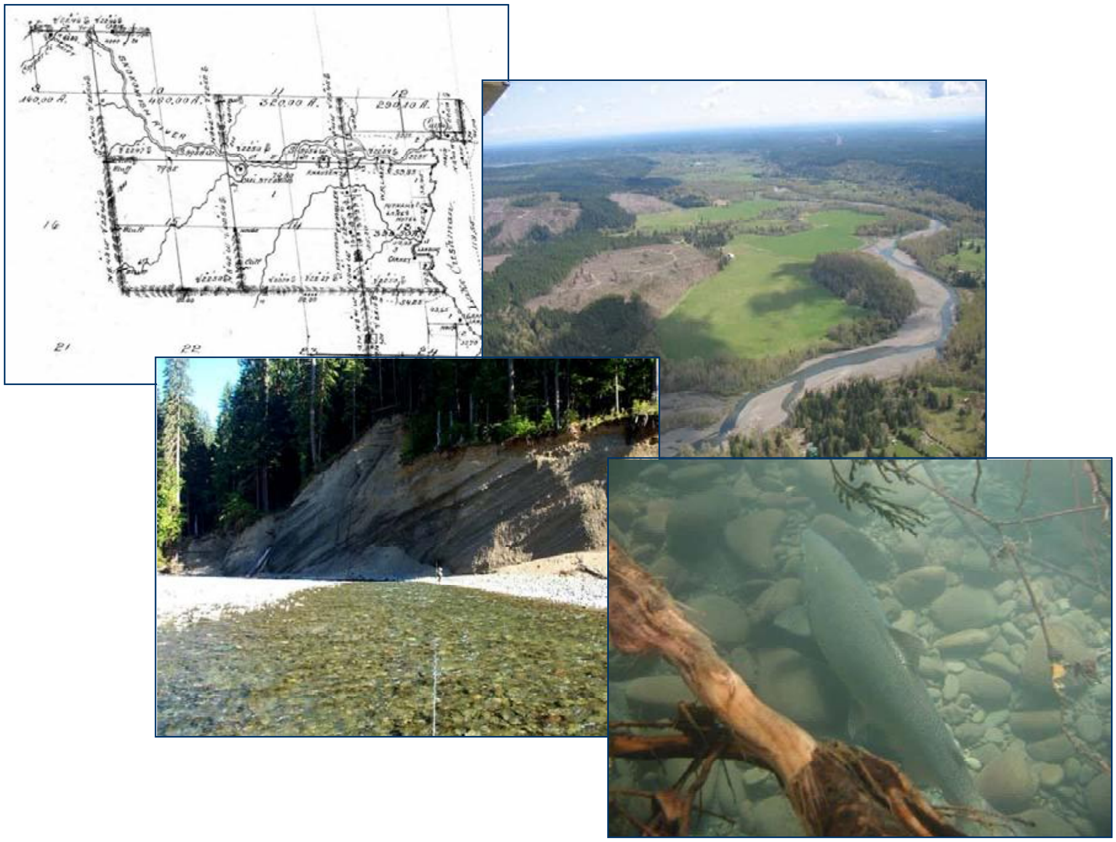
Recovery Plan for Skokomish River Chinook Salmon



Skokomish Indian Tribe
Washington Department of Fish and Wildlife

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Table of Contents

List of Figures

List of Tables

Chapter 1. Introduction

> *"The recovery of the Pacific salmon will be thwarted until at least some of the natural pathways through the riverscape are restored, until we give life to the ghosts of those salmon life histories that were once present in healthy rivers."*
>
> \- Jim Lichatowich, *Salmon Without Rivers*

On March 24, 1999, the National Marine Fisheries Service (NMFS) listed all naturally spawned populations of Chinook salmon (*Onchorhynchus tshawytscha*) and five artificial propagation programs within the Puget Sound evolutionarily significant unit (ESU) as a threatened species under the Endangered Species Act (ESA). The threatened species status was reaffirmed on June 28, 2005, and an additional 21 artificial propagation programs within the ESU were added to the listing. The listing included the Chinook stock currently produced in the Skokomish watershed, comprised of hatchery-produced fish from the George Adams and Rick's Pond Hatcheries and naturally-produced fish from the Skokomish River.

This listing under the ESA requires NMFS to develop and implement recovery plans for the conservation and survival of Chinook salmon within the Puget Sound ESU. The NMFS Puget Sound Technical Review Team (PSTRT) identified Hood Canal as one of five biogeographical regions within the Puget Sound ESU. Each region has unique habitat attributes, shaped by its own topographical and climatic variations, that have supported similar evolutionary development by Chinook there. The PSTRT recognized two aggregate historic groups of Chinook in the Hood Canal region as independent populations, those produced in the Skokomish watershed and those produced in Mid-Hood Canal rivers (Ruckelshaus et al. 2006). The recovery of two Hood Canal populations is considered required to meet the PSTRT's viability criteria for the long-term survival of the species in the Puget Sound ESU (Puget Sound Shared Strategy 2007).[1]

The central goal of this plan is to re-establish a productive, self-sustaining Chinook population in the Skokomish watershed. This will require the re-emergence of a population adapted to the natural environment, such as to key watershed characteristics—one which would exhibit life histories that resemble those seen in aboriginal Skokomish Chinook.

Historically, Skokomish Chinook exhibited a diverse set of life histories, having, among other traits, a wide range of river entry timing patterns. Both early-timed (spring/summer) and late-timed (fall) racial groups were supported by the river.[2] Besides differences in river entry timing, these groups differed markedly in their spatial use of the watershed. Both indigenous racial groups are now extinct in the river basin (Ruckelshaus et al. 2006). This fact presents particular challenges for recovery since a well-adapted genetic stock source does not currently exist in the river system.

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[1] / Recovery means that the population would be self-reproducing and have at least a 95% probability of persistence over a 100 year period.

[2] / Early-timed, or spring/summer, Chinook are generally considered as those that return to the river during the months of April (or earlier in some cases) through August. Late-timed, or fall, Chinook are considered as those that enter during September through December.

The premise on which this plan is built is that population recovery requires restoring life histories that are adapted to the environmental conditions that either still exist in the watershed or that are being restored. We have developed this plan around this life history perspective—it guides every part of the plan. Knowledge of the aboriginal life histories that existed prior to their extirpation provides an essential part of this guidance. Moreover, in developing the plan, we placed much importance on diagnosing the factors that caused the extirpation of the aboriginal life histories. This diagnosis has helped provide direction to the plan, and has helped set restoration priorities and sequencing for strategies.

The best prospect for recovering a Skokomish population, at least in the near-term, has been determined to be for the early-timed racial group. Significant issues exist in restoring habitat function sufficiently within the core spawning areas used by late-timed fish to support a viable population. Also, the recent Cushman Settlement reached by the Skokomish Tribe, Washington State, and the Federal government with the City of Tacoma over the Cushman Dam Project provides significant resources and impetus for initiating recovery actions aimed at early-timed Chinook.

The highest recovery priority, therefore, is being given to the early-timed racial group. Because of its extirpation, recovery necessitates a re-introduction of a suitable early-timed stock to the watershed. Once this has been accomplished, the plan has been developed to treat the re-introduced stock as the listed Chinook in the watershed. As the plan goes forward, and as progress is made in restoring key habitats in the lower valleys, the potential for expanding recovery efforts to include the late-timed racial group will be re-evaluated. Failure to make significant progress toward recovering the early-timed group over the next 10 to 12 years, however, would be cause to re-examine plan direction and possibly reset the priority to the late-timed life history group.

The Demise of Indigenous Skokomish Chinook

The demise of the indigenous racial groups was due to multiple factors, operating in concert and set in motion by various events—both locally and in distant waters—since the late 1800s. In brief, a combination of effects, escalating in intensity over time, far exceeded the productive resiliency of the indigenous populations for sustaining themselves. Hydro development, water diversion, floodplain development, estuarine alterations, liquidation of old growth forests, greatly expanded fishing patterns—all of these contributed to the extinction of the aboriginal Chinook populations in the Skokomish River.

As the runs declined, the need to bolster their abundances became evident—leading to the construction of George Adams Hatchery in 1961. Hatchery Chinook stock of Green River lineage was imported to facilitate startup. Over time, this event, combined with all of the other factors listed above, led to a complete replacement of population structure (Myers et al. 1998; Ruckelshaus et al. 2006). The life history diversity of Chinook produced in the watershed today is a distant shadow of that of the historic aggregate populations.

The Environment

The Skokomish River, located in the southeast corner of the Olympic Peninsula, drains 240 square miles of mostly forested land. Originating in the Olympic Mountains and foothills, it empties to the southern end of Hood Canal, a branch of the Puget Sound complex (Figure 1.1). Hood Canal is a natural, glacier-carved fjord more than 60 miles long, which forms the westernmost waterway and margin of the Puget Sound basin.

The Skokomish watershed's topography is widely varied, consisting of steep mountain slopes, more moderately sloping foothills, and flat valley bottoms. The two arterial rivers, the North and South forks, that join to form the main Skokomish River flow south and east out of the mountains, descending through incised valleys, interspersed with steep gorges and sections of widened valley bottoms, before joining in the wide, flat lower valley. From here, the river generally meanders to its extensive delta in the southwestern corner of Hood Canal (Figure 1.2).

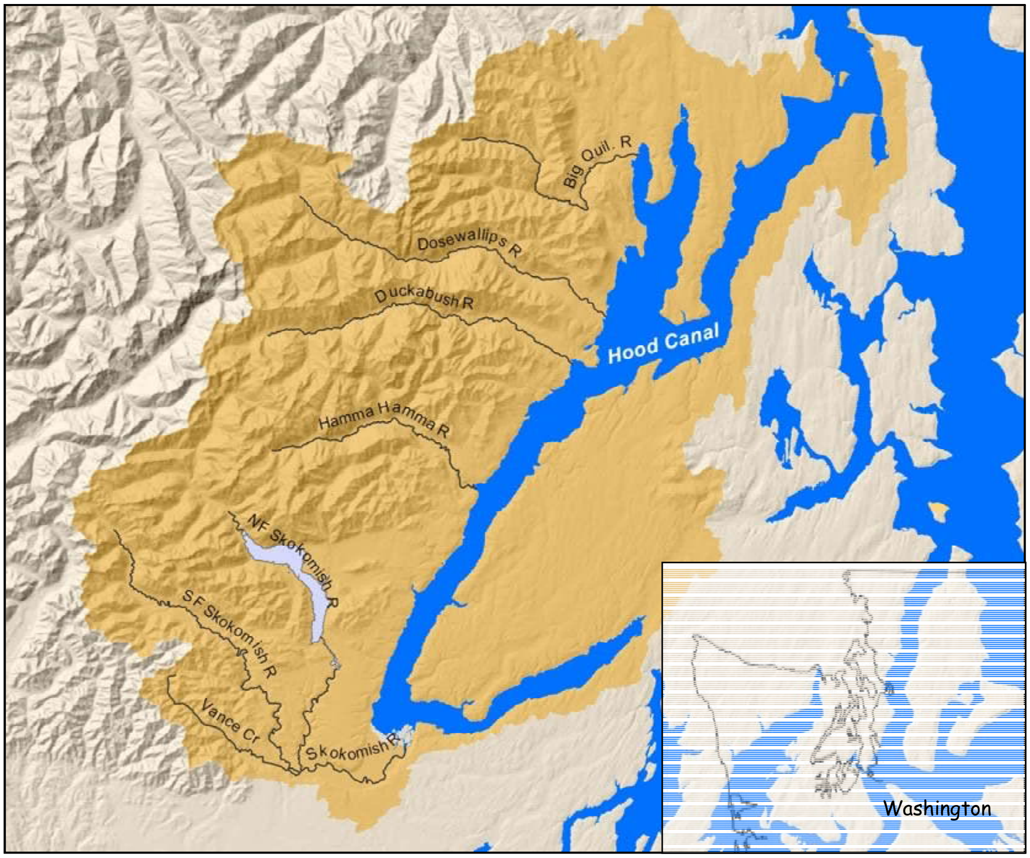

Figure 1.1. Hood Canal with major river systems located. The watershed area draining to Hood Canal is shaded.

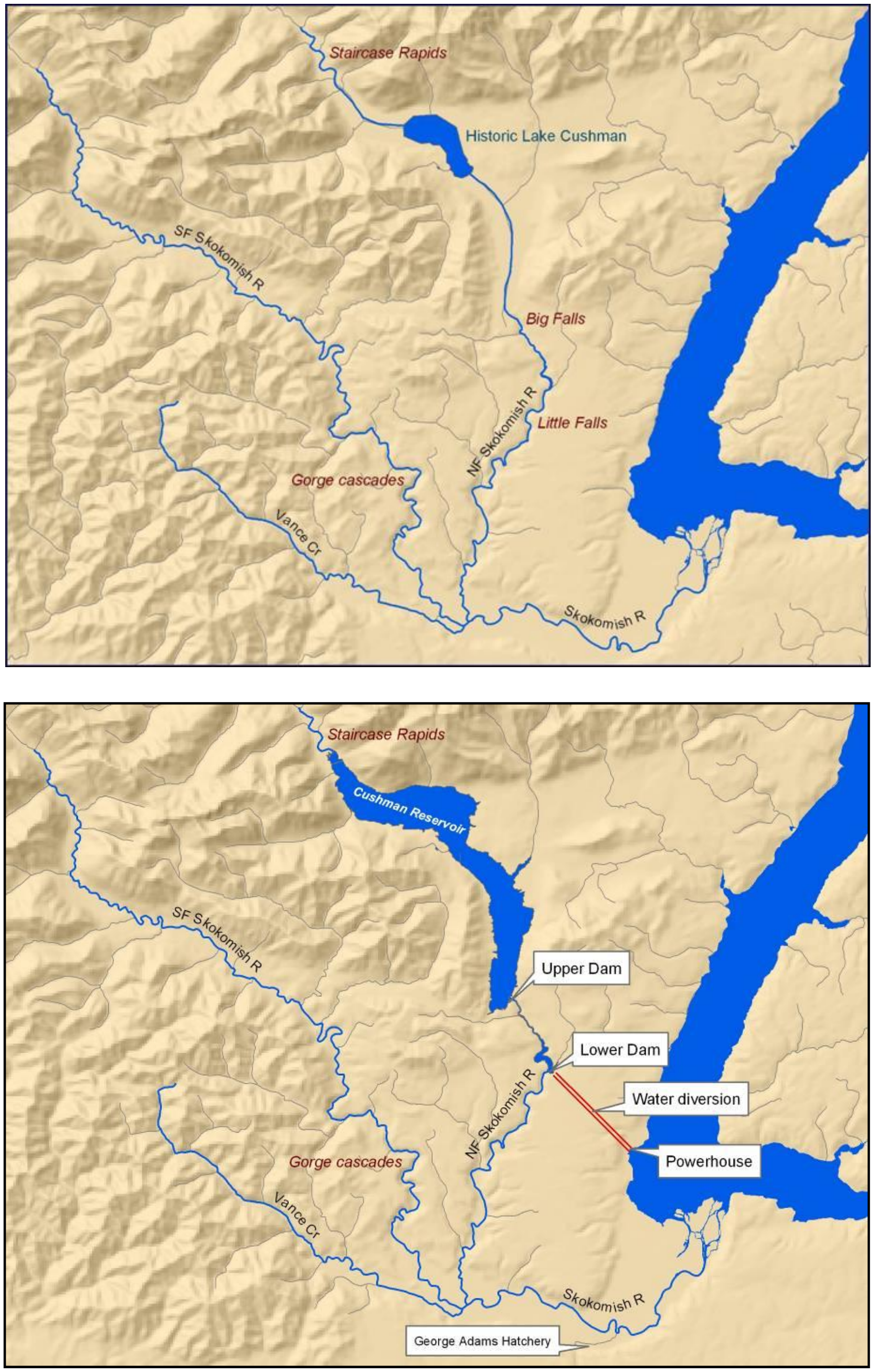

Figure 1.2. Features of the Skokomish River system prior to and after construction of the Cushman Project. The top map shows the approximate size of the original Lake Cushman and locations of Big and Little Falls. The major components of Cushman Project are shown in the bottom map, as well as the location of George Adams Hatchery.

Over the past 150 years, many features of the watershed have been radically altered through landuse and hydro development, including river flow, lake size, land cover, and riverine and riparian characteristics. Forest harvest and agricultural practices since the late 1800s are two principal reasons for these changes. The most dramatic alterations, however, occurred in the North Fork, with the construction of the two Cushman dams, inundation of much of the upper North Fork to form Cushman Reservoir, and the diversion of the river's flow out of the watershed and directly to Hood Canal (Figure 1.2). No provisions for fish passage were provided at the dams, which were built in the late 1920s. The Cushman Settlement, agreed on in January 2009, will provide for fish passage, re-introductions of salmon into the upper North Fork, and restoration of normative flow characteristics, among other provisions (see Chapter 7).

The George Adams Hatchery is located in the lower part of the Skokomish River valley (Figure 1.2). Built in 1961, it is operated by WDFW primarily for the purpose of augmenting harvest opportunity for treaty Indian and non-treaty fisheries. The facility was built to mitigate for lost salmon production due to the extensive watershed alterations, of which the Cushman Project was considered to be the most significant (WDF 1957b).

Vision for Restoration and Recovery

Defining recovery goals, strategic objectives, and implementation actions within this recovery plan begins with establishment of a vision statement for the Skokomish watershed:

> *The co-managers envision the watershed restored to normative ecosystem functions, supporting productive, diverse salmon populations that meet recovery goals, as well as providing for sustainable social, cultural, and economic values within and outside the recovery region.*

Realizing this vision would mean:

- Meeting the recovery goals for abundance, productivity, spatial distribution, and diversity for Chinook salmon and other ESA-listed species;
- Achieving healthy and harvestable populations of species that are either currently ESA-listed or unlisted; and
- Recognizing and preserving the social, cultural, and economic values derived from the Skokomish ecosystem by tribal and non-tribal communities.

The terms "normative ecosystem" and "normative river flow" are used throughout this plan to mean an altered system that has a balanced mix of natural and cultural features such that indigenous life histories of salmon populations can be supported. These terms, developed for application to salmon recovery planning in the much altered Columbia River system (Williams 2006; Liss et al. 2006), recognize that modern society often causes substantial changes in watershed processes and functions. Still, in many watersheds, ecological processes can be maintained—or restored—sufficiently to support salmon life histories that were historically adapted to them. Normative refers to the norms of ecological functions and processes characteristic of salmon-bearing streams. These features, when balanced with society's needs and demands, result in an ecosystem in which both natural and cultural elements exist in a balance, allowing salmon to thrive and many of society's present uses of the river to continue, although not without modification (Liss et al. 2006).

The role of each of the H's is implicit in our vision. Habitat must be accessible and exist in sufficient quality and quantity for all salmonid life stages. Hatcheries cannot produce more risks than benefits to the ecosystem and the salmonid populations. Harvest must be at levels that do not diminish populations beyond their ability to sustain themselves at productive levels within the available habitat. Hydropower must facilitate—not hinder—restoration of naturally-produced Chinook and other species.

Achievement of the desired future condition is a long-term endeavor. For this planning phase, we consider a 40-year time horizon, consistent with the period of years encompassed by the new FERC license for operating the Cushman Project.[3] A suite of strategies—part of the re-licensed Cushman Project—aimed at restoration and recovery of habitat and salmon in the North Fork, lower Skokomish River, and the estuary will be implemented over this 40-year period. Other strategies, unrelated to the Cushman Project, will also be implemented, some of which will likely extend well beyond the 40-year time horizon. It is expected, for example, that some strategies aimed at restoring the upper South Fork will need to mature over at least a 100 year time frame before their full benefit is realized.[4] Active restoration of some normative conditions benefiting Chinook salmon, however, can also occur over much shorter periods.

It is important to also recognize that hatchery operations will play an essential role in re-establishing early-timed Chinook in both the North and South forks, as well as in continuing to provide important harvest benefits (Figure 1.3). The recovery effort will be benefitted by hatchery production to initiate the re-introductions of early-timed Chinook and to supplement natural reproduction while habitat restoration progresses. At the same time, hatchery production of the existing George Adams summer/fall Chinook stock will be maintained to help meet harvest needs as part of on-going mitigation for lost fish production. Hence, hatcheries and habitat restoration strategies operating in unison can provide an effective approach to achieve both the short- and long-term goals for the watershed.

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[3] / The new license was issued by FERC on July 15, 2010. It approves operation of the Cushman Project for a 40-year period under provisions specified by the Cushman Settlement of 2009.

[4] / It is expected that the complete re-establishment of large, stable conifers near and adjacent to the South Fork mainstem will exceed 100 years. See Chapter 4 for details.

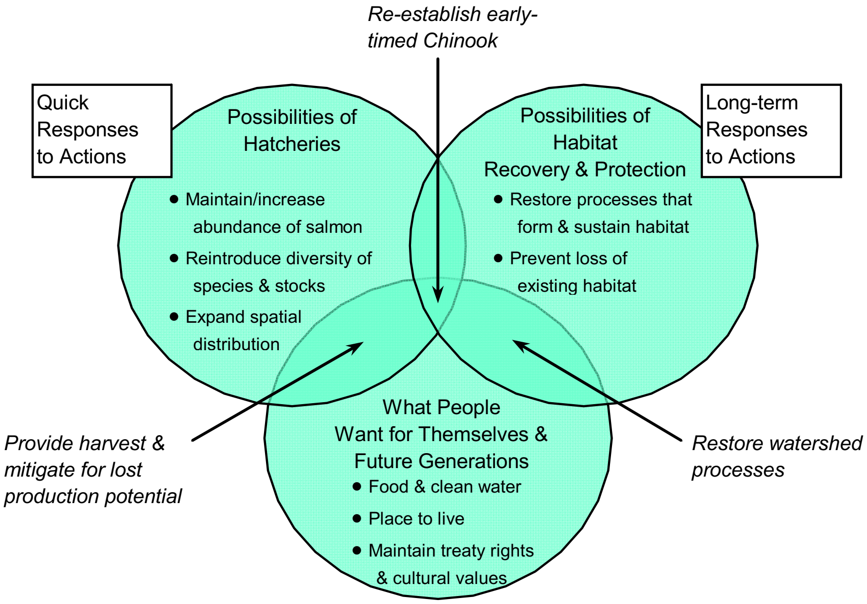

Figure 1.3. Relationship of the roles of hatcheries and habitat restoration with public policy for recovery of Skokomish River Chinook salmon.

Overarching Hypotheses of The Recovery Plan

Two overarching hypotheses guide this plan. The first addresses what we refer to as the stock issue, which considers what genetic stock source is suitable for achieving recovery within a reasonable time period. This matter is of particular importance to this plan because the extant stock produced in the Skokomish River is not indigenous and it has life history traits unlike those of either of the aborginal racial groups (see Chapter 2). The second hypothesis considers the feasibility for restoring normative habitat characteristics within the Skokomish watershed.

The stock issue raises this critical question: If the proposed strategies for restoring normative habitat characteristics are successful, would life histories re-emerge from the existing extant summer/fall stock to resemble those of true early-timed Chinook? The answer may hinge on how long we are willing to wait. In theory, adapted life histories could eventually re-emerge, but probably only after many human generations, and then, only if local, regional, or trans-regional environmental issues did not develop to stymie their re-emergence.

The overarching hypothesis that addresses this question considers both the ultimate potential for success and the length of time that might be needed to realize success. The hypothesis is that a reasonably close match is required between life history traits of the genetic stock source to be used in the recovery effort and that of the aboriginal early-timed racial group that was adapted to the Skokomish watershed. One of the key traits is river entry timing, which should occur principally during the months of April through July corresponding to the spring runoff for the early-timed racial group. The North Fork hydrograph downstream of the Cushman Project is to be managed to provide a normative pattern to facilitate upstream passage during spring and early summer over Little Falls (see Figure 1.2) and to the base of the lower dam. Active steps, therefore, are seen as necessary to introduce life histories that are predisposed for such a return timing. These life histories should be reasonably adapted to the restored flow regime pattern and its associated habitats. The extant stock does not exhibit such characteristics. Chapter 2 of the plan presents this hypothesis in greater detail.

The second overarching hypothesis within this plan is that normative habitat charactistics can be sufficiently restored to the Skokomish River to support a self-sustaining, productive population of early-timed Chinook. In its current state, the river system is radically different than its prior state. Analysis of habitat conditions indicates that the river is currently unlikely to be able to sustain a population of self-reproducing Chinook. A major thrust of this plan is to restore normative watershed processes, which in turn, will form and maintain habitat function that can support naturally produced Chinook life histories. However, the plan also incorporates habitat strategies that will use engineered solutions, such as those that will provide for upstream and downstream passage at the Cushman Project. Chapter 4 of this plan presents this hypothesis in greater detail.

Plan Organization

This plan is organized into nine chapters as follows:

1. Introduction;
2. Chinook Salmon Life History Profiles and The Key to Recovery;
3. Recovery Goals;
4. Habitat Recovery Strategies;
5. Hatchery Recovery Strategies
6. Harvest Management Recovery Strategies;
7. Hydropower Management Recovery Strategies;
8. Integration of Habitat, Hatchery & Harvest Strategies; and
9. Adaptive Management and Monitoring

The flow of information through the plan and its integration are illustrated in Figure 1.4.

Two appendices are contained in the plan. Appendix A provides some pertinent background information on hatchery production in the basin. Appendix B provides details on articles of the FERC license issued to Tacoma Power on July 15, 2010 for operation of the Cushman Project.

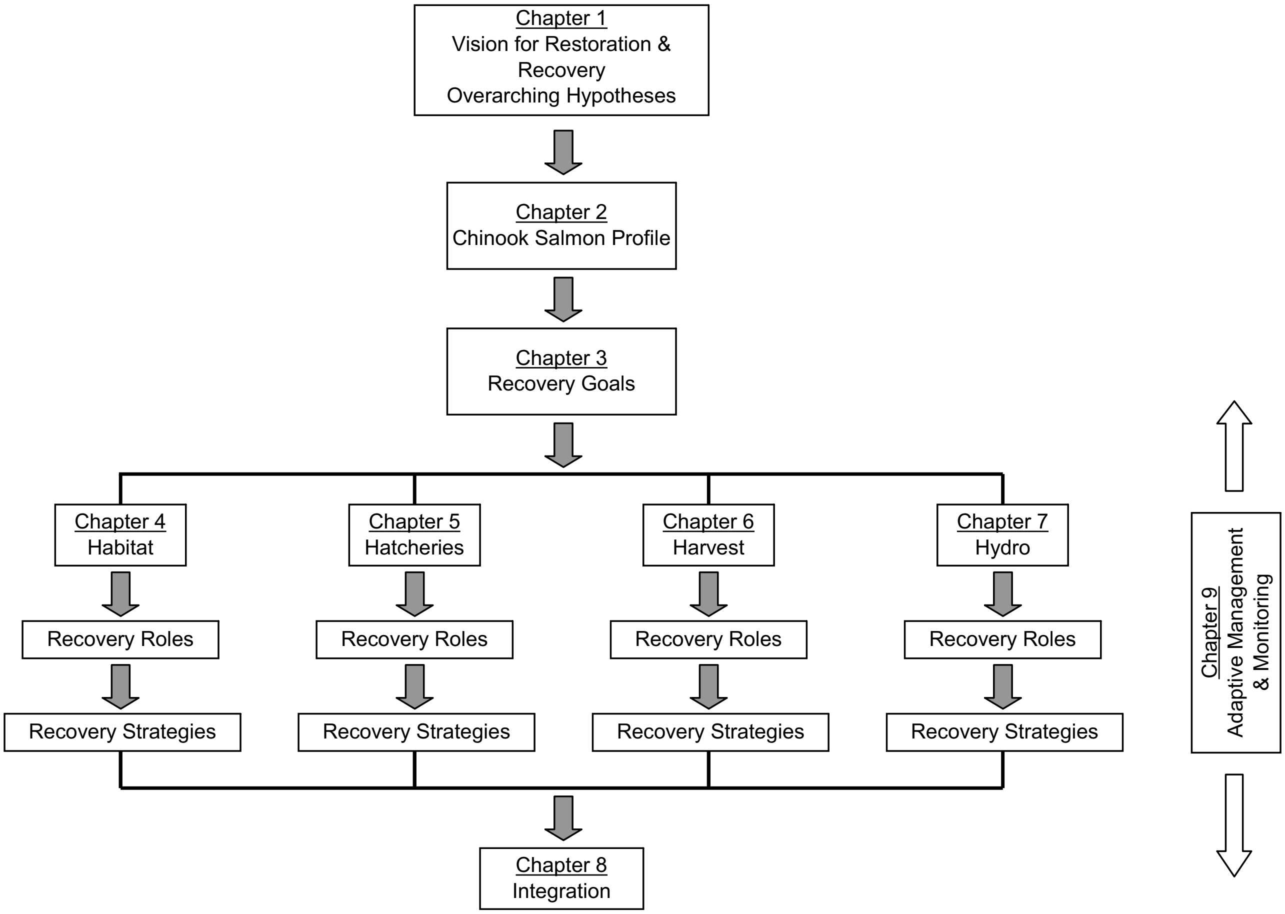

Figure 1.4. **Components of the recovery plan as described in its nine chapters and how they relate to one another.**

Chapter 2. Chinook Salmon Life History Profiles and The Key to Recovery

This chapter presents the central theme that unifies the many parts of the recovery plan: population recovery will require both the restoration of normative watershed functions, and the recovery of Chinook life history types adapted to them. Understanding the relationships between the environment and adapted life history types is seen as critical in formulating a plan that can succeed. This life history perspective guides the direction, scope, and sequencing of the various parts to the plan.

The central goal of this plan is to recover a productive, self-sustaining Chinook population in the Skokomish watershed. Historically, Skokomish Chinook exhibited a diverse set of life history types, having, among other characteristics, a range of river entry timing patterns. Both early-timed (spring/summer) and late-timed (fall) racial groups were supported by the river. Besides differences in river entry timing, these groups differed markedly in their spatial distribution within the watershed. Both indigenous racial groups are now extinct in the river basin.

In the near-term, the best prospect for recovery has been determined to be for the early-timed racial group. Significant issues exist in restoring habitat function sufficiently within the core spawning areas used by late-timed fish to support a viable population. Therefore, the highest priority for recovery has been established for the early-timed racial group. As the plan goes forward, and as progress is made in restoring key habitats in the lower valleys, the potential for expanding recovery efforts to include the late-timed racial group can be re-evaluated.

An important step in understanding how environmental characteristics shape life history patterns is to assess likely historic life histories and how they have been changed by human activities. Beechie et al. (2006) proposed that relating life history diversity to environmental attributes, such as the flow regime, can facilitate understanding historic diversity and its adaptation to local conditions. This can then be used to examine why current life history patterns differ from historic patterns. Similarly, Lichatowich et al. (1995) showed that a comparison of habitat and life history relationships between historic and current conditions can be used to diagnose constraints on existing population performance. Knowledge gained through such an analysis can guide recovery planning for re-establishing productive life history types adapted to restored habitat.

This chapter profiles both historic and existing life history patterns of Skokomish Chinook and relates them to environmental conditions, with a focus on flow regime characteristics. A comparison of these patterns, in light of historic, current, and projected future flow regimes, is then used as the basis for formulating an overarching hypothesis for Chinook recovery in the basin.

This chapter is organized into the following sections:

- Life history perspective;
- Skokomish River flow regimes;
- Profiles of historic Chinook life histories;
- Profiles of existing Chinook life histories populations; and
- The key to recovery

Life History Perspective

The Chinook displays the greatest amount of diversity in life history tactics among the Pacific salmon species (Healey 1991). The broad array of tactics includes variation in age at seaward migration, variation in length of freshwater, estuarine, and oceanic residence, variation in ocean distribution and ocean migratory patterns, and variation in timing of adult return migration and spawning. Tactical patterns can differ significantly between populations and within populations. This variation represents adaptation to dynamics in juvenile survival and productivity within freshwater, estuarine, and early marine environments. As a result, populations reflect adaptations to both regional and more localized environmental conditions for their survival.

A salmon population's life histories need to be considered in the context of its habitat, because habitats are the templates that organize life history traits (Southwood 1977). Lichatowich (1999) concluded that the amount of variation in life history traits in salmon shows that the species and their habitats are inextricably linked—that a population and its habitat should be treated as a single unit, especially in attempts to manage and restore them.

The flow regime within a watershed is the most dynamic aspect of salmon habitat during freshwater and estuarine life stages. This suggests that a primary driver of historic salmon life histories within a watershed was the river's natural flow regime.

Skokomish River Flow Regimes

This section introduces the concept of flow regime and its importance in shaping salmon life histories within the riverine environment. Chapter 4 of this plan (Habitat) provides a more in-depth review of the natural and altered flow regimes in the Skokomish watershed. Flow regimes have been changed radically in the North Fork since 1930, and will change again under a new FERC license. The influence of these regimes in affecting the success of Chinook life histories is considered later in this chapter.

The flow regime has been called the master variable that shapes the riverine ecosystem (Poff et al. 1997). Over the millennia, it operated as the major forcer of important processes that influenced both physical and biological features of the historic riverine ecosystem. The flow regime is defined by five characteristics in flow: magnitude, timing, frequency, duration, and rate of change. Over some period of years, these characteristics vary within a range determined by prevailing climate patterns and various watershed features, such as its size, location, topography, configuration, geology, and land cover.

Under largely natural conditions, the patterns and ranges of variation in flow characteristics comprise what is called the watershed's natural flow regime. These characteristics are the ones that salmon populations adapted to in the centuries prior to the rapid alterations that occurred in Western Washington watersheds over about the past 100 years.

Historic Skokomish River Flow Regimes

The hydrograph pattern that occurred historically in the lower Skokomish River can be approximated by combining USGS gauging data collected in the lower mainstem with the data from the upper North Fork (Figure 1.1). The years 1944-1953, the first ten years when the gauging station operated on the lower Skokomish River, are used to represent historic conditions. The reconstructed hydrograph shows the bi-modal runoff pattern characteristic of a regime transitional between a snow-melt dominated regime and a rainfall-dominated regime. The largest period of runoff occurred during winter with a second mode, a smaller one, occurring during spring due to snowmelt (see Chapter 4 for further details).

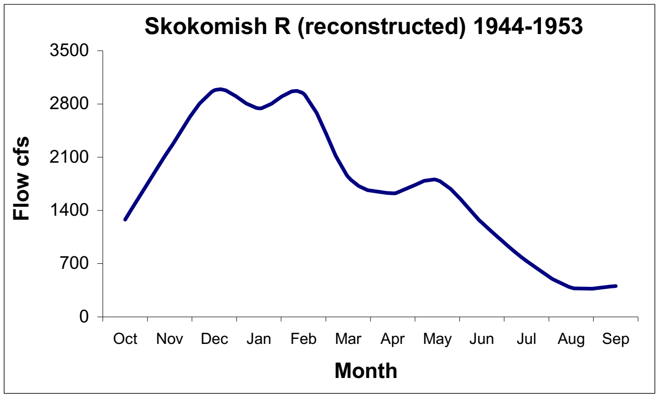

Figure 2.1. Reconstructed hydrograph for the lower Skokomish River for 1944-1953. The hydrograph was formulated by adding mainstem river flows (downstream of forks) to North Fork flows upstream of Cushman reservoir to approximate the historic shape of the hydrograph prior to the water diversion from the North Fork to Hood Canal.

Between and within year variation in runoff can be assessed by examining a series of annual hydrographs. The following patterns of variation are evident:

- Annual low flows typically occurred in September or early October;
- The first significant increase in flows following summer usually began about the middle of October, though in some years it occurred earlier while in others it happened later;
- By early November, average daily flows were always much higher than during the low flow months;
- Annual peak flows normally occurred between late November and the end of March;
- High flow events could occur frequently in any given year between early November and the end of March;
- Daily variation and peak flow magnitude during the late spring snowmelt period were much less than typically seen during winter and early spring.

Existing Skokomish River Flow Regimes

Since the construction of the Cushman dams by the city of Tacoma in the late 1920s, Skokomish River flow regimes have undergone significant changes. Some aspects of the regimes have changed dramatically, while others still demonstrate characteristics like those of the historic regimes.

The greatest change occurred in the North Fork's flow regime downstream of the lower Cushman Dam. After the closure of the lower dam, flows to the river below that point were essentially cutoff. Almost the entirety of the flow was diverted via pipelines directly to Hood Canal, approximately five miles north of the Skokomish River mouth. Since then, approximately 40% of the annual runoff in the Skokomish watershed has been diverted out of the basin (Jay and Simenstad 1996). Flow releases were increased in 1988, 1998, and again in March 2008. The current release pattern does not provide for any type of variation, except due to a reservoir inflow constraint. The releases will change again under the new FERC license for the Cushman dams.

The alterations to the North Fork regime beginning in 1930, combined with intensive logging in the basin outside the Olympic National Park and development of the lower valley and estuary, led to significant changes to sediment routing, channel characteristics, and flood frequency (Jay and Simenstad 1996; Stover and Montgomery 2001). Aggradation—an increase in river bed elevation due to sediment deposition—has occurred throughout the lower portions of the forks and the main Skokomish River, leading to increased flooding. As a result, the Skokomish River is now considered the most flood prone river in Washington State, and arguably in the Pacific Northwest. This characteristic, notable in itself, is more remarkable because peak flows in the lower Skokomish River have actually been significantly reduced due to the out-of-basin water diversion.

The general patterns and extent of variation in the mainstem river flow regime are generally similar between those in recent years and historic patterns with some notable differences. The following is concluded:

- Annual low flows still occur in September or early October, but levels are much lower compared to historic lows;
- Fall, winter, and early spring freshets in recent years generally produce the same types and patterns of variation as occurred historically, though flood levels are now frequently reached in winter;
- A period of snowmelt runoff is not evident in late spring due to the out-of-basin water diversion;
- Peak annual flows would be higher if the Cushman diversion was not in place even though flooding now occurs more often.

Future Skokomish River Flow Regimes

The flow regimes of the North Fork and lower mainstem river will change again in the near future. Under the new FERC license, issued on July 15, 2010, a normative-type flow regime pattern will be provided by the Cushman dams. The new regime will have these features:

- The shape of the annual hydrograph will resemble the natural pattern, and provide for a spring flow pulse to simulate snowmelt runoff;
- Channel and habitat maintenance flows will be provided to aid in re-creating and maintaining channel flow capacity and physical habitat in the North Fork and lower mainstem river; and
- Periods of flow variation will be provided, timed to occur during normal freshets.

Profiles of Historic Chinook Life Histories

Major demographic and life history characteristics of the historic Chinook populations are profiled below to the extent that information was available. In addition, descriptions are given of how these characteristics appear to have been adapted to the watershed's flow regime and other related environmental factors.

Population Characteristics

Within the past 100 years, the Skokomish River system supported Chinook comprised of an early-timed component and a true late-timed component. Historic population structure is unclear, and as a result the Puget Sound TRT chose to identify the components as one population (Ruckelshaus et al. 2006):

> "Because the TRT could not confidently identify two historical populations in the Skokomish River, we concluded that there was at least one historical population."

The TRT identified, however, three Chinook run-timing groups: (1) an early-timed group in the upper North Fork, (2) an early-timed group in the upper South Fork, with spawning occurring as far downstream as Vance Creek, and (3) a late timed group in the lower North and South forks and the mainstem below the forks.

This plan recognizes this uncertainty in attempting to delineate populations. Efforts aimed at trying to recover either the early-timed or late-timed components would require different approaches, which, in effect, would treat them as different populations.

Spawning Distribution

The historic spawning distribution of Chinook in the basin extended to the upper reaches of both the North and South forks, major tributaries to both forks, and the entirety of the mainstem downstream of the forks (Figure 2.2) (Elmendorf and Kroeber 1992; Smoker et al. 1952; Deschamps 1954; WDF 1957a). The separation between early and late-timed run components was generally regarded to be in the vicinity of Little or Big Falls[5] in the North Fork and the vicinity of the gorge in the South Fork. As noted by the TRT, however, some early-timed fish may have spawned as far downstream as Vance Creek in the South Fork.[6]

James (1980), after interviewing many people who had visited or fished at the two sets of falls, including both Indians and non-Indians, described the two falls in the North Fork as follows:

> "The Upper and Lower Falls on the North Fork were not a total barrier to Chinook, steelhead, coho or sockeye. The falls were excellent sites for fishing during salmon and steelhead runs. Fish congregated below the falls during spawning runs and navigated the falls during high flows."

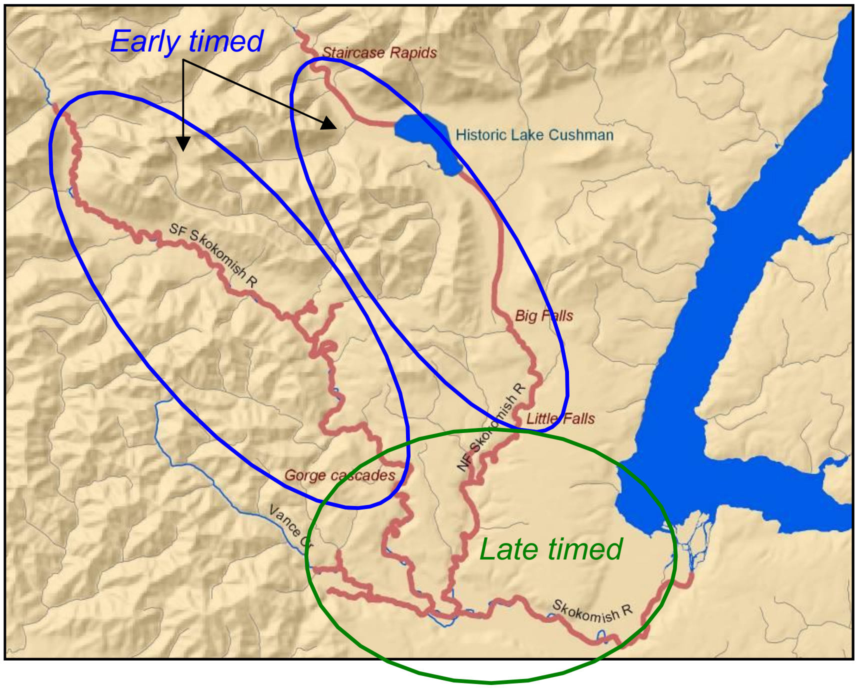

Figure 2.2. Historic distribution of Chinook in the Skokomish River system. Sources: WDFW SalmonScape for overall distribution; Deschamps (1955) and WDF (1957) for distribution of early and late-timed components.

Big Falls, located between the two dam sites, was described as being between 12-15 ft high. Little Falls was described as being about 10 ft high. As seen today, Little Falls is stair-stepped, allowing fish prior to dam construction to pass under certain flow conditions.

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[5] / The two falls are also often referred to as Upper Falls (Big Falls) or Lower Falls (Little Falls), as discussed in James (1980).

[6]/ The spatial separation of early from late-timed fish in the South Fork is based on limited observations on spawning timing made by Deschamps (1954). Deschamps' conclusions were based on inference and not on being able to tie time of spawning to river entry timing.

River Entry and Spawning Timing

Smoker et al. (1952) summarized information available in the 1940s to characterize run timing of the spring and fall runs in the river at that time. Their characterization provides the most detailed view of run timing prior to construction of the George Adams Hatchery. Their conclusions were drawn from an examination of tribal gillnet catch data. They concluded:

> "The spring Chinook enter from April through July with no apparent peak. The fall Chinook rise to a sharp peak in late October."

The gillnet catch data for that period suggested that the strongest run component was the fall run, although it should be noted that by that time the early-timed component would have been extinct on the North Fork due to the Cushman Dams. The abundance and distribution of the fall run would also have been affected by the Cushman project by this time. It is uncertain, therefore, what the relative strengths were prior to dam construction of the two timing components. The catch data evaluated by Smoker et al. showed that, in general, the majority of the late-timed fish were caught in October with smaller numbers taken in September and November.

Smoker's conclusions regarding the late-timed fish are consistent with how Skokomish tribal elders have characterized Chinook run timing into the river, seen below in information assembled by Elmendorf and Kroeber (1960)[7]:

> "The king run starts in later September and continues for two to three months, annually. The runs come mixed with silvers and, in alternate years, with humpbacks. The kings were said to appear slightly earlier than the other two kinds, and to "lead them in."

The Elmendorf and Kroeber quote suggests that the largest Chinook run component was the late-timed run since there was no mention of the spring run. The quote also suggests that the peak of the late-timed component occurred sometime after early October.

To graphically display Chinook run timing into the river, Smoker et al. used daily catch data from two different years. Two years were required to form a composite picture because of apparent data gaps in some years, particularly for the early-timed component. It is unclear whether the Skokomish River was open to Chinook fishing during August and September in either of these years, so no conclusion can be reached about migration during those months. Based on the data available to them at the time, Smoker et al. assembled what they considered to be a reasonable characterization of run timing between April and November (Figure 2.3). The summary conclusions of these authors stated above were largely based on this chart. It bears noting that although Figure 2.3 does not show catches in August and September, data from other years in the 1940s and 1950s clearly demonstrated that Chinook also entered the river during those months.

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[7] / Source is attributed to Henry Allen, a Skokomish Indian, born in 1865 and died in 1956.

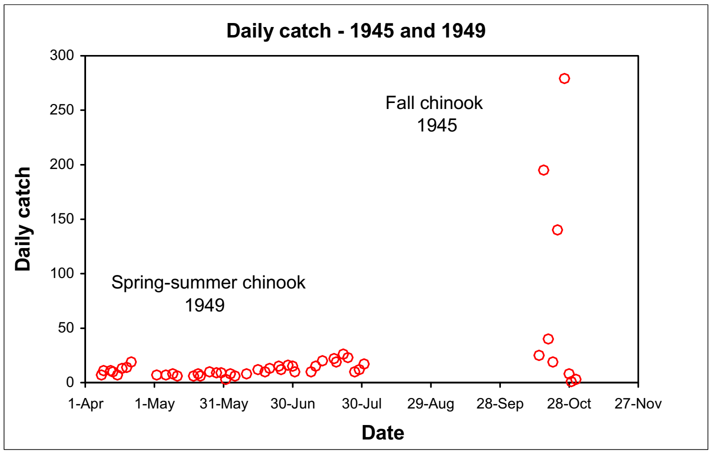

Figure 2.3. Recreation of graph from Smoker et al. (1952). The chart was formulated by Smoker to graphically display Chinook run timing into the Skokomish River. It was assembled from data for two years—1949 for the early-timed component and 1945 for the late-timed component.

The portion of Figure 2.3 for the late-timed component (year 1945) is shown with greater temporal resolution in Figure 2.4 to illustrate differences in daily catch together with the 1945 Skokomish River hydrograph. October 1945 was exceptionally dry through much of the month, with rains beginning late. The catch timing pattern suggests that river entry of adult Chinook was affected by flow and the onset of fall storm fronts. This topic will be explored in more detail in a subsequent section within this chapter.

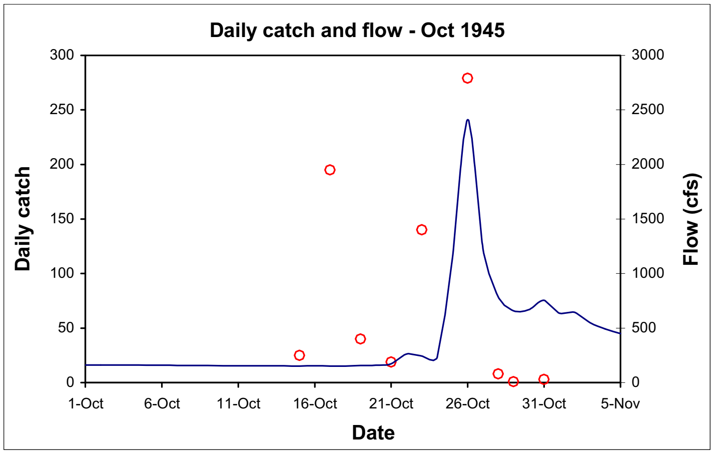

Figure 2.4. Reported gillnet catches of Chinook in the tribal Skokomish River fishery in October and November 1945 and flow levels during the same period. Catch data from Smoker et al. (1952).

WDF (1957a), as part of an assessment of salmon populations in the South Fork in the mid 1950s, characterized spawning timing as follows:

> “The spring and summer Chinook which are confined to the upper South Fork, spawn from August through October. The fall run spawns from September through November in the South Fork within and below the canyon and in the main Skokomish River and various river tributaries.”

Elsewhere in the same assessment the authors stated with regard to fall Chinook spawning timing:

> "Spawning occurs from September through November, with the peak in October."[8]

It bears noting that the statement about the "peak in October" was based on very limited data.[9] The river entry timing shown in Figure 2.4 for the fall run suggests that peak spawning time in 1945 would likely have not occurred prior to about November 1 and may not have occurred until several days later. Comparing the statement about the "peak in October" from WDF (1957a) and inferences that might be drawn from Figure 2.4 reflect uncertainty in the historic spawning timing. River entry timing of wild fall Chinook in rivers along the Washington Coast will be shown later in this chapter to be similar to Skokomish fall Chinook of the 1940s. Peak spawning timing in those rivers usually occurs sometime between November 10-20.

Juvenile Life History Patterns

The only known data available to characterize juvenile life history patterns of Skokomish Chinook prior to operation of the George Adams Hatchery are from surveys made in 1955 by WDF (WDF 1957a). The surveys were part of an assessment to collect baseline data in anticipation that another dam was likely to be built in the South Fork by Tacoma. Fyke nets were operated at several sites in the river system to assess outmigration timing and relative juvenile abundance. Sites trapped included lower and upper South Fork, lower Vance Creek, lower North Fork, and the mainstem river below the forks. Trapping occurred between mid February and September.

Trap catches combined with data on fry sizes suggest that fry emergence occurred between late February and May, peaking between mid March and mid May depending on site. The migration of newly emerged fry at the lower South Fork site occurred primarily between late April and late May.

Outmigrant timing in the upper South Fork, which apparently consisted entirely of early-timed run fish, occurred primarily in late July and August and consisted of much larger sized fish than those trapped earlier in lower South Fork. The upper South Fork data suggest that juveniles from the spring run component reared in the upper river prior to moving downstream in mid to late summer. This pattern for freshwater rearing by early-timed Chinook, i.e., emigrating seaward as young-of-the-year juveniles, is seen in many rivers west of the Cascade crest (Lichatowich and Mobrand 1995; Lestelle et al. 2006). In contrast, early-timed Chinook east of the Cascade crest generally emigrate as yearlings. It bears noting, however, that those produced in rivers with

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[8] / We note that the authors of the WDF (1957a) report also stated that "fall Chinook" were caught by Skokomish tribal fishers "from August through November, with peak catches occurring in September and October." The statement reflects the interannual variability that can occur in river entry timing, as discussed later in this chapter.

[9] / The WDF (1957a) study drew its conclusions about spawning timing from field work reported by Deschamps (1954). Deschamps made two surveys upstream of the South Fork gorge, on September 24 and October 15, 1954. Downstream of the gorge, two surveys were also made—on October 1 and October 15, 1954. No surveys were made after October 15; hence no data were collected during the time period that would have reflected late-timed fall Chinook adults having a river entry timing described by Smoker et al. (1952). Indeed, the counts of live adults on the spawning grounds categorized by Deschamps as being fall Chinook were highest on October 15, suggesting that that spawning activity was still increasing at the time of the October 15 survey.

strong snow-melt hydrographs west of the Cascades can have a significant portion of the outmigrants leaving as yearlings, as predicted to have occurred in the upper North Fork Skokomish River by Beechie et al. (2006).

These juvenile life history patterns for the historic Skokomish Chinook demonstrate that considerable diversity likely existed, consisting of a variety of rearing and outmigration patterns. While some fry began emerging in late February, the large majority apparently emerged between mid March and mid-May with different rates of seaward emigration occurring afterwards. Such a suite of rearing and outmigration patterns is consistent with what has been observed for wild Chinook in the Queets River (QDNR 1978; QDNR 1979), the Skagit River (Beamer et al. 2004), and in small rivers on the Oregon coast (Reimers 1973).

Adaptations of the Historic Life Histories to the Natural Flow Regime

The characteristics of the historic life histories of Skokomish Chinook are considered here in relation to the historic flow regimes and other related environmental factors. This examination provides insights into how the historic Skokomish populations were adapted to the natural flow regimes.

Adult Migration Timing

We conclude from the previous discussion that both the early-timed and late-timed racial groups entered the river principally during periods of elevated flow compared to summer low flow levels. The available information suggests that comparatively few adult Chinook migrated into the river during late summer and early fall when flows were lowest.

The early-timed population migrated primarily during the period of spring and early summer snowmelt, which is the typical pattern for early-timed Chinook in Western Washington (Beechie et al. 2006). Moving during elevated and relatively constant flows at that time facilitates passage over cascades and falls (Myers et al. 1998), which existed in the middle reaches of both the South and North forks. It is noteworthy that the South Fork early-timed population appears to have been experiencing difficulties passing cascades in the gorge reach by the time of WDF's assessment in 1955. The South Fork hydrograph during that era showed relatively weak contribution of snowmelt, and it appears to have been declining. WDF (1957a) noted:

> "Migration through the South Fork canyon appears to be quite difficult for the spring and summer Chinook, judging from the sizeable numbers of fish having head injuries."

The much larger contribution of snowmelt in the historic North Fork would have been particularly conducive for an upstream migration of early-timed fish. WDF (1957a) noted that "considerable numbers" of spring and summer fish used the river to such an extent prior to dam construction that an Indian fishery occurred at the falls on the river.

River entry timing of true late-timed Chinook in Western Washington is also keyed to elevated stream flow. The historic run timing of the Skokomish fall run occurred from September through November, when fall freshets typically first begin. The nature of this correspondence can be seen by comparing the pattern of tribal gillnet catches and the hydrograph for the Skokomish River in 1945 to those in another river, the Queets, where more complete data are available.

The Queets River, located on the west slopes of the Olympic Mountains, has a natural flow regime that is very similar to the historic regime in the Skokomish River. The dominant run type of Chinook in the Queets River is late-timed, though a run of early-timed Chinook also exists. The population is wild stock and has not been mixed with out-of-basin hatchery fish. Catches in the tribal gillnet fishery on this river give clear evidence of the correspondence between Chinook migration timing and flow events in the fall.

Figure 2.5 compares the daily catch pattern of Chinook in the Skokomish River in 1945, together with the hydrograph, to the patterns seen in the Queets River in a similar type of flow year, in this case 2006. That year was dry through late October with only very minor rainfall until early November. The catch pattern in the Queets River shows that adult Chinook did not enter the river to much extent until late October, following minor rainfall and just days before the first major storm front. A similar response to an approaching storm occurred in the Skokomish River in 1945, suggesting the same sensitivity to both dropping barometric pressure in advance of a storm and increased flow as the storm passed. Catches in both rivers in the years shown peaked during the first major freshet that occurred after early October.[10]

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[10] / The question has been raised whether the comparison between the rivers is justified since no fishing effort data (number of fishermen or nets) are presented for either river. In this case, a unit of effort is best expressed by a day of fishing because it is well known that the number of fishermen is related to the availability of fish. When few fish are present, few fishermen participate. When the run is strongly developing, the number of participants increases accordingly. The catch recorded within a single day, compared to other days in the season, is, therefore, strongly indicative of the run entry pattern. A comparison of patterns between rivers is a good measure of how timing compares. Similarly, comparing patterns between years reveals how timing differs between years.

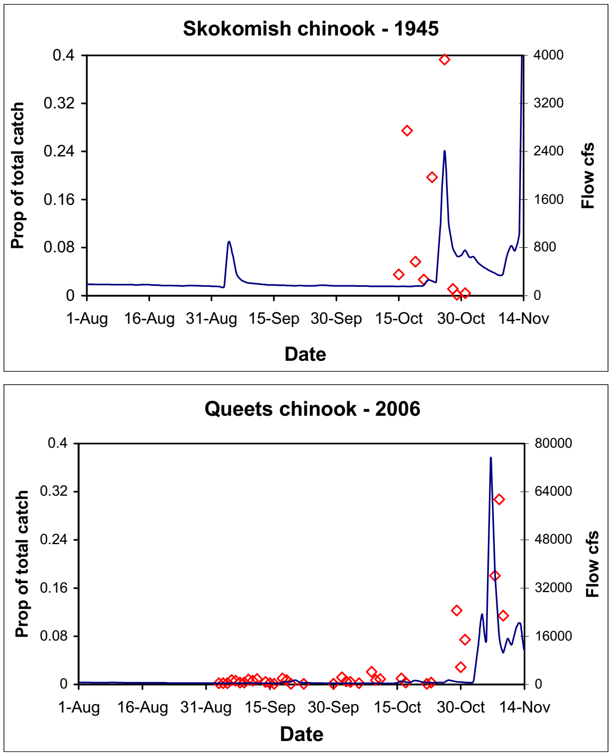

Figure 2.5. Daily catch proportions of the season's total catches of late-timed Chinook in the Skokomish River in 1945 and the Queets River in 2006 and corresponding flow levels. Flows in the two years compared were low through most or all of October, with flows increasing rapidly thereafter.

Examination of river entry patterns in the Queets River in other years having different flow patterns shows a consistently high sensitivity of the wild late-timed Chinook to flow events (Figure 2.6). It bears noting that in some exceptionally low flow years, such as 2002, the migration would begin regardless of extended low flow. In such cases, spawning distribution seems to be reduced compared to higher flow years.[11]

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[11] / Larry Lestelle, Quinault tribal biologist for 16 years, *personal communications*.

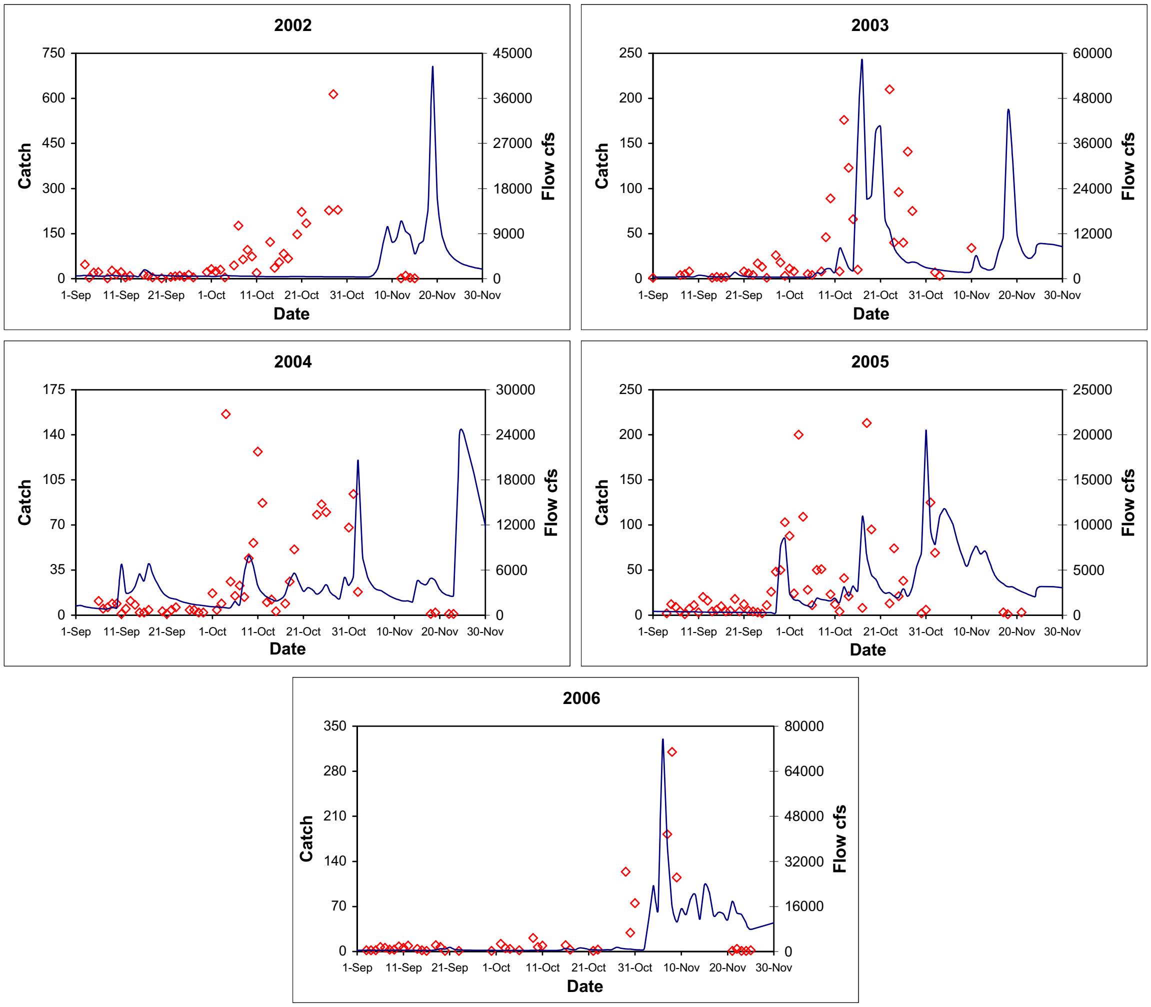

Figure 2.6. Daily gillnet catches of Chinook in the tribal fishery in the Queets River in years 2002-2006 and corresponding flow levels.

Based on the available information, it is reasonable to conclude that the historic late-timed Chinook in the Skokomish River responded to fall freshets in a similar manner as seen in the Queets River. There are likely multiple survival advantages to river entry being keyed to increased flow in this manner, including having improved passage over riffles, reduced vulnerability to mammalian predation, and arrival timing on the spawning grounds when conditions are more suitable for spawning site selection. The latter reason will be discussed further in the next section.

Spawning Timing

The time of spawning by salmonids is thought to be keyed primarily to temperature regimes and other environmental factors that prevail during incubation (Brannon 1987; Quinn et al. 2002). Both migration and spawning timing are largely under genetic control and therefore can be highly selected for. Spawning date is the main factor that controls when fry emerge from the gravel, thereby determining what conditions will be encountered by the newly emerged fry. Early emerging fry may encounter periods of frequent freshets or find little food. Late emerging fry miss opportunity for rapid growth in the spring if they emerge after food has become readily available, putting them at a competitive disadvantage with earlier emerging fish. Fry emergence timing, therefore, tends to be stabilized so that fry find optimal conditions for survival (Miller and Brannon 1981). This is discussed further in the next section.

Another factor, however, that has largely been overlooked in the scientific literature is how the flow regime can affect spawning site selection by salmon, thereby influencing spawning timing. The importance of this factor is likely greatest for Chinook whose river entry and spawning occur when and where snow and ice melt is not significant, i.e., for the late-timed component. If spawning were to occur during periods of extreme low flow, then redd sites would necessarily tend to be in the thalweg (i.e., deepest part of pool tailouts and riffles) of the mainstem river channel. These sites are prone to scour during large winter freshets (Lestelle et al. 2006). Chinook that spawn under higher flow conditions will frequently select sites along the mainstem channel margin, in side channels, or in tributaries, areas more protected from scour during high flows (Larry Lestelle, *personal communications*). The effect is that fall-run Chinook that migrate upstream in association with elevated flows have greatly expanded opportunities for redd site selection.

The spawning timing of historic late-timed Skokomish Chinook likely occurred primarily after the onset of fall freshets, giving access to more protected redd sites, thereby increasing the likelihood for embryo survival.

Emergence Timing

Emergence timing of wild Chinook fry (i.e., without hatchery influence having affected timing) is believed to be adapted to natural flow and food abundance patterns to maximize fry survival under prevailing natural conditions (Miller and Brannon 1981; Healey 1982). Studies show that if fry emergence timing in nature is advanced, whether due to early timed hatchery fish spawning naturally or a shift in temperature regimes, fry survival is then substantially reduced (Hartman et al. 1982; Nickelson et al. 1986).

The timing of fry emergence given in WDF (1957) for sites in the Skokomish basin—considered here to reflect historic timing—is consistent with timing patterns that have been observed elsewhere for wild Chinook in Western Washington. In general, peak emergence of wild Chinook fry from populations without hatchery influence usually occurs between mid March and early May, as found for the Skagit River (Kinsel et al. 2008) and Queets River (QDNR 1978).

If Chinook fry in the Skokomish River had emerged earlier than about mid March, they would have frequently encountered freshet conditions (see Figure 4.7 in Chapter 4). In such cases, they would have been readily swept downstream, as reported to happen during high flow events by Healey (1991) and Seiler et al. (2004). Such movements, acting as a dispersal mechanism, can transport fry considerable distances, carrying them into the estuary. Under these circumstances, fry would arrive to the estuary prior to rearing conditions conducive to good survival. In Hood Canal, as well as in other areas of Puget Sound, zooplankton are not typically abundant until mid to late March. Simenstad et al. (1980) reported a pattern of increasing abundance of epibenthic zooplankton along beaches of Hood Canal from late winter to late spring in 1977-1979. Dempster (1938) documented low zooplankton volumes in Hood Canal surface waters between early January and late March, with peak volumes occurring in late April.

The historic pattern for fry emergence in the Skokomish River was one of occurring primarily after winter and early spring freshets. Fry that emerged at that time would usually have found favorable conditions for growth within the river due to warming temperature and food availability (Hynes 1970). Fry migrants, including fry dispersed downstream due to high flows, they would have arrived in the estuary when conditions were improving rapidly for feeding and growth.

Profiles of Existing Chinook Life Histories

Major demographic and life history characteristics of Chinook currently produced in the Skokomish watershed are profiled below. Three spawning groups currently exist, two of which are anadromous and the other is land-locked behind upper Cushman Dam. The two anadromous spawning groups are essentially the same stock, those that are spawned in George Adams Hatchery and those that spawn naturally in the river. By far, the largest production component is the one produced in the hatchery. The size of the land-locked population is very small and questions exist about its origin (Ruckelshaus et al. 2006). That stock also appears to exhibit a severe genetic bottleneck and will not be discussed further in this plan. This section describes characteristics known or as can be inferred for the anadromous components.

Population Characteristics

The existing anadromous spawning aggregate is sometimes described as being a summer/fall run (WDF et al. 1993), in recognition that its river entry and spawning timing encompass both summer and early fall periods. The Puget Sound TRT labeled it a late-timed Chinook population (Ruckelshaus et al. 2006), although as already noted it does not have characteristics of a true late-timed population. It was identified as an independent population within the Puget Sound ESU, composed of both natural-origin and hatchery-origin fish (WDFW and Puget Sound Treaty Tribes 2004; Ruckelshaus et al. 2006).

The early-timed component (spring/summer) is extinct in both the North and South forks.

Origin and Genetic Profile

The existing spawning aggregate in the Skokomish River has its origin largely in hatchery fish introduced into the system as part of Hood Canal hatchery programs (Ruckelshaus et al. 2006). The program influencing Skokomish River fish to the greatest extent has been George Adams Hatchery due to its location in the lower river. This hatchery, as well as the nearby Hoodsport Hatchery, was populated mainly by fish originally sourced to the Green River in South Puget Sound (HGMP 2002). Extensive transfers occurred for many years into these hatcheries from various facilities, whose fish are of Soos Creek Hatchery (Green River) ancestry. Transfers to

Hood Canal hatcheries were eventually stopped and the programs are now maintained solely with fish returning to those hatcheries.

It is important to note that the Green River hatchery program, located at Soos Creek, has been in existence since 1901. Since that time, certain characteristics of the runs returning to Soos Creek, as well as to other facilities using Green River hatchery fish, have been altered substantially (e.g., Quinn et al. 2002). These characteristics include entry and spawning timing. The changes appear to be the result of hatchery practices and domestication pressures. Some of these changes are described in detail in the next section.

Marshall (2000, cited in HGMP 2002) concluded through genetic analysis of Skokomish basin natural spawners and juveniles that the naturally spawning fish are largely, though perhaps not entirely, comprised of George Adams and Hoodsport hatchery origin. There was some evidence that since cessation of the transfers, subsequent Skokomish generations show some differences from South Puget Sound populations. It was suggested that this trend may possibly reflect some level of adaptation to local conditions or simply reproductive isolation from other Puget Sound fish. However, the majority of the Chinook that spawn naturally in the Skokomish basin are hatchery-origin fish. This means that any trend reflecting dissimilarity to South Sound fish is due to reproductive isolation and associated hatchery practices at the George Adams Hatchery.

The co-managers recently initiated an effort to compile all available spawning data to better estimate the proportions of natural-origin and hatchery-origin Chinook on the spawning grounds. From 1988 through 2006, preliminary estimates mostly range from about 20% to 80% hatchery-origin Chinook in the Skokomish River system natural escapement, with an average of about 60% (WDFW and PSIT 2007).

Spawning Distribution

The current distribution of naturally spawning Chinook is less than 1/3 of what it was historically in the Skokomish basin (Figure 2.7). There are presently only about 16 miles of stream habitat being used by natural spawners, which occur mostly in the lower North Fork and in the mainstem downstream of the confluence of the North and South forks.

Only approximately 2.5 miles of the 16 miles are located in the lower South Fork—a number that is shrinking because of difficulties of adult Chinook in accessing the South Fork in recent years. In some years, severe aggradation in the lower South Fork and Vance Creek channels, combined with late summer low flows, causes flow in some reaches to be entirely subsurface at the time that adult Chinook are moving upstream (see Figure 4.34 in Chapter 4). In those years, adult Chinook are prevented from accessing the South Fork and Vance Creek. Spawning has often ended by the time flows are recharged by fall freshets in such cases.

The existing Chinook in the Skokomish watershed do not appear capable of moving through the gorge reach (approximately RM 5-8) at the time of their upstream migration. Deschamps (1954) and WDF (1957a) noted that only the spring/summer run appeared to be capable of ascending the rapids within the gorge. It is noteworthy that WDF (1957a) anticipated that some alterations would be needed to the gorge cascades in the South Fork to facilitate upstream movement by adult Chinook. It appears likely that passage at that point was becoming difficult for adult Chinook due to diminishing snow-melt contributions during late spring and early summer. This recovery plan includes provisions to rectify this passage issue.

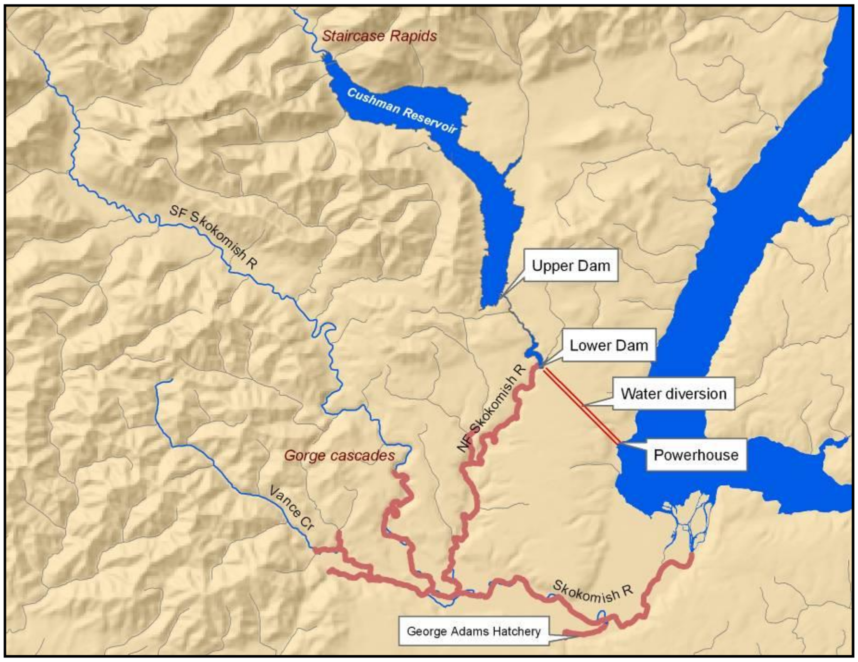

Figure 2.7. Current distribution of Chinook in the Skokomish River system Source: WDFW SalmonScape.

River Entry and Spawning Timing

Peak entry timing of adult Chinook in recent years into the Skokomish River is reflected by daily gillnet catches in the tribal commercial fisheries for 2002-2005 (Figure 2.8). The fisheries operated consistently in those years over the duration of the period when Chinook would have been entering the river. Entry in this four year period generally occurred between early August and the end of September, peaking between late August and mid September.

It bears noting that river entry timing of Chinook now produced in the watershed shows no correspondence to flow level (Figure 2.8). In fact, river entry occurs during the lowest flow period of the year and peaks when flow is typically at its most extreme low (Figure 2.9). This pattern for river entry is striking because it shows no resemblance to the historic timing and no correspondence to flow. The Puget Sound TRT also commented on (Ruckelshaus et al. 2006) this unusual pattern with respect to another Puget Sound population (Nisqually) that is now comprised mainly of Green River origin hatchery fish:

> "Current entry timing also corresponds to the lowest flows in the historical hydrograph (which are now controlled by flow regulation), suggesting that historical entry timing must have been different."

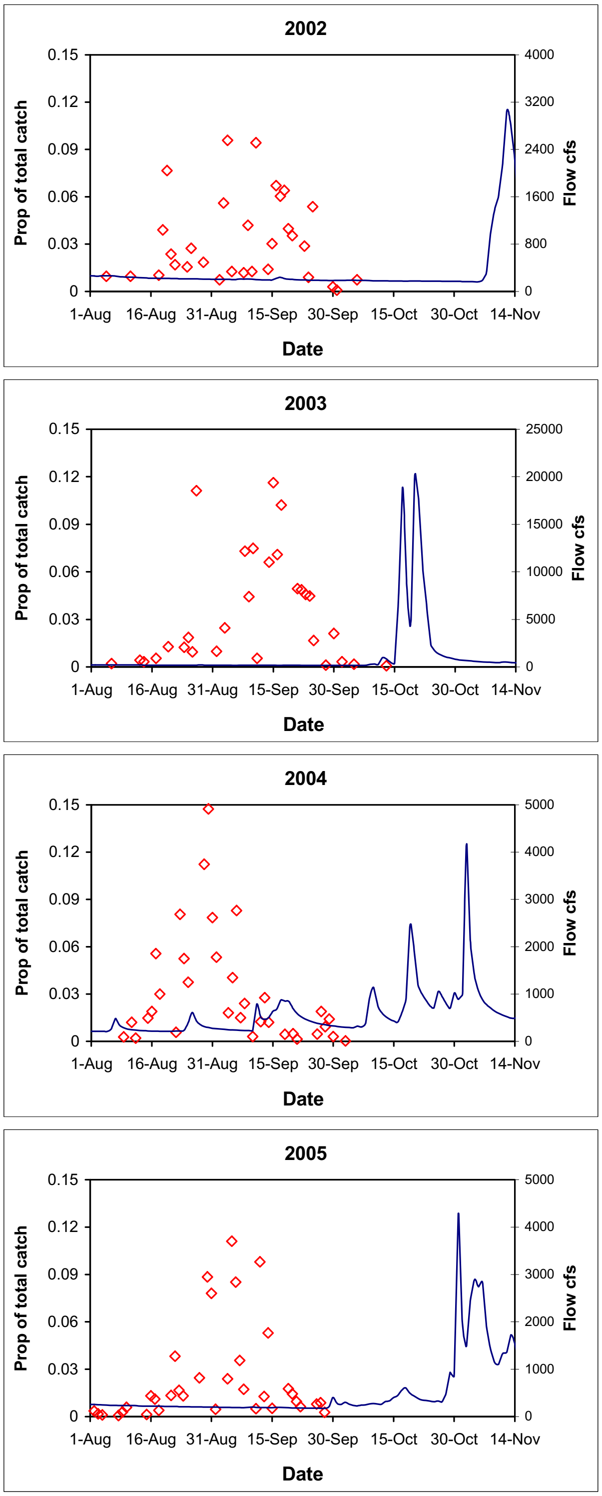

Figure 2.8. Daily catch proportions of the season's total catches of Chinook in the Skokomish River in 2002-2005 and corresponding flow levels in the lower Skokomish River.

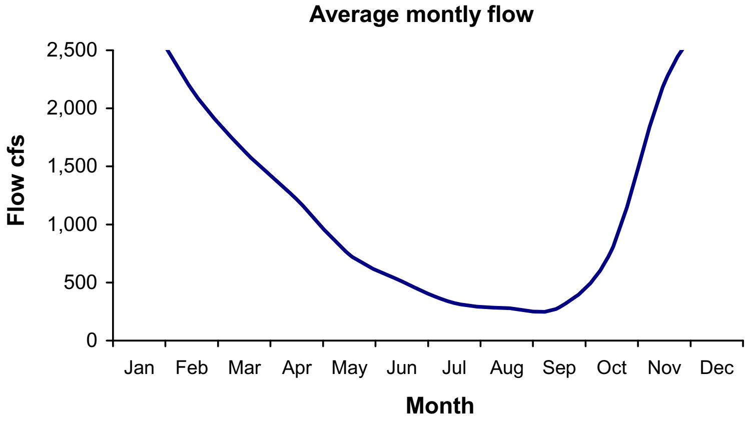

Figure 2.9. Average annual hydrograph for the Skokomish River showing mean monthly flows (cfs) measured at the mainstem river gauging station near Potlatch (USGS 12061500) for years 1990-2006.

The timing of natural spawning by Chinook in the mainstem Skokomish River is reflected by redd counts made by WDFW for 2002-2005 (Figure 2.10). The data show that peak spawning occurs about the end of September, and is nearing its end by mid October. The time of actual spawning, however, would be somewhat earlier than shown in Figure 2.10, since surveys are made every 7-10 days on average. Redds are constructed earlier than the dates when redds are observed. Accounting for a lag between redd construction and time of observation, the patterns seen in Figure 2.10 are consistent with spawn timing at George Adams Hatchery. Peak spawning in the hatchery typically occurs between mid to late September (Ed Jouper, George Adams Hatchery manager, *personal communications*). Hence, fish that spawn naturally in the river do so when flows are at or near the extreme lows of the year.

The average times when hatchery fish enter the river and spawn have not been static. It is relevant to this review to understand how timing patterns of Green River origin hatchery fish have advanced over time. Quinn et al (2002) analyzed entry and spawn timing of hatchery Chinook at three hatcheries producing fish having Green River ancestry: Soos Creek, Issaquah Creek, and University of Washington. Since 1960, the beginning year for the analysis, timing has steadily advanced at each location with greatest change occurring at Soos and Issaquah creeks (Figure 2.11).

In 1960, the mean spawn date at Soos Creek Hatchery was approximately October 16. Spawn timing at George Adams Hatchery when it was built (1961), therefore, would have been roughly the same date. By 2000, peak spawn timing had advanced by over two weeks at Soos Creek, then occurring in late September. A similar advance over this period, if not greater, appears evident at George Adams Hatchery based on when spawning currently occurs.

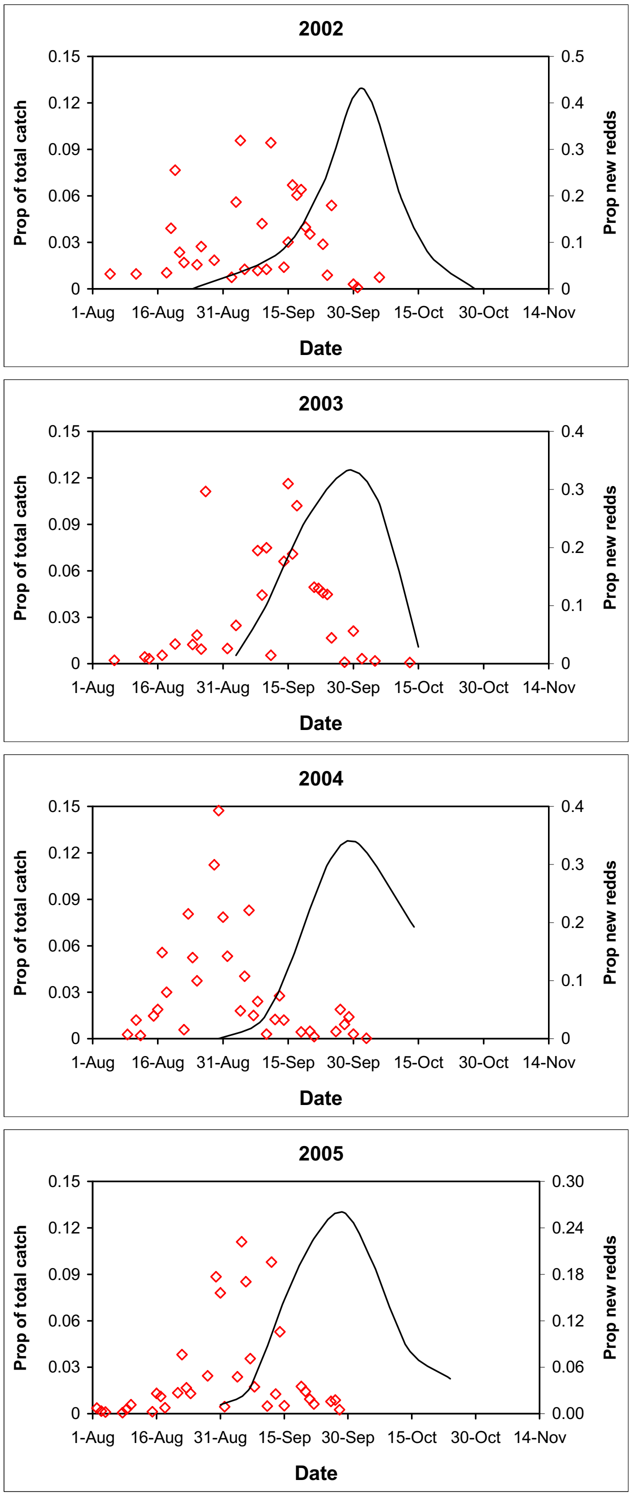

Figure 2.10. River entry timing as seen in daily catch proportions compared to spawning timing of naturally spawning Chinook in the Skokomish River in 2002-2005

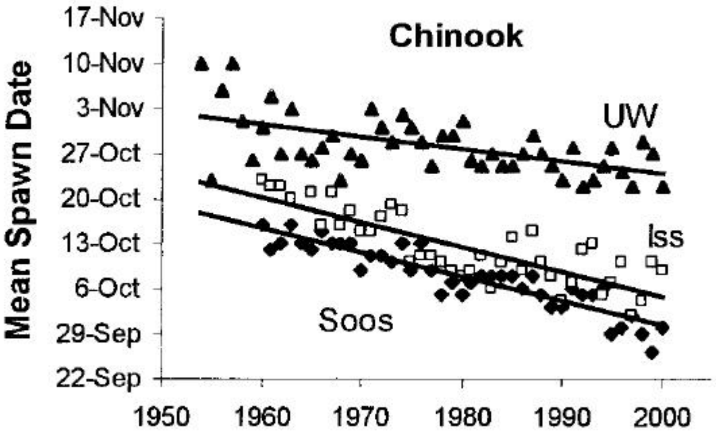

Figure 2.11. Mean spawning dates of female Chinook at the Issaquah Creek (Iss), Soos Creek (Soos), and University of Washington (UW) hatcheries. Taken from Quinn et al. (2002).

Based on the trends seen in Figure 2.11, it is obvious that the same pattern must have been occurring prior to 1960 at Soos Creek. Other data on time of entry into the hatchery support this. Becker (1967) presented graphs showing entry timing of adult Chinook moving into Soos Creek Hatchery from the adjacent stream for 1944-1965. Those graphs were used to estimate the 50% entry date over those years (Figure 2.12). The data show that hatchery entry was advanced by approximately two weeks over the entire period. A 10 day advance occurred between 1944 and 1960, the starting year for Quinn's analysis.

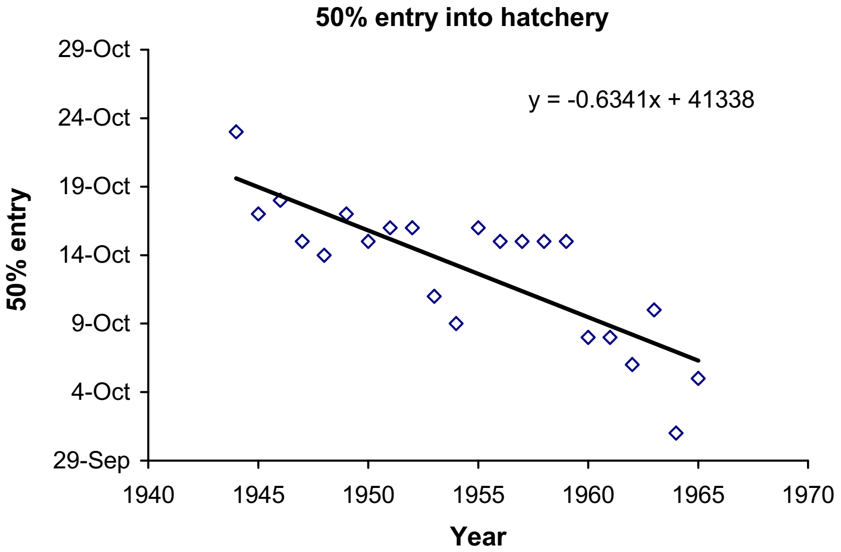

Figure 2.12. Change in estimated dates when 50% of hatchery Chinook had entered the Soos Creek Hatchery (Green River) between 1944-1965. Data source: Becker (1967).

There is some use in projecting back into time still further for approximating historic timing, because Soos Creek Hatchery went into operation in 1901. Recognizing the limitations of such projections, it is evident that the advance in timing did not begin in 1944, the first year in Becker's report. Projecting backwards to just 1920, then accounting for the delay between entry time and spawn time at Soos Creek from Quinn's analysis, suggest that the average spawn timing in that year would have been approximately November 10, or about when wild fall Chinook spawn on the Washington Coast (e.g., Queets River). This would have been nearly six weeks later than the mean spawn timing in 2000 at Soos Creek. Applying this to the current spawn timing at George Adams Hatchery suggests an even greater advance in timing between the original wild stock used at Green River and today's timing in the Skokomish River.

It bears noting here, as it relates to hatchery fish timing, that it appears that selection within the hatchery environment has been the major determinant of river entry and spawning timing in the Skokomish River over the past several decades. The timing pattern of natural spawning in the river closely resembles that in the hatchery. The advance in spawn timing described for Green River hatchery fish, therefore, would appear to be representative of naturally spawning fish also.

The question is raised: Why have entry and spawning timing patterns been so advanced for these hatchery fish populations, and what are the implications for fish that spawn naturally in rivers that have experienced such changes in timing?

Timing of migration and reproduction in salmonid species is largely under genetic control, thereby being subject to natural selection in nature and artificial selection in hatcheries. Salmonids have evolved spawning dates that are appropriate for temperature and flow regimes and other factors affecting the performance of affected life stages (e.g., embryos and emergent fry).

Selective pressures within the hatchery environment can affect spawning timing in a direction opposite to those operating in nature. Hatchery practices can directly select for spawn time by using early returning fish and discarding late returners, as often happened in a previous era to ensure that egg goals were met. This practice was generally stopped many years ago. Indirect selection for earlier spawning fish can occur if progeny of later spawning fish are (1) culled as too small, (2) cannot compete as well in the hatchery with larger progeny of earlier spawners, (3) experience delayed or ineffective smolt transformation, or (4) have lower survival at sea (Quinn et al. 2002). The findings of Quinn et al. (2002) suggests that strong inadvertent selection has continued over a long period in the three hatcheries examined, despite factors operating in the natural environment that should select against it; they noted:

> *"Lake Washington, Soos Creek, and Issaquah Creek have been getting warmer in the summer and fall over the past three decades, and the warming trend would be expected to select for later timing of migration and spawning. Thus, the advanced spawning date at all three hatcheries has occurred despite water temperature changes, not as a consequence of them."*

The authors of that paper found that the degree of timing advance for each of the three hatcheries was related to the severity of warm temperatures during September and October when spawning occurs (i.e., cooler thermal regime, greater advance in timing): coolest at Soos Creek, then Issaquah Creek, and warmest at UW Hatchery (Figure 2.11).

It is notable that the Puget Sound TRT reported that the mean spawn timing of Chinook in Hood Canal rivers (including Skokomish River) is somewhat earlier than in South Puget Sound (including Green River), as well as in Issaquah Creek (Ruckelshaus et al. 2006). Water temperatures in September are likely cooler in the Skokomish system than they are in the Lake Washington system where elevated temperatures are protracted due to thermal loading in the lakes. This suggest that the timing advance has been greater for George Adams Hatchery fish than at either Soos Creek or Issaquah Creek hatcheries.

The implications to recovery of the current timing profile for Skokomish Chinook is discussed later in this chapter.

Emergence Timing

The emergence timing of fry now produced by Skokomish Chinook is much earlier than it was historically. At a minimum, emergence timing has been advanced by at least the same amount of time that spawning has been advanced. Considering the more rapid accumulation of temperature units by incubating eggs due to spawning earlier when water is warmer, the timing advance has likely been much greater than the difference in spawning timing.

Most Chinook fry in George Adams Hatchery are placed on feed between mid December and the end of December. The last group to be ponded in 2009 at the hatchery was on January 9 (Assistant Manager George Adams Hatchery, personal communications). While the time of hatchery ponding is not the same as when fry emerge under natural riverine conditions, primarily due to warmer temperatures during incubation in the hatchery, it provides some indication of timing.

Implications of the Existing Life Histories in Relation to the Flow Regime

The characteristics of existing life history patterns of Chinook produced in the Skokomish watershed are considered here in relation to the current flow regime and to the transitional and restored normative flow regimes of the future. The implications to recovery of how well these life history patterns fit with these flow regimes and related habitat characteristics are examined.

Adult Migration Timing

The river entry pattern of Skokomish Chinook is now starkly different than the pattern exhibited by either the early-timed or late-timed components. The entry patterns of the historic runs were keyed to the flow regime, whereas Skokomish Chinook now demonstrate no sensitivity between migration timing and flow level or flow patterns. Most notably, Skokomish Chinook now return to the river when flows are usually at their annual lows.

The current run timing is approximately 2-4 months later than the historic early-timed run and between 5-7 weeks earlier than the historic late-timed run. Run timing is now intermediate to those of the historic populations.

The current return timing is ill-adapted for migration into the South Fork system, including Vance Creek, especially under current degraded habitat conditions. The adults return to the vicinity of the South Fork at a time when the lower reaches of those streams can be effectively blocked to upstream migration due to subsurface flow. As a result, movement into the South Fork has not occurred in most recent years. The frequency of this occurrence seems to be increasing (Matthew Kowalski, Skokomish Tribe, *personal communications*). The extreme low flows at this time of year in the lower South Fork are the result of aggradation and, perhaps, loss of base flow in the subbasin due to land use practices. Restoration of more normative conditions in this reach is not anticipated for a period of years, though actions to address the root causes are already being implemented.

Similarly, upstream migration in other reaches outside the South Fork are also likely made less effective due to timing corresponding to seasonal low flows. Vulnerability to predation is likely higher than it would be if fish migrated during periods of higher flows. Moreover, upstream migrating adults probably expend greater energy swimming over shallow riffles than they would if they returned at times when flows are higher—this likely reduces reproductive success.

The Cushman Settlement and this recovery plan call for re-introducing an early-timed population to the upper North Fork because that area is believed to have been the historic stronghold of the early-timed component. The historic run migrated to the upper watershed during the spring snowmelt runoff, when passage over falls was made possible. As part of the Cushman Settlement, a normative flow pattern will be created in the lower North Fork, which will include a simulated snowmelt pulse. This flow pattern should enable early-timed Chinook to pass Little Falls several miles downstream of the lower Cushman Dam during their migration to the dam. Passage over the falls will likely only be possible during a window of time corresponding to the timing of the snowmelt pulse.

Spawning Timing

Spawning timing, like migration timing, is significantly different now for Skokomish Chinook than it was historically. Whereas spawning timing today is comparable to some segments of the early-timed historic run, those historic fish spawned much higher in the river system where conditions differed than those that exist in downstream areas currently spawned in. The extant stock that now spawns in the river does so in areas historically used by the late-timed population. Spawning timing in these areas is estimated to now be earlier by at least 6 weeks than occurred historically in the same areas.

Spawning now takes place primarily when flow is at or near its annual low. Spawners by necessity are forced to build their redds primarily in the thalweg of the main channel, areas prone to scour during winter freshets. The effect of this is likely much greater in this river than if it was to occur in many other Western Washington rivers. Aggradation of the river bed has occurred at an alarming rate in the Skokomish River over the past several decades. Simultaneously, the frequency of flooding has increased. Chinook redds built in the mainstem river under these conditions are at high risk of being scoured (Lestelle et al. 2006).

The situation for egg survival in the mainstem river associated with spawning during low flows is likely to not improve for some period of years. It is expected that conditions will become much worse by the implementation of various channel and flow restoration measures during a period of transition. Under the Cushman Settlement, one component of the new flow regime will be to prolong the duration of bankfull flows for the purpose of using hydraulic energy to deepen the channel and increase flow capacity of the river. The action is being designed to increase scour in the river and to facilitate sediment routing to the delta and Hood Canal. Similarly, flows in the North Fork will increase current peak levels to higher magnitudes for the purpose of re-creating a more normative river channel in that subbasin with the objective of improving habitat conditions. During the transition, the river will be much more dynamic than it has been for decades, before returning to a more stable state in the future.

These actions, aimed at restoring more normative channel processes, therefore, are expected to increase adverse impacts on Chinook redds built in areas prone to scour. These areas are within the natural range that was used by the historic late-timed run. If that late-timed population was to be targeted for recovery, a significant amount of channel restoration would first be required.

Emergence Timing

The indicators of fry emergence timing demonstrate that fry produced by naturally spawning parents now emerge in the river much earlier than they did historically. Their emergence, therefore, is much more likely to coincide with winter and early spring freshets. As a result, these fish are likely to find conditions much less suitable for feeding and growth compared to later emerging fish. Many are likely swept to the estuary during high flows, prior to the time of abundant zooplankton.

The effect of such an advanced emergence timing would be to reduce growth and survival of fry compared to those with historic life histories.

The Key to Recovery

Population recovery will require both the restoration of normative watershed functions and characteristics, and the recovery of Chinook life history patterns adapted to them. The concept of "normative" habitat means that enough of the historic habitat characteristics needs to be restored so that it is capable of supporting most or all of the historic diversity of Chinook life histories. Hence, recovery depends both upon re-establishing normative habitat characteristics and the presence of populations that are capable of adapting life histories that match those characteristics.

Overarching Hypothesis

This plan proposes to restore riverine and estuarine habitats to a normative range of characteristics capable of supporting viable life history patterns of naturally produced Chinook. Suites of strategies are presented in the plan to accomplish this. The strategies are based on a set of hypotheses about how the watershed historically functioned, how watershed processes have been impaired, and how normative processes and functions can be restored. Given the extent and length of time that watershed processes have been severely impaired, the scale and extent of the needed restoration work is necessarily large.

Critical questions for recovery arise: If the proposed strategies for restoring normative habitat characteristics are successful, would this necessarily lead to the recovery of viable life histories? Would life histories re-emerge, characteristic of true early or late-timed racial groups, from the existing spawning aggregate supported by George Adams hatchery fish?

The answers to these questions may hinge on how long we are willing to wait. It would seem that productive, adapted life histories could—in theory—re-emerge, but possibly only after the passage of many human generations. Along such a path, what regional or trans-regional environmental issues might develop to stymie the re-emergence of adapted life histories?

Certain known factors bear on how rapidly the existing spawning aggregation could give rise to life histories re-adapted to the watershed conditions that are being restored. A significant level of fishery mortality will continue as a result of the many fisheries that have some impact on Skokomish fish. Within the watershed, many environmental conditions that affect the freshwater performance of Chinook will be severely disrupted for a period of years as the river is gradually reset to more normative conditions. The differences that exist between current life histories and those that would match conditions being restored make the probability for successful re-adaptation uncertain.

The overarching hypothesis set forth here considers both the ultimate potential for success and the length of time that might be needed to realize success. The hypothesis is that a reasonably close match is required between life history characteristics of the population to be used in the recovery effort and the restored flow regime and corresponding habitat characteristics (Figure 2.13).

Active steps, therefore, are seen as necessary to introduce life histories more adapted to the restored flow regime and associated habitats than are exhibited by the existing population. The key to recovery is seen as the use of a population that has sufficient genetic material to allow for a rapid enough re-emergence of life histories adapted to the conditions being restored. Introduction of an early-timed stock is considered to be the best prospect for accelerating the process of recovering a locally adapted population.

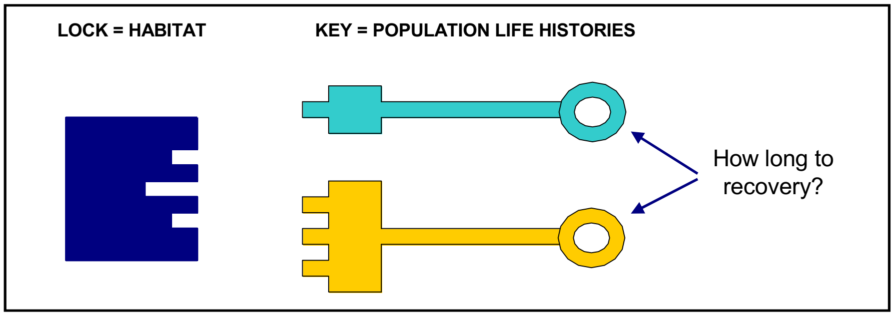

Figure 2.13. The key to recovery—matching life histories to Skokomish River habitats.

Target Population for Recovery and Projected Timeline

The focus on an early-timed population is based on the following:

- Agreement has already been reached by the co-managers and federal agencies as part of the Cushman Settlement, together with the City of Tacoma, to re-introduce and restore early-timed Chinook to the upper North Fork, where they were present historically;
- All of the major elements for re-introducing and establishing a population in the upper North Fork have been agreed to by the involved parties, though a donor stock has not yet been selected;
- Funding for the restoration of the population in the upper North Fork is secured, as agreed to in the Cushman Settlement;
- Habitat in the upper North Fork, though limited in quantity, is in pristine condition and will remain in protected status due to its location within Olympic National Park;
- Significant progress is expected for restoring habitat conditions in the upper South Fork, where early-timed Chinook were present historically much more quickly than will occur in the lower South Fork, lower North Fork, and mainstem Skokomish River where late-timed Chinook were present historically, and where channel conditions require longer-term solutions (see Chapter 4);
- Suitable donor stocks for restoring an early-timed population exist within the ESU, while there is concern that no true late-timed donor stock exists within the ESU.

Steps to initiate the recovery program for the early-timed population have begun by the co-Managers in conjunction with Tacoma as part of the Cushman Settlement. In 2010, the emphasis of the start-up phase is on selection of a donor stock and completion of the operational plan for re-introduction into the North Fork.

A tentative timeline for re-introduction has been formulated (Table 2.1), though elements of the effort remain to be finalized. The new FERC license was issued on July 15, 2010 and Tacoma has nine months to finalize an operational plan. The timeline shown provides a basis for developing the operational plan. The timeline shows when eggs are projected to begin to be imported, when local broodstock (adults returning to the Skokomish River) should become available, and when adults are projected to begin to be moved to the upper river (above Lake Cushman) and to the South Fork. The timeline is based on an assumption that program start-up would be of moderate size. It is projected that 4-year old adults would be the first fish transported to the upper river beginning in 2015, though some 3-year olds might be transported in the previous year. The exact year, however, will depend on the scale of the program at start-up. Once local brood stock becomes available, the program should rapidly develop to its full potential.

Table 2.1. Projected timeline for re-introduction of early-timed Chinook into the North and South forks. The timeline assumes that donor stock eggs would be available in brood year 2011. The table identifies when hatchery facilities are to be operational—upstream and downstream passage facilities would be operational in the years when passage activities would commence.

Year	Emphasis	Import eggs?	Local brood stock?	Transport to upper NF?	Expand to SF?
2010	Complete operational plan	No	No	No	
2011	Facilities completed	Yes	No	No	
2012	Hatchery procedures	Yes	No	No	
2013	Hatchery procedures	Yes	No	No	
2014	Hatchery procedures & local brood stock	Likely	Likely	Unlikely	No
2015	Local brood stock and transport	Unlikely	Yes	Likely	No
2016	Local brood stock and transport	Unlikely	Yes	Yes	No
2017	Local brood stock and transport	No	Yes	Yes	Possible
2018	Local brood stock and transport	No	Yes	Yes	Possible
2019	Local brood stock and transport	No	Yes	Yes	Likely
2020	Local brood stock and transport	No	Yes	Yes	Yes

Consideration for Possible Effort to Recover Late-Timed Life Histories

The scope and scale of the actions that will be implemented in the next several years to restore watershed function, as well as to re-establish an early-timed population, are necessarily large. As the recovery plan goes forward, and as progress is made in restoring key habitats in the lower valleys, the potential for expanding recovery efforts to include the late-timed racial group will be re-evaluated. Failure to make significant progress toward recovering the early-timed group over the next 10 to 12 years, however, would be cause to re-examine plan direction and possibly reset the priority to the late-timed life history group.

Role of Existing Skokomish Chinook Production

The George Adams Hatchery program will be maintained to fulfill its long-standing purpose for fisheries enhancement. Its mission has been to mitigate for lost production due to the Cushman Project and other lost habitats in the Skokomish watershed and other nearby watersheds. The watershed restoration programs that are underway, including the one in the Skokomish, will never fully restore these systems to their historic potential. The North Fork Skokomish River, for example, will remain impaired under provisions of the new FERC license, even though significant improvements are to be made. The largest part of the most productive habitats prior to dam construction will remain inundated (see Chapter 4).

George Adams Chinook production will be managed in a manner to protect it from alteration or genetic deterioration (see Chapter 6). On-going management activities to accomplish this consist of prudent fisheries regulation, which is reflected in the Co-managers' Puget Sound Chinook Harvest Management Plan (see Chapter 6), and employment of hatchery BMPs as specified in the Hatchery Genetic Management Plan for the program (see Chapter 5).

If at a future date recovery of true late-timed life histories is pursued due, for example, to insufficient progress in recovering an early timed run, the George Adams stock will be included in considering stocks to be used in the start-up efforts. One of the questions that would need to be addressed is whether the latest segment of the stock could be successful. Whether, and how rapidly, this segment of the existing production program could be moved later in both entry and spawning timing as a way of re-creating late-timed life histories would be evaluated, along with other potential options.

Chapter 3. Skokomish Early-Timed Chinook Planning Targets

An important step in recovery planning is the development of population performance goals. They allow fisheries managers, local governments, watershed planning groups, and funding agencies to assess progress over time of the various recovery strategies and actions in improving population performance. The targets should also assist NOAA Fisheries in evaluating delisting criteria for the population of concern. This chapter describes the approach used to define the planning targets and presents the resulting numeric values. The same approach is used herein as the one used in defining targets for most Chinook populations in the Puget Sound ESU.

Recovery Measures

The recovery targets presented here should not be construed as the goal for delisting. Delisting criteria have not been set by NOAA Fisheries for Puget Sound Chinook. The targets we present represent an initial, long-term goal for re-establishing a productive population of early-timed Chinook that can provide a range of ecological services, including meaningful fisheries. They provide a goal for evaluating progress toward realizing the vision given in Chapter 1. NOAA Fisheries delisting criteria are policy constructs that consider biological goals, mitigation of threats, legal obligations, risk tolerance and other considerations (ICTRT 2007).

It is important to recognize that this plan aims to re-establish a population that has been extirpated. The re-establishment of an extinct population brings additional uncertainties compared to an effort aimed at recovering performance of an established natural population.

Salmon recovery Technical Recovery Teams (TRTs) evaluate population viability using four key characteristics of viable salmonid populations (VSP)(McElhany et al. 2000): abundance, productivity/growth rate, diversity, and spatial structure. All four parameters are seen as being critical for population and ESU viability. The planning targets presented for Skokomish early-timed Chinook focus on two of these characteristics, abundance and productivity.[12]

For application to Skokomish Chinook, the other two viability measures can be evaluated by the success of re-establishing runs into both the North and South forks (spatial structure) and by the life history diversity that is produced. Success in producing life history diversity can be measured by comparing ranges of life history characteristics for established early-timed populations in Western Washington to those observed in the re-introduced population. Examples of life history characteristics of importance are river entry timing, spawning timing, juvenile emergence and outmigration timing, age structure, and adult body size.

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[12] / Two different measures of productivity are applied in salmon recovery planning throughout the Pacific Northwest, one that measures population growth rate from generation to generation and another that assesses intrinsic productivity, defined as maximum population growth rate when free of density-dependent limitations. The latter is the productivity measure produced by a stock-recruitment analysis and by EDT, and is the measure used in this plan.

Planning Ranges and Planning Targets for Puget Sound ESU Populations

The recovery goals for other Chinook population in the Puget Sound ESU were defined through two sets of abundance ranges (Shared Strategy 2005). Productivity was encompassed in the metrics through the approaches used to derive abundance values. The two ranges were referred to as (1) planning ranges and (2) planning targets. The planning range was derived by the Puget Sound TRT using several methods, including consideration of estimates of historic run sizes. The ranges tended to be very wide, as they included variation in environmental conditions and uncertainty in historical information.

The second set of ranges, called planning targets, gave a more specific measure within a somewhat lower range of values, reflecting some level of watershed alteration. These ranges were used for evaluating the effects of actions that would be applied in recovery. The planning targets were developed to incorporate NMFS' indices of Properly Functioning Conditions (PFC). The PFC concept was created originally by the Bureau of Land Management (BLM) to assess the natural habitat-forming processes of riparian and wetland areas (Pritchard et al. 1993). When these processes are working properly, it can be assumed that environmental conditions are suitable to support productive populations of native fish species. The concept for salmonid systems was advanced by NMFS (1996) to address salmon recovery under ESA. PFC does not imply pristine or unaltered conditions. It is consistent with the normative river concept described in Chapters 1 and 4 of this plan.

For most populations within the Puget Sound ESU, the planning targets were derived using EDT modeling (e.g., Thompson et al. 2009).[13] Characteristics of PFC in riverine environments as affecting salmon species have been translated into the EDT habitat attributes, providing a straightforward way of deriving the planning targets for each population using PFC. The PFC concept has not, however, been expanded by NMFS to describe a similar level of ecosystem function in estuarine systems, nor has any comparable translation been made to estuarine attributes in EDT. As a result, recovery planners within the Puget Sound ESU applied a PFC-Plus concept to ensure that the estuaries were incorporated into the planning process. PFC-Plus was defined as PFC in freshwater and the historic (unaltered) conditions in the estuary. Thus, any targets based on PFC-Plus reflect a higher standard than just PFC.

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[13] / EDT is a salmon habitat model that evaluates the effects of habitat conditions on the survival of salmon during each life stage, and provides estimates of population expressed through abundance and productivity parameters (Mobrand et al. 1997; Blair et al. 2009). EDT has been used extensively throughout the Pacific Northwest to predict the benefits and impacts of changes in habitat conditions resulting from land uses or restoration actions. It is used widely to guide ESA recovery planning.

Skokomish Population Planning Targets

Planning targets for recovering Skokomish early-timed Chinook are presented in this plan using the EDT model. The Puget Sound TRT did not develop a planning range for the Skokomish population; hence a comparable range has not been formulated for this plan. To use the EDT model, we first characterized all river reaches in the watershed using the standard EDT attributes (Blair et al. 2009). The characterization was done for both the historic (pre-settlement) and existing conditions to reflect our conclusions about the effects of watershed threats presented in Chapter 4 of this plan. We included in this characterization how we expect the lower river reaches to respond in the near-term to a new flow regime to be implemented in 2010 as part of the new Cushman Project FERC license (see Chapter 4).

The EDT model produced results that we found to be reasonable and consistent with levels for early-timed Chinook in other comparably sized rivers in Western Washington, based both on empirical observations and modeling (WDFW and WWTIT 1994; Shared Strategy 2005; Quinault Department of Natural Resources, unpublished).

To understand the approach for defining the planning targets, it is helpful to illustrate it using output from EDT modeling. The basic output is given in the form of a stock-recruitment (S-R) curve, which defines the underlying relationship between number of spawners and resultant production (as adult recruitment)(Figure 3.1). The curve is defined by two parameters, intrinsic productivity and capacity, from which average abundance is calculated. The parameters are derived by the model based entirely on the characterizations of habitat attributes for each stream reach.

The top part of Figure 3.1 displays the S-R production curve derived for the historic Skokomish early-timed population. Certain characteristics of the S-R curve are worth noting. One is the replacement line, which is the number of recruits needed to exactly replace the parent spawning stock. The distance between the replacement line and the production curve identifies the number of recruits that exceeds the number of recruits needed to exactly replace the parent spawning stock. Where that distance is maximized defines the traditional fishery concept of maximum sustainable yield. The point where the replacement line intersects the production curve defines what is called equilibrium abundance (Neq)—here being the average number of recruits expected in the absence of all fishing. If there had been no fishing, the Neq shown in Figure 3.1 (top) is the predicted average number of spawners that would have occurred prior to settlement by Euro-Americans.

The bottom part of Figure 3.1 compares the historic S-R curve to one representing current habitat conditions in the Skokomish watershed. The changes from the historic to the current production curve are due entirely to alterations of the watershed.[14] A diagnosis of the factors responsible for these changes is presented in Chapter 4.

Table 3.1 provides the population parameters for both the historic and current habitat scenarios. It bears noting that the results for the current habitat scenario are not inconsistent with the

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[14] / The changes do not incorporate any genetic fitness loss or harvest impacts.

population being extinct, even though a current average abundance of 120 is predicted. The abundance values shown are those for adult recruits in the absence of all fisheries. The total number of recruits would drop to some lower level depending on harvest levels. Also, harvest rates for an early-timed racial component would be projected to now be much less than when rates were at their maximum (see Chapter 6). The results, therefore, are entirely consistent with the population having been extirpated at some time in the second half of the 20th century.

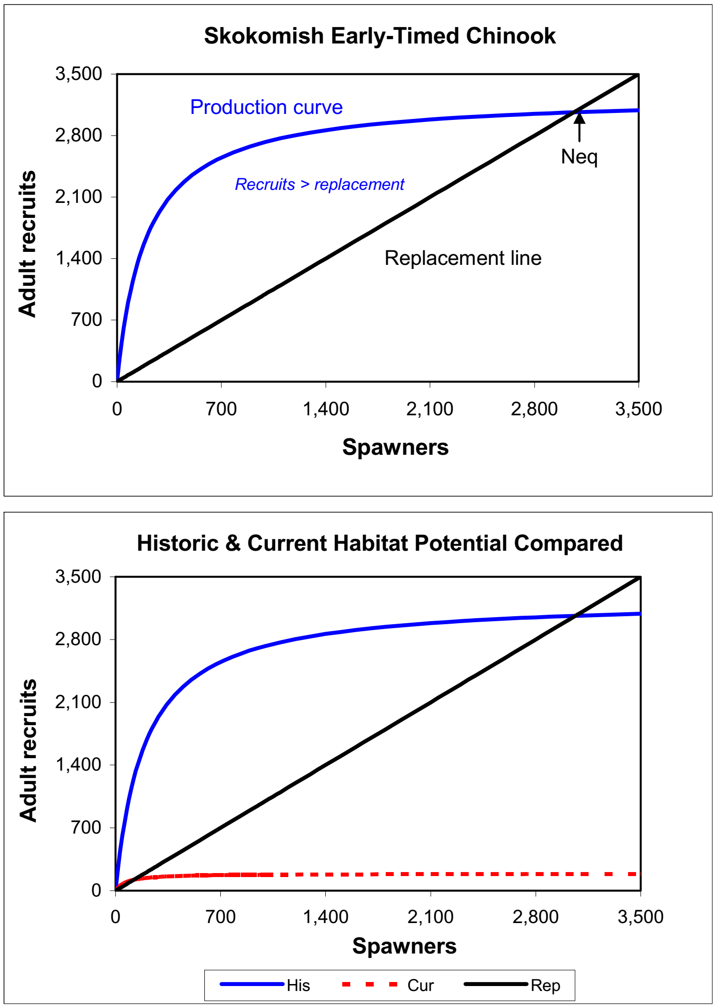

Figure 3.1. (Top) Stock-recruitment (S-R) curve derived by EDT modeling representing the historic Skokomish early-timed population. The point Neq is the equilibrium (i.e., average) number of early-timed adult recruits in the absence of fisheries for the S-R curve shown. (Bottom) S-R curves for the historic and current habitat conditions, reflecting differences in conditions between the two scenarios.

Figure 3.2 and Table 3.1 provide population performance results for early-timed Skokomish Chinook under habitat scenarios that reflect PFC and PFC-Plus conditions in the watershed, except for conditions driven by the Cushman Project. We modeled these scenarios to be consistent with provisions of the new Cushman license, i.e., keeping the reservoirs in place, providing a flow pattern as dictated by the license, and achieving NOAA standards for fish passage at the dams. Both of these scenarios result in intermediate production characteristics between those of the current and historic scenarios. The average spawner abundance (Neq) for the PFC-Plus scenario is approximately 50% of the estimated historic abundance.

Figure 3.3 illustrates how the planning targets would be set if only the PFC-Plus scenario was used. The upper end of the range (where recruits per spawner equals 1.0) is the Neq value. The lower end of the range is set at the number of spawners that maximizes the number of recruits in excess of replacement. The important aspect of this approach, therefore, is that the planning target is actually to achieve habitat conditions consistent with the S-R relationship itself. That relationship defines the level of normative habitat function that is being targeted in recovery. The exact number of spawners that would result would be determined by harvest management objectives with that level of normative habitat function occurring.

Table 3.1. Performance parameters for the Skokomish early-timed population under four different scenarios as derived by the EDT model.

Scenario	Productivity	Capacity	Abundance (Neq)
Historic	16.7	3,260	3,060
Current	2.8	190	120
PFC	7.3	1,230	1,060
PFC-Plus	9.9	1,660	1,500

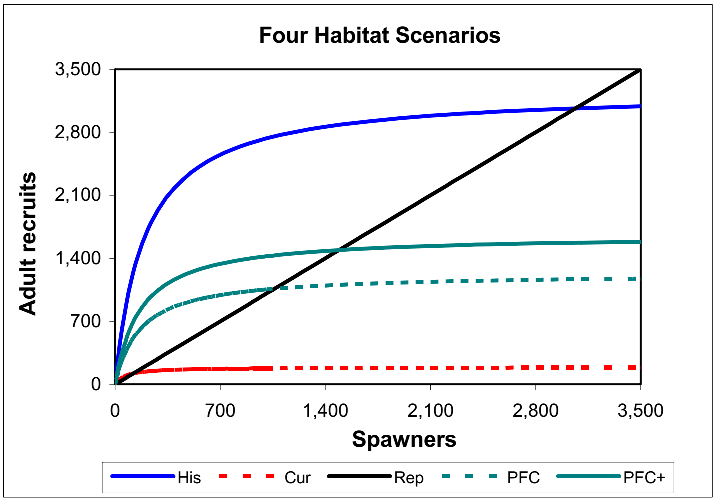

Figure 3.2. Modeled S-R curves for Skokomish early-timed Chinook under four different habitat scenarios: historic, current, PFC, and PFC-Plus.

We recognize, however, that it is unrealistic to set the planning targets based on restoring the estuary to its pristine state. We, therefore, define the planning targets in a way to bracket an as yet not precisely defined S-R relationship that is intermediate between ones corresponding to the PFC and PFC-Plus scenarios. Figure 3.4 illustrates how this planning target range is bracketed to encompass more realistic intermediate set of values for recovery (Table 3.2).

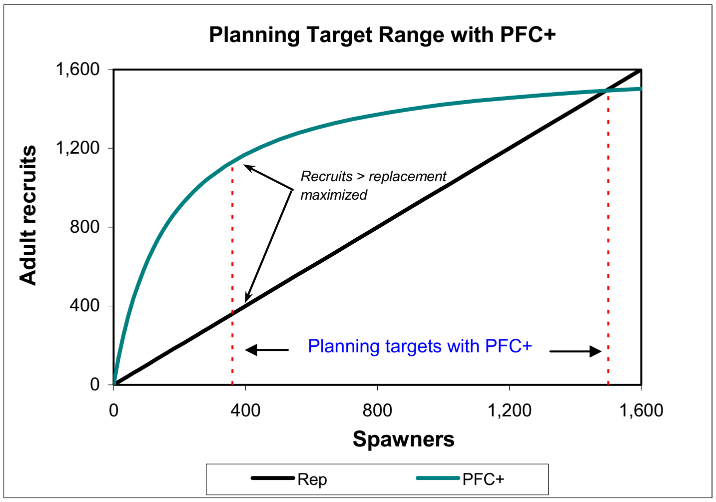

Figure 3.3. Definition of the planning target range for the PFC-Plus habitat scenario for Skokomish early-timed Chinook. The lower end of the range is defined by the number of spawners that maximizes the number of recruits in excess of its replacement level. The upper end of the range is defined by the number of spawners that maximizes equilibrium recruits in the absence of fisheries.

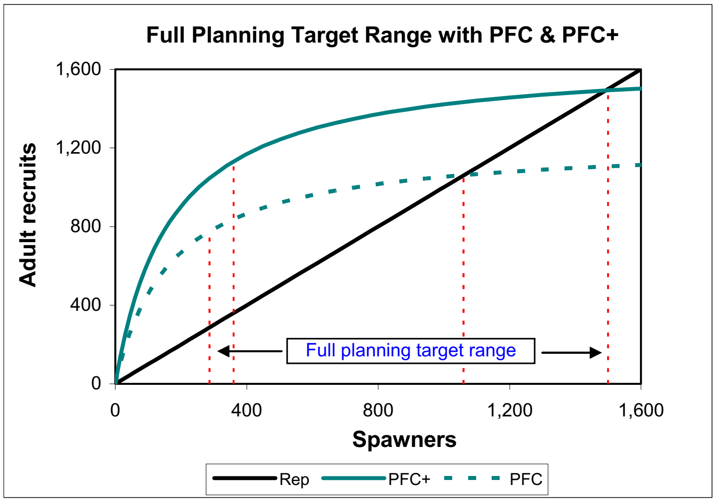

Figure 3.4. Definition of the full planning target range for Skokomish early-timed Chinook, which is bounded by both the PFC and PFC-Plus habitat scenarios. The lower end of the range is defined by the PFC scenario. The upper end is defined by the PFC-Plus scenario.

Table 3.2. Planning target range associated with the PFC and PFC-Plus scenarios and the range that brackets the PFC scenario at the low end and the PFC-Plus scenario at the upper end.

Scenario	Low target		High target	
	Spawners (S)	Recruits/S	Spawners (S)	Recruits/S
PFC	287	2.7	1,060	1.0
PFC+	360	3.1	1,500	1.0
Combined	287	2.7	1,500	1.0

Chapter 4. Habitat Recovery Strategies

Over the past 150 years, the Skokomish watershed has undergone extraordinary alterations, transforming riverine and estuarine habitats from their prior productive states. These changes were a major cause of the decline and extirpation of the indigenous Chinook life history types. This chapter describes the principal habitat-related threats that need to be addressed to achieve recovery, and identifies proposed strategies for doing so.

The chapter presents a thorough examination of each of the habitat threats in the watershed (Table 4.1), and where appropriate, provides hypotheses about how they have affected habitat structure and function. Much has been written and considered over the past 15 years about how the watershed has been changed by man's activities, some of it contradictory. For example, there has remained considerable uncertainty and controversy about the factors that are primarily causing flooding and aggradation in the lower valleys.

We considered it important to review all of the available material, synthesize it, then to formulate hypotheses about how the watershed is currently functioning. These hypotheses are fundamental to assessing limiting factors (Lichatowich et al. 1995), identifying potential solutions, and giving our prospects for recovery. Hence, portions of this chapter are detailed out of necessity for documenting how we have reached our conclusions.

Table 4.1. The principal habitat threats to the recovery of Skokomish Chinook.

Principal Threats	**Description**
Altered flow regimes (hydro and climate related)	The magnitude, timing, and variability of flow in the North Fork were dramatically altered by hydro operations beginning in the 1920s, continuing to the present. Climate change has also reduced snow melt runoff in the South Fork, posing passage problems for adult Chinook within the gorge reach.
Loss of fish access to upper North Fork and inundation	Construction of two Cushman dams in the 1920s blocked fish passage to 26 miles of anadromous fish habitat. The most productive habitat for early-timed Chinook was inundated by the Cushman Reservoir, which will remain for at least the next 40 years.
Degraded upper watershed conditions in South Fork and Vance Creek	The upper South Fork watershed has not recovered from intensive harvesting of the old growth forest, associated road building, wood removal from the channel, and other alterations made in preparing for construction of a proposed third Cushman dam.
Degraded lower floodplain and channel conditions	A series of alterations occurred in the lower valleys over the past 150 years, leading to massive changes in channel structure and stability. This, in combination with the other principal threats, has resulted in severe channel aggradation and frequent flooding. This issue is perhaps the most complex threat to be address for watershed restoration.
Degraded estuarine conditions	The Skokomish estuary was extensively diked, filled, and disconnected from its wetlands over the past 70 years for the purpose of agriculture, recreation, and development.

The primary approach applied herein is to focus on restoring and protecting physical and biological processes that form and sustain Chinook habitats. This approach reflects the model that ecosystems are a dynamic interaction between spatial and temporal variations within larger landscapes (Figure 4.1). As vegetation, geology, climate, and gross reach morphology (controls) interface over time, they create variable natural processes that in turn result in a wide range—a dynamic mosaic—of local environmental conditions. Salmon, and Chinook in particular, have adapted to this mosaic of historic environmental conditions (Beechie and Bolton 1999; Beechie et al. 2003), producing diverse life history types as discussed in Chapter 2.

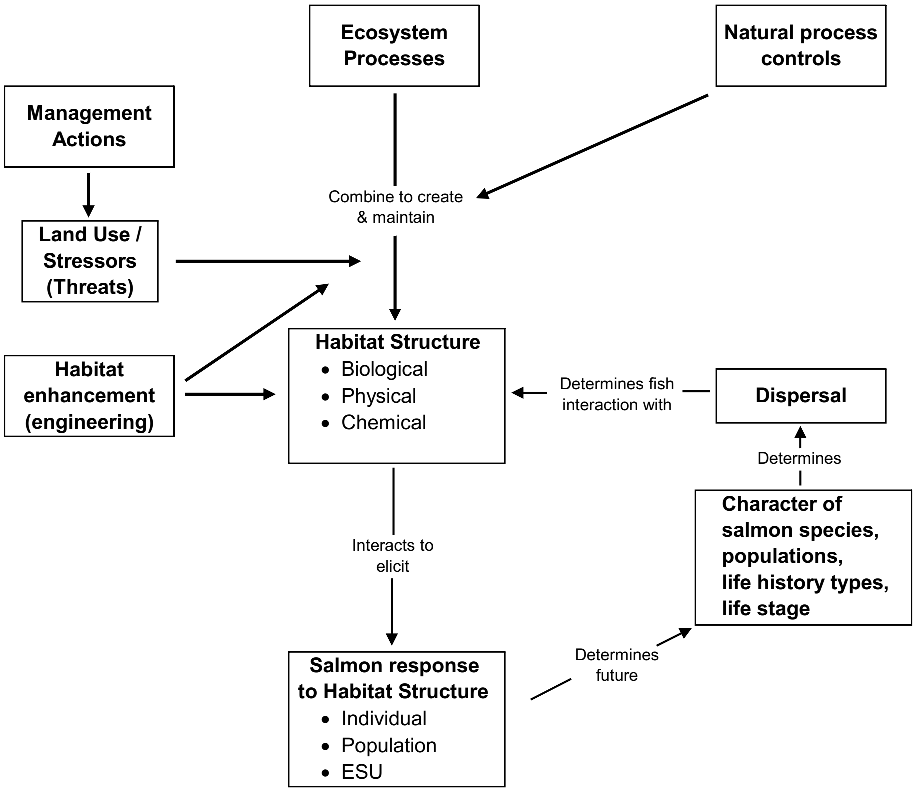

Figure 4.1. Conceptual model for restoring habitat attributes needed to recover Chinook in the Skokomish watershed (from PSAT [2005] as adapted from Beechie et al. [2003]). Habitat enhancement (using engineering) has been added to the figure to illustrate how engineering solutions will also have a role in Chinook recovery.

Intensive land and water uses in the Skokomish watershed that began after 1850 significantly altered the balance of how these natural processes formed habitat. These land and water uses substantially changed the frequency and magnitude of natural processes, creating a sea change in the basic functions of the ecosystem. The net impact of this altered environment was a decrease in Chinook survival in all life stages that occur in the watershed. Other salmonids, as well as many other animal and plant species, responded similarly.

The habitat recovery strategies proposed here were largely identified to promote restoration of disrupted natural processes and protect those that remain intact. It is recognized that only partial restoration is possible due to both the severe extent that the watershed has been altered and on-going land and water uses. The Cushman Hydroelectric Project, for example, has been issued a new license by FERC, which will keep the North Fork dams, reservoirs, and flow diversion in place for the next 40 years. Therefore, the habitat recovery strategies aim to restore a *normative* range of processes and functions, not to restore pre-altered conditions. Normative refers to the norms of ecological processes and functions that can support natural salmon populations, even within watersheds containing a mix of natural and cultural features (Liss et al. 2006). Thus enough of the historic processes need to be restored so that sufficient suitable habitats are formed and maintained to support the recovered population.

This approach for restoring normative watershed processes provides for sequencing strategies and actions so that the highest priority goals can be targeted (Beechie and Bolton 1999). Prioritization in this context does not alter the types of restoration strategies but rather the sequence in which they are performed. The emphasis of this plan, until which time it might be updated in future years, is on recovering early-timed (spring-summer) Chinook. Thus the plan calls for a certain sequence of strategies consistent with this emphasis.

The types of strategies called for in this plan also include some that are outside the realm of affecting physical watershed processes (Figure 4.1). Such strategies, designed to enhance certain existing habitat features, call for employing engineered solutions to address specific issues that are not driven by watershed processes. An example of this type of strategy is the installation of fish passage facilities at the Cushman dams.

The chapter is organized into the following sections:

- Goals and objectives for habitat recovery strategies;
- Watershed description;
- Principal threats;
- Habitat limiting factors – priorities and sequencing;
- Strategic framework for habitat strategies.

Each threat is reviewed by comparing the relevant historic and existing watershed conditions after the approach of Lichatowich et al. (1995). The comparison between historic and existing conditions serves as the basis for formulating hypotheses about the causes of habitat change and effects on Chinook performance. These hypotheses are in effect a diagnosis of the watershed as it relates to Chinook recovery. They provide an important aspect of the limiting factors analysis presented near the end of the chapter.

The final section of the chapter—Strategic Framework for Habitat Strategies—identifies treatment strategies. The strategies are presented within a framework that links the threat to its relevance to Chinook, then to cause and strategies for addressing the cause. These are then linked to the habitat-related objectives. Critical uncertainties are also identified. Hence, the framework summarizes the logic-train for why various strategies are needed, and how they are hypothesized to improve conditions and the potential for recovery.

Goals and Objectives for Habitat Recovery Strategies

Recovery of Skokomish Chinook will require the combined benefits of habitat restoration, protection, and enhancement measures. The major thrust is to restore normative watershed processes and functions, but concerted efforts are also needed to protect and enhance existing habitat conditions. While it is recognized that the watershed will never be restored to its pre-developed state, it is believed that it can be restored and enhanced to an extent to once again support productive, diverse Chinook life histories. This section presents goals and objectives for addressing the principal habitat-related threats to recovery.

The terms "normative ecosystem" and "normative river flow" are used throughout this plan to mean an altered system that has a balanced mix of natural and cultural features such that indigenous life histories of salmon populations can be supported. Liss et al. (2006) described the normative ecosystem within a salmon recovery context as follows:

> "We need a view of an ecosystem as a dynamic mix of natural and cultural features that typify modern society, but that can still sustain all life stages of a diverse and productive suite of salmonid populations if the essential ecological conditions and processes necessary to maintain the populations still exist within the ecosystem. We call this ecosystem, with its balanced mix of natural and cultural features, a 'normative' ecosystem.
>
> Normative refers to the norms of ecological functions and processes characteristic of salmon-bearing streams. These features, when balanced with society's needs and demands, would result in an ecosystem in which both natural and cultural elements exist in a balance that allows salmon to thrive and many of society's present uses of the river to continue, although not without modification…The normative ecosystem is not a static target or a single unique state of the river, rather it is a continuum of conditions from slightly better than the current state of the river at one end of the continuum to relatively pristine at the other end."

Figure 4.2, adapted from Liss et al. (2006), illustrates the normative river concept as it is applied in this plan. It reflects the different degrees of restoration that are envisioned for different parts of the Skokomish system, depending on their current state of degradation and what is believed to be possible over the next 10-20 years. The term of the FERC license for Cushman Project is 40 years. Strategies and actions, as well as specific habitat objectives for various parts of the river system beyond 10-20 years, will necessarily need to be adaptive as the plan goes forward and the responses of the system to actions are monitored and understood. Thus it is uncertain what the actual extent of restoration might be 40+ years into the future.

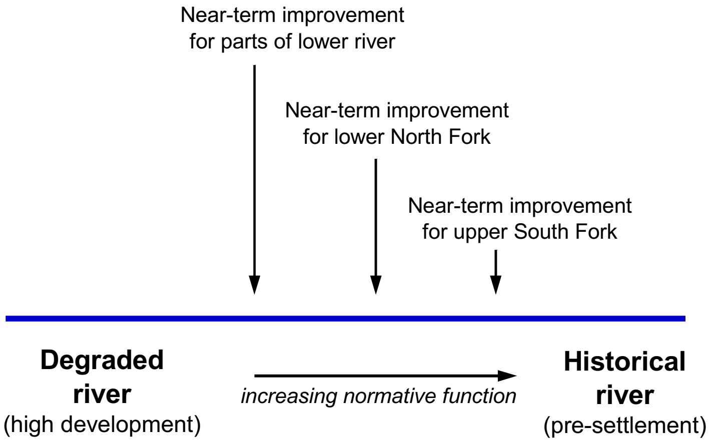

Figure 4.2. Conceptual representation of three different levels of habitat restoration in the Skokomish watershed along a continuum of conditions. What is possible to achieve in the near-term (10-20 year time horizon) for restoration is envisioned to vary for different parts of the watershed, depending on the degree of past alteration. Adapted from Liss et al. (2006).

The goals and objectives for restoring, protecting, and enhancing habitat conditions for the purpose of recovering Chinook are listed below. Three goal statements are presented, one each for restoration, protection, and enhancement. A fourth goal is also presented, which operates in conjunction with the other three—it emphasizes the need for a collaborative process for engaging institutions and stakeholders in working together to achieve the other three goals. Each goal is followed by a set of objectives that provide greater specificity for targeting strategies.

1. Restore normative ecological processes, functions, and forms of the Skokomish watershed associated with the Skokomish River, its tributaries, and estuarine and adjacent near-shore areas.
    a. Restore a normative flow regime to the North Fork to promote channel and habitat reformation and channel conveyance capacity in the North Fork, the lower end of the South Fork, and in the lower Skokomish River, including through its estuarine zone.
    b. Restore upland landscapes, including rates of sediment delivery and land cover structure and vegetation species composition, to restore watershed processes, function, and forms.
    c. Restore floodplain function and connectivity along the Skokomish River and its tributaries.
    d. Restore normative fluvial geomorphic processes through the channel corridors to restore channel form and function and sediment movement.
    e. Restore estuarine and near-shore processes that promote restoration of habitats, including those within the floodplain, delta, and near-shore shoreline.

2. Protect ecological processes, functions, and forms of the Skokomish watershed from on-going land and water uses that would further threaten Chinook recovery.
    a. Protect from further loss channel conveyance capacity of the mainstem rivers and the estuarine zone
    b. Protect from further loss the volume and connectivity of tidal prism within the estuarine zone
    c. Protect floodplain corridors from further loss of connectivity with active channels
    d. Protect riparian corridors from further degradation by safeguarding native species, forest age and structure
    e. Protect water quality from further degradation from non-point and point pollution sources
    f. Protect from further loss aquatic habitat structure, including wood structure, edge structure, and the distribution and composition of habitat types
    g. Protect from further degradation the structural elements that contribute to near-shore habitat forming processes and associated key habitats

3. Enhance environmental conditions within the Skokomish watershed to facilitate recovery of Chinook life histories that were adapted to the historic Skokomish River.
    a. Provide for effective upstream and downstream passage of migrant salmonids at the Cushman dam sites; upstream passage is to be given at the lower dam site and downstream passage at the upper dam site.
    b. Enhance fish passage capability within the South Fork gorge to help ensure that early-timed Chinook can successfully pass upstream.
    c. Provide for conservation hatchery facilities within the North Fork subbasin (located at Lake Kokanee) to support an *integrated* population component of early-timed Chinook in the North Fork, potentially requiring the use of flow management techniques through the upper Cushman Dam to help maintain appropriate temperature profiles in Lake Kokanee for those facilities.

4. Establish a collaborative framework for coordinating restoration, protection, and enhancement activities within the watershed for facilitating Chinook recovery.
    a. Establish a Skokomish watershed-focused framework for promoting and maintaining effective coordination between all parties engaged in habitat restoration, protection, and enhancement.
    b. Hold regularly scheduled summits or conferences to share information on progress of restoration and enhancement activities, research and monitoring results, revisions to watershed plans, and other related activities.
    c. Develop and implement innovative ways of interaction, outreach, and education with the public to strengthen partnerships and participation in watershed restoration and salmon recovery.

Watershed Description

The Skokomish River, located in the southeast corner of the Olympic Peninsula, drains 240 square miles of mostly forested land (Figure 1.2). Originating in the Olympic Mountains and foothills, it empties to the southern end of Hood Canal. Watershed topography is widely varied, consisting of steep mountain slopes, more moderately sloping foothills, and flat valley bottoms. Headwater areas are bounded by mountains that rise to 3,000 to 6,000 ft. The two arterial rivers that join to form the main Skokomish River flow south and east out of the mountains, descending through incised valleys, interspersed with steep gorges and sections of widened valley bottoms, before joining in the wide, flat lower valley. From here, the river generally meanders to its extensive delta in the southwestern corner of Hood Canal.

The topography and character of the stream valleys and channels were shaped by past glaciations, and more recently by erosional and depositional processes. Both continental and alpine glaciations over thousands of years left their marks in the various valley forms and the huge deposits of glacial sediments in the valleys and along the valley walls (Tabor 1975; GeoEngineers 2007; Godaire et al. 2009). At the end of the continental glaciations, about 14,000 years ago, meltwater from alpine glaciers and surface runoff continued to affect the channels and accumulations of sediment on the lower valley floor and delta. Mass wasting events in the uplands and unstable glacial deposits added to the steady supply of sediments to the river channels. This on-going process formed the narrow canyons and ravines of the North and South forks, and contributed to the large amounts of sediment that eventually filled the lower Skokomish valley bottom (GeoEngineers 2007).

While the Skokomish basin is generally drier than those on the Pacific side of the Olympic Mountains, annual precipitation is still high with an average of about 134 inches in the upper basin (Canning et al. 1988). Less precipitation falls at lower elevations, averaging approximately 101 inches at Cushman Dam and between 66-89 inches in the valley (GeoEngineers 2007). Approximately 80 percent of the annual precipitation falls in late fall and winter. Significant snow accumulation can occur above 2,500 ft and is greater in the North Fork subbasin due to its higher, more extensive mountainous areas. Climates differ slightly between the major subbasins, with the South Fork and Vance Creek drainages, which are more exposed to the prevailing northeasterly winter storm fronts, being wetter than the more protected North Fork drainage (GeoEngineers 2007).

The watershed can be delineated by four distinct geographic areas due to the unique characteristics of each: (1) lower Skokomish River, (2) North Fork, (3) South Fork, and (4) the river mouth estuary.

The lower Skokomish River extends from the confluence of the North and South forks at approximately RM 9.0 downstream into the river mouth estuary. The floodplains here are utilized largely for agricultural and residential purposes and have been extensively diked. The major tributaries, which are generally small, include Weaver, Hunter, and Purdy creeks (Figure 4.3). Tributary flows through this area contain significant amounts of groundwater. Two fish hatchery complexes operate in this area, located on Purdy and Weaver creeks. The Skokomish

Indian Reservation is located adjacent to the north bank of the river between Highway 101 and the river mouth.

The North Fork drains approximately 118 square miles and heads in the pristine wilderness of Olympic National Park. The Cushman Project, consisting of two dams that impound one large reservoir (Lake Cushman) and a smaller one (Lake Kokanee) is located approximately midway into the subbasin. The lower dam (Cushman Dam No. 2) is situated at RM 17.3, approximately eight miles upstream of the confluence of the North and South forks (note: river miles along the North Fork continue from those in the main Skokomish River). The Cushman Project diversion occurs at the lower dam, where water is diverted via pipelines directly to Hood Canal. Approximately 40 percent of the annual runoff in the Skokomish watershed has been diverted out of the basin since 1930 (Jay and Simenstad 1996). The dams have blocked all anadromous fish migrations since their construction in the 1920s. The upper North Fork, which is free-flowing upstream of RM 28 is contained entirely within Olympic National Park. McTaggert Creek is the only noteworthy tributary downstream of the Cushman Project (Figure 4.3).

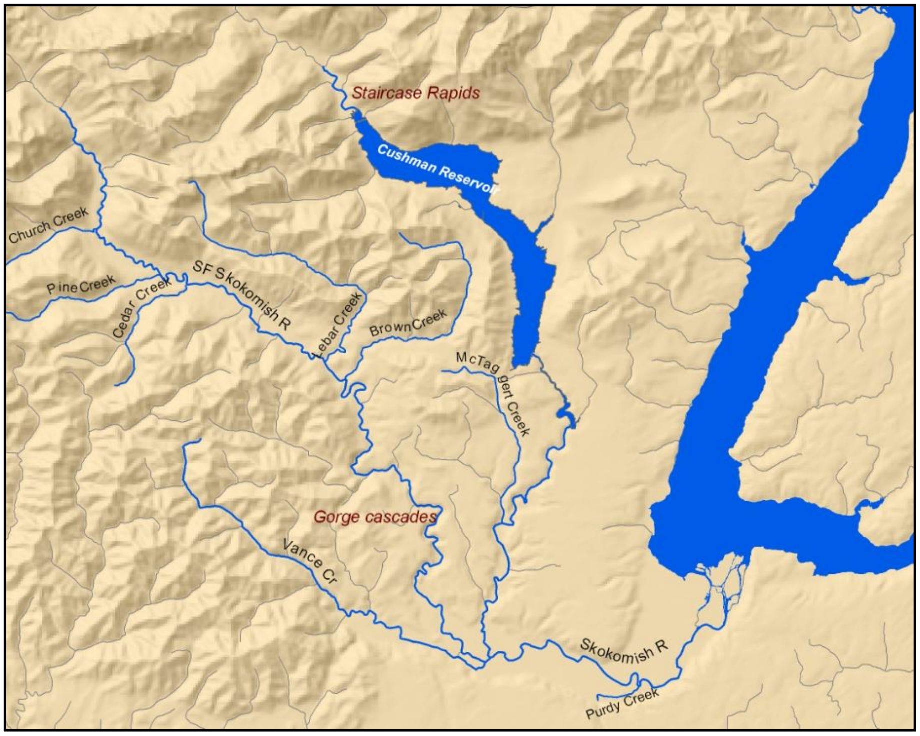

Figure 4.3. Major tributaries to the Skokomish River and its forks discussed in the text.

The South Fork drains approximately 105 square miles, of which about 25 square miles is contained within its largest tributary, Vance Creek, which enters at RM 0.8. The large majority of the subbasin is forested, though parts of the floodplains of the lower river and lower Vance Creek are used for agricultural and residential purposes. Most of the subbasin was intensively logged over the past 60 years through the combined actions of the Simpson Timber Company and the U.S. Forest Service (USFS). The mainstem South Fork can generally be delineated into three zones: (1) the lower river between RM 0.0-3.5, where the active channel and its floodplain are relatively wide; (2) a generally well confined section between RM 3.5-9.7, which contains both gorge reaches interspersed with less confined reaches; and (3) the upper river upstream of RM 9.7 where the channel is contained in an alluvial valley. Steep cascades within a gorge located in the vicinity of RM 5.5-6.5 kept historic spawning of late-timed Chinook downstream of that point (WDF 1957a). Major tributaries in the upper South Fork include Brown, LeBar, Cedar, Pine, and Church creeks (Figure 4.3).

The river mouth estuary is the section of river, including its delta that is tidally influenced. The upper end of tidal influence has apparently moved downstream over time, probably due to aggradation of the river bed and estuarine diking. The upper end of tidal influence is now thought to occur in the vicinity of RM 3.5-4.0 (Marty Ereth, former Skokomish tribal biologist, *personal communications*). Parts of the lower floodplain, including a major part of Nalley Island, have been used for agricultural and recreational purposes over the past century. The Skokomish Indian Reservation is located along the lower 6.5 miles of river.

Most of the watershed lies within federal ownership, with approximately half managed by the USFS and another 18 percent held within Olympic National Park. The remainder is owned by the City of Tacoma (6%), State of Washington (3%), Skokomish Tribe (2%), Green Diamond Resource Company (15%), and other private owners (8%). Most of the upper elevation lands are within the federal jurisdiction, while lower elevation lands are generally in private ownership (SWAT 2007).

The river currently supports natural production of Chinook, coho, chum, and steelhead, as well as bull trout and cutthroat trout. Historically, sockeye were also produced (James 1980).

Description of Principal Threats

The term “threats” is more broadly defined in this document than how it is often used in recovery planning. NMFS defines it to mean a specific human activity that causes degradation of fish habitat, such as logging or hydro operations. We have broadened its definition herein to represent the general set of conditions, or stressors, that result from a collection of human activities, thereby allowing us to locate the related habitat conditions to a geographic area of the watershed. Hence, degradation of lower river valley floodplains and channels is called a threat, which, in this case, is the result of various human activities, such as logging, agriculture, changes in flow regime, and so on. We also then identify the specific causes of the degradation (logging and so on).

The environmental conditions associated with the five principal habitat-related threats are described in the following sections. Historical and current conditions associated with each issue are contrasted. Hypotheses about how watershed processes and functions are currently operating are provided as part of each threat, where appropriate. The hypotheses help in identifying restoration strategies under the last section in the chapter, Strategic Framework.

Altered Flow Regimes

The flow regimes in the Skokomish watershed are significantly different than those that existed prior to the construction of the Cushman dams in the North Fork during the 1920s. Flow magnitude, timing, and variability have been altered. In addition, long-term climate change may have contributed to changes in some flow characteristics over the past century. Changes to the flow regimes contributed to the decline and extirpation of the indigenous Chinook life histories in the watershed.

The flow regime is the master variable that shapes the riverine ecosystem (Poff et al. 1997). It functioned as the major forcer of important processes that influenced both physical and biological features of the historic riverine ecosystem (Figure 4.4. It is defined by five characteristics in flow: magnitude, timing, frequency, duration, and rate of change. Over some period of years, these characteristics vary within a range determined by prevailing climate patterns and various watershed features, such as its size, location, topography, configuration, geology, and land cover. Under natural conditions, the patterns and ranges of variation in flow characteristics comprise what is called the watershed's natural flow regime. This regime is the one that Chinook adapted to in the centuries prior to the rapid alterations that occurred over about the past 100 years (Figure 4.5).

<u>Historic Condition</u>

Three types of flow regime patterns existed within the subbasins of the Skokomish watershed prior to hydro-electric development that occurred in the 1920s. The three patterns reflect the degree of snowmelt influence: strong snowmelt influence, weak snowmelt influence, and no snowmelt influence. The patterns are seen in historic USGS data within the basin, or can be inferred from elevation.

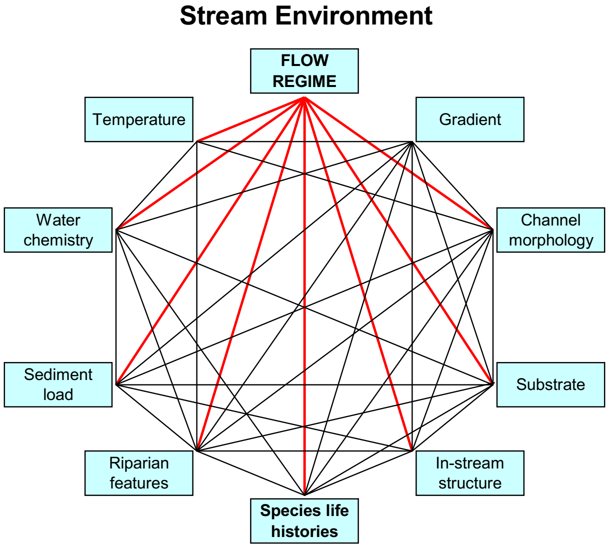

Figure 4.4. Factors affecting habitat and biological processes and functions within the stream environment, showing the important role of the flow regime. Adapted from Giger (1973).

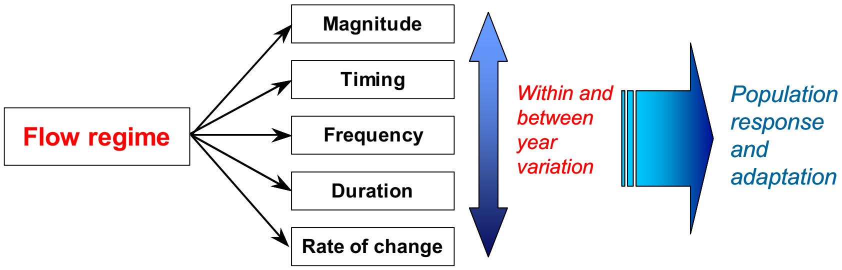

Figure 4.5. Characteristics of the natural flow regime that shape life history adaptations of Chinook salmon in rivers. Based on Poff et al. (1997).

The amount of snowmelt influence between the upper North and South forks is significantly different (Figure 4.6) The upper North Fork hydrograph (represented by years 1944-1953) shows two major periods of strong runoff—one during fall and winter associated with rainfall driven and rain-on-snow driven freshets, and one in late spring associated with snowmelt. Beechie et al. (2006) classified the upper North Fork flow regime as transitional between a snowmelt-dominated regime and a rainfall-dominated one.

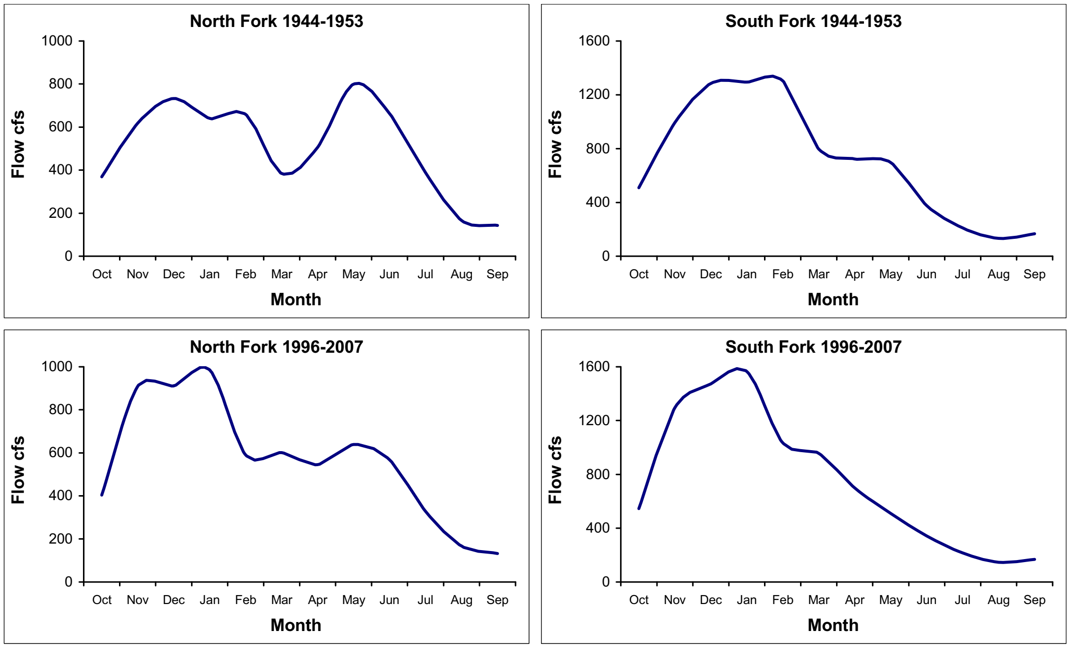

Figure 4.6. Shapes of the hydrographs in the North and South forks of the Skokomish River, based on average monthly flows during two ten year periods. The North Fork gauge is located upstream of Cushman reservoir.

In contrast, the South Fork historically showed a much weaker snowmelt signature due to lower elevation headwaters than occurs in the North Fork. Beechie et al. (2006) classified the South Fork as having a rainfall-dominated hydrograph, though the flow data shows that the snowmelt signature was much stronger prior to about 1960 than it has been since then (Figure 4.5). Timber harvest in the upper South Fork may have contributed to a more rapid runoff in late winter, but there has also been a decline in snowmelt contribution in the upper North Fork, which has never been logged. This suggests that the loss in snowmelt influence has been at least partly due to long-term climate change.

A third hydrograph pattern, no snowmelt influence, would represent a number of smaller subbasins, such as Vance Creek, that originate in the lower elevation hills within the watershed. This pattern is also reflected by the more recent pattern seen in South Fork.

The hydrograph pattern that occurred historically in the lower Skokomish River can be approximated by combining USGS gauging data collected in the lower mainstem with the data from the upper North Fork. Between 1930 and 2008, essentially all flows that originated upstream of the Cushman Dams on the North Fork were diverted out of the basin and, therefore, are not represented in the lower river flows. Adding the upper North Fork flows (upstream of Cushman reservoir) to the lower river flow data provides an approximation of what the flow pattern would have been without the Cushman Dams in place. The years 1944-1953, the first ten years when the gauging station operated on the lower Skokomish River, are used to represent historic conditions. The reconstructed hydrograph shows the bi-modal runoff pattern characteristic of a transitional flow regime, though the spring pulse is much reduced from that seen in the upper North Fork (Figure 4.7).

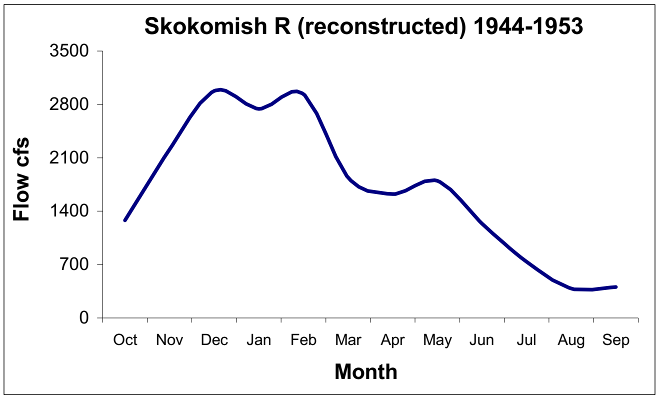

Figure 4.7. Reconstructed hydrograph for the lower Skokomish River for 1944-1953. The hydrograph is meant to represent the pre-Cushman hydrograph of the 20th century.

Patterns of interannual and intraannual variation in the Skokomish flow regime are illustrated by combining daily flow data from the lower mainstem river and the upper North Fork as described above. The period for water years 1944-1953 is used again here. Historic patterns in variation (Figure 4.8 can be characterized as follows:

- Annual low flows typically occurred in September or early October;
- The first significant increase in flows following summer usually began about the middle of October, though in some years it occurred earlier while in others it happened later;
- By early November, average daily flows were always much higher than during the low flow months;
- Annual peak flows normally occurred between late November and the end of March;

- High flow events could occur frequently in any given year between early November and the end of March;
- Daily variation and peak flow magnitude during the late spring snowmelt period were much less than typically seen during winter and early spring.

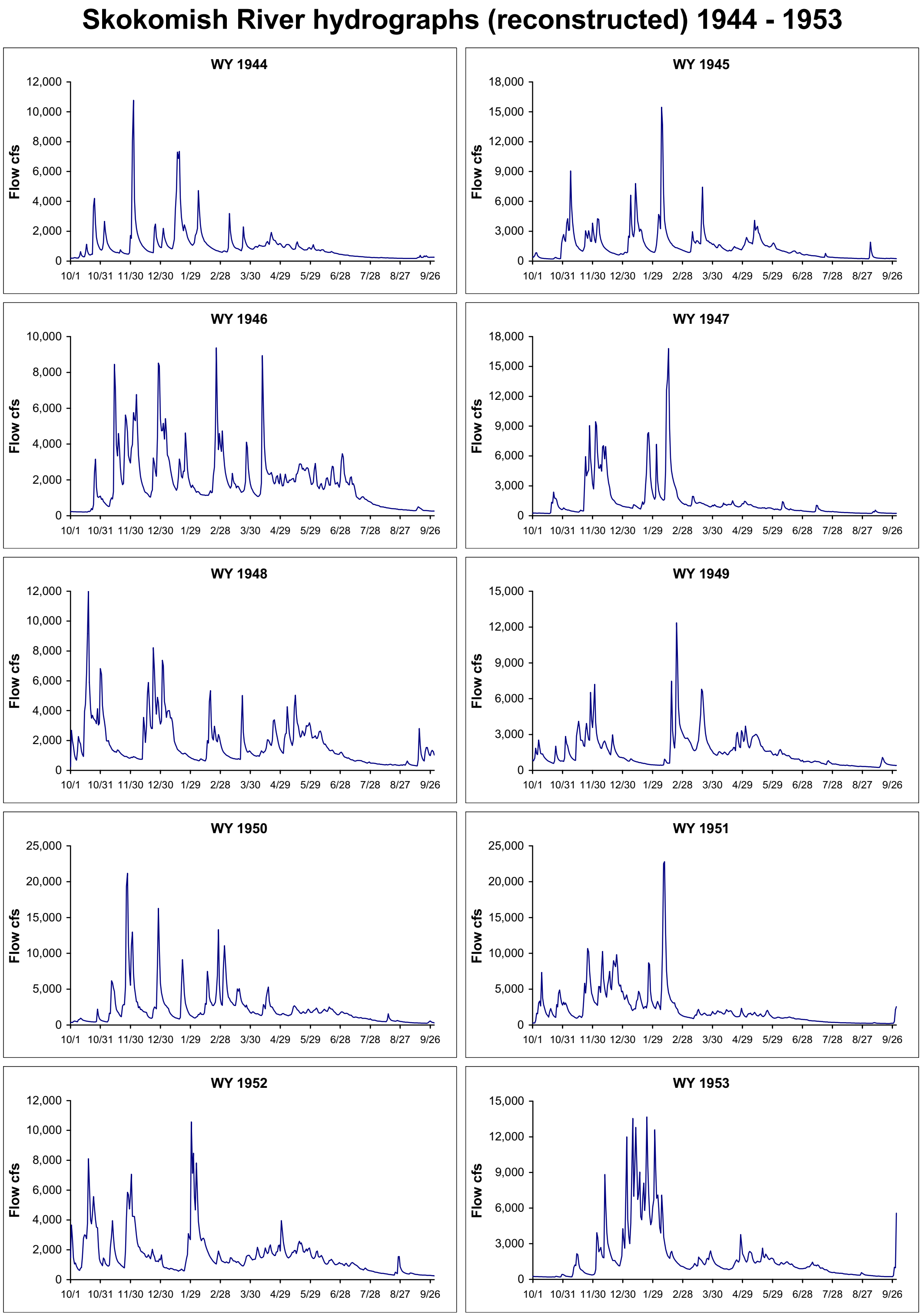

Figure 4.8. Reconstructed annual hydrographs for the lower Skokomish River for water years 1944-1953. The reconstruction is only partial because only the amount of flow passing Staircase Rapids on the North Fork was added in to the observed main Skokomish River flow. Another 41 square miles of drainage area downstream of that point (yet upstream of Cushman Dam No. 2) also produces runoff, which was not incorporated.

Existing Condition

Since the construction of the Cushman Dams by the city of Tacoma on the North Fork in the late 1920s, Skokomish River flow regimes have undergone significant changes. Some aspects of the regimes have changed dramatically, while others still demonstrate characteristics like those of the historic regimes.

The greatest change occurred in the North Fork's flow regime downstream of the lower Cushman Dam. After the closure of the lower dam at RM 17.4, flows to the river below that point were essentially cutoff. Almost the entirety of the flow was diverted via pipelines directly to Hood Canal, approximately 5 miles north of the Skokomish River mouth. Between 1930 and 1988, only sporadic flow releases were made for emergency dam spills or maintenance (Figure 4.9. The flow regime of the lower North Fork became the result of flows generated within the lower part of the North Fork subbasin. Tacoma increased flows below the lower Cushman Dam to approximately 35 cfs in 1988 and again in 1998 to 60 cfs. Then, as a result of court action, flows were increased to 240 cfs in March 2008, which is the existing condition except when inflow to the reservoir drops below that level. The current release pattern (i.e., pre-initiation of the Cushman Settlement) does not provide for any type of variation, except due to the inflow constraint.[15]

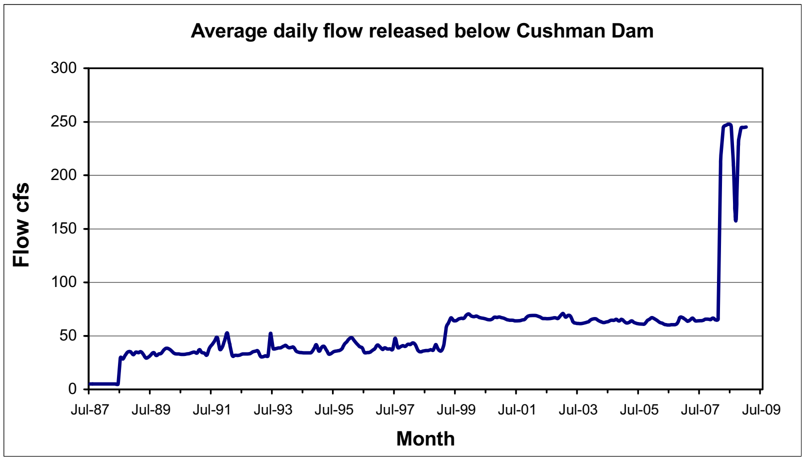

Figure 4.9. Flows released into the North Fork at the lower Cushman Dam between July 1987 and March 2009. Flows between 1930 and July 1987 were comparable to those in July 1987, except for rare emergency flow releases.

The alterations to the North Fork regime beginning in 1930, combined with intensive logging in the basin outside the Olympic National Park and development of the lower valley and estuary, led to significant changes to sediment routing, channel characteristics, and flood frequency (Jay and Simenstad 1996; Stover and Montgomery 2001). As a result, the Skokomish River is now considered to be the most flood prone river in Washington State, and arguably in the Pacific Northwest. This characteristic, notable in itself, is more remarkable because peak flows in the lower Skokomish River have been significantly reduced due to the out-of-basin water diversion.

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[15] / A new, normative regime will be implemented on August 1, 2010 under terms of the new FERC license.

As a result of the aggradation and other changes to the channel, the flow capacity of the lower river has been significantly reduced, producing greater flood frequency. Historically, the river would have flooded on average roughly once every 1-2 years (Leopold et al. 1964; Gordon et al. 2004).

The river now floods multiple times during an average winter season. Dave Montgomery at the University of Washington has described the situation as follows (Stricherz 2002):

> "It's always on the leading edge, the first one to flood and it floods several times. Typically a river will flood about once a year. But the Skokomish floods two, three, four, five, six times a year."

The shape of the hydrograph for the lower river in recent years has been much different than the historic pattern (Figure 4.10). Most notably, the spring snowmelt pulse has been removed, due to the flow diversion on the North Fork and the decline of snowmelt contribution in the South Fork.

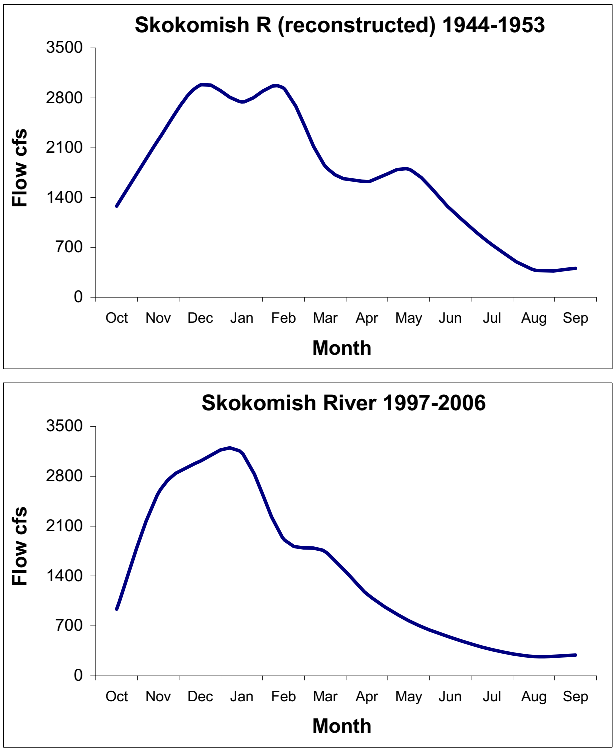

Figure 4.10. Comparison of a reconstructed (partial only) hydrograph for the lower Skokomish River (showing approximate flows without Cushman Project) to the current average hydrograph.

Patterns and extent of variation in the mainstem river flow regime appear to generally be similar between those in recent years and historic patterns, except for loss of the spring snowmelt pulse. Also, the levels of annual flow extremes would be seen to be different with a more detailed analysis—both lows and peaks have been reduced due to the diversion of flow from the North Fork to Hood Canal.

In summary, the following is concluded regarding the flow regime in the lower Skokomish River:

- Annual low flows still occur in September or early October, but levels have been lower compared to historic lows;
- Fall and winter freshets in recent years generally appear to produce the same types, extent, and patterns of variation as occurred historically;
- A period of snowmelt runoff is not evident in late spring due to the Cushman flow diversion and long-term climate change;
- Peak annual flows would be higher if the Cushman diversion was not in place;
- The altered regime has contributed to increased aggradation and flood frequency in the lower river valleys.

The Future Normative Flow Regime

The flow regimes of the North Fork and lower Skokomish River will change again in 2010 with implementation of the Cushman Settlement, scheduled to begin on August 1. The term of the license is 40 years. Under the new 40-year license, the existing release of 240 cfs will be altered to provide for a more normative pattern, including variation, of flows downstream of the lower dam.

The new flow regime in the North Fork will have these features:

- The shape of the annual hydrograph will resemble the natural pattern, and provide for a spring flow pulse to simulate snowmelt runoff;
- Channel and habitat maintenance flows will be provided to aid in recreating and maintaining channel flow capacity and physical habitat in the North Fork and lower mainstem river; and
- Periods of flow variation will be provided, timed to occur during normal freshets.

Because Tacoma Power will continue to operate the hydroelectric facility by diverting water out of the basin, the total amount of runoff released into the lower North Fork will remain significantly reduced compared to the unaltered state.

The North Fork flow releases will be regulated by a set of rules that will dictate month-specific base flows as well as amounts and timing of additional flows to correspond with natural high flow events. One component of the flow releases has been designed to facilitate sediment transport in both the lower North Fork and the lower Skokomish River during times of high flow. The objective of this flow component is to enhance the natural process of channel scour to help reverse the pattern of aggradation that has occurred for decades in both channels. This action calls for a specified, significant increase in flow from the lower Cushman Dam immediately following a bank overtopping event in the lower river valley (i.e., a flood event). The added discharge is to be made as flow in the lower Skokomish River returns to within its banks and done so that it extends the flow at just below or at the bankfull level. In doing so, bankfull flow will be prolonged for up to an additional 48 consecutive hours beyond what would have normally occurred. Most sediment is transported by a river when flow exceeds a depth of about 80 percent of the bankfull level (Gordon et al. 2004), hence this action should prolong the period of sediment transport. The action is to be carried out in a manner to avoid exacerbating flooding.

The sediment transport flow component will be experimental and its potential for restoring more normative channel structure and function is uncertain. The Cushman Settlement requires that this flow measure be implemented for seven years before making a determination about its overall effectiveness and how, or whether, it should be continued. It is expected, however, that the aggradation issue will require much longer-term remediation, thus the roles of various measures, including flow, are to be adaptively developed.

Of special importance to this recovery plan are the adverse effects that the sediment transport flow component would have on certain Chinook life history patterns if those patterns would be present. Late-timed Chinook, if present, would spawn in the lower rivers and be detrimentally affected by flows generated to facilitate channel scour. Egg losses could be expected to be high while channel conveyance capacity is being restored through flow manipulations. The likelihood for such an effect is one of the reasons that this plan focuses on recovery of early-timed Chinook, which would spawn upstream of the channels undergoing these modifications.

Adult Passage through the South Fork Gorge

A series of steep cascades within the South Fork gorge are a natural partial barrier to upstream Chinook migration. Besides steelhead and bull trout, only early-timed Chinook are known to have ascended the rapids historically (WDF 1957a). The early-timed adults migrated upstream primarily when flows were elevated due to snow-melt runoff. By the 1950s the amount of snow-melt was declining in the South Fork due to climate change, making passage over the cascades more difficult as noted by WDF (1957a):

> "Migration through the South Fork canyon appears to be quite difficult for the spring and summer chinook, judging from the sizeable numbers of fish having head injuries."

The authors added that during periods of low flow, Chinook carcasses were observed below the falls having injuries that were incurred from jumping at the falls.

Engineers for WDF (1957a) concluded that safe passage over the cascades needed to be facilitated by some type of corrective action. Four locations within the gorge were identified as requiring one of the following: full vertical slot fishways, modified vertical slot fishways, modified Denil-type fishway, pool and weir, or correction by blasting. Specific locations of each of the cascades were identified as follows:

- SE¼ S26 T22N R5W, about 1½ miles below the steel bridge
- NE¼ S26 T22N R5W, about ¼ mile below the steel bridge and visible from same
- SW¼ S23 T22N R5W, about ½ miles above the steel bridge
- Section line between 21 and 22 T22N R5W, between the proposed Cushman No. 3 dam site and the confluence with Rock Creek

It is likely that passage through the gorge would be more difficult currently due to greater loss of the spring snow-melt contribution to flow. Therefore, we believe that the barriers identified by WDF (1957a) will need to be addressed for successful re-introduction of Chinook into the upper South Fork.

Loss of Fish Access to the Upper North Fork and Inundation by Reservoir

The North Fork of the Skokomish River was historically a major producer of salmon, including Chinook. Access to the upper North Fork by anadromous salmonids ceased in the 1920s when the Cushman dams were built. No provisions were made for fish passage. In addition, the upstream migrations of salmon were also severely hindered in parts of the river downstream of the dams due to dewatering of much of the North Fork channel that occurred between 1930 and 1988, and to a lesser degree since then.

The direct result of these changes in access and flow was the complete destruction of the early-timed racial group of Chinook in the North Fork and a severe reduction in the late-timed racial group (1957a). The entirety of the North Fork's early-timed Chinook are thought to have been produced upstream of the upper dam. The North Fork's late-timed population is believed to have been produced downstream of the lower dam.

Another drastic change to the North Fork as a result of the Cushman Project was the inundation of the large majority of spawning and rearing habitat used by the early-timed population upstream of the dams. This condition will persist for at least the next 40 years under provisions of the new license for operating the Cushman Project.

Historic Condition

The early-timed Chinook produced in the North Fork migrated upstream during the period of snow-melt runoff. Passage over Big Falls, located between the two dam sites, was facilitated by the spring runoff . Historically, the vicinity of the falls served as an important fishing location for the Skokomish Tribe (WDF 1957a; James 1980), as fish were caught there ascending the falls.

Characteristics of the historic river contained within the boundaries of the existing reservoirs can be inferred from notes and maps of early surveyors and explorers. The surveyors for the General Land Office (GLO), made notes of general land features along section boundaries and produced maps, sometimes indicating channel form. Additional information is provided in the journal entries of members of the O'Neil Expedition, a reconnaissance of the Olympic Mountain region in 1890 by the U.S. Army.

Construction of the upper dam inundated what was likely some of the most productive salmon habitats in the Skokomish system. Near the center of the modern-day Lake Cushman was the historic lake, approximately two miles long and three-quarters mile wide. Wood (1976), in summarizing notes from the O'Neil Expedition, described the lake as follows (single quotations indicate quotes from the O'Neil notes):

> "Here the Skokomish River, no longer confined to its deep-cut valley, emerged from the mountains and broadened into a 'suddenly widening expanse.' The lake occupied a natural basin having a depth of about 200 feet, the stream flowing into the north end and out the south…The place was a paradise for fishermen because brook trout were large and plentiful, the 'red-spotted variety' running as high as fifteen pounds. The surrounding hills, thickly clad 'with forests of gigantic fir timber'…"

Downstream of the lake, the GLO surveyor William Jameson (1873) showed the river as being a single-threaded channel (Figures 4.11), as is normally the case for rivers below natural lakes. Wood (1976), capturing notes from the O'Neil Expedition, described this section of river as follows:

> "Below the lake the topography was broken, with bottomland intervening along the streams. Edged by virgin forests, the Skokomish was 'generally wide and shallow' and 'flowed with a gentle fall'…Although the scenery was picturesque and the fishing good, the river later rushed through 'a very bad gorge'…"

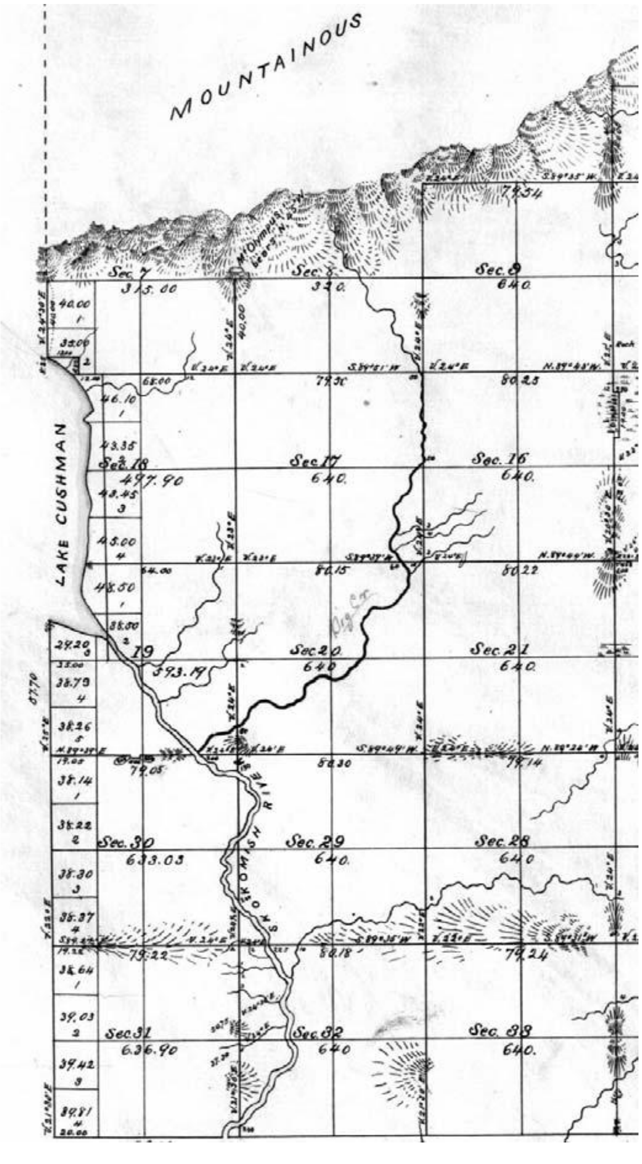

Figure 4.11. Map of the North Fork between the lower end of Old Lake Cushman and extending downstream to approximately one mile upstream of the site of the upper Cushman Dam (Cushman No. 1), as contained in the cadastral survey field notes and plats prepared by the General Land Office. The map shown here is from Jameson's survey in 1873. Big Creek is the large tributary entering from the east.

Jameson located the “bad gorge” as beginning at the location of the upper dam and extending downstream to a site upstream of the lower dam (Figure 4.12). He noted that the lower half of the gorge was “impassable” with respect to being able to survey the section boundaries through that reach—this is the likely vicinity of Big Falls.

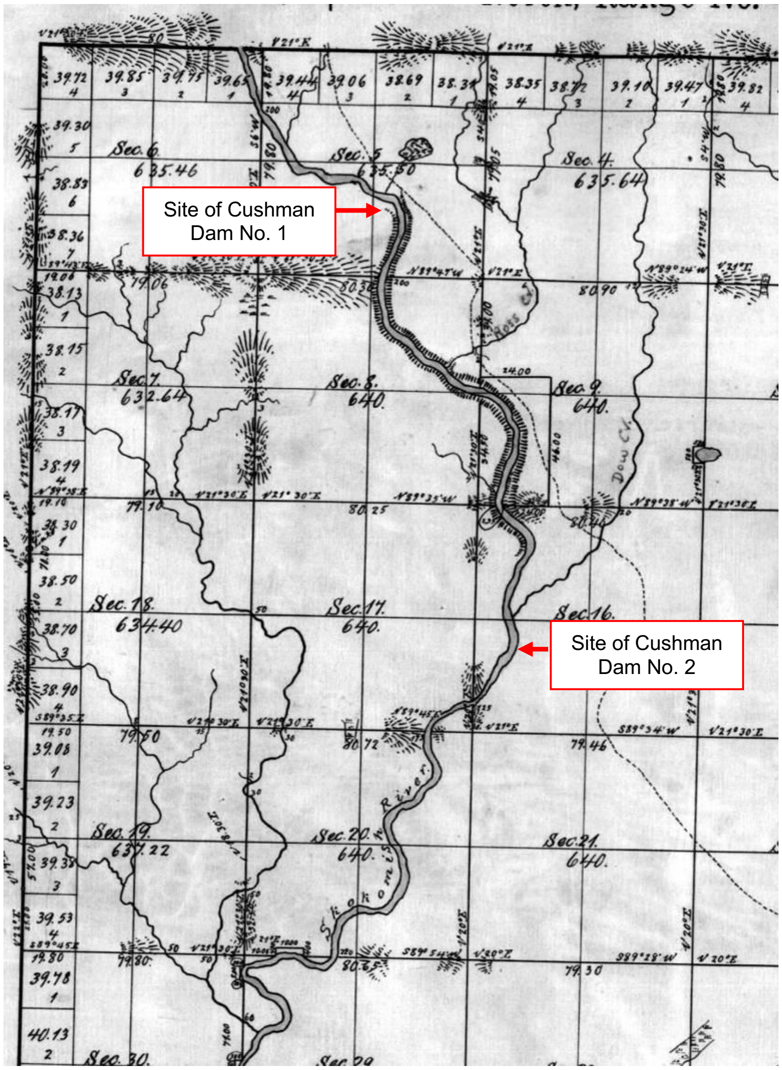

Figure 4.12. Map of the North Fork between a point (at top) approximately one mile upstream of the upper Cushman Dam (Cushman No. 1) extending downstream to near the mouth of McTaggert Creek (at bottom), as contained in the cadastral survey field notes and plats prepared by the General Land Office. The map shown here is from Jameson’s survey in 1873. McTaggert Creek is the large tributary entering from the west. Approximate sites of Cushman dams are located. The section of stream with hatch marks (between the two dam sites) along the banks delineates an area of extended steep canyon, the lower half being noted by the surveyor as impassible for surveying section boundaries.

Upstream of the historic lake, the land was flat, creating a wide floodplain dissected by relict channels and active multi-threaded channels (Figures 4.13-4.14). The GLO surveyor Clinton Pulcifer in 1892 described some of the attributes of the area as “land level Skokomish River bottom”, “soil 1st and 2nd rate”, “heavy timber & dense undergrowth”, and “land level mostly in old river beds and on bars.” This area would have been the most productive zone for the early-timed Chinook in the Skokomish watershed, where the wide floodplain enabled development of stable side channels—as seen in Pulcifer’s survey notes and map. It is very likely that numerous logjams existed due to the nature of the river and the old-growth trees present. The diverse river channels would have been especially productive for early-timed Chinook (Lestelle et al. 2005). Such habitats, closely associated with the lake downstream, would likely have made this the most productive area for early-timed Chinook in the Skokomish basin.

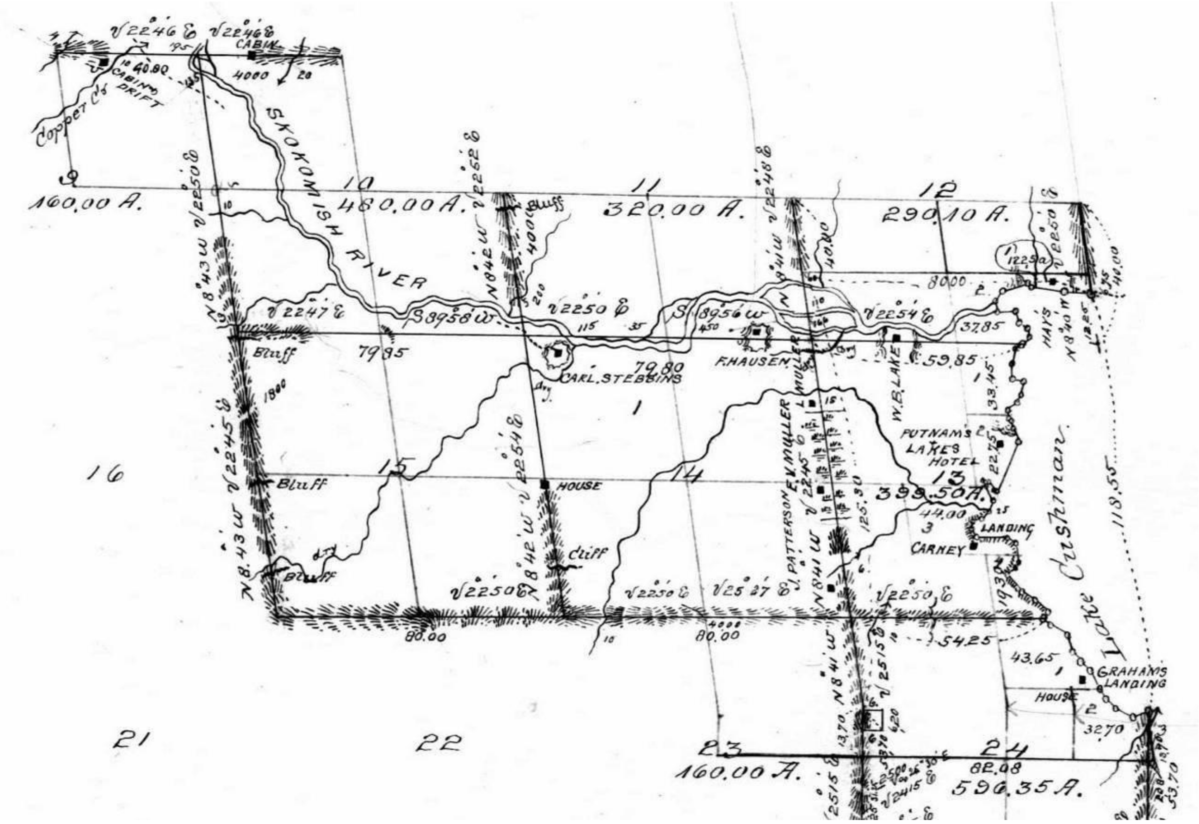

Figure 4.13. Sketch of the upper North Fork between the upper end of Old Lake Cushman and Copper Creek as contained in part of the cadastral survey field notes and plats prepared by the General Land Office. The map shown here is from Pulcifer’s survey in 1892. Copper Creek is located near the mouth of the river at the upstream end of the modern-day Lake Cushman.

The valley upstream of the lake narrows at the upper end of the modern-day reservoir, near the confluence of Copper Creek and the river. It is evident, therefore, that the reservoir inundated the entire section of river where the floodplain supported channel features most productive for early-timed Chinook.

Upstream of Copper Creek, the river and surrounding land is still largely pristine due to the presence of Olympic National Park. The river in this area is comprised of a mixture of channel types, with both tightly confined and moderately confined reaches (Figure 4.14). It is not known how far upstream the historic early-timed Chinook ascended the upper North Fork, but their limit can be assumed to have been downstream of RM 33 (Figure 4.15 bottom), approximately five miles upstream of the upper end of the modern-day lake.

Figure 4.14. The upper North Fork a short distance upstream of historic Lake Cushman ca. 1913, looking to the northeast. Used with permission by the University of Washington Special Collections.

Figure 4.15. Three reaches in the upper North Fork: top – downstream of Staircase Rapids; middle – upstream of Staircase Rapids; bottom – rockfall within gorge at approximately RM 33. Photos courtesy of Tacoma Power

Existing Condition

No upstream fish passage has occurred past the Cushman dams since their construction between 1926 and 1930. This resulted in the extinction of anadromous Chinook in the upper North Fork.

The modern-day Lake Cushman impounded by the upper dam is 9.6 miles in length and is contained by approximately 23 miles of shorelines. Covering slightly more than 4,000 acres, it inundates the large majority of the historic riverine habitat that comprised the spawning and early-rearing area used by early-timed Chinook in the North Fork (Figure 4.16).

A much smaller reservoir is impounded behind the lower dam and forms Lake Kokanee. It covers 150 acres.

The river upstream of the Lake Cushman is within Olympic National Park and is essentially unaltered by human activities. In this area, the river is comprised of a mixture of channel types, with both tightly confined and moderately confined reaches (Figure 4.15).

Figure 4.16. Lake Cushman as viewed from Mount Ellinor. Photo by Gregg M. Erickson. Used with permission.

Future Condition to Exist Under New License

The FERC license for the Cushman Project issued on July 15, 2010 stipulates that the Cushman Dams and associated reservoirs will remain in place for the next 40 years. Surface levels of the reservoirs will be kept at the same elevations as existed in recent decades.

The license requires that both upstream and downstream passage for migratory salmonids be provided at the dams. Measures are to be implemented between 2011 and 2013 to begin fish passage. The re-introduction of early-timed Chinook, together with other anadromous salmon species, will occur in conjunction with the implementation of fish passage.

Upstream passage will be provided through a trap-and-haul system to be installed at the lower dam. Returning adult salmon will be trapped at the base of the dam, then transported by truck upstream and released either directly into Lake Cushman or in the river where it enters the lake, depending on species. Terms of the license stipulate that the effectiveness of this operation is to be consistent with NOAA Fisheries passage standards as required for such facilities.

Downstream passage of juveniles emigrating out of Lake Cushman will be provided using a state-of-the-art Baker Reservoir style trap. The trap will be operated during all periods of the year when juvenile salmon are actively emigrating. Terms of the license stipulate that the effectiveness of this operation is also to be consistent with NOAA Fisheries passage standards.

It bears noting that the potential for the upper North Fork to produce early-timed Chinook through entirely natural reproduction over the life of the FERC license will be severely constrained by the limited amount of free-flowing river available for spawning. Moreover, the section of river that is still accessible is in the extreme upper end of the historic distribution and is sub-optimal for reproduction. The best habitats for spawning and rearing were inundated by the reservoir. Therefore, supplementation techniques will be necessary to help maintain the population in the upper North Fork. The population will be managed as an integrated population by regulating ratios of hatchery-origin and natural-origin spawners in both the natural and hatchery environments using HSRG guidelines.

To succeed in ultimately recovering a completely self-sustaining, naturally reproducing population of early-timed Chinook in the Skokomish basin will likely depend upon the re-introduction measures to be carried out in the South Fork. That stage of the recovery plan will follow re-introduction into the North Fork once a source of brood has been effectively established there to be transplanted to the South Fork.

Degraded Upper Watershed Conditions in South Fork and Vance Creek

The upper South Fork landscape was transformed within a few decades in the second half of the 20th century by the liquidation of most of its old growth forest and development of the associated road infrastructure. The forest, which developed over thousands of years—and had been mostly without disturbance for hundreds of years—was cut in a relatively brief period. To accomplish this, a network of hundreds of miles of roads was built throughout the subbasin (USFS 1995), much of it on steep hillslopes susceptible to mass wasting. These changes accelerated sediment delivery to water courses and, in turn, to the main channels of both the South Fork and Vance Creek. Other associated changes occurred, including alterations to riparian structure, runoff patterns, and in-channel large wood jams.

The combined effects of these alterations de-stabilized the main channels, increased amounts of exposed sediments within the active channels, and—with little doubt—increased sediment transport rates to the lower river valleys, all of which continue to the present. Other changes, far-reaching ones, are believed to have followed as a result. Notably, increased sediment transport to the lower valleys has likely contributed significantly to the enormous changes to the floodplains and channels of the lower rivers and related flood frequency (see section Lower River Floodplains and Channels). All of these changes are believed to have had important roles in the extirpations of both the early-timed Chinook in the upper South Fork and of the late-timed Chinook in the lower basin.

The geographic scope of this threat as presented here is defined to be the upper South Fork subbasin, i.e., from the lower end of the canyon at RM 3.4 and continuing upstream, and the entirety of Vance Creek. Between RM 3.4 and RM 9.7, the South Fork flows through gorge reaches interspersed with a few less confined reaches. It emerges from the upper gorge into an alluvial valley having deep glacial sediment deposits. The valley continues upstream to approximately Steel Creek at RM 22.9. Historically, early-timed Chinook spawned over the entire length of this alluvial valley.

Historic Condition

Prior to the mid-20th century, the large majority of the South Fork subbasin was covered by an old growth coniferous forest. But it had not always been that way. Glaciations, notably the Puget Lobe of the Cordilleran ice sheet, advancing from mountains in British Columbia, extended as far as the mid section of the South Fork subbasin at least twice in the past (Long 1975). In addition, alpine glaciers originating in the Olympic Mountains also pushed into the upper valleys, contributing to a diverse set of glaciated conditions in the Skokomish watershed. Some understanding of these conditions is important to diagnosing the state of the modern day river.

The South Fork alpine glacier advanced and retreated at least three times during the most recent glacial advance, which ended about 10,000 years ago, leaving large coarse and fine-grained deposits throughout the upper valley (Long 1975; STC and WDNR 1997). Extensive, deep deposits left by this glacier extend downstream to LeBar Creek (RM 13.5), where they are intermingled with larger deposits left by the most recent advance of the Puget Lobe of the continental ice sheet.

Glacial deposits record two advances of the Puget Lobe into the South Fork, an earlier one that extended two miles upstream of LeBar Creek and a more recent one reaching nearly as far (Long 1975). The terminus of the most recent advance was in the vicinity of the confluence of LeBar Creek, the glacier having pushed down into the LeBar and Brown creek drainages after overtopping the hills to the east and also filling the lower Skokomish valley. This advance also pushed up into Rock Creek and Vance Creek, lower in the South Fork. The height of the continental glacial ice has been mapped at about 2,000 ft along the Olympic Mountain front near Vance and Rock creeks (Long 1975; STC and WDNR 1997).

Each of these glacial events left massive amounts of glacial material in the Skokomish valleys and veneered on the hillslopes. Large lakes were impounded by ice dams within the basin at different times (Bretz 1913; Smith et al. 2007), and because the ice sheet blocked access to the Pacific Ocean via Puget Sound, the Skokomish River diverted to the ocean through the Chehalis basin to the south (Thorson 1980). As the Puget Lobe made its final retreat from the Skokomish basin about 14,000 years ago, hundreds of feet of glacial sediments were left deposited in the South Fork subbasin as far upstream as LeBar Creek. These events produced periods of enormous instability in the watershed.

The relatively rapid retreat of the glaciers left highly unstable conditions on the hillslopes and within the river valleys. Meltwater undoubtedly produced significantly higher flows than occurs in the modern river (Church and Ryder 1972), providing a means to move massive quantities of sediment downstream and to accelerate the forming of the gorge reaches in the river system (STC and WDNR 1997). Post-glacial processes, producing such accelerated geomorphological activity by the rapid retreat of the glaciers, have been referred to as paraglacial processes (Church and Ryder 1972).

Church and Ryder (1972) described these processes as "non-glacial processes that are directly conditioned by glaciation." The paraglacial concept is important to understand the changes that have occurred to the upper South Fork, as well as those in the lower river, since the mid 20th century.

Deglaciated landscapes often undergo rapid adjustment to non-glacial conditions through enhanced processes, such as slope failure, debris flows, and fluvial reworking of sediment. These conditions constitute the operation of paraglacial processes. The paraglacial period, which can last hundreds of years following glacier retreat, is defined as the timescale over which the glacial sediments are essentially exhausted or attain stability in relation to being reworked by various processes (Ballantyne 2002a). Once this has happened, the sediment transport system can be said to have reached an equilibrium of sorts, or a non-glacial state, in which sediment yield is indistinguishable from that occurring from primary erosion of land surfaces.

The re-establishment of vegetation, particularly trees, is important in the transition towards a stable state following glaciation. In the Pacific Northwest, trees took hold in the river valleys relatively soon after deglaciation, indicating a rapid transition to a non-glacial climate without an intervening stage of tundra vegetation (Clague 1981). As the temperate forest became re-established, sediment supply rates to the rivers diminished and river channels transitioned to greater stability (Brierley 1983). These conditions served to greatly slow, or arrest, the releases of paraglacial sediments into river systems. This would have been the progression in the Skokomish watershed.

Figure 4.17 illustrates the degree of stability that can exist in a river valley formerly affected by paraglacial processes as a result of a re-established forest. The entire valley seen in the photo was at one time glaciated and would have undergone considerable instability through subsequent paraglacial processes. Collins et al. (2003) explains that the stability of this type of river is affected strongly by two factors: dense stands of large trees that have become established throughout the river valley corridor and by large log jams associated with the channels. In this condition, channel avulsions typically occur by the active channel switching to a relic channel without wholesale destruction of vegetated islands. This serves to maintain a relatively high degree of stability to the channel network over hundreds of years. The standing large trees act as hard points to facilitate channel switching and the jams serve to help regulate flow through overflow and active side channels. The river channel in this condition is said to be in equilibrium, i.e., neither aggrading nor degrading.[16] In this state, the river achieves a balance

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[16] / River profiles are theorized as being essentially stable over a period of years, more or less achieving a balance between erosion and deposition, hence achieving a sort of steady state equilibrium. In this state, the river is referred to as a graded stream, one in which the slope, velocity, and discharge combine to transport its sediment load with

between its sediment transporting capacity and the amount of sediment delivered to it. It can reasonably be assumed that the South Fork, as well as the lower Skokomish River, achieved such a state at some point following deglaciation.

Figure 4.17. Taiya River valley in Southeast Alaska, illustrating the extent of channel stability that exists in this glaciated drainage. Picture taken from QIN and Herrera Environmental Consultants (2008). Photo by T. Abby (2002).

A river formerly subjected to paraglacial processes, but attaining an equilibrium state, can be sensitive to external perturbations that can re-activate paraglacial sediment transport (Ballantyne 2002a). Once re-activated, perhaps as a result of some threshold being reached (e.g., Schumm 1977), the channel network can again go through a period of considerable instability and floodplain unraveling. Sediment stores stabilized and held in place by the river corridor forest are thereby retapped as the floodplain unravels. Types of perturbations possible in pre-developed watersheds are tectonic uplift, climate change, extreme climatic events, and anthropogenic activity (such as burning or deforestation by aboriginal peoples). Figure 4.18 illustrates the influence of external perturbations on the temporal pattern of paraglacial sediment release, in this case due to extreme rainfall events. Re-activated paraglacial sediments are attributed to secondary paraglacial processes, where significant re-entrainment of sediments stored in valley fills can occur well after the original paraglacial period has ended (Ballantyne 2002a). Once such instability had recurred, recovery time to regain equilibrium could be considerable and would depend on the extent of disturbance that occurred.

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neither erosion nor sedimentation (Mackin 1948). Land or water uses can disrupt this balance, leading to large redistributions of erosion and deposition zones, reshaping the channel as forces operate to move conditions to a new equilibrium (Norman et al. 1998). The graded stream concept is generally held to be valid over intermediate time scales even though a valley will evolve (e.g., incise or aggrade) over very long periods of time (Schumm 1977). Dynamic equilibrium describes how over such long time periods, the channel is continuously adjusting to changes in discharge and sediment load, causing fluctuations about an average trend.

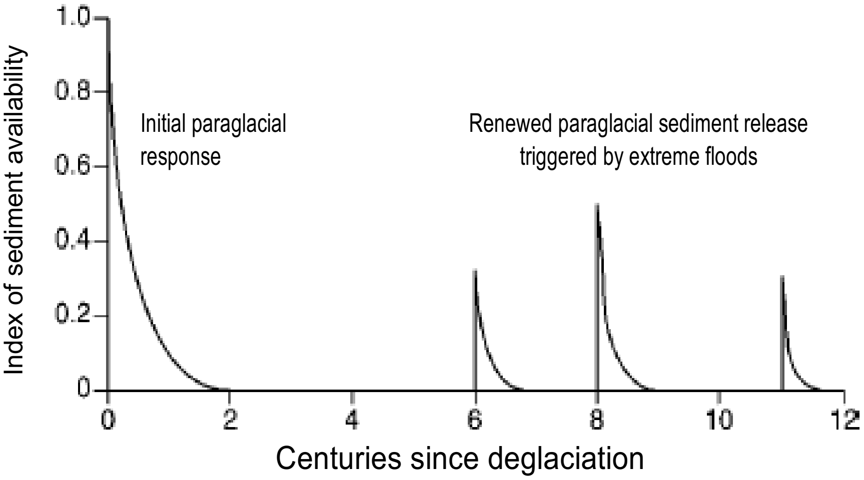

Figure 4.18. Influence of external perturbation on the temporal pattern of paraglacial sediment release. Here, the pulses of renewed paraglacial sediment would be triggered by extreme rainstorm events. From Ballantyne (2002b).

The upper South Fork appears to have been in a state of equilibrium during the early part of the 20th century. Based on a review of aerial photographs taken in 1929, STC and WDNR (1997) reported that the South Fork subbasin upstream of its lower valley at that time "consisted of an unbroken carpet of huge conifer trees." Only the largest portions of the mainstem channel could be seen in the 1929 aerial photos beneath the thick forest canopy. Although the same channel pattern was evident as exists today, active channel widths were much narrower than occur currently. Approximately 90 to 95 percent of the riparian areas examined in the analysis was classified as "Coniferous Old and Dense," with good canopy cover. The authors of the 1997 watershed analysis stated:

> "Further confirmation of the previous existence of conifer stands (within the riparian areas) was found in field observations. Large conifer stumps were found in the riparian areas of all segments for which stump information was recorded."

Large log jams within the South Fork channel were also visible in the 1929 photos (STC and WDNR 1997; Bair et al. 2009). Wood jams, frequently large ones, are a common feature of the pre-management condition in rivers on the Olympic Peninsula (Fox and Bolton 2007).

Based on vegetation patterns found today in nearby watersheds within the Olympic National Park, it can be assumed that the coniferous forest in the historic South Fork was interspersed with some deciduous trees within riparian corridors and on the scars of burns and landslides. Prior to the modern period of forest management, the principal disturbance factor in the upper South Fork watershed was fire. Both the 1995 and 1997 watershed analyses presented a fire history of the watershed dating back to the year 1250 (USFS 1995; STC and WDNR 1997). It was determined that no large fire has burned in the watershed since 1834, when a fire burned approximately 2,500 acres, about 4 percent of the watershed. The last very large fire occurred in 1701, which burned approximately 34,000 acres, about 50 percent of the watershed. Prior to

1700, large fires occurred about once every 200 years. The largest events probably resulted in periods of destabilized channels and heightened sediment transport as secondary paraglacial processes were activated, in addition to erosion from burned hillsides.

Besides fire, landslides have always been a cause of disturbance within the natural forest in the upper South Fork. There is no reason to suspect, however, that erosion and mass wasting rates were any higher than in other Olympic Peninsula watersheds.

Soils in the South Fork subbasin in general are of low erodibility on lower relief and moderately to highly erodible on steeper relief when exposed to direct rainfall and runoff (STC and WDNR 1997). Fires and landslides are the factors that would have exposed these soils to active erosion in the historic condition.

In its natural state, the South Fork had a dynamic flow regime. While the Skokomish basin is generally drier than the Pacific side of Olympic Mountains, annual precipitation is still high with an average of about 134 inches in the upper basin (Canning et al. 1988). The level of the two-year peak flow (the highest flow that occurs on average every other year) generated per square mile of drainage area in the South Fork is among the highest in Western Washington (see Table 4.4 in section Lower River Floodplains and Channels). It should be noted, however, that the high intensity of storm events should not have caused a greater frequency of flooding in this subbasin compared to other rivers in Western Washington. Channel capacity for runoff is normally determined by the size of the peak event that occurs on average once every 1-2 years (Leopold et al. 1964; Gordon et al. 2004). There is no reason to suspect an anomalous pattern in the Skokomish watershed.

Approximately one-half of the South Fork subbasin is within the rain-on-snow zone (also called the transient snow zone), located between about 1,400 and 3,600 feet (STC and WDNR 1997). The rain-on-snow zone is the portion of the landscape in which timber harvest is most likely to affect hydrologic processes and peak flow generation.

All of the conditions known to have existed in the upper South Fork prior to the advent of logging are consistent with a Western Washington river that would have been in a state of equilibrium. Erosional and depositional processes within the channel network would have been more or less in a state of balance. In-channel habitat conditions can be assumed to have been highly productive for supporting the South Fork Chinook spawning aggregate.

The remainder of this section dealing with the upper South Fork examines the response of the river to escalating logging beginning in the middle of the 20th century. Insights are gained by looking at how the river changed as commercial logging progressed through the subbasin.

Existing Condition

By the mid 1990s, approximately 80 percent of the South Fork subbasin had been logged (Table 4.2). Logging accelerated greatly in the second half of the 20th century, then declined sharply near the end of the century.

Table 4.2. Estimated number of acres logged by period in the South Fork subbasin through 1995. The subbasin is 105 square miles in size (67,200 acres). From USFS (1995).

Years	Acres
pre 1915	6,000
1916-1935	6,000
1936-1955	13,950
1956-1975	14,511
1976-1985	12,232
1986-1995	6,179
Total	58,872

A description of the progression of logging in the South Fork follows. The timeline is important for interpreting observed changes in the South Fork channel.

Small logging operations, including land clearing for farming, occurred along the lower South Fork and Vance Creek between about 1887 and 1920 (Amato 1996; STC and WDNR 1997). In the early years, log driving on the river was used to float logs to the river mouth. These operations appear to have been conducted entirely downstream of the gorge on the South Fork.[17]

Large-scale clearcutting upstream of Vance Creek and in the Vance Creek drainage began in the late 1920s and early 1930s. Between about 1930 and 1948, about 12-13 percent of the South Fork was cut, mostly in the lower parts of the subbasin.

In 1946, the Shelton Cooperative Sustained Yield Unit (CSYU) was created through the cooperation of the USFS and the Simpson Timber Company. The CSYU agreement covered approximately 60 percent of the entire South Fork drainage, combining into one management area lands held by Simpson Timber and the USFS. While its stated purpose was "sustained yield", the rate at which logging then progressed was anything but sustainable. Once the agreement was implemented, logging progressed rapidly.

The 1951 aerial photos show logging was moving up into the South Fork from the lower part of the subbasin. By that year, road building and clearcutting had progressed along the north side of the river as far upstream as Brown Creek (RM 12.8). Clearcutting was nearly continuous along that side of the river, including within the riparian corridor, to the limit of Brown Creek. Logging had still not moved into upper Brown Creek. On the south side of the river, logging had progressed only as far upstream as RM 9.5, as well as into the mid section of Rock Creek (RM 8.7). The road networks into these areas were extensive. The photos give no visual evidence of any road building or logging further upstream on the river's south side beyond that point.

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[17] / We found no evidence to suggest that log driving occurred anywhere upstream of the gorge. Any logging of near-stream coniferous forest in that area would have been extremely minor if it occurred.

In 1952, another event occurred that further spurred the rate of logging into the subbasin. A third Cushman Dam was proposed to be built, this one to be located at RM 9.5 on the South Fork.[18] Preparations for moving forward with the project were put into place, resulting in extensive, rapid logging of the lower end of the proposed reservoir area during the 1950s. Eventually, the plan was abandoned due to the discovery of a geologic fault line (Bair et al. 2009), but in the meantime it accelerated logging into the upper South Fork. The 1962 aerial photos show that a wide swath of the river valley had been clearcut between the proposed dam site and LeBar Creek (RM 13.5), as well as the lower valleys of Brown and LeBar creeks. Clearcutting occurred within the riparian corridors also, most likely including any forested islands within the channel network. In addition, log jams were removed from the river (Bair et al. 2009), presumably to clear the channel of wood that might interfere with construction activities.

The 1962 aerial photos document the extent of logging into the upper South Fork at that time. Logging, including road building, had not progressed past LeBar Creek on the north side of the river. But on the south side, very extensive logging and roading had occurred as far upstream as Pine Creek (RM 19.2). Extensive clearcutting had occurred in both Cedar (RM 17.9) and Pine creeks, as well as into several tributaries downstream of Cedar Creek. The road network, while not completely finished in these areas, was well developed, with many spurs branching into the patch quilt of clearcuts. A relatively wide buffer strip was left intact between LeBar Creek and Pine Creek along the mainstem South Fork. However, clearcutting to the stream banks had occurred in many reaches of the various tributaries. Upstream of Pine Creek, the mainline road to Church Creek (RM 21.4) had been built.

After 1962, logging accelerated even faster (STC and WDNR 1997). It reached its peak in the late 1970s and early 1980s, then slowed dramatically after 1986. By then, the road network and clearcutting had been pushed into the headwaters of all of the tributaries up to and including Church Creek, as well as further up along the hillslopes slightly beyond Steel Creek (RM 22.9) and into that drainage. Within a few years of 1986, the large majority of the subbasin's old growth forest was gone. Since the mid 1990s, logging has occurred primarily on private timber lands in the South Fork aimed at harvesting second growth trees.

By the mid 1990s, there were approximately 470 miles of State, Federal, County and private roads within the South Fork subbasin (USFS 1995). The road density by subdrainage at that time varied from a high of 6.0 road miles per square mile to an overall average for the entire subbasin of 2.8 road miles per square mile. Since then a substantial number of roads within federal lands has been decommissioned. Existing policy within the National Forest in the watershed is to minimize future road construction and decommission or permanently close many existing roads. Some roads have been decommissioned on private lands also. Also, both federal and private road networks are being managed better through maintenance programs to reduce hydrologic and sediment impacts and minimize culvert failures.

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[18] / The proposed dam would have created a large reservoir, inundating approximately ten miles of the mainstem South Fork, as well as the lower ends of Brown and LeBar creeks (1957a). The upper end of the reservoir would have been in the vicinity of Pine Creek (RM 19.2). Water was to be diverted out of the South Fork through a four mile tunnel to Lake Cushman, then eventually discharged to Hood Canal through the Cushman No. 2 diversion out of the basin. The dam would have been over 300 ft high, roughly 75 ft higher than Cushman Dam No. 1.

As the primeval forest was cleared and converted to a new, younger one, changes in watershed processes and forms relating to aquatic habitat followed. Major changes occurred in sediment delivery, flow characteristics, riparian structure and wood loading, and channel dynamics. These are described below.

The development of the road network across the subbasin was a catalyst for increasing the amount of sediment delivered to stream courses. As part of the 1997 watershed analysis, aerial photo analysis revealed that 584 landslides had occurred in the South Fork between 1946 and 1995. Most were associated with the road network and, according to the authors, presumably would not have occurred in the absence of forest management (STC and WDNR 1997). Mass wasting was estimated to have increased by 209 percent over background levels (assumed historic rate) throughout the areas affected by forest management. In the areas most heavily logged and roaded, the average rate of increase was estimated to be 380 percent more than background.

The amounts of sediment generated by forest management activities in the South Fork were estimated to be large in the 1997 watershed analysis. Despite this fact, it bears noting that the authors downplayed its significance to sediment processing and channel stability in the watershed. In general, their conclusion was that the quantities of sediment generated by logging-related activities were small compared to the natural (pre-logging) amounts, mainly of glacigenic origin, stored both within the active channel and the vegetated streamside terraces of the South Fork. By inference, the conclusion was that any effects to the system would have been minor. In reaching this conclusion, the authors relied upon an older analysis of a reach in the upper South Fork near Church Creek described in the 1995 watershed analysis. The older analysis had concluded that the upper South Fork was a naturally dynamic, sediment rich stream that was prone to avulse, and in doing so continually reactivated sediments stored along the river. The reasoning was rooted in a conclusion reached by Everest (1981) as he considered the effects of forest practices in the upper South Fork; he stated:

> "The instability of the South Fork is a historic characteristic and is apparently not related to recent timber management activities in the watershed."

Everest's conclusion was based on an interpretation of how the river channel appeared to have changed in the vicinity of Church Creek (RM 21.4) between 1929 and 1962 based on review of aerial photos in those years. The vicinity of Church Creek had not yet been logged prior to 1962, as noted above, except for the building of the mainline road to that area. Everest saw evidence of channel avulsions in the vicinity and concluded that they could not have been due to logging.[19]

The authors of the 1997 analysis added that flood history combined with the large amounts of glacigenic sediments stored in the streamside terraces were responsible for the instability in the watershed, including in its natural state. The authors, based on how much sediment had been added by logging related landslides compared to the huge amounts of glacigenic sediments stored in the river valley, stated:

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[19] / The Everest (1981) analysis was prepared as part of an affidavit in response to a lawsuit brought in 1980 by the Skokomish Tribe and a local environmental group charging that forest harvest practices in the upper South Fork were unsustainable and negatively affecting fisheries resources. F. Everest was an employee of the USFS. The case was dismissed by the court.

> "These data strongly suggest that management-related mass wasting does not have a strong effect on channel sedimentation in the upper South Fork. This implies that erosion of terraces and/or increased rates of sediment transport and /or bank erosion related to flood history are the primary processes determining the pattern of sediment deposition and channel migration in the upper South Fork Skokomish."

They further added that the bulk of coarse sediment produced since forest management began in the upper South Fork was unlikely to have been transported to the confluence of the North and South forks. On the other hand, they did conclude that management induced mass wasting in upper Vance Creek had at that time contributed significantly to aggradation in the upper alluvial valley of Vance Creek.

These conclusions will be considered in light of other information presented below, as well as in the section on Lower Valley Floodplains and Channels.

The 1997 watershed analysis found that timber management had altered the runoff pattern in the South Fork subbasin (STC and WDNR 1997). The analysis indicated that forest harvest activities had increased winter storm volumes by upwards to 18 percent compared to what would have been expected without logging. Increases in flow were believed to have occurred by extending the duration of high flow, but in such a manner that peak flows were not increased. The authors stated:

> "These results indicate that timber management in the South Fork watershed increases the volume of storm flows by broadening storm hydrographs and increasing the durations of high flows. Volume increases are in the range of 8 to 18 percent. These increases in storm volumes could translate to increases in sediment transport and channel disturbance."

The authors explained the increase in storm runoff volume because "areas converted to roads will necessarily deliver more water during rainstorms, and clearcuts will deliver a greater volume of water during rain-on-snow events."

It should be noted that the authors' conclusion given above, i.e., increased storm volumes could translate to increases in sediment transport and channel disturbance, contradicts what they stated elsewhere in the same report that the instability of South Fork was due to flood history and was a natural pattern.

Logging of the upper South Fork also altered the integrity of the riparian corridor and in-channel wood jams. This is especially true in the unconfined reaches between the lower gorge and LeBar Creek (RM 13.5), where the riparian stands had been leveled and logjams removed in preparation for building the proposed dam at RM 9.5 (Bair et al. 2009). Upstream of that point, the riparian corridor along the mainstem South Fork was described by STC and WDNR (1997) as having a mixed composition, with some reaches having been logged to the active channel and others with leave strips of mature confers still intact.

The 1997 watershed analysis examined changes over time in the apparent amounts of exposed sediments within the active channel of the upper South Fork and Vance Creek (Figure 4.18).

These results are striking and provide the key to understanding how the channels in these areas responded to forest harvest. By closely examining a time series of aerial photos, the authors calculated the surface areas of exposed (i.e., unvegetated) sediments within the active channels. These surface area measurements made over relatively long lengths of channel, then divided by the channel length, produced a relative index of the average widths of the active channel. The index represents the relative amounts of sediment in temporary storage within the active channel that would be mobilized during the typical two-year flow event. As such, changes in the index reflect the degree of channel shifting, bank erosion, and bedload sediment transport over time.

The change over time in the channel width index is shown for four reaches in the upper South Fork and Vance Creek (Figure 4.19; Table 4.3). The most downstream reach in the South Fork (Oxbow reach) is contained within the area that was clearcut in the 1950s in anticipation of the new dam to be built. This reach encompasses a naturally confined section located in an oxbow of the river, as well as an unconfined section. The Mid South Fork reach is located between LeBar Creek (RM 13.5) and Cedar Creek (RM 17.9). The upper reach in the South Fork, called the Cedar SF reach, is located between Cedar Creek and Pine Creek (RM 19.2). These three reaches represent a general range of confinement from least confined to most confined as one moves upstream. One reach is located in Vance Creek.

Table 4.3. Locations of the four reaches analyzed for temporal changes in active channel widths.

Reach name	Location
SF Oxbow	Mainstem South Fork downstream of Brown Cr; 2.1 mi reach.
Mid SF	Mainstem South Fork between LeBar and Cedar Crs; 1.4 mi reach.
SF at Cedar Cr	Mainstem South Fork between Cedar and Pine Crs; 2.1 mi reach.
Lower Vance Cr	Vance Cr from canyon mouth to upper County Road bridge; 1.8 mi reach.

The patterns of change in the relative widths of the four reaches track closely with the progress of logging in the subbasin, though it appears from Figure 4.19 that the Oxbow reach is an exception in that it does not show the same level of change. A more recent analysis by Bair et al. (2009) presented clear evidence that logging severely impacted that reach—some of that evidence will be presented below after first considering the reaches upstream of the Oxbow reach.

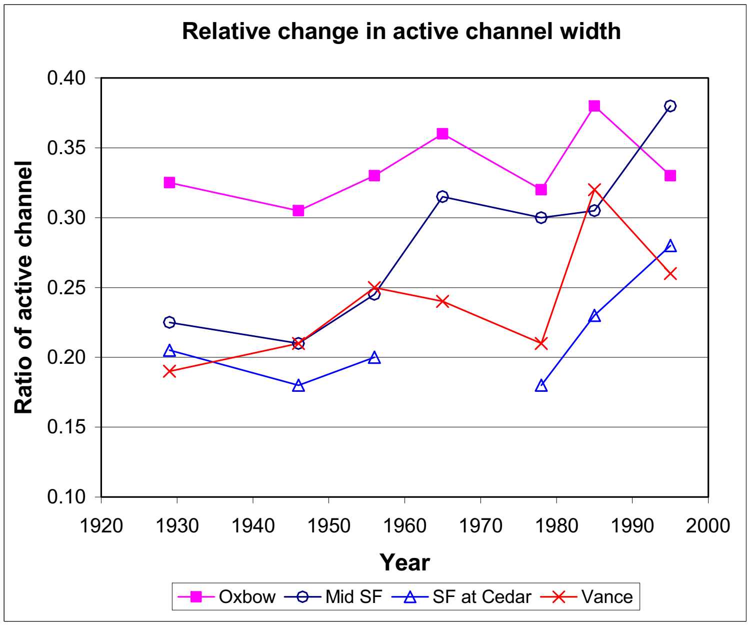

Figure 4.19. Temporal changes in the channel width index for four reaches in the South Fork subbasin. The index represents the relative width of the active channel (unvegetated channel zone) computed from analysis of aerial photos as reported by STC and WDNR (1997). The reaches within the mainstem South Fork are Oxbow (downstream of Brown Creek), Mid SF (between LeBar and Cedar creeks), SF at Cedar (between Cedar and Pine creeks), and Vance Creek. No data existed for SF at Cedar in 1965. Figure is adapted from STC and WDNR (1997)

The two reaches upstream of the Oxbow reach show a strong correspondence with the progression of logging and road building, with the most dramatic change occurring in the Mid SF reach. Index ratios seen at the Mid SF and the Cedar SF reaches in 1929, 1946, and 1956 show levels of variation presumed to represent natural conditions, as little or no logging had yet occurred upstream of them.[20] The ratio sharply increased in 1965 at the Mid SF reach. No data existed that year for the Cedar SF reach. Ratios leveled off in the Mid SF reach in 1978 and 1985, then increased sharply again in 1995. The data show essentially no change in the ratios at the Cedar SF reach prior to 1985 and sharp increases in both 1985 and 1995. The 1995 values were 68 percent and 44 percent greater than the averages of the values prior to 1965, which represent the pre-logging state, in the Mid SF and Cedar SF reaches, respectively.

The patterns in the responses in the Mid SF and Cedar SF reaches reflect differences in the morphology of the two reaches and rates of logging that had occurred upstream of the reaches prior to the dates of the photos. Differences in the history of glaciation between the two reaches may also be reflected. The Mid SF reach is located between LeBar Creek (RM 13.5) and Cedar Creek (RM 17.9) and the Cedar SF reach is between Cedar Creek and Pine Creek (RM 19.2). The Mid SF reach has only a small amount of naturally confined sections, while the Cedar SF has a substantial amount of natural confinement.

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[20] / Some road building and logging may have recently begun upstream of the reaches, but if so, it would have been very minor.

In all years representing periods when logging had occurred upstream of the two reaches (i.e., beginning with 1965), differences exist between the two reaches in how much logging had occurred that could have affected each reach. These differences account for the amount of logging that occurred between Cedar Creek and LeBar Creek, including within Cedar Creek, none of which would have affected the Cedar SF reach. The greater amount of logging to have potentially affected the downstream reach was substantial.

It may be noteworthy that the Mid SF reach was subjected to glaciations from both alpine and continental glaciers. The advances of the Cordilleran ice sheet stopped somewhere between Cedar and LeBar creeks. Therefore, the Cedar SF reach was affected only by alpine glaciers. A greater increase in instability seen in the Mid SF reach compared to the Cedar SF reach corresponding with logging may reflect a difference in sensitivity of the reaches due to their glacial histories.

The conclusion drawn here is that the stability of both of these reaches has been strongly affected by logging practices. This conclusion is in stark contrast to those presented in both the 1995 and 1997 watershed analyses. While the authors of those documents acknowledged that changes had occurred in runoff patterns and sediment loading, they stopped short of recognizing a change in channel stability corresponding to logging. Instead, they suggested that the South Fork was naturally dynamic, and therefore channel stability and sediment transport did not reflect logging histories. They argued that the volume of sediment added by logging-related mass wasting was too little prior to 1965 to produce the effect seen in the Mid SF reach displayed in Figure 4.18.

The hypothesis set forth in this recovery plan is profoundly different. It is that the close correspondence between change in channel stability and logging/road building history reflects a very high level of sensitivity of these channels to the combination of disruptions that occurred due to logging, of which mass wasting was only one part. Such sensitivity would suggest that the South Fork in its natural state was prone to a degree of destabilization, but its extent was limited by processes governed by the old growth forest. Large-scale logging, when added to the natural tendency for some level of destabilization, pushed the system beyond a threshold, which destabilized the channels and started a process of unraveling that was then exacerbated as logging accelerated.

A series of aerial photos is presented in Figures 4.20 to 4.22 to visually show the amount of destabilization that has occurred in the upper South Fork upstream of LeBar Creek to the vicinity of Church Creek. The photos are for 1939, 1951, and 2006, the only years of photos readily available to the authors of this plan. The years 1939 and 1951 show conditions in their pristine state, while 2006 shows conditions approximately 10 years after the 1997 watershed analysis was completed. Figure 4.20 shows the active channel downstream of Pine Creek (RM 19.2) to about RM 15.0. Figure 4.21 provides a closer detail of a section downstream of Cedar Creek for examining the wetted channel pattern within the active channel corridor. Figure 4.22 shows changes to the active channel between Pine and Church creeks (RM 19.2 to 21.4). It is noteworthy that the channel in the area of the confluence with Church Creek shows a degree of destabilization in the 1951 photo, which is likely what Everest (1981) saw in the 1962 photos. It appears that there was channel switching between relic channels, as described earlier for channels flowing through an old growth forest, but not extensive unraveling.

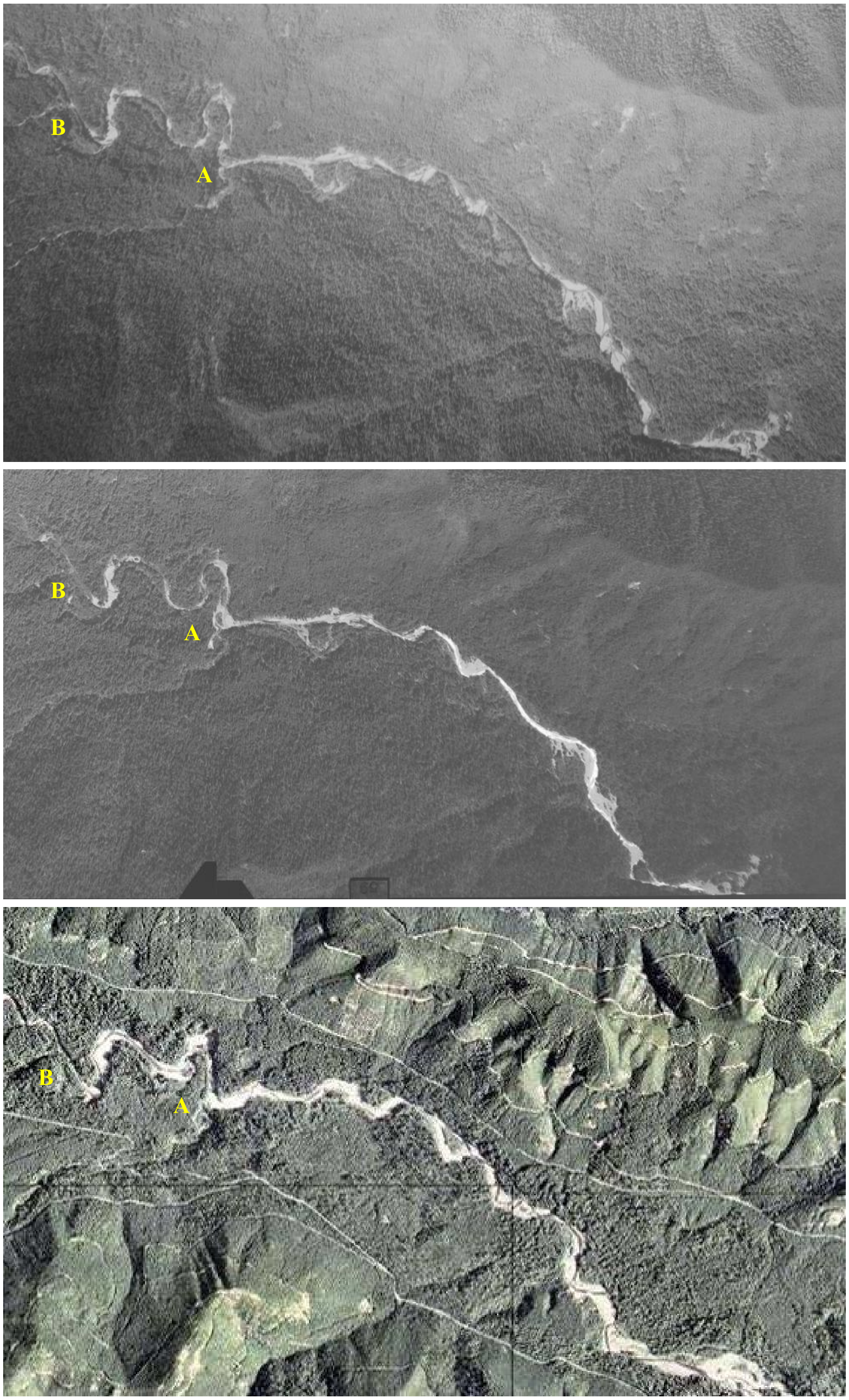
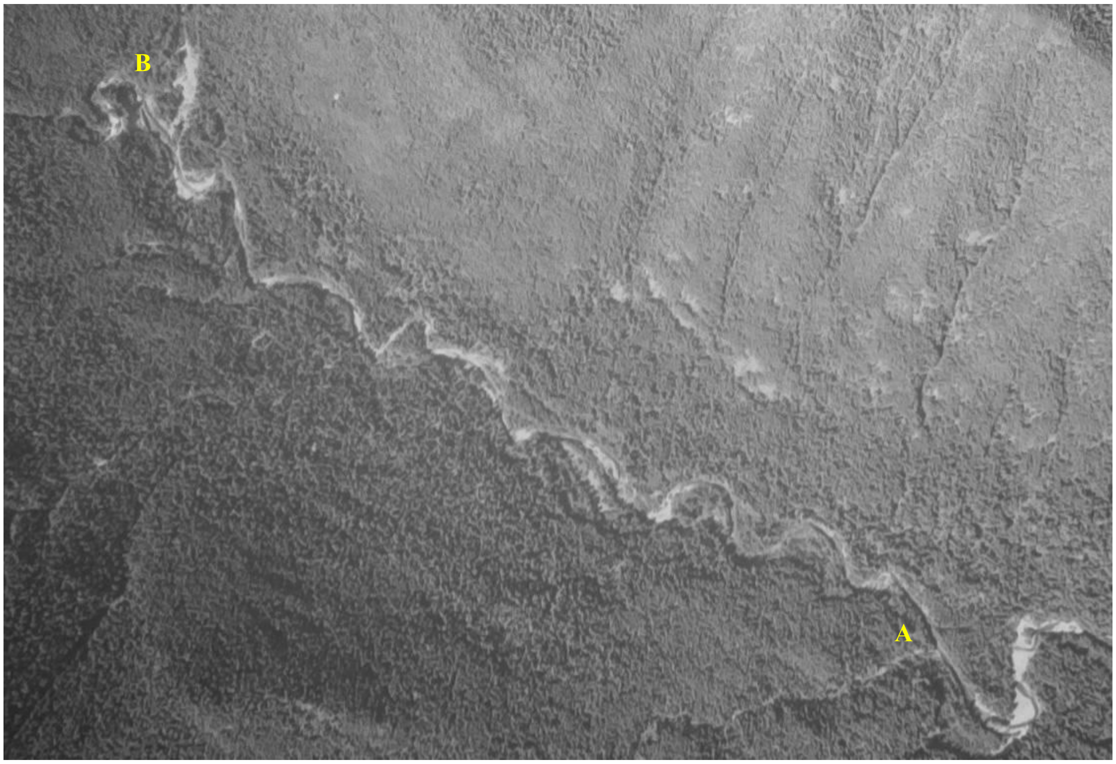


Figure 4.20. Aerial photos of the upper South Fork between approximately RM 15.0 (lower right) and 19.2 in 1939 (top), 1951, and 2006. The confluences of Cedar and Pine creeks are marked A and B, respectively. Scale is the same in all of the photos.

Figure 4.21. Enlarged view of a section of the reach shown in Figure 4.19 in 2006. The confluence of Pine Creek is seen at far left and that of Cedar Creek to the left of center near bottom.



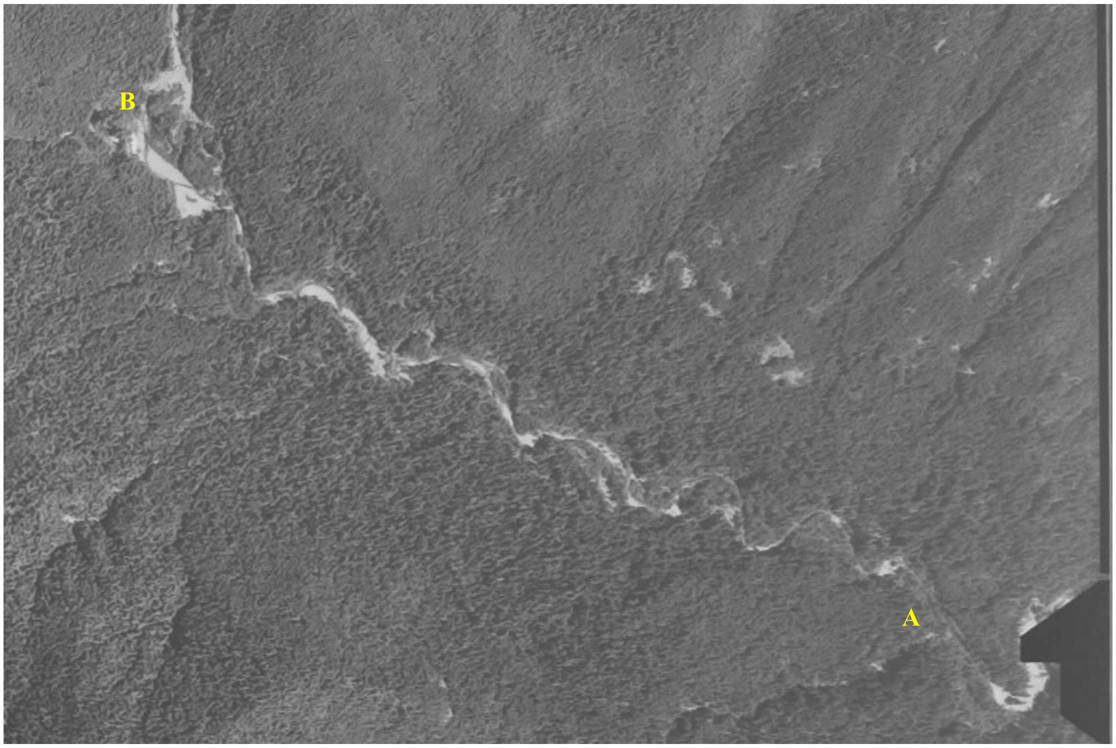


Figure 4.22. Aerial photos of the upper South Fork between approximately RM 18.7 (lower right) and 21.6 in 1939 (top), 1951, and 2006 (next page). The confluences of Pine and Church creeks are marked A and B, respectively. Note the area of channel avulsion seen in the vicinity of Church Creek in 1951. There is some distortion between the 1939 and 1951 photos. Scale is the same in all photos.

Figure 4.22 continued.

Vance Creek also exhibited an upward trend in the channel width index ratio corresponding with logging history (Figure 4.19). It is uncertain why the 1978 data point showed a drop in the ratio value, but overall the pattern is consistent with that seen in the reaches in the upper South Fork.

The relative index width in Figure 4.18 does not show as significant of a response to logging in the Oxbow reach of the South Fork, which is located downstream of Brown Creek (RM 12.8), though it has a similar trend. The reach is called the Oxbow reach because of a large oxbow located at about RM 12.5, where the river is naturally confined. Downstream of the oxbow, the floodplain is wider than that of the two upstream reaches represented in Figure 4.19. It is not certain exactly what part of the river downstream of Brown Creek was included in the 1997 analysis, only that a reach length of 2.1 was used. The entirety of the area between the proposed dam site at RM 9.5 and LeBar Creek (RM 13.5) was clearcut—and logjams removed from the river—in the late 1950s in preparing to construct the third Cushman dam. Given the amount of channel widening that occurred upstream of LeBar Creek following logging, one would expect that Figure 4.19 should have shown a similar magnitude of effect downstream of Brown Creek. We hypothesize that the different characteristics of this reach, compared to the Mid SF reach and Cedar SF reaches, resulted in a different pattern of floodplain/active channel responses in magnitude of change. For example, the wider floodplain in this area is conducive to the regrowth of alder whereas the more incised reaches upstream have not promoted alder revegetation to the same extent. This, we believe, is reflected in the downturn of the data point for this reach in 1995 relative to the other reaches.

The USFS recently completed an extensive analysis of the river in the Oxbow area between RM 10.4 and 12.7 to assess channel changes (Bair et al. 2009). It was concluded that past logging had caused extensive changes to the river in the area of a similar magnitude described above for between LeBar and Cedar creeks. Figure 4.23 displays a partial set of the series of aerial photos presented in Bair et al. (2009) that showed channel changes beginning in 1929. Channel instability was found to have increased and the historic pool-riffle morphology had devolved into a plane-bed morphology with elongated riffle/glide sections. Channel sinuosity had declined and channel length had been reduced. The active channel width had increased by 68 percent—the same level of increase described earlier for the reach between LeBar and Cedar creeks. The increased channel width resulted in greater exposure to sunlight. Based on field measurements, summer water temperatures were found to be exceeding Washington State water quality standards—the river in that area was listed as 303(d) impaired by the Washington Department of Ecology.

Bair et al. (2009) concluded that the causes of these changes to the river channel were due to past clearcutting of the area, including the riparian zone, removal of logjams, increased sediment loading from mass-wasting upstream, surface erosion from logging roads, and streambank and channel erosion and degradation. The authors also stated that these conditions within the reach were contributing to greater sediment loading in the lower South Fork and to the mainstem Skokomish River.

The conditions within the Oxbow reach, together with those upstream to beyond Church Creek, show that nearly the entire length of the South Fork upstream of the gorge has destabilized. Floodplains have unraveled. Amounts of coarse sediment being mobilized and reworked by the river during high flows have increased significantly since the advent of commercial logging. Vegetated terraces continue to erode, indicating that the active channel is likely still widening in many areas. Figures 4.25-4.27 provide ground-level photos of representative sections of the upper South Fork between RM 10.5 to 21.6.

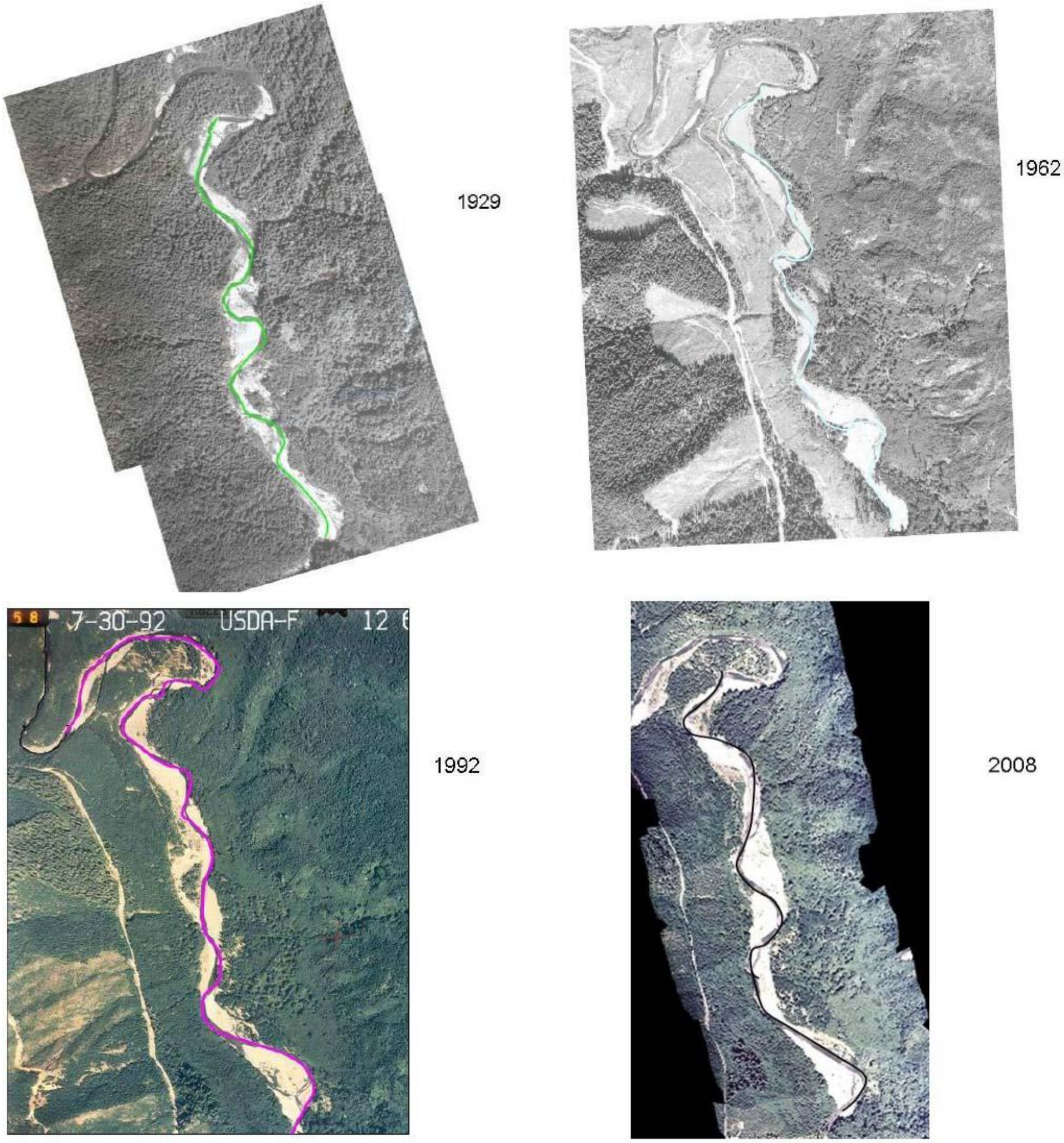


Figure 4.23. Aerial photos of the reach downstream of the oxbow on the South Fork (RM 10.4 to 12.7) in 1929, 1962, 1992, and 2008. The photos were extracted from a larger series of photos contained in Bair et al. (2009). Figure 4.24 provides an enlarged picture of the reach in 2006 for a closer examination of the channel.

Figure 4.24. Enlargement of photo from 2006 of the reach seen in Figure 4.23. This reach is scheduled for restoration work by the USFS in 2010 to accelerate re-stabilization of the channel and floodplain (Bair et al. 2010).

The US Forest Service and the Skokomish Tribe have proposed and are implementing intensive restoration work in the Oxbow reach in summer 2010 to accelerate stabilization of the reach and increase channel heterogeneity, among other objectives (Bair et al. 2009). The work will consist of strategically placing engineered logjams and related large wood structures within the reach and restoration of floodplain and riparian areas.

Figure 4.25. Channel conditions within the Oxbow reach of the upper South Fork in 2005. Top photo shows braiding condition and extensive gravel bars. Bottom photo shows eroding floodplain terrace. Many stumps from past logging occur within the channel. Photos by Merlin Biological, courtesy of Marc McHenry (USFS).

Figure 4.26. Channel conditions downstream of Cedar Creek in the upper South Fork in 2005. Top photo shows high terrace with exposed coarse sediments; surveyor is standing in distance. Terrace erosion is occurring at the right of the photo. Bottom photo shows a different exposed high terrace with significant erosion occurring, adding large amounts of sediment to the channel. Photos by Merlin Biological, courtesy of Marc McHenry (USFS).

Figure 4.27. Channel conditions in the vicinity of Church Creek in the upper South Fork in 2005. Top photo shows channel incising through coarse sediments within the active channel downstream of Church Creek, note perched wood on gravel to right. Bottom photo is located upstream of Church Creek, showing eroding terrace and beginning of recruitment of large wood to the channel. Photos by Merlin Biological, courtesy of Marc McHenry (USFS).

Hypothesis for Instability of the Upper South Fork and Vance Creek

This plan views the current state of disequilibrium in the channels of the upper South Fork as the result of contemporary events interacting with watershed processes shaped by the river's glacial history. Rapid, large-scale logging of the subbasin appears to have triggered the re-activation of secondary paraglacial processes (Ballantyne 2002a) and sediment stores that had been stabilized by the old growth forest. This view is set forth as a hypothesis to explain how the upper South Fork was de-stabilized and is now contributing large amounts of glacigenic sediments to the river within this area and to the lower South Fork and mainstem Skokomish River.

Aerial photos indicate that the river prior to logging was in equilibrium, though it is likely that it was prone to a degree of instability (Everest 1981; USFS 1995). Watershed processes governed by the old growth forest, however, appear to have limited the extent of instability. As road building and logging progressed into the subbasin, aerial photos show that the river corridor began to unravel. Close correspondence between logging progression and river corridor response suggests a high level of sensitivity to the logging-related disturbances. The active channel widened as streambanks and terraces appear to have eroded. Runoff patterns from the logged and roaded areas changed, with the volumes of storm runoff being increased by upwards to 18 percent. Because of the unusually high intensity of storm events in the South Fork (see Table 4.4 in Lower River Floodplains and Channels), enhanced storm runoff may have been the strongest factor in initiating the de-stabilization process. Mass wasting is estimated to have increased by 380 percent over background in the most heavily logged areas (STC and WDNR 1997). Riparian logging and removal of instream woody debris further affected instream stability. As the active channel widened, this likely also de-stabilized logjams that had helped hold the system together. The cumulative effect of all of these factors is seen as the likely cause of the system's deterioration.

We hypothesize that large-scale logging, when added to the river's natural tendency for some level of destabilization, pushed the system beyond a threshold, below which a state of equilibrium had been maintained (Schumm 1977). Once the threshold was exceeded, channels were de-stabilized. This process was then exacerbated as logging accelerated. These conditions re-activated secondary paraglacial processes as glacigenic sediments were retapped in streamside terraces. These processes continue to be active. Ballantyne (2002a) suggested that re-activated paraglacial processes may take a considerable time to be re-stabilized and the system to regain equilibrium.

Restoration Actions Previously Implemented or Soon To Be

The USFS and Green Diamond Resource Company have been engaged in restoration work in the upper South Fork since the late 1980s, primarily by improving, closing or removing roads and sidecasts. STC and WDNR (1997) reported that the road abandonment program carried out in the previous five years had eliminated many problem roads, especially mid-slope roads. Maintenance and upgrading were also reported to be improved and erosion had been reduced. McNulty (2003) reported that as of 2003 a little more than 100 miles of roads had been repaired, with many more closed without restoration by the USFS in the Skokomish watershed. SWAT (2007) stated that between the early 1990s and 2003, the USFS and various partners accomplished $10.6 million of restoration work in the South Fork, most of it in road-related work. Some instream restoration work within the upper South Fork subbasin was also accomplished during this period. For example, wood enhancement has occurred in lower LeBar Creek.

During 2005-2009, the USFS completed another 15.1 miles of decommissioning, 1.1 miles of conversion to trail, and 7.8 miles of road closure. In addition, over 16 miles of roads were stabilized and road drainage was upgraded. These projects, combined with other habitat related work, required approximately $6.5 million (SWAT 2010).

In FY 2010 the USFS received $2,680,000 of Legacy Roads funding to decommission and stabilize other roads within the upper South Fork. Work is anticipated for 29 miles of road decommissioning and approximately 30 miles of road stabilization.

The USFS has also completed planning on a major restoration project for the Oxbow reach of the upper South Fork (Bair et al. 2009). The project is aimed at restoring a section of river that had been affected by clearcutting and stream clearing done in the 1950s in preparation for building a third Cushman Dam, as described previously. Work will consist of constructing a series of logjams and other channel-stabilizing elements between approximately RM 11 and 12. Riparian restoration work will also occur. The objective of the project is to accelerate re-stabilization of that reach and increase channel heterogeneity. This would also have the effect of beginning to slow the rate of sediment transport to the lower river from the upper South Fork.

Degraded Lower Floodplain and Channel Conditions

In a little more than a century, the floodplains and river channels of the lower Skokomish watershed have been dramatically altered from their pre-settlement[21] conditions. The effects of these changes on the performance and viability of Skokomish Chinook have undoubtedly been severe, contributing to the extinction of some life history forms in the river. One aspect of these changes has been significantly increased aggradation within the river, which continues unabated. This, combined with naturally intense fall and winter storms, has made the Skokomish River the most flood prone river in Washington State. As a consequence, the lower river and portions of its forks are frequently hostile to Chinook embryos and young fry when present.

The geographic scale and complexities of this threat to recovery are large. Multiple land and water uses operating at a landscape scale over many decades are the cause. Created over a long time period, many years are expected to be needed to address the problem. Moreover, the remedial actions that will be required will likely significantly worsen the environment for Chinook eggs and fry in the lower river until channel conditions begin to stabilize and more suitable conditions develop.

The potential effects of this threat on Chinook recovery are not the same for all of the species' life history patterns that existed historically. Recovery of late-timed Chinook, because they would spawn in the lower valleys of the watershed, would be much more affected than early-

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[21] / Pre-settlement refers to prior to settlement by Euro-Americans.

timed fish that would spawn upstream of the areas affected. This difference between the racial groups is a primary reason that this plan focuses on recovery of an early-timed population. While the threat is considered to be less on the early-timed population, remediation of this threat is still important for this racial group. The lower river valleys have important roles both in juvenile rearing and upstream adult migration of early-timed fish.

Historic Condition

Until the arrival of Euro-American settlers in the 1850s, the Skokomish watershed had remained almost completely unaltered by human development. Little change occurred as a result of the life styles of the aboriginal Twana people. Their permanent settlements were located in the lower valleys of Vance Creek, North Fork, and the main Skokomish River, but land clearing there had only been on a small scale. Large old-growth conifers, interspersed with groves of alder and cottonwood, blanketed the pre-settlement landscape (Wickersham 1890 cited in Amato 1996; Richert 1964).

The river in its natural state had a dynamic flow regime. While the Skokomish basin is generally drier than the Pacific side of Olympic Mountains, annual precipitation is still high with an average of about 134 inches in the upper basin (Canning et al. 1988). Floods could sometimes be severe (Richert 1964), likely the result of the intensity of winter storms in this geographic area compared to some regions of Western Washington (Figure 4.28, Table 4.4). The level of the two-year peak flow (the highest flow that occurs on average every other year) generated per square mile of drainage area in the South Fork is among the highest in Western Washington. For stream gauges that have a sufficient period of record for estimating the two-year peak flow (Q_2), only the Calawah River on the west slopes of the Olympics demonstrates a greater intensity of runoff as measured by the ratio of Q_2 to drainage area.[22] Storm severity in the upper North Fork is also high, but not as high as in the South Fork.

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[22] / It has been determined that peak flow in the South Fork has not been increased as a result of logging (WDNR 1997); therefore the Q_2 flow in Table 1 can be assumed to represent natural conditions. It is noted that the ratio of Q_2 to drainage area is affected by the size of the watershed upstream of the gauging station (Black 1996), with the ratio generally reduced as watershed area increases. This effect would be seen over a very large range in watershed sizes.

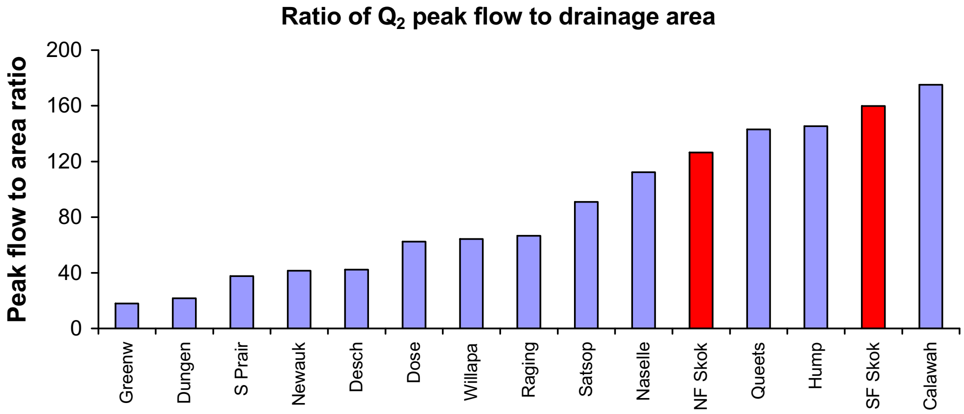

Figure 4.28. Ratios of the two-year peak flow (Q_2) to drainage area for different rivers in Western Washington. Streams were selected to show the range of values that exist. The only stream found to have a higher ratio than the South Fork was the Calawah River. See Table 1 for additional information. Footnote 1 explains why available data for the South Fork are useful for describing the river's pre-alteration peak flow characteristics.

The Skokomish River has a sediment-rich valley system due to a long history of both glacial and fluvial processes at work. Both alpine and continental glaciers advanced multiple times into the watershed from different directions during the Pleistocene, leaving enormous quantities of glacigenic sediments (Long 1975). During deglaciation, tremendous instability would have existed in the river valleys as a result of accelerated geomorphic processes, called paraglacial processes (Ballantyne 2002), described earlier. Eventually the river channels and floodplains stabilized as the temperate forest became established. It is envisaged that the prehistoric north and south forks of the river above their mainstem confluence would have had similar characteristics to the one seen in Figure 4.17, in that its channels and floodplains attained relative stability. In that state, the river channel would have been in equilibrium (Schumm 1977), neither aggrading nor degrading when considered over decadal to century time scales.

Table 4.4. Information on streams with ratios computed for the two-year peak flow (Q_2) to drainage area for different rivers in Western Washington.

River	Basin	USGS gauge stn	Years in record	Drainage area (mi^2)	2 yr peak (Q_2)	Ratio Q_2/mi^2
Calawah R	Quillayute	12043000	29	129	22,600	175
SF Skokomish R	Skokomish	12060500	53	76	12,200	160
Humptulips R	Humptulips	12039000	39	130	18,900	145
Queets R	Queets	12040500	63	450	64,400	143
NF Skokomish R	Skokomish	12056500	82	57	7,210	126
Naselle R	Naselle	12010000	71	55	6,150	112
Satsop R	Chehalis	12035000	77	299	27,200	91
Raging R	Snoqualmie	12145500	62	31	2,040	67
Willapa R	Willapa	12013500	57	130	8,360	64
Dosewallips	Dosewallips	12053000	38	93	5,810	62
Deschutes R	Deschutes	12079000	53	90	3,800	42
Newaukum R	Chehalis	12025000	60	155	6,420	41
South Prairie Cr	Puyallup	12095000	51	80	2,990	38
Dungeness R	Dungeness	12048000	69	156	3,380	22
Greenwater R	Puyallup	12097500	57	74	1,320	18

Collins et al. (2003) described the pre-settlement channel characteristics of various rivers in the Puget Lowland after two archetypical rivers in the region: the lower Snoqualmie River and the lower Nisqually River (Figure 4.29). Both types appear to have been evident in the lower Skokomish valley prior to watershed development. Some understanding of the differences between these two is helpful for diagnosing the modern Skokomish River and in identifying possible restoration strategies. Descriptions of the two types given here are largely extracted from Collins et al. (2003).

In their pre-settlement state, the two river types differed in channel and floodplain characteristics due to different effects of the continental glaciations. The Snoqualmie type, with a single-threaded meandering channel, flowed through a wide valley carved by ice and subglacial runoff. Its floodplain was broad and flat and, in some cases, lower than the meander belt of the river. Post-glacial (Holocene) fluvial deposits of fine sediments on the floodplain were deep as the valley floor was aggrading over time. Wetlands and off-channel ponds were abundant on its floodplains. The river channel migrated very slowly within the valley, with infrequent avulsions. In the case of the Snoqualmie River, for example, its channel has changed very little in form and location since earliest mapping in 1870. In this river type, the extensive wetlands and off-channel ponds provide excellent fish rearing habitat for some species, though they are not heavily used by Chinook fry in Western Washington as the more riverine-associated habitats (Lestelle et al. 2005).

By contrast, the Nisqually type flowed through a somewhat narrower, steeper valley, and was incising its channel through the general Pleistocene glacial deposits. As a consequence, the Nisqually type contained more split channels and larger gravel bars, and could revert to a braided type[23] under disturbance. Prior to watershed development, this river type contained relatively stable vegetated islands, maintained by old-growth trees within the riparian corridor and by large log jams. A variety of secondary channels often existed, including overflow channels, perennial side channels, groundwater channels, along with short sections of braided channels.

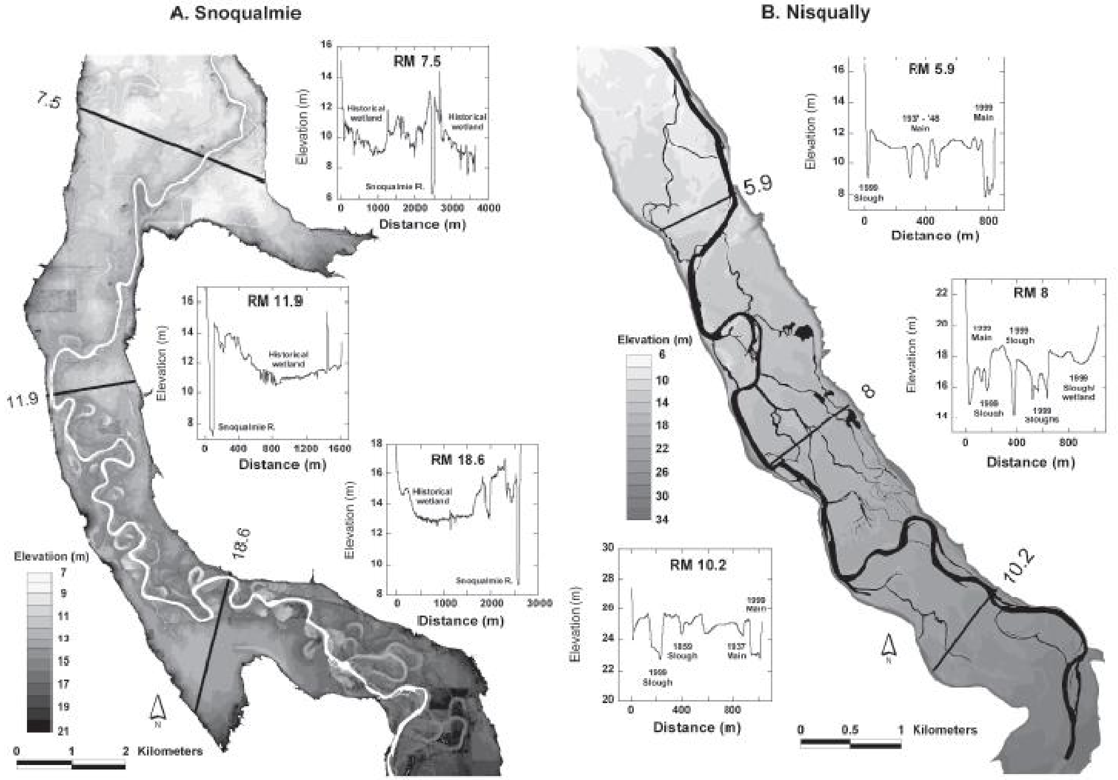

Figure 4.29. Channel form of the (A) lower Snoqualmie River and (B) lower Nisqually River in the Puget Lowland. From Collins et al. (2002).

Although the Nisqually type avulsed much more often than the Snoqualmie type, the frequency and way in which it did were largely governed by the presence of log jams and old-growth trees within the riparian forest. The most common kind of avulsion was the river's switching back and forth between the main channel and side channels on the floodplain, separated by vegetated islands. The jams served to "regulate" the flow of water into floodplain channels, thereby helping

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[23] / A braided channel is indicative of watershed and channel characteristics important to this discussion. This channel type has multiple branches, separated by exposed alluvial bars (Rosgen 1996). Bars tend to be transient, unvegetated and submerged at bankfull flow (Knighton 1988), which occurs about once every 1.5 to 2 years. Braided reaches occur naturally, particularly in glacial valleys with active glaciers, but can also result from riparian destabilization, inputs of large amounts of sediment, or other disturbances (Buffington et al. 2003). Braided channels are often wide and shallow because bedload materials are frequently coarse (sands and gravels) and non-cohesive. From an ecological perspective, severely braided channels are hostile environments because of their dynamic nature (Tockner et al. 2008) caused by high volumes of sediment movement, channel avulsions and often variable flow.

to avoid frequent and deleterious avulsions. They also served to form, then stabilize, the vegetated islands within the channel network, which further served to help maintain the channel complex. The prevalence for this channel switching dynamic over more continuous channel migration was due in part to patches of old growth trees within the riparian corridor. These patches could remain uneroded for centuries because the river avulsed around them. Thus the old growth acted as "hard points" that helped maintain the stability of the channel network in conjunction with log jams.

The Nisqually-type channel network also functioned in a way that maintained a relatively stable primary channel with year round flow. Flow would be concentrated within the main channel sufficiently to promote scour there, resulting in a relatively low width to depth ratio.

It bears noting that the channel complex contained within the Nisqually-type river was tremendously productive for salmon, including Chinook, because of its relative stability and its rich diversity of habitat types (Sedell and Luchessa 1981; Collins et al. 2003; Lestelle et al. 2005). The periodic, moderate-scale avulsions served to "reset" the continuum of channel types within the network, thereby maintaining a diversity of habitat over time. Major avulsions occurred infrequently enough that mortality to a salmon population over many generations was low.

Prior to settlement, evidence shows that the lower part of the Skokomish River system was composed of both river types.[24] The lower South Fork, and likely the lower North Fork, had a channel form like that of the Nisqually type. Jay and Simenstad (1996) noted, however, that the South Fork likely always produced a greater amount of sediment than the North Fork because of sediment trapping in the pre-dam Lake Cushman. Also, at the top end of the lower South Fork, where it emerges from the canyon, there was always an alluvial fan section where coarse sediments were deposited due to the sudden change in slope and valley width (Montgomery and Buffington 1998). Hence some braiding in that section would have always been present. Members of the O'Neil Expedition in 1890 observed such a condition at that location (Wood 1976).

Downstream of the forks, the river transitioned to a single-threaded meandering channel similar to that of the Snoqualmie type. The nature of the two channel types and their transition from one to another correspond with the change in the channel slope along the river's longitudinal profile downstream of the South and North Fork canyons (Figure 4.30). (The channel profile seen in the figure would have been slightly different prior to watershed development, but the general shape and slope breaks would have been comparable.)

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[24] / Other rivers in the Puget Lowland also demonstrated both types along their channel courses, for example, the Nooksack River and the Snohomish-Skykomish system (Collins et al. 2002).

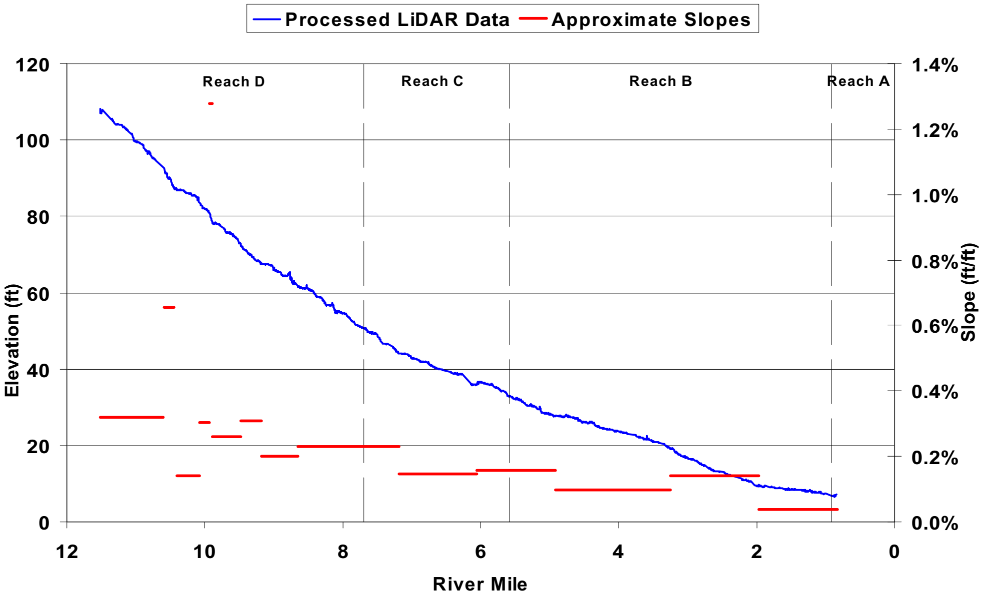


Figure 4.30. Channel profile from near the Skokomish River mouth to the beginning of the canyon on the lower South Fork. and local channel slope. Reaches shown are those applied by the USBOR in Godaire et al. (2009). River miles shown are those estimated by the USBOR; these do not conform exactly to those in the WDF stream catalog. The North Fork enters at about RM 8.5 on this scale. Note the drop in channel slope downstream of RM 8.0—this corresponds approximately to the change in channel form from a Nisqually type to a Snoqualmie type. Chart is taken from Godaire et al. (2009).

It is evident that stable, vegetated islands existed in both forks within the upper half of the lower valley, supporting the view that the river there had a Nisqually-type form. One example of a large island complex occurred about a mile downstream of the lower canyon in the South Fork as recorded by the GLO surveyor Ross Shoecraft in July 1875 (Figure 4.31). Both branches shown in the figure were described in the notes as being flowing channels of the Skokomish River. At a section corner within the interior of the island, he described the land as “level, soil 1st rate” with “timber fir, cedar, maple, cottonwood & alder.” The island still existed in the 1920s, as shown in a map of that time contained in Richert (1964)(Figure 4.32), indicating its stability for at least 50 years despite land use changes that were already accelerating. Both maps depict the island as being the same size and shape. The island was approximately one mile long and a half mile wide. Channel mapping by Godaire et al (2009)(Figure 4.33) shows that the island was no longer evident in the 1930s.

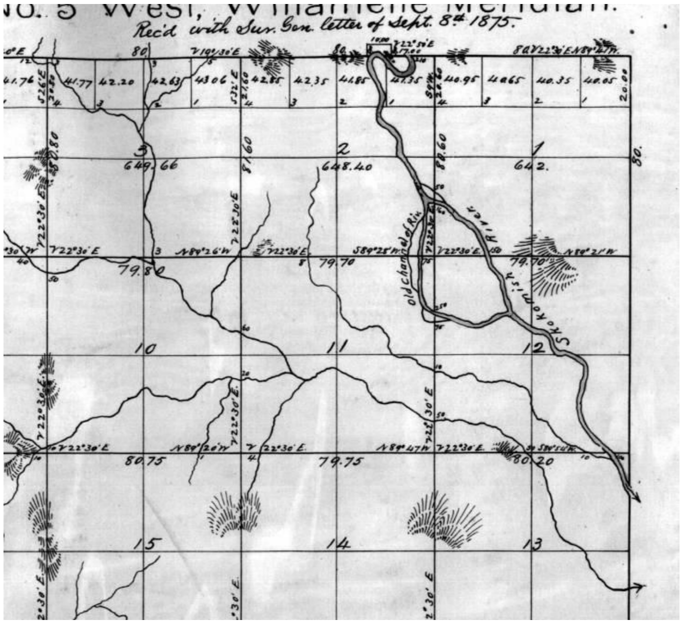
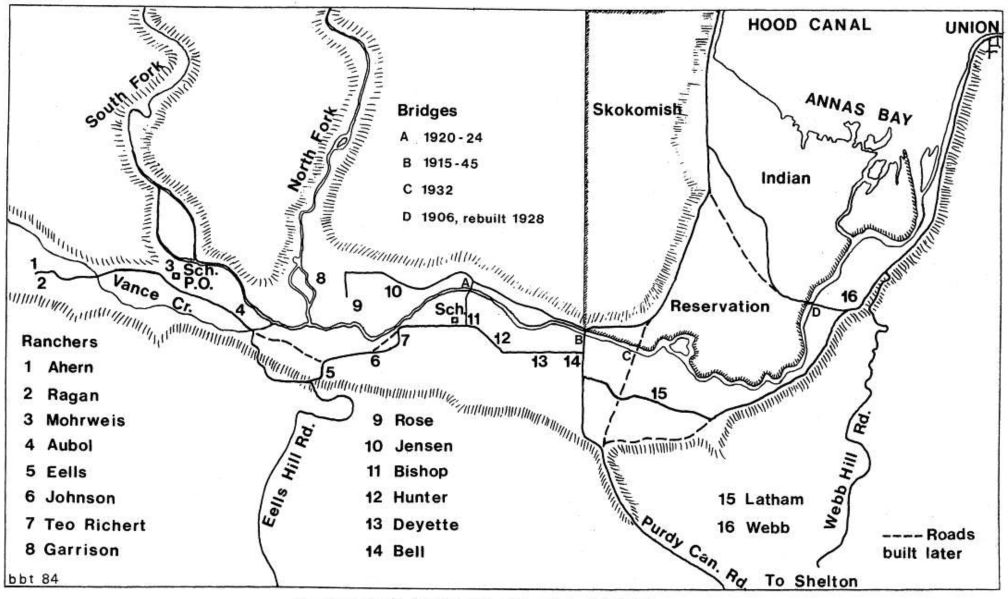
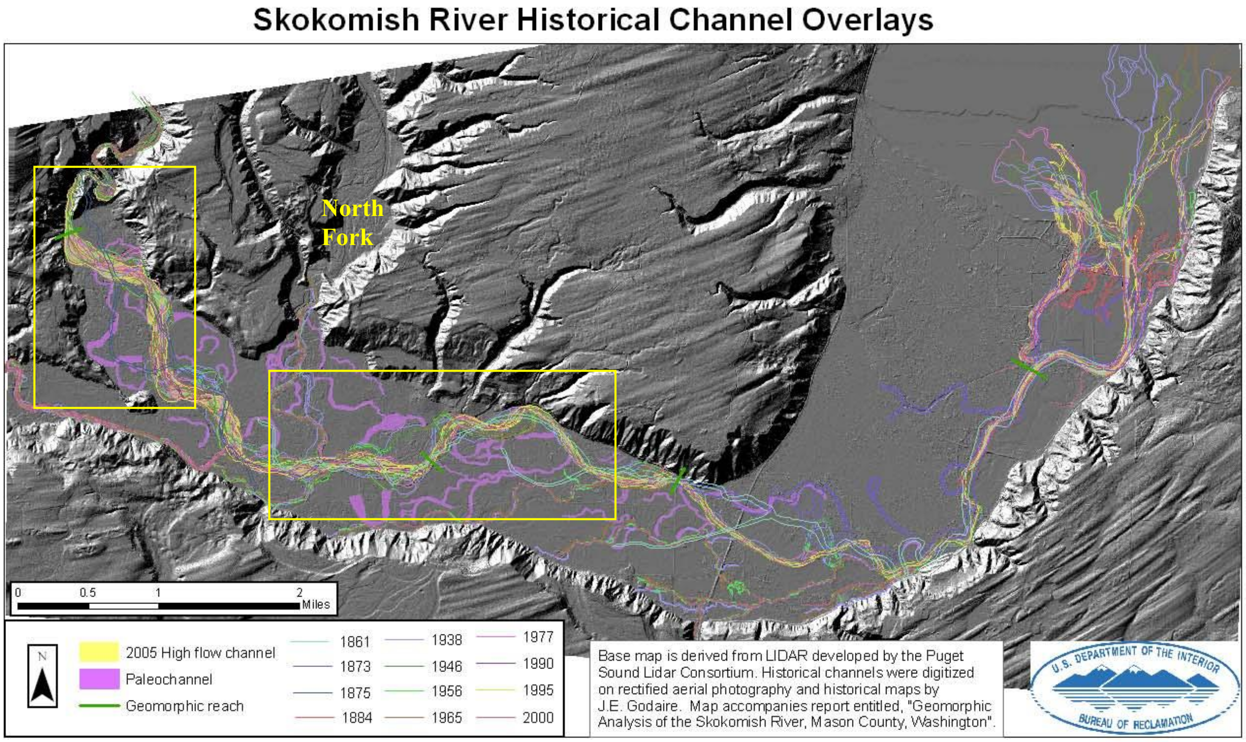


Figure 4.31. Map of the South Fork between just above Vance Creek and the mouth of the lower canyon as made by a GLO surveyor in July 1875. Vance Creek is the most downstream tributary shown (leaving the map before entering the South Fork). The bottom of the canyon is at the top of the map. The vegetated island is shown to be approximately one mile downstream of the canyon.



Skokomish Valley in the 1920's.

Figure 4.32. Map of the Skokomish Valley showing approximate channel location and configuration in the 1920s. Taken from Richert (1964). Note the presence of the large island located in the same vicinity shown on the map in Figure 4.31.



Base map is derived from LIDAR developed by the Puget Sound Lidar Consortium. Historical channels were digitized on rectified aerial photography and historical maps by J.E. Godaire. Map accompanies report entitled, "Geomorphic Analysis of the Skokomish River, Mason County, Washington".

Figure 4.33. River channel locations within the Skokomish Valley as determined by work of the U.S. Bureau of Reclamation. The yellow box on the far left outlines the approximate area shown in Figure 4.31. The yellow box to the left of center outlines the area shown in Figure 4.32. Close examination of this map shows the channels in Figures 4.31 and 4.32. Taken from Godaire et al. (2009).

Another example of what appears to be part of an island complex is seen in a GLO survey of the Skokomish River in August 1861 approximately 2 ½ miles downstream of the forks (Figure 4.34). The south channel near the center of the figure, which appears as a slough, would likely have been connected to the main river upstream during months of higher flow more so than in late summer, forming a side channel complex. It is mapped in Figure 4.33 by Godaire et al. (2009) in the vicinity of several paleochannels (relict channels now filled with sediment)—the channel pattern suggests an island formation with relatively long-term stability.

As noted above, the pre-settlement river transitioned to a single-threaded Snoqualmie-type form downstream of the forks, somewhere in the vicinity of Weaver Creek (RM 6.3).[25] This river type continued downstream, extending into river's estuarine reach (tidally affected). Geomorphic analysis by Godaire et al. (2009) concluded that the lower channel—from approximately RM 5.5 downstream—had shown virtually no change in location over the past 150 years. This stability, together with its low gradient, meandering channel type and wide valley, support the view of it having a Snoqualmie-type form.

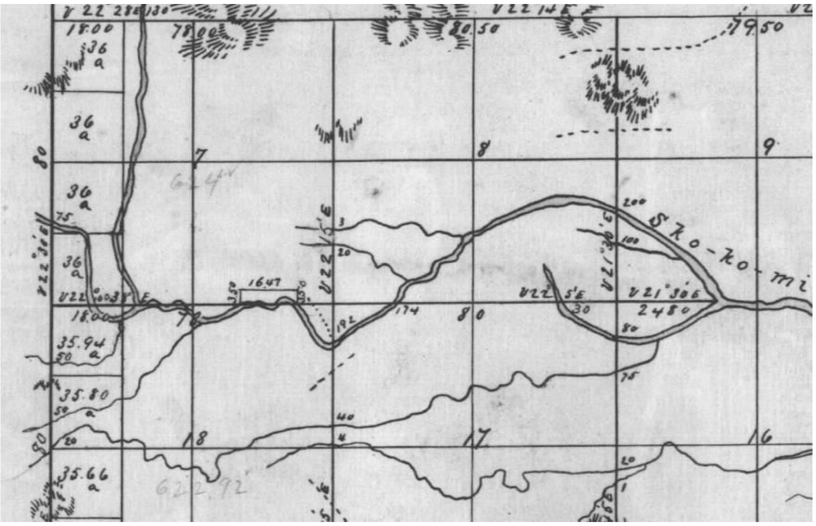


Figure 4.34. Map of the Skokomish Valley between the North Fork and Weaver Creek made by a GLO surveyor in August 1861. The curved channel shown as a slough on the right side suggests the presence of a stable vegetated island. See text for complete description.

The characterization of Godaire et al. (2009) of the lower valley is helpful here:

> "The river valley morphology was shaped primarily by late Pleistocene glaciations, which carved the Skokomish Valley into its present form with minor changes during the Holocene.[26] Rising base level caused by apparent tectonic subsidence and sea level rise have maintained the valley's flatbottomed form following deglaciation with essentially no terrace development. This indicates that over the long term and certainly within the last 2,000 years, the Skokomish River Valley is an aggradational environment.

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[25] / USGS maps call the right bank tributary at approximately RM 6.3 Weaver Creek, but the WDF catalog (Williams et al. 1975) calls it Hunter Creek.

[26] / Post-glacial.

> Holocene deposits along the Skokomish River form one broad surface throughout the valley and vary in age based on the lateral migration history of the Skokomish River. Areas that have been part of the active channel recently are younger and areas that are further from the main channel are presumably older. Limited well log analyses show that in the lower river valley, main channel deposits are located in many areas, but are buried by 20-30 feet of overbank sediments. This indicates that overbank sedimentation is high with few channel avulsions observed. In the upstream reaches, the channel appears to be more dynamic, with a greater number of paleochannels and gravelly deposits near the surface, which would indicate a higher degree of channel splays and greater numbers of channel avulsions."

Especially noteworthy is the conclusion of Godaire et al. regarding the lower valley as being a long-term aggradational environment. In shorter time intervals, however, measured in a few human generations, the pre-settlement river was in a state of equilibrium. The same was true of the Snoqualmie River valley that underwent the same type of glaciations as the lower Skokomish valley. Bethel (2004), in an extensive review of the geomorphology of the Snoqualmie River, said of that valley that it was "inevitably filling with sediment" due to the inability of the low gradient river to transport the enormous amounts of naturally generated sediments being moved into it—though over a very long time period. This natural condition of these rivers suggests a relatively high sensitivity to disruptions in processes and watershed components that might affect their equilibrium. These components, which operate both within and upstream of the lower valleys, include riparian structure, in-channel structure, flow patterns, and sediment inputs.

Existing Condition

The existing condition is the result of a series of alterations that were made to the landscape and flow regime that began with settlement by Euro-Americans. The progression of these changes is described below.

Euro-American settlers began moving into the Skokomish valley in the 1850s and farms were established on the floodplains of the lower river and its forks (Amato 1996). Over the next 20-30 years, the amount of land cleared for farming along the lower rivers steadily increased. By 1910, extensive parts of the lower valley had been cleared, major log jams had been removed, and low elevation areas along the rivers had been logged (Richert 1964; Amato 1996). Particularly notable is the description by Richert (1964) of a giant logjam downstream of the forks in 1891. It was described as having been formed over a 50 year period and "as being about three miles thick." One logging company "had been working for 18 months in wrecking the jam." Log driving, timed to the arrival of freshets in the fall, was used to move harvested timber down the river. The changes to the riverine landscape as a result of these actions were extensive.

The Cushman dams were built in the 1920s. In the final phase of developing the complex, virtually all of the flow originating upstream of those structures was diverted out of the basin beginning in 1930, then discharged through pipelines directly to Hood Canal. Until 1988, the only water releases from the lower dam into the North Fork were for emergency spill purposes, which were rarely made. Approximately 40 percent of the annual runoff from the Skokomish watershed has been diverted annually since 1930 (Canning et al. 1988). This also means that peak flows in the lower Skokomish River were dramatically reduced beginning in 1930. Since then, the two-year peak flow event in the lower river has been reduced by approximately 12,000 cfs.[27]

Diking began in the 1920s, then expanded between the late 1930s and early 1940s (Amato 1996; Todd et al. 2006). The lower estuary was diked for the purpose of increasing agriculture lands. Diking became commonplace in the lower valleys upstream of the estuary for both flood protection and increasing the amount of agricultural lands. The system of dikes in these areas grew significantly in the 1950s and 1960s, with improvements and dike lengthening continuing to be made after that (Amato 1996).

We hypothesize that one of the most important impacts from diking other than direct channel and side channel disconnection was the severe decrease in available active channel width and its ability to store and remediate bed load sediments. Of particular note is the “car body levee” which was completed in the mid 1950s at the old confluence of the North and South Forks, which in combination with the south shore levee decreased channel width by several-fold. As a result, instead of spreading bed load out horizontally and maintaining a moderately stable channel in equilibrium, the river was forced to aggrade vertically. This effect has been further exacerbated by non-conventional diking upstream, specifically Skokomish Valley Flats Road construction at the “dips” and bank revetments along the Skokomish Farms just above the Vance Creek confluence.

Portions of the lower river were channelized during the 1930s and 1940s, especially evident in the reach between the Highway 101 and Highway 106 bridges. This river section is partly within the tidally affected estuarine reach. These actions created major channel changes that have remained stable in plan form to the present (Godaire et al. 2009), though vertical aggradation continues to exacerbate habitat degradation and flooding. Additional areas where channel straightening and alteration is thought to have occurred include the Bambi Farms area just below the canyon of the South Fork, the “dips” below the current Vance Creek confluence, and the South Fork between the old confluence-car body levee and the church dike.

Large scale logging began in the North Fork drainage in the early 1900s. Logging in the other drainages continued to expand, and in 1932 began on USFS lands in the South Fork (Amato 1996). With the creation of the Shelton Cooperative Sustained Yield Unit in 1946, forest harvesting accelerated greatly in upper Vance Creek and upper South Fork. Logging on these lands continued to expand in the 1960s and 1970s before the rate of cut declined in the 1980s. By the early 1990s, approximately 80 percent of the South Fork subbasin had been clearcut (SWAT 1990s).

As logging progressed into the upper South Fork and Vance Creek drainages, a corresponding change occurred to primary stream channels and floodplains in those areas. The active channels significantly widened and show clear evidence of greatly increased instability (see section Upper South Fork and Vance Creek). Bedload amounts appear to have increased based on how the

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[27] / The estimate of 12,000 cfs is made by multiplying the ratio of Q_2/mi^2 from Table 1 by the area upstream of Cushman Dam No. 2 (98 mi^2).

channels responded. The changes track closely with projected increases in storm flow volumes, increases in sediment inputs, alterations to riparian structure, and changes in large wood jams.

The combined effect of all of the changes that occurred to the lower river's floodplains, river channels, and flow regime has been wide scale aggradation and related flooding during the second half of the 20th century. While the relative contributions of the various factors to aggradation have been extensively argued (Jay and Simenstad 1996; Stover and Montgomery 2001; Godaire et al. 2009), there is common agreement that the river bed has aggraded significantly and flood threshold and frequency has increased. A brief synopsis of the river conditions follows:

- Stover and Montgomery (2001) concluded that the mainstem river channel at the USGS gauge near Potlatch aggraded nearly 0.5 m between 1939 and 1944, oscillated at amplitudes up to 1 m with little net change from 1945 to 1964, then aggraded over 1.3 m between 1965 and 1997.
- Jay and Simenstad (1996) reported that aggradation had occurred on the inner delta of the river mouth between 1885 and 1972 and steepening (degradation) had occurred at the outer delta face over the same period.
- GeoEngineers (2007) characterized all of the reaches between the lower end of the South Fork canyon to approximately one mile downstream of the North Fork mouth (pre 2008 location) as "aggrading braided channel."
- Godaire et al. (2009) indicated that the main area of channel aggradation extends from at least Vance Creek downstream to perhaps the mouth of the river. The channel in these areas is characterized by gravel bars that have similar elevations as vegetated stream banks and by the presence of ephemeral reaches that were previously perennial, in which streamflow disappears into the gravel substrate.
- The Skokomish Tribe (Matt Kowalski, *unpublished*) documented that the river was completely dry for 4,200 ft downstream of Vance Creek during most of the period between mid August and October 14 of 2009 (Figures 4.35-4.36). Godaire et al. (2009) reported that dry channel can occur between Vance Creek and Weaver Creek; they cited Rich Geiger (Mason County engineer) as stating that this condition has only been observed in several recent years.
- GeoEngineers (2007) reported that a number of areas within the lower South Fork and mainstem river are at risk of major channel avulsions.
- Both GeoEngineers (2007) and Godaire et al. (2009) suggested that a narrowing of the river channel has occurred between approximately Weaver Creek and the river mouth.
- Godaire et al. (2009) described how aggradation has elevated the channel above the surrounding floodplain causing groundwater levels to rise in surrounding land, potentially reversing groundwater flow directions and forcing it to flow from the channel to the floodplain, thereby impeding floodwaters from returning to the main channel.
- Dave Montgomery (Stricherz 2002) stated that the Skokomish River is the most flood prone river in Washington State (Figure 4.37): "Its always on the leading edge, the first one to flood and it floods several times. Typically a river will flood about once a year. But the Skokomish floods two, three, four, five, six times a year."

Figure 4.35. Dry reaches in the lower South Fork Skokomish River in August and September 2009. Note the visible evidence of extreme aggradation by comparing the bed height to the surrounding vegetation.

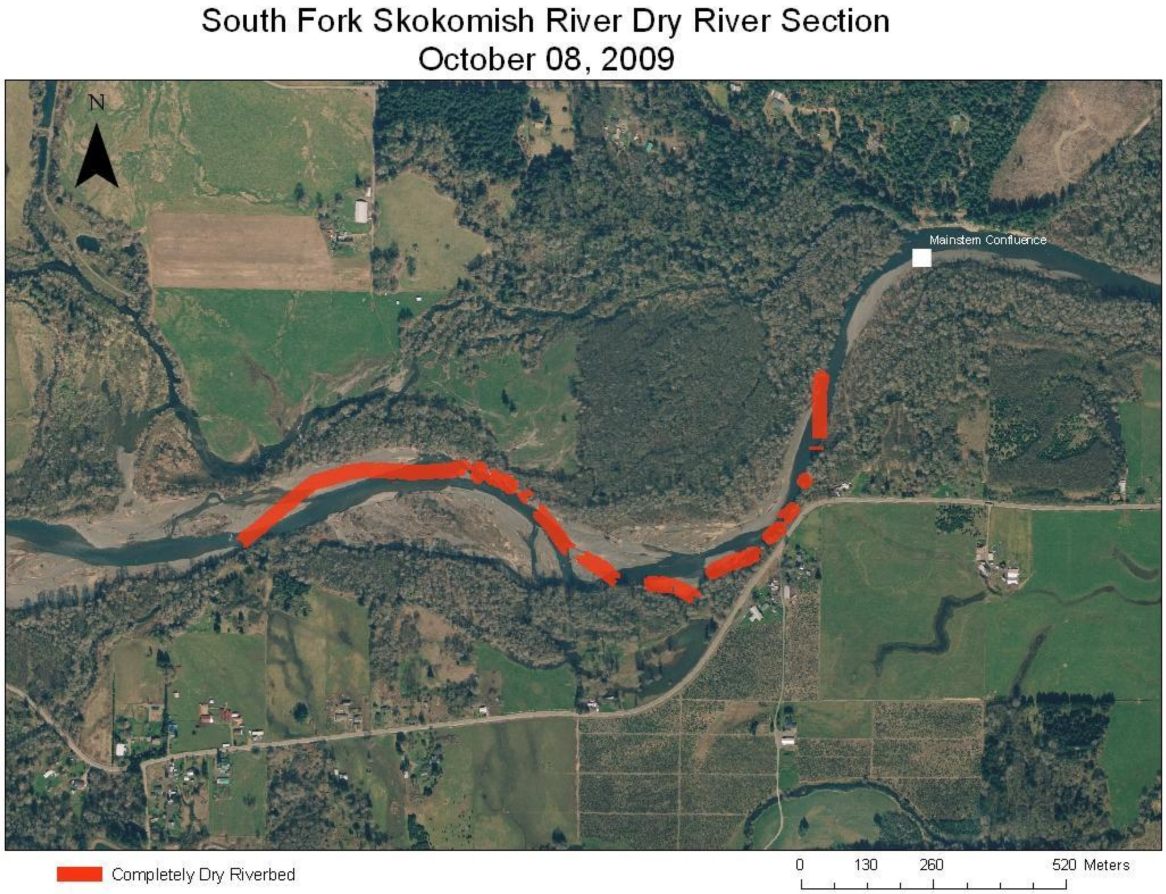

Figure 4.36. Extent of dry river channel on October 8, 2009 downstream of Vance Creek in the South Fork. The confluence of the South and North forks prior to 2008 was located at the most upstream end of where the dry channel is shown. Beginning in 2008, the confluence had moved downstream to the site indicated as a result of a breach in the car body levee on the Skokomish Farms. Note the course of the lower North Fork currently, which follows a relict channel that existed in the 1930s seen in Figure 4.40.

Figure 4.37. The Skokomish River is considered to be the most flood prone river in Washington State.

Hypothesis for Increased Aggradation and Flooding

This plan hypothesizes that the combined—perhaps synergistic—effects of multiple factors resulted in greatly increased aggradation and flooding in the Skokomish basin. It is assumed that the river was in equilibrium prior to the advent of large-scale alteration by humans (Mackin 1948; Gordon et al. 2004). A timeline that conceptualizes how the various land and water uses combined to affect aggradation is given in Figure 4.38. A summary of the principal factors presumed to have operated under this hypothesis follows.

Stover and Montgomery (2001) suggested that the principal causes of the increased aggradation and flooding were increased sediment loading in the South Fork, combined with a reduced transport capacity from flow diversion on the North Fork. The South Fork was historically a sediment rich stream—more so than the North Fork. The combined flows out of the two forks prior to dam construction would have been critical in maintaining the stream channels in the lower valleys in a state of equilibrium. Changes in both sediment load and peak flow would have disrupted the equilibrium state of the river channel (Schumm 1977).

Decade	Events
< 1850	Only minor alterations of watershed exist by human activities; homeland of Twana peoples.
1850	Euro-American begin settling lower Skokomish floodplain.
1860	Land clearing and agricultural development of lower Skokomish floodplain.
1870	Land clearing and agricultural development of lower Skokomish floodplain.
1880	Continued agricultural development of lower Skokomish floodplain and beginning of industrial logging in lower valley.
1890	Logging of lower valleys, log jam clearing, log driving; farm development continued.
1900	Logging of lower valleys, log jam clearing, log driving; farm development continued.
1910	Extensive logging of lower NF on Pope and Talbot lands.
1920	Construction of Cushman dams; diversion of NF flow out of basin at Cushman Dam No. 2 in 1930.
1930	Clearcut logging begins on USFS lands in the SF; extensive diking within river delta for farm development; channel straightening; river channel gravel mining; evidence of aggradation.
1940	Creation of Shelton Cooperative Sustained Yield Unit (CSYU) Agreement on Simpson Timber and USFS lands in the SF (1946); logging accelerates; lower mainstem aggrades 1-1/2 ft.
1950	Clearcutting/logjam removal in SF anticipating hydroelectric project; logjam removal in other streams; variable aggradation in lower river but continues; diking in Vance and lower river.
1960	Extensive development of dikes; accelerating road building and logging in the CSYU; evidence for increased aggradation in lower river.
1970	Dike and revetment system and lengthened and repaired; road building and logging in CSYU occurring at high rate.
1980	Rapid logging of CSYU continues to early 1980s, then declines; dike structural repairs and additions to various structures made; 3.2 ft of aggradation since 1969 measured at Hwy 101.
1990	Logging on ONF lands in SF reduced significantly then essentially stopped (mid 1990s); watershed restoration activities begin on ONF lands. Extensive logging of second growth on Simpson lands.
2000	Logging of second growth on Simpson lands; flooding frequent; continued evidence for aggradation; restoration work in upper SF to close roads. GI Study initiated; Cushman Settlement reached (2009).

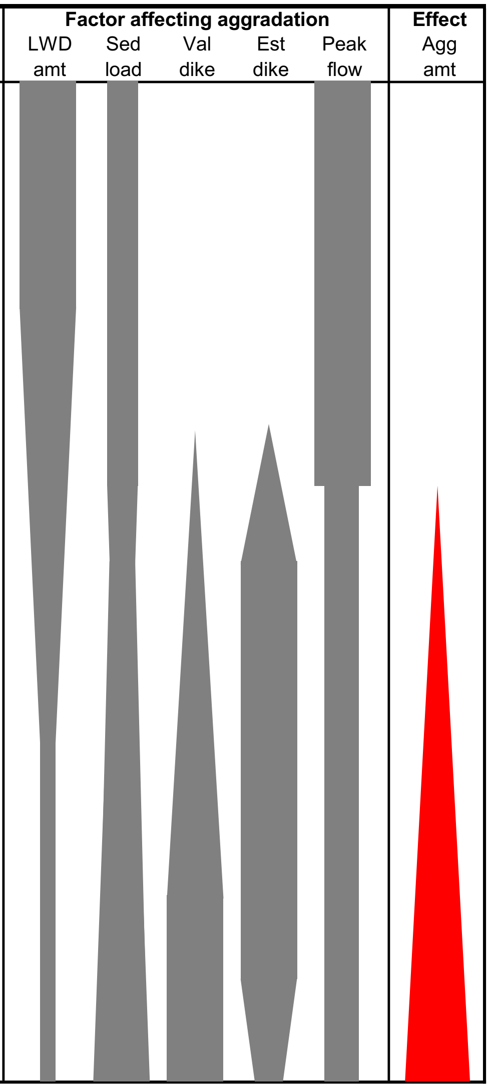

Figure 4.38. Conceptualized effects of various factors affecting aggradation in the lower Skokomish River since 1850. The figure illustrates the hypothesis presented herein about the operation of factors in increasing aggradation (Agg amt) in the lower Skokomish basin. Factor abbreviations are: LWD amt – large woody debris amount, Sed load – sediment load, Val dike – dikes within the river valley, Est dike – dikes within the estuarine zone, Peak flow – the average annual peak flow in the river.

Jay and Simenstad (1996) estimated the loss in transport capacity due to the decreased flow out of the North Fork to be between 40-70 percent. This sudden change in the flow regime would have had immediate effects to the balance between erosion and deposition in the lower North Fork as well as in the main river. In the North Fork, the channel greatly narrowed over time, the bed aggraded (due to sediment sources downstream of the lower dam), and a riparian forest encroached on the channel (Figure 4.39). The riparian forest grew into the channel due to the stepped nature of flow release periods: the flow release was de minimis prior to 1988, it was increased to 30 cfs between 1988-1998, and it was increased again in 1998 to 60 cfs. Figure 4.39 also illustrates that there is currently a very large amount of material in the lower NF that will be transported to the lower Skokomish River under the new flow regime dictated by the Cushman Settlement (see section Altered Flow Regimes).

Godaire et al. (2009) showed a narrowing of the channel downstream of the North Fork and extending into the estuarine zone since the mid 20th century—a condition that often occurs following loss in peak flow due to damming (Gordon et al. 2004). It is noteworthy that the reach immediately downstream of the North Fork underwent severe disruption in the 1930s (Figure 4.40). It appears that the combined effects of many changes to the channels and flows were at work. Channel avulsions in the confluence reach between the North and South Forks have also occurred in the past two years, indicating continued instability in this area due to the aggradation. Moreover, this is the area of the channel where late summer flows have gone sub-surface in recent years. It is also the reach where the channel transitioned historically from the Nisqually-type form to the Snoqualmie-type. Channel slope declines abruptly and the competence of the river to transport sediment load declines sharply. There is some evidence that the transition point of slope breaks and bed aggradation has migrated downstream over the recent historical period.

Operating in conjunction with these factors has been the effect of the removal of logjams from the high water channel. Bair et al. (2009) suggested that the loss of LWD in the South Fork upstream of the lower canyon beginning in the 1950s, in conjunction with increased sediment supply due to logging, destabilized that section of river, releasing a greater sediment load to the lower basin as well as decreasing the channel's ability to process these sediments.

The greatest effect of the loss of logjams, however, was likely initiated much earlier but its effects would have been long lasting—continuing to the present. The very extensive channel clearing that began in the 1890s, which continued for decades, in the lower South Fork and main river was very likely transformative to the channel. Logjam removal in this area would have led to the eventual destruction of stable vegetated islands and side channel complexes. As a result, large amounts of coarse sediment would have been released to further destabilize the channel and transform it over time into more of a braided channel. This effect occurred in conjunction with the complete removal of old growth trees along the lower river valleys, which historically served as hard points around which channel switching occurred (Collins et al. 2002).

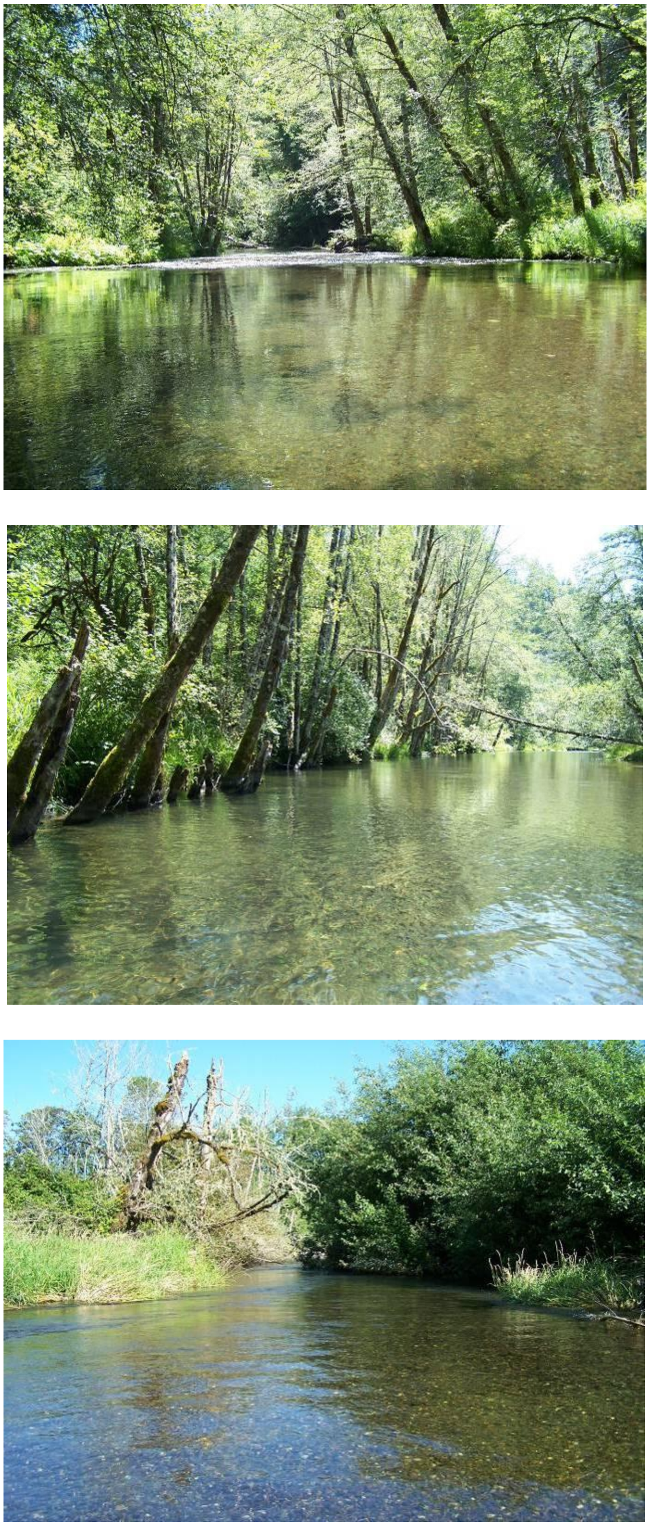

Figure 4.39. Channel conditions within the North Fork downstream of McTaggert Creek in August 2007. Flow was 60 cfs. Note narrow channel, encroachment of riparian forest, absence of gravel bars, and stream bed aggraded with fine gravel.

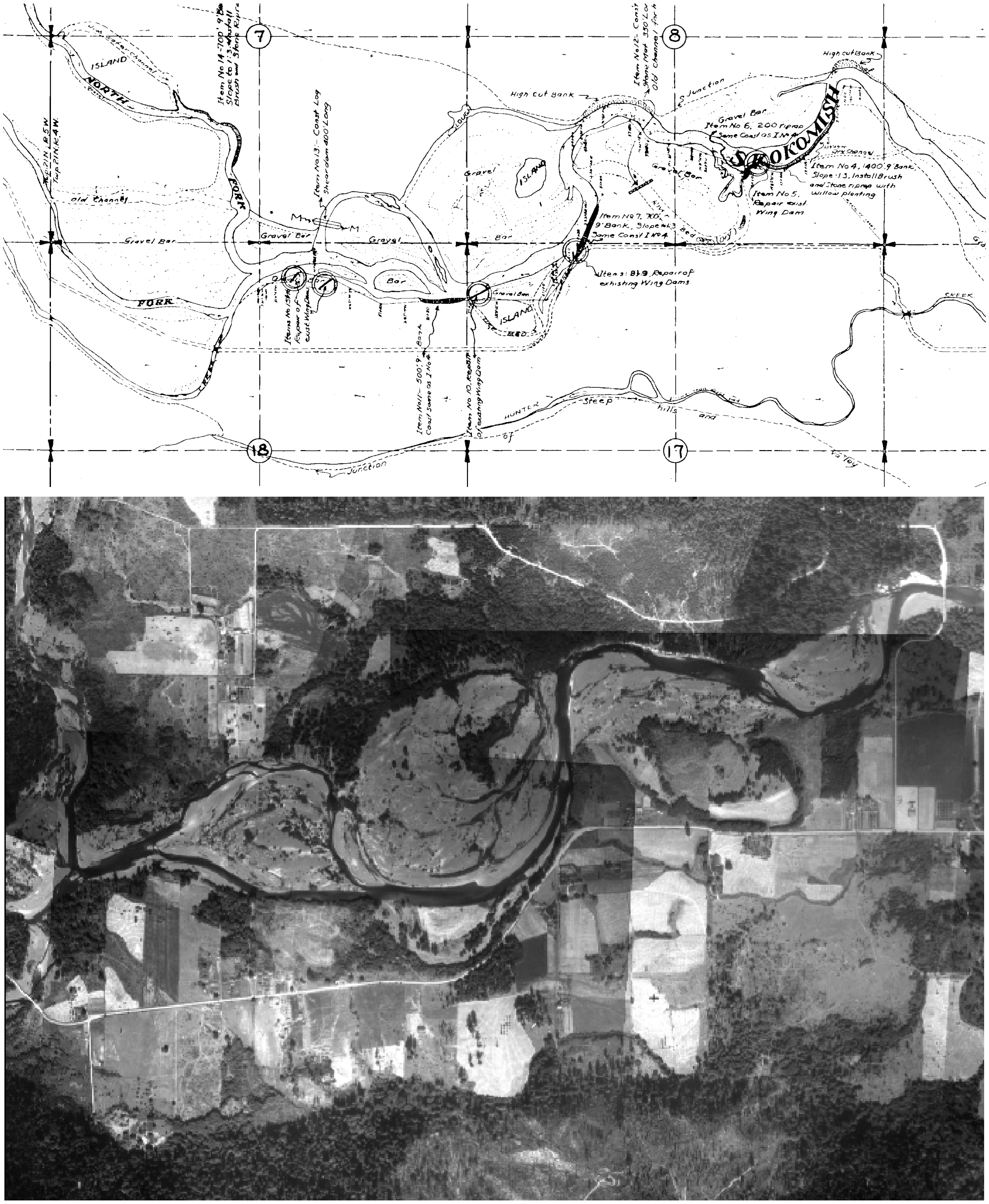

Figure 4.40. Top - Diagram of the Skokomish River between the North Fork (RM 9.0) and approximately RM 7.0 circa 1935. Note the presence of a small island (labeled) and the extensive area of exposed gravel downstream of the North Fork. Bottom – Aerial photo of the same area in 1938. Continued to next page.

Figure 4.40. continued. Photo shows the same area seen in the two pictures above. All three pictures are from Godaire et al. (2007).

Godaire et al. (2009) emphasized another major factor that has operated in conjunction with those described above—the construction of the levee system, which began in the 1920s, then expanded greatly in the 1950s and 1960s. As the river was destabilized in the early to mid 20th century, and farms developed along its channels, it was evident that levees were needed to hold back flood waters. The levees, while meant to help, worsened the situation according to these authors. The levees further disconnected the main channel from its floodplain, which leads to aggradation in the channel if sediment cannot be conveyed through the leveed reach. Moreover, if stream banks are prevented from eroding—as accomplished by diking, then the channel is not able to widen or adjust its form to accommodate increased sediment. This further increases the stage of discharges as the channel aggrades and the conveyance capacity of the channel is reduced, according to the authors. Levee breaches become more frequent as the channel conveys less and less flow. This scenario appears to have occurred, as evidenced by the car body levee and church dike failures in the early to mid 2000s.

Another factor that has been given little attention in understanding the causes of aggradation in the Skokomish basin is loss of tidal prism.[28] It is represented in Figure 4.38 by estuarine diking, but in actuality tidal prism has been more broadly affected by aggradation of the channel, connectivity within the entire estuarine zone, and the narrowing and channelization of the estuarine reach. The function of a river mouth estuary and its tidal prism to transport finer sediments completely to the marine environment as a part of the lower river continuum is illustrated in Figure 4.41. Within the reach length affected by tidal flow, sediment transport is normally more affected by tidal energy or mixed energy (combination of river and tidal energy) than it is by just riverine flow. Note in Figure 4.41 that the maximum amount of energy to move sediment occurs a short distance downstream of the upper end of tidal influence, where both riverine and tidal energy gradients combine. The effect of tidal prism operates on both the ebb and flood tides to suspend and move sediments, but the dominant direction of transport is on the ebb tide as it flushes sediment out of the river. This is likely particularly true for the Skokomish estuary due to the general lack of marine sediments being swept in during the flood tide in this region (Jay and Simenstad 1996).

As aggradation occurred in the lower river, continuing down into the upper end of the estuarine zone, the effectiveness of tidal prism was being reduced within the estuarine zone. It can be presumed that this sediment accumulation acted in some manner as a “plug” on the system upstream, further slowing the movement of small gravels, sands, and silts out the lower river.

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[28] / Tidal prism is defined as the total volume of water that passes through a channel cross section during the course of a tidal cycle. The total volume of tidal prism in a river mouth estuary would encompass all of the intertidal areas in immediate proximity to the river mouth including its delta, as well as the entirety of the zone of tidal influence within the river channel itself, including all distributaries, blind channels, and the lower ends of tributaries affected by tidal exchange. The volume and shape of the tidal prism are important for flushing away sediments which have been carried down river.

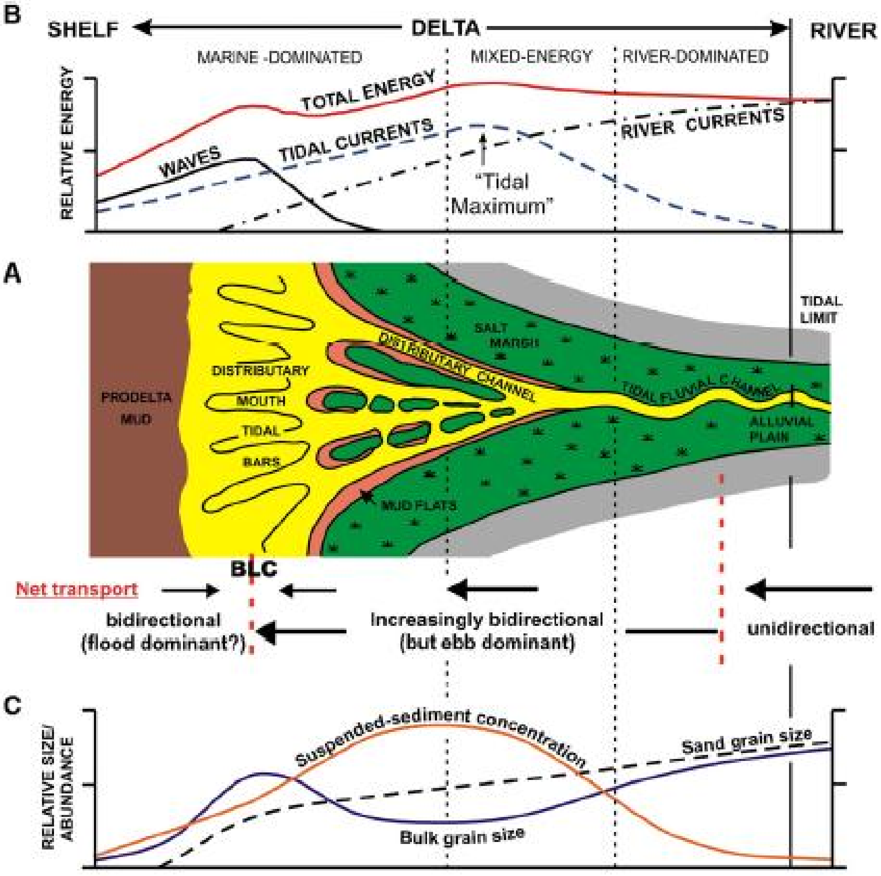

Figure 4.41. Energy to transport sediment within the estuarine zone of a river mouth estuary that has extensive delta development. Note the location of the upper end of tidal influence. The level of energy associated with strictly riverine currents begins dropping at the upper end of tidal influence. The level of tidal energy to move sediment reaches its peak somewhere between the upper end of the outer delta and the upper end of tidal influence. Mixed energy represents the combination of riverine and tidal energies, generating the highest level of energy close to where tidal currents reach their peak. Taken from Dalrymple and Choi (2007).

As aggradation occurred in the lower river, continuing down into the upper end of the estuarine zone, the effectiveness of tidal prism was being reduced within the estuarine zone. It can be presumed that this sediment accumulation acted in some manner as a "plug" on the system upstream, further slowing the movement of small gravels, sands, and silts out the lower river.

The upper half of the estuarine reach, historically beginning at about the Highway 101 bridge and continuing down to about the Highway 106 bridge has significantly less flow capacity than reaches upstream. The estuarine reach and continuing for some distance upstream appears to be the bottleneck for flow capacity in the lower river. Reduced capacity in this reach is the result of a narrowed channel, aggradation, and low gradient. Todd et al. (2006) described the Skokomish estuary as being "severely impaired", due in part to its loss of connectivity (Figure 4.42). The effect of this, combined with the remaining dikes within the lower estuary, is to reduce the function of the existing tidal prism. This effect needs to be considered along with the other factors operating upstream to better understand the nature of aggradation in the river.

Figure 4.42. Skokomish River delta and lower estuarine zone. Highway 106 bridge is visible at the most upstream end of where river water can be seen. Note the presence of the dike at the lower end of Nalley Island, showing the breach that occurred by storm action in 1995. The somewhat reddish area to the right of photo center is diked, which was completely removed in summer 2007. Other restoration activities occurred on the island in 2010.

It is useful to view the entire river corridor from the upper South Fork to the estuary with a landscape perspective (Figures 4.43-4.44). Changes in the active channel width between the upper South Fork and the estuary are illustrated.

The General Investigation (GI)

The U.S. Army Corps of Engineers (ACOE) is currently conducting a multi-year investigation of the Skokomish River to address ecosystem restoration issues and flooding in the watershed. The study is formally called the "Skokomish River Basin Ecosystem Restoration and Flood Risk Management General Investigation", or GI. Its purpose is to enable progress towards implementing a solution to the flooding problem while also aiding in the recovery of listed ESA species. The ACOE has partnered with Mason County, the Skokomish Tribe, and several State, Federal, and local governmental entities to complete the study.

The goals of the GI are to:

- Improve ecosystem functions and processes in the Skokomish River basin to benefit fish and wildlife, including listed salmonids;

- Reduce flood risk in the Skokomish River basin to residences, businesses, infrastructure, and tribal property and increase public safety through structural and non-structural measures;
- Investigate potential for ecosystem projects that secondarily meet limited flood risk management goals.

Currently, the project partners are studying the feasibility of certain actions that will meet the initial goals of the investigation. Some of the actions being considered are:

- Upper South Fork sediment management;
- Road removal and relocation;
- Mainstem river gravel removal;
- Flood routing;
- Setback levees and levee removal;
- Floodway acquisition;
- Bridge modification;
- Sediment basins and traps;
- Flood response plan.

The schedule calls for completing the final draft report by January of 2014.

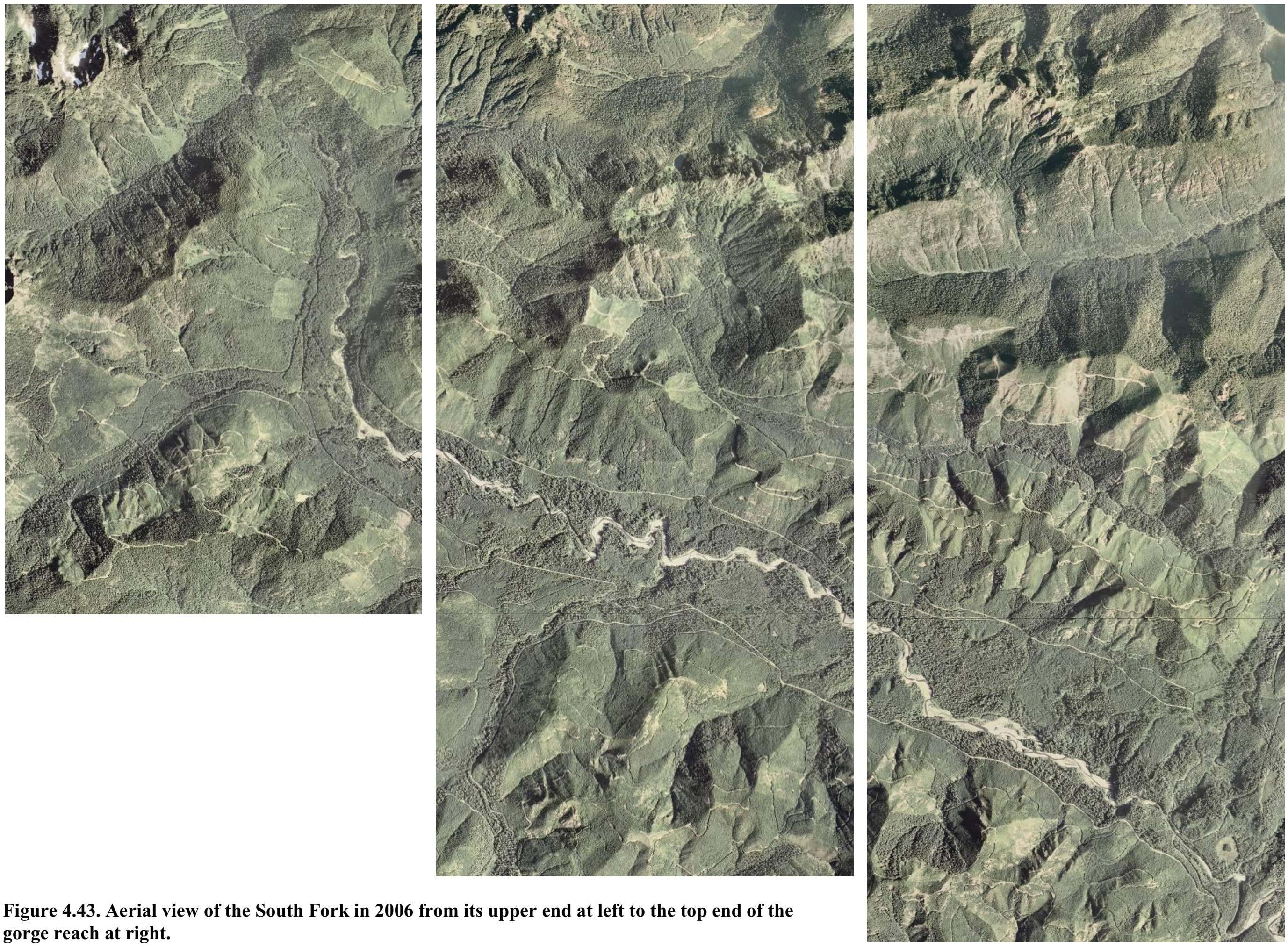

Figure 4.43. Aerial view of the South Fork in 2006 from its upper end at left to the top end of the gorge reach at right.

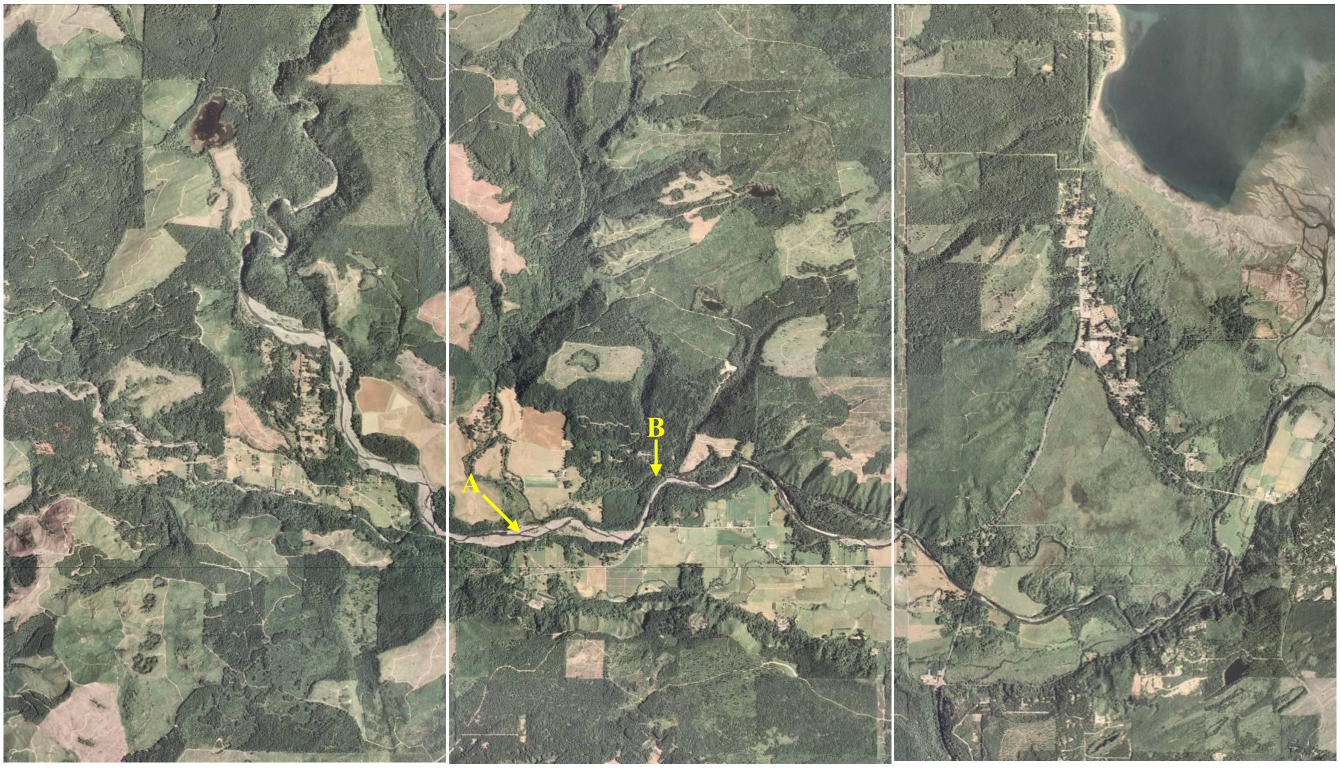

Figure 4.44. The Skokomish River valley in 2006 showing the lower South Fork (within the gorge reach at far left), lower North Fork, and mainstem Skokomish River. Note the widths of the active channel beds. The letter A marks the mouth of the North Fork. Since the photo was taken, the mouth of the North Fork has moved to the letter B as a result of channel avulsion. Also note the channel width in the North Fork relative to that of the South Fork.

Degraded Estuarine Conditions

This threat encompasses the many types of alterations that have made to estuarine habitats within both the Skokomish watershed and the Hood Canal region. These habitats provide critical functions in the life histories of Chinook produced in the Skokomish watershed. Over the past 150 years, extensive modifications have been made to these habitats as a result of a wide variety of land and water uses.

The Skokomish River estuary is the largest and most complex of the river mouth estuaries in Hood Canal (Todd et al. 2006). It extends from the upper limit of tidal influence in the lower river to the outer extension of the mud and sand flats on its outer delta (Figure 4.42). The shape of the Skokomish delta is typical of fjords, i.e. an isolated shallow region along a normally steep shoreline (Jay and Simenstad 1996).

Formed by the interplay of fluvial processes and marine influence, the Skokomish estuary encompasses a mosaic of aquatic habitats. These habitats provide four general functions for juvenile salmonid (Simenstad et al. 1982; Williams and Thom 2001):

- Foraging and rapid growth;
- Refuge from predation and from extreme physical events (such as freshets)
- Mixing areas for fresh and salt waters that assist physiological transition of juvenile salmon through smoltification; and
- Migratory corridor.

It is important to recognize that the Skokomish estuary is actually part of a much larger estuary—the Puget Sound-Georgia Strait complex. The entirety of this larger complex is technically an estuary because freshwater is measurably diluted by seawater. The complex is a continuum of estuarine characteristics—from strong to faint—moving from the southern ends of Hood Canal and Puget Sound to the western extremity of the Strait of Juan de Fuca (Friebertshauser et al. 1971).

The river mouth estuary is important in the life history of juvenile salmon in general, but it is of particular importance to Chinook (Healey 1982). Pacific salmon species utilize the estuary of their natal stream in different ways. Some species pass through it quickly, even spending a few hours there before moving to more marine-like waters beyond. Chinook, in contrast, can spend extended periods there, lasting up to several months. Healey (1982) concluded that Chinook is the most dependent on the natal estuary of all salmon species since members of all life history types feed and grow there for some amount of time. Fry migrants (those that emigrate rapidly out of riverine environment) are especially dependent on the natal estuary as they typically spend an extended period there (Healey 1982; Beamer et al. 2005).

In addition to the natal estuary, juvenile Skokomish Chinook are also believed to utilize non-natal stream deltas, shoreline salt marsh complexes, and fringing, shallow water corridors during their seaward migration through Hood Canal (Hirschi et al. 2003; Beamer et al. 2003; Bahls 2004). These areas provide extended opportunities for young Chinook to benefit from estuarine habitats. The open water habitats within Hood Canal are also important to Chinook life histories during their marine phase, including the resident blackmouth phase. The extent of impact to

Chinook salmon and their habitats and food webs from recently documented low dissolved oxygen and high acidity conditions in lower Hood Canal is of concern but has not been directly studied to date.

Historic Condition

The Skokomish estuary was a productive and diverse habitat complex prior to the advent of watershed development with settlement by Euro-Americans. Its features included an old riparian forest, extensive emergent freshwater marshes, low growing salt marsh communities, a network of tidal channels, and extensive mud and sand flats.

Large wood recruitment, riparian vegetation patterns, an intact forested watershed upstream, and the river's natural flow regime maintained relative stability of the entire complex (Simenstad et al. 1992; Collins et al. 2003). There is no doubt that the Skokomish estuary contained numerous log jams, given their known prevalence not far upstream as noted in previous sections of this chapter and clear documentation in other similar river types throughout Puget Sound. Godaire et al. (2009) concluded that the primary channel pattern and locations have remained essentially unchanged over the past 500 years. Channel avulsions within the estuarine zone appear to have been infrequent in the river's natural state.

It is believed that the primary channels of the Skokomish estuary were deeper prior to watershed development, and that tidal influence extended further upstream than it does currently. Jay and Simenstad (1996) noted that tidal influence extended almost to the confluence of the South Fork and North Fork, citing Canning et al. (1988). Godaire et al. (2009) stated that it extended to somewhere near the Highway 101 bridge. Marty Ereth (former biologist for Skokomish Tribe, *personal communications*) had concluded that tidal influence currently ends several miles downstream—to about midway between the Highway 106 and Highway 101 bridges. This change in the upper extent of tidal influence appears to be related to changes in channel depth. Jay and Simenstad (1996) stated:

> "Prior to dam construction, contemporary accounts and existing pilings show that the lower river was used by tugs towing barges and log rafts. It is now accessible to gillnet boats only at high water, and requires portaging a kayak at low water."

Based on analyses by Jay and Simenstad (1996) and Todd et al. (2006), the pre-settlement Skokomish estuary appears to have contained a balanced mix of the four zones that characterize river mouth estuaries: forested riverine tidal, transitional, emergent marsh, and tide flats. The landscape effect of the mixture of these zones would have produced a rich array of food organisms used by juvenile salmon. Each zone in its unaltered state would have contributed differently—combined they provided for nutrient cycling for a detritus based food-web within the estuarine landscape (Naiman and Sibert 1979). The Skokomish estuarine complex would have functioned to support a wide variety of Chinook life history types that likely existed, including fry migrants in late winter and early spring, parr migrants in late spring through early fall, and yearling migrants in spring.

Beyond the Skokomish River estuary, the pre-settlement Hood Canal contained many other smaller river mouth estuaries and a variety of tidal wetland habitats (Todd et al. 2006). The sizes and abundance of these features appear to have been much more limited than what occurs in other regions of Puget Sound, but they would have provided important near-shore functions for Hood Canal Chinook.

Existing Condition

Jay and Simenstad (1996) and Todd et al. (2006) presented detailed information on the progression of changes that occurred over the past 150 years to the Skokomish estuary and to other estuarine habitats in Hood Canal. We summarize their findings here.

The earliest documented changes to the Skokomish estuary after the arrival of Euro-Americans occurred sometime before 1884 when the BIA facilitated land clearing for farming and residences (Todd et al. 2006). The configuration of the estuary is seen Figure 4.45 as it existed in 1884, showing a modest amount of alteration at that time. As described in previous sections of this chapter, logging and land clearing of the lower valleys was progressing rapidly by the end of the 19th century but changes to the estuary remained relatively small for some period.

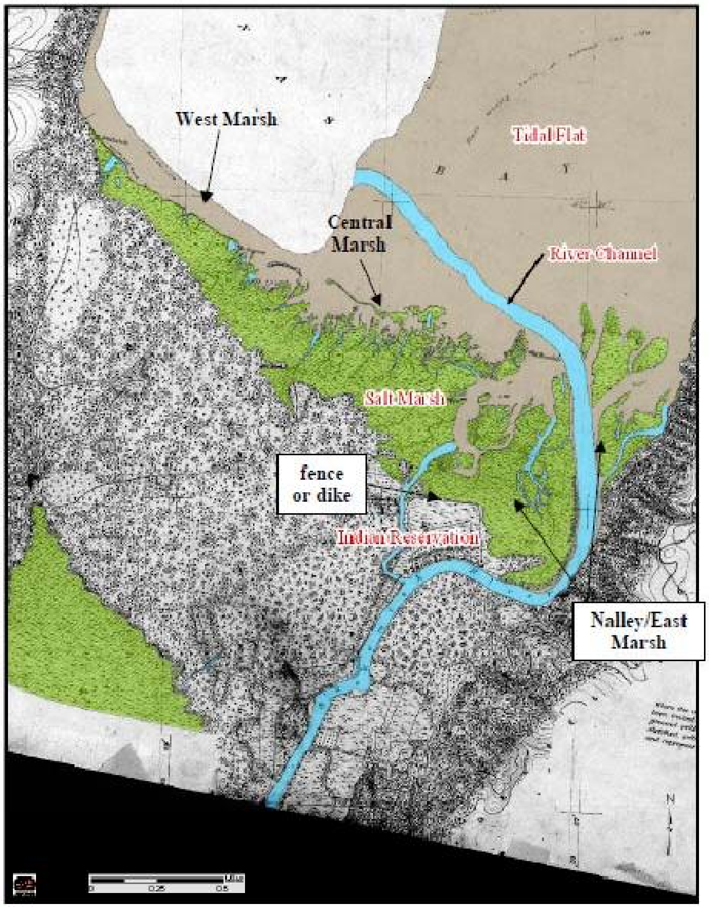

Figure 4.45. The 1884 topographic sheet (T-sheet) showing the Skokomish estuary and three areas of tidal marsh discussed by Todd et al (2006). The Skokomish Indian Reservation in 1884 was located at the south part of what is today called Nalley Island, near the center of image. This area was either fenced off or diked off from the salt marsh at the time. From Todd et al. (2006).

Beginning in the late 1930s, extensive diking and drainage of wetlands occurred in the delta area, including on Nalley Island (the island formed by the major distributary seen in Figure 4.45) and on the west side of the delta, referred to locally as Nalley Slough. Parts of the salt marsh and adjacent river channel substrates were dredged to provide material for building dikes. The diking project resulted in severe truncation of several major tidal channels and sloughs as well as to a vast network of smaller dendritic channels (Figure 4.46). Eventually, the entire perimeter of Nalley Island was diked. These alterations changed the stream and tidal flow patterns throughout the area, as well as changing the vegetation patterns of the complex. The area was then farmed and used for private duck-hunting for several decades beginning in the 1940s. Other areas along the fringes of those areas already altered saw more changes in the 1950s and later. Todd et al. (2006) noted that by 1958, the river channel was beginning to shallow, apparently giving rise to salt marsh islands that have since grown into much larger patches of salt marsh.

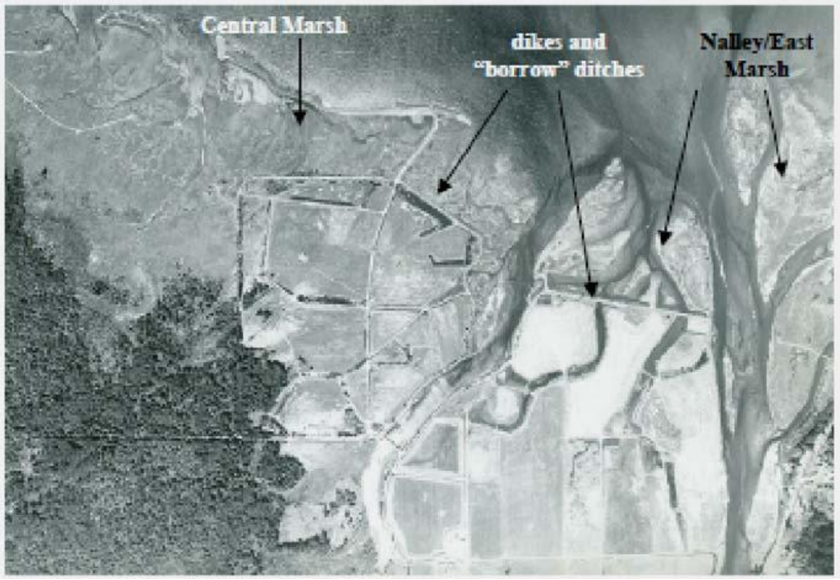

Figure 4.46. A 1958 air photo showing the system of dikes and borrow ditches and pits, most of which was constructed between 1938 and 1942. From Todd et al. (2006).

Jay and Simenstad (1996) reported on changes to in-channel sediment composition and distribution within the estuary that occurred over the period of extensive watershed modifications. They concluded the following:

- Widespread shoaling (shallowing) had occurred to the channels of the inner delta based on a comparison of 1885 and 1972 survey data.
- The outer delta face had experienced overall steepening due, they believed, to the widespread shoaling that had occurred upstream of that area.
- Sediments throughout the inner delta, i.e., within the area of shoaling, had become finer over time with the upper layer consisting of very fine sand with local intermixing of silt and clay. Coarser material (medium sands to gravel) was found deeper than this layer.
- Loss of coarser material being moved to the outer delta appears to be the factor causing erosion of the outer delta face, resulting in steepening of that area.

- The changes in sediment composition and distribution were likely due primarily to the loss of flow in the North Fork because to the Cushman diversion, but diking may have contributed through a reduction in tidal prism. The authors of that particular study discounted increased sedimentation coming from the South Fork.
- These changes have likely caused a loss of estuarine fish habitat (approximately 17 percent of eelgrass beds and 15-19 percent of the lower intertidal area).

The Skokomish estuary began a course to restoration in the winter of 1994-1995 when one of the main dikes on Nalley Island was naturally breached during a storm event. Other restoration actions have been taken since then, including extensive dike removal and borrow ditch remediation on Nalley Slough in 2007 and Nalley Island in 2010.

Todd et al. (2006) described anthropogenic changes that have occurred to each of 187 estuarine features within the Hood Canal region. The majority of these features were shown to be substantially altered, with both individual and cumulative impacts to Chinook salmon.

Hypothesis on Effects of Impaired Estuarine Conditions

The findings reported above for how the structure and function of the estuary have been changed over the past 150 years are the basis for several hypotheses described here on the effects of these changes.

Jay and Simenstad (1996) concluded that a loss of sediment transport capacity caused erosion of the outer Skokomish delta combined with shallowing on the inner delta and in the lower part of the mainstem river. Associated with these changes was a buildup of much finer sediment in the top layer of the bed. They attributed these changes principally to the altered flow regime. We suggest that the changes were likely caused by many factors combined—discussed earlier in this chapter, including an increase in sediment delivery from the upper South Fork.

Jay and Simenstand further concluded that the loss of sediment transport capacity resulted in a loss of primary productivity in the estuary and a compression of the mesohaline (i.e., brackish) mixing zone. These changes, they hypothesized, would have caused a sharp reduction in the amount of optimal estuarine habitat available for foraging and physiological adaptation by juvenile salmon (Figure 4.47). These losses would have been particularly important to juvenile Chinook, which have a greater need for these estuarine functions than other salmon species (Healey 1982).

Using a different approach, Todd et al. (2006) hypothesized a similar level of loss in function in the Skokomish estuary. In considering the various effects of loss in habitat quality, quantity, and connectivity within the estuary, as well as watershed-scale effects in the flow and sediment regimes, they categorized the estuary as “Severely Impaired.”

We further hypothesize that the shallowing, or aggradation, of the inner delta, which apparently has occurred throughout the estuarine zone except on its outer extremity, may serve as type of plug on the lower end of the river system, thereby inhibiting sediment transport from upstream. Therefore, we suggest that the solution to the aggradation and flooding problems in the lower valley will require remediation of the aggradation in the river delta. Actions to address this issue will require a more thorough analysis of estuarine sediment and flow processes, which should be forthcoming through the General Investigation (GI) now being conducted.

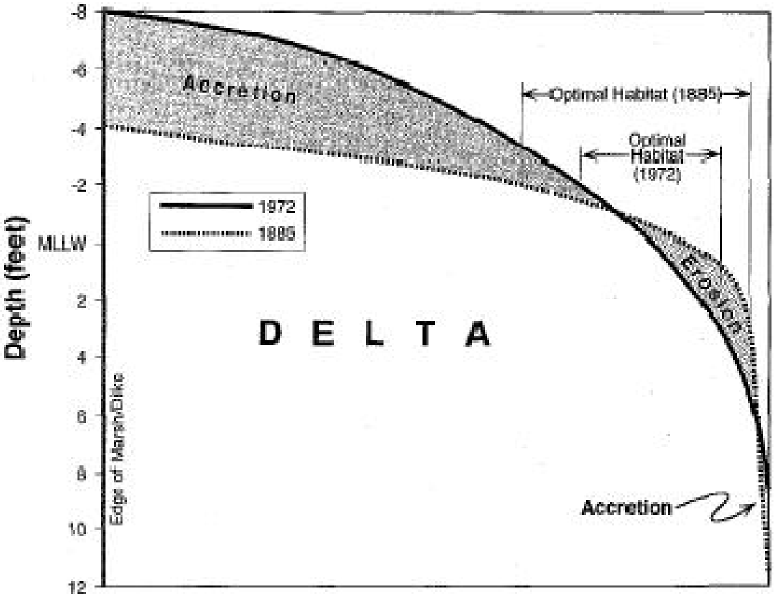

Figure 4.47. Hypothesized effects of changes in estuarine structure on the amount of optimal estuarine salmon habitat due to upstream alterations of watershed processes in the Skokomish watershed. From Jay and Simenstad (1996). Accretion on the inner delta and erosion on the outer delta margin has reduced the surface area of optimal low intertidal salmon habitat. From Jay and Simenstad (1996).

Finally, we hypothesize that the impaired estuarine function described above would have a greater effect on juvenile life histories of late-timed Chinook than on those of early-timed fish. As noted above, Chinook fry migrants have a greater dependence on river mouth estuaries than on older juveniles when they move into the estuary. Older and larger juvenile Chinook can transition into more marine-like waters more quickly (Healey 1982; Beamer et al. 2005). Data collected on juvenile outmigration patterns in the Skokomish watershed collected in the 1950s suggest that the aboriginal early-timed Chinook had a later downstream movement than that of juveniles produced by late-timed spawners (WDF 1957a); hence progeny of early-timed spawners did not exhibit a fry migration. These are also the patterns of juvenile Chinook outmigrations observed in the Queets River (QDNR, unpublished). We note, however, that Beamer et al. (2005) have found evidence of fry migrants in all Chinook populations in the Skagit River, including early-timed ones.

Restoration Actions Previously Implemented or Soon To Be

Significant steps have already been taken to restore the Skokomish estuary. As noted, nature began the process in 1995 when a major dike on Nalley Island was naturally breached (see Figure 4.42). Then, in 1999 the Skokomish Tribe initiated active restoration by taking action to increase flow access to the major distributary (Nalley Slough) on the west side of Nalley Island by removing abandoned bridge foundations blocking flow. This was followed in 2007 by an even larger project to remove the dikes and to fill borrow ditches on the west side of Nalley

Slough. That project, considered Phase 1 of the current estuarine restoration program, is outlined in Figure 4.48.

Phase 2 of the program was completed in the summer of 2010 (Figure 4.48). This phase removed the vast majority of dikes on Nalley Island including the perimeter dikes, filled multiple borrow ditches, removed interior roads and bridge approaches, and restored the channel network where possible. This phase addressed the largest outstanding issue in the Skokomish estuary, though several other smaller scale projects remain, as well as the aggradation of the primary channels.

Figure 4.48. View of the Skokomish delta showing (as outlined) Phase 1 of the estuarine restoration program (on left) and Phase 2 of the program (on Nalley Island).

Habitat Limiting Factors – Priorities and Sequencing

We used the EDT model to help diagnose habitat the limiting factors in the watershed for Chinook performance and to identify restoration priorities. The EDT habitat attributes were characterized to reflect the existing conditions of the watershed as described in the previous sections on threats. We included in this characterization how we expect the lower river to respond in the near-term to the new flow regime being implemented in 2010. One component of the new regime is designed to increase channel substrate scour in hopes of increasing the channel's flow conveyance capacity.

We assessed limiting factors for both an early-timed and late-timed population having life history patterns like those of the aboriginal populations. The performances of the modeled populations for both historic and existing habitat conditions were presented near the end of Chapter 3. Those results, together with the summary of limiting factors analysis shown here, provide a diagnostic snapshot of the watershed to produce natural Chinook in its current state. It needs to be recognized that the performance values given in Tables 3.1 reflect populations with full genetic fitness.[29]

Figure 4.49 presents the summaries of the limiting factors analysis, using the standard output produced by the EDT model. The figure employs a consumer-report style format to identify the highest priorities for restoration for geographic areas of the river system and associated habitat factors. The reader is referred to Blair et al. (2009) and Thompson et al. (2009) for a detailed description of this type of limiting factors analysis.

The conclusions regarding an early-timed Chinook population are summarized as follows:

- The watershed is unlikely to be able to sustain early-timed Chinook in its current state, due to a small equilibrium abundance associated with relatively low productivity (see Table 3.1). Any fishery impacts would reduce the equilibrium abundance to an even lower level.
- The highest priority geographic areas for restoration are the Cushman Project area, South Fork gorge, areas of the upper South Fork (upstream of gorge), then the river-mouth estuary, though it should be noted that these areas are strongly and negatively affected by adjacent areas as well.
- The highest priority habitat factors identified for restoration are passage over obstructions (at the Cushman Dams, South Fork gorge cascades, and dry channel in the lower South Fork), channel stability (in the upper South Fork, followed by stability in the lower valleys), water temperature (several areas), key habitat amount, and the inundation of the upper North Fork by Lake Cushman (represented in the factor "sediment load"). All of these factors, except the inundation, have the potential of being restored or protected at some level of normative condition over the next 40 years.

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[29] / Performance values of a population composed of hatchery domesticated fish with life history patterns like those of George Adams Hatchery fish would be much less than those listed in Tables 3.1.

Skokomish River Early-Timed (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
Skokomish Estuary	○	∘			•		•		•									⬤
Lower Skok below 101	○						•		•									●
Lower Skok above 101	∘		•				•		•									●
Lower NF			•				•		•									●
Cushman Project		◯	•		•			•			⬤			•	⬤	●		⬤
Big Creek			•					•	•							•		
Upper NF								•										
Lower SF	∘						•		•		⬤							●
SF canyon	○	◯						•	•		⬤							•
Upper SF below Lebar Cr	○	○	⬤				•	•	•						•	●		●
Brown-LeBar Crs	∘		•					•	•							•		●
Upper SF above Lebar Cr	◯	○	●				•	•	•						•	●		●
Upper SF above Church Cr	○		●				•	•	•						•	●		●

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

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

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

Skokomish River Late-Timed (Fall) 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
Skokomish Estuary	◯	○			•		•		•									⬤
Lower Skok below 101	◯	○					•		•					•				●
Lower Skok above 101	○	◯	⬤				•		•	•				•	⬤			⬤
Lower NF	◯	◯	⬤				•		•					•	●			●
Lower SF	∘	◯	⬤				●		•		●				•			●
Vance Cr	◯	○	●				•		•						•			●
SF canyon		○	⬤				•	•	•						•			●

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

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

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

Figure 4.49. Summary of limiting factors analysis produced by the EDT model. The figure employs a consumer-report format to illustrate priorities identified by the model for restoration and protection by geographic area, as well as the relative importance of addressing different factors affecting Chinook performance. See Thompson et al. (2009) for further description

The conclusions regarding a late-timed Chinook population are summarized as follows:

- The watershed is highly unlikely to be able to sustain late-timed Chinook in its current state, due to both a small equilibrium abundance and an extremely low productivity (see Table 3.1). Fisheries impacts would drive productivity even lower and push the equilibrium abundance value to zero for the modeled population.
- The highest priority geographic areas for restoration are all of the lower river valleys in the watershed, including that of the main river, the lower South Fork and the lower North Fork, then the river-mouth estuary and reaches within the South Fork canyon, though it should be noted that these areas are strongly and negatively affected by adjacent areas as well.
- The highest priority habitat factors identified for restoration are channel stability, sediment load, flow characteristics, key habitat amounts, and passage through the de-watered channel in the lower South Fork (shown under "obstructions"). All of these factors relate to the aggradation and flooding issues occurring in the lower river valleys.

These conclusions support the priority of this plan being placed on recovering the early-timed racial component. The most complex restoration issue in the watershed involves the aggradation, channel and floodplain diminishment, and flooding problems within the lower river valleys. That issue is most critical to be remedied if late-timed Chinook life histories are to be recovered. The solutions to that issue are expected to be long-term ones, given that they depend in part on restoring normative channel conditions in both the upper South Fork and the lower North Fork.[30] Sediment delivery to the lower valleys needs to be stabilized and diminished to help reduce aggradation there.

We conclude that strategic sequencing for restoring normative watershed processes and functions to support Chinook recovery will involve working simultaneously from the upper watershed areas and the river mouth estuary toward the mid section of the watershed (i.e., towards the middle of the lower valleys). High priority should be given to stabilizing and restoring the upper South Fork and the estuary, as strategies are being developed and implemented to restore the lower valleys to normative function. Concurrent with such an approach, fish passage issues at the Cushman Dams and in the South Fork need to be addressed.

Framework for Habitat Strategies

This section identifies strategies for addressing the habitat-related issues described in the preceding sections. The strategies are presented within a framework that links each threat to its relevance to Chinook, then to causes, potential solutions, and finally to strategies for realizing those solutions. These are then linked to the habitat objectives described earlier in this chapter. The framework also identifies critical uncertainties that will need to be considered as monitoring and evaluation move forward. Benchmarks and indicators for measuring progress toward meeting those objectives are provided in Chapter 9 (Adaptive Management and Monitoring).

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[30] / The new flow regime is expected to scour sediment deposits in the lower North Fork and move it downstream into the lower Skokomish River.

A total of 26 strategies, grouped according to the threat that they address, are identified in the framework (Table 4.5). Collectively, these strategies have the potential to restore watershed processes and habitat functions to normative levels that would achieve the recovery goals given in Chapter 3.

Some of the habitat strategies are described in general terms to represent a group of different actions that could potentially be used to realize the same solution. An example of this is the strategy "Strategically address key sediment deposits and install log jams to improve channel efficiency" aimed at the lower valley floodplains and channels. The specific actions that would constitute this strategy could involve different types of measures, such as ones that rely solely on natural processes to facilitate sediment transport (e.g., through targeted use of log jams and/or side channel reconnection) to ones that also employ some amount of bar scalping and channel dredging in conjunction natural processes. Specific design of actions remains to be done as part of implementation planning. Results of the General Investigation are expected to help refine definition of specific actions associated with some of the strategies.

Table 4.5. Framework for habitat **strategies**.

Threat, Issues, Watershed Processes	Relevance to Chinook	Causes	Solutions	Strategies	Objectives	Critical Uncertainties
Degraded Upper Watershed Conditions in South Fork and Vance Creek <u>Issues:</u> Significantly increased sediment load; unstable sediment and channels; altered in-channel sediment processing; altered hydrologic processes; decreased LWD recruitment; increased solar radiation; loss of channel complexity; reduced accessibility of adult Chinook access to the upper SF at cataracts. <u>Processes:</u> Geomorphic processes; hydrologic processes; hydraulic processes; sediment delivery; LWD recruitment; thermal inputs; reactivated paraglacial processes	▪ Aggradation in lower SF and Vance Cr., reduces surface flow, hindering upstream movement of adult Chinook during low to moderate flows and limits spawning site selection ▪ Increased sediment load adversely affects egg to fry survival due to degraded channel conditions ▪ Loss of channel complexity reduces habitat quality for egg and fry survival ▪ Increased sediment loading increases delivery to lower Skokomish valley, compounding habitat issues there ▪ Increased thermal loading reduces suitability for early-timed Chinook performance ▪ Reduced spring-time snowmelt pulse reduces passage efficiency at gorge cascades	▪ High road density and failures, importing coarse and fine materials; ▪ Insufficient road maintenance; ▪ Large-scale and rapid clearcutting of subbasin; ▪ Logging of riparian zone in many areas ▪ Stream clearing and channel destabilization; ▪ Erosive sub-drainages; ▪ More rapid snowmelt and diminishment of the spring snowmelt pulse, possibly due to climate change; ▪ Glacial history and re-activation of paraglacial process.	▪ Reduce anthropogenic sediment inputs ▪ Restore sediment sorting processes ▪ Re-establish coniferous riparian forests having old-growth characteristics ▪ Increase channel stability and complexity ▪ Restore floodplain connectivity in response reaches ▪ Improve forest hydrologic maturity ▪ Arrest paraglacial processes that have been reactivated ▪ Improve passage for re-introduced salmonids through gorge cascades	▪ Decommission roads and maintain remaining road & trail network ▪ Stabilize sediment sources ▪ Maintain and/or expand riparian reserves ▪ Restore riparian conditions ▪ Increase woody debris and log jam loading ▪ Silviculture treatments to increase hydrologic maturity ▪ Remedial measures to improve adult passage at the gorge cascades	▪ Restore upland landscapes and vegetation that improve and restores watershed form and function ▪ Restore the fluvial geomorphic processes in the watershed channels, channel form and function, and sediment movement ▪ Restore floodplain function and connectivity in the Skokomish River and tributaries ▪ Protect riparian and floodplain corridor, in-channel habitat, water quality, and channel conveyance capacity from further degradation ▪ Enhance fish passage effectiveness in the gorge cascades	▪ Relative impacts between sediment sources (slope versus in-channel); ▪ Hydrologic impacts on basin and sub-basin scales from forest management; ▪ Time required to arrest re-activated paraglacial processes; ▪ Significance of sub-basin erosion and deposition to geomorphic and biological processes; ▪ Adequate levels of woody debris and ELJ loading; ▪ Short-term and long-term effects of climate change; ▪ Funding levels for restoration and recovery actions.

Table 4.5. (continued) Framework for habitat strategies.

Threat, Issues, Watershed Processes	Relevance to Chinook	Causes	Solutions	Strategies	Objectives	Critical Uncertainties
Altered Flow Regime in North Fork <u>Issues:</u> Extreme alterations to natural flow regime, including its magnitude, timing, variation; channel narrowing and aggradation in NF; loss of floodplain storage in NF; promotion of aggradation in lower mainstem with loss of channel flow capacity; habitat simplification in NF (in-channel and off-channel); loss of lateral habitat connectivity in NF. <u>Processes:</u> Hydrologic processes; hydraulic processes; geomorphic processes	▪ Characteristics of flow regime in NF over past 80 years not supportive of native Chinook life histories (loss or changes in queues and habitat conditions for adult migration, spawning, and fry migration) ▪ Losses in habitat quantity in NF due to extreme reductions in flow ▪ Severe aggradation in lower mainstem reduced habitat quantity and quality (creating more unstable conditions for egg incubation) -- effects have extended into the river mouth estuary	▪ Dam construction and associated hydro-electric operations with water diversion out of basin	▪ Re-creation of normative flow regime in the NF through change in how flows are regulated at Cushman Dam ▪ Regulation of high flows at Cushman Dam to promote channel scour and facilitate return to more normative conditions	▪ More normative flow regime created by changes in regulation at Cushman Dam – Base flow shape with spring runoff – Variation to mimic freshets – Extended high flows and bankfull flows to promote channel scour	▪ Restore normative flow regime to promote channel and habitat reformation, channel flow capacity, and re-creation of normative queues for biological responses. ▪ Restore floodplain function and connectivity in the Skokomish River and tributaries. ▪ Restore the fluvial geomorphic processes in the watershed channels, channel form and function, and sediment movement.	▪ Effectiveness (extent and rate) of new flow regime to restore channel characteristics and flow capacity in the NF and lower mainstem. ▪ Effectiveness of new flow regime to remediate sediment deposits sufficiently or will other strategies be needed? ▪ Number of years needed to attain substrate and channel characteristics required to support viable life histories of naturally reproducing Chinook.
Loss of Fish Access to Upper North Fork and Inundation by Reservoir <u>Issues:</u> Cushman Project isolated anadromous fish habitat by not providing fish passage facilities, as well as inundating high quality stream habitat under the lake for both anadromous and resident fish. <u>Processes:</u> Watershed connectivity; hydrologic processes; geomorphic processes; hydraulic processes; ecological processes by inundation	▪ Loss of access resulted in extinction of early-timed Chinook in the NF ▪ Loss of accessibility for Chinook to re-colonize naturally ▪ Loss of a major portion of productive Chinook habitat in the Skokomish basin due to inundation by Cushman reservoirs	▪ Dam construction without passage facilities ▪ Inundation of productive habitat by reservoirs	▪ Fish passage for migrating early-timed Chinook ▪ Re-introduction and on-going supplementation of early-timed Chinook using artificial propagation methods	▪ Trap and haul fish passage facilities for upstream passage of adult early-timed Chinook at Cushman Dam. ▪ Trap and haul fish passage facilities for downstream passage of juvenile early-timed Chinook at Cushman Dam. ▪ Implement early-timed Chinook hatchery supplementation program (see Hatchery Chapter)	▪ Provide for effective upstream and downstream passage of migrant salmonids at the Cushman dam sites ▪ Provide for conservation hatchery facilities within the North Fork subbasin to support an integrated population component of early-timed Chinook (see Hatchery Chapter)	▪ Migration effectiveness of adult Chinook to base of lower Cushman Dam ▪ Trapping effectiveness of adult Chinook at the base of Cushman Dam ▪ Downstream passage effectiveness of juveniles through Lake Cushman and through the trapping facility ▪ Impact of loss of productive stream habitat through inundation, and ability of re-introduced population to perform with reduced habitat.

Table 4.5. (continued) Framework for habitat strategies.

Threat, Issues, Watershed Processes	Relevance to Chinook	Causes	Solutions	Strategies	Objectives	Critical Uncertainties
Degraded Lower Floodplain and Channel Conditions (in-channel, off-channel, riparian) Issues: High sediment load; aggradation and shallowing; de-watering; loss of channel complexity; loss of LWD structure; decreased LWD recruitment; unstable sediments and channels; loss of connectivity (in-channel and off-channel); fish stranding; increased thermal loading; decreased biological productivity; reduced riparian functions; increased flood frequency. Processes: Geomorphic processes; hydrologic processes; hydraulic processes; connectivity; biological productivity;	▪ Loss of adult migration, spawning, incubation, and juvenile habitat quality and quantity; ▪ Loss in Chinook performance at all life stages; ▪ Tremendously unstable spawning, egg, and fry habitats; ▪ Loss of adult Chinook access to South Fork; ▪ Juvenile stranding in dry channels; ▪ Loss in food diversity and quantity for juvenile Chinook.	▪ Land clearing of valley bottoms for farming and settlement; ▪ Log-driving and channel clearing of logjams; ▪ Flow diversion from Cushman Dams out of basin; ▪ Wholesale logging of lower floodplains and uplands with increased sediment delivery; ▪ Glacial history and re-activation of paraglacial process; ▪ Levee and dike system and loss of channel migration potential; ▪ Aggradation of lower river channels; ▪ Loss of channel flow capacity.	▪ Reduce anthropogenic sediment inputs; ▪ Restore sediment sorting processes ▪ Re-establish coniferous riparian forests having old-growth characteristics; ▪ Increase channel stability and complexity; ▪ Restore floodplain connectivity in response reaches; ▪ Improve forest hydrologic maturity; ▪ Arrest paraglacial processes that have been reactivated; ▪ Expand available channel migration zone (CMZ); ▪ Re-creation of normative flow regime in the North Fork; ▪ Regulation of high flows at Cushman Dam to promote channel scour and facilitate return to more normative conditions.	▪ Extend CMZ through regulatory, incentive, and education programs; ▪ Strategically remove impediments to meander, avulsion and channel connectivity; ▪ Construct ELJs to restore channel complexity and sediment processes ▪ Strategically address key sediment deposits and install log jams to improve channel efficiency; ▪ Protect riparian lands through regulatory, incentive, and education programs; ▪ Restore effective riparian forest width; ▪ Restore riparian forest quality with conifer underplantings; ▪ Inventory and control invasives such as knotweed.	▪ Restore upland landscapes and vegetation that improve and restores watershed form and function; ▪ Restore the fluvial geomorphic processes in the watershed channels, channel form and function, and sediment movement; ▪ Restore floodplain function and connectivity in the Skokomish River and tributaries; ▪ Protect riparian and floodplain corridor, in-channel habitat, water quality, and channel conveyance capacity from further degradation; ▪ Restore normative flow regime to promote channel and habitat reformation, channel flow capacity, and re-creation of normative queues for biological responses.	▪ Sediment delivery rates from the upper South Fork; ▪ Amount of sediment and wood loading to come from the North Fork with implementation of new flow regime; ▪ Effectiveness of new flow regime to accelerate sediment routing and transport in the lower river valley; ▪ Effectiveness of strategies to arrest re-activated paraglacial processes in the South Fork; ▪ Appropriate level of channel conveyance and sustainability given how flow regulation will continue to occur and on-going land uses in the basin; ▪ Sufficient size of CMZ by reach; ▪ Sufficient level of woody debris and ELJ loading; ▪ Funding levels for restoration and recovery actions.

Table 4.5. (continued) Framework for habitat strategies.

Threat, Issues, Watershed Processes	Relevance to Chinook	Causes	Solutions	Strategies	Objectives	Critical Uncertainties
Degraded Estuarine and Near-shore Conditions **Issues:** Loss of tidal marshes and channels; decreased primary and secondary productivity; channel aggradation and loss of pool complexity; loss of non-natal estuarine habitats **Processes:** Tidal inundation; primary and secondary productivity; geomorphic processes; connectivity; near-shore drift-cell processes.	▪ Loss of juvenile estuarine habitat quality and quantity; ▪ Loss of biological productivity to supply abundant food for young salmon; ▪ Reduced distribution and frequency of suitable non-natal estuarine habitats to provide stop-over feeding sites and refuge from predators; ▪ Aggradation of the river-mouth estuary and reduced tidal prism contributing to the many changes in channel condition upstream of the estuary (due to “plugging” effect of the estuary by aggradation).	▪ Levee construction; ▪ Filling and road building; ▪ Ditching; ▪ Vegetation conversion; ▪ Increased coarse sediment load; ▪ Decreased channel efficiency; ▪ All of the factors listed under the other threats associated with sediment routing and delivery, flow regime characteristics, and channel characteristics.	▪ Increase and improve tidal inundation; ▪ Improve local channel complexity and conveyance; ▪ See sediment load and delivery solutions listed under the other threats; ▪ Restore and protect non-natal estuarine habitats.	▪ Remove levees and landfill; ▪ Fill borrow ditches; ▪ Rip compacted road beds; ▪ Excavate tidal channels where needed; ▪ Strategically address key sediment deposits and install log jams to improve channel efficiency; ▪ Restore and protect non-natal stream deltas, tidal embayments, and beaches; ▪ Other strategies associated with restoring sediment routing and a normative flow regime.	▪ Restore nearshore habitat, the estuary, and associated floodplain habitat and function; ▪ Restore flow conditions monitor habitat forming flow regimes and channel geometry; ▪ Restore the fluvial geomorphic processes in the watershed channels, channel form and function, and sediment movement.	▪ Sediment delivery rates from the upper South Fork and how these affect aggradation in the estuary; ▪ Amount of sediment and wood loading to come from the North Fork with implementation of new flow regime and how these will affect aggradation in the estuary; ▪ Effectiveness of new flow regime to accelerate sediment routing and transport in the lower river valley and through the estuary; ▪ Appropriate level of channel conveyance and sustainability given how flow regulation will continue to occur and on-going land uses in the basin; ▪ Long-term constraints placed on estuary restoration by electric infrastructure; ▪ Extent and type of non-natal estuarine habitats needed to be restored.

Chapter 5. Hatchery Recovery Strategies

Hatchery technology is an essential tool for recovering Chinook life histories adapted to the environmental conditions being restored to the Skokomish watershed. Habitat restoration and hatcheries, operating in unison, are seen as being a necessary, effective approach to achieve both the short- and long-term recovery goals for the watershed. This chapter outlines the ways in which hatcheries will be employed to achieve these goals.

The chapter is organized into the following sections:
- The role of hatcheries in recovery;
- Hatcheries – past and present;
- Hatchery management objectives;
- Strategy implementation;
- Benefits and risks of hatchery strategies.

The Role of Hatcheries in Recovery

A fundamental hypothesis of this plan is that restoration of habitat-forming processes will provide the habitat needed for the re-expression of successful Chinook life histories, allowing the species to recover to viable levels (Chapter 1). No indigenous, locally adapted Chinook exist in the Skokomish watershed currently (Myers et al. 1998, Ruckelshaus et al. 2006). Consequently, just as active restoration of habitat forming processes is necessary, active restoration of demographic processes using artificial production[31] can increase the likelihood and pace of re-establishing adapted Chinook life histories compared to passive management that relies on natural recolonization. To be successful, however, the appropriate sequencing, timing, location, and magnitude of hatchery actions with habitat recovery must also provide ecosystem services, harvest, and other benefits to the people investing in these choices.

Habitat restoration is the cornerstone to Chinook recovery, but rehabilitating degraded natural processes that create and sustain critical habitat may take 50 to 100 years or more to attain full benefits. Active restoration of normative conditions benefiting Chinook salmon can occur over shorter periods, however, and hatcheries will continue to play an essential role in managing and protecting the resources of the watershed (Figure 1.3, Chapter 1).

Hatcheries offer the possibilities of maintaining or increasing abundance and distribution of salmon, reintroducing stocks or species, and providing for harvest. Salmon can respond quickly to these actions but the results may not be sustainable without continued hatchery production. In contrast, habitat recovery can restore ecosystem processes that form and sustain salmon life histories and salmon populations, but the results may take much longer. Using hatcheries and habitat recovery in unison is a more efficient and successful approach to achieving the short- and long-term goals for the watershed than using either one alone.

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[31]/ Tools of artificial production include translocation and reintroduction; choice and control of brood stock and spawning; management of fish parasites and diseases, growth, and behavior through rearing conditions; time, location, size and status of fish released into the wild; and monitoring.

Hatcheries – Past and Present

Hatcheries for raising and releasing Chinook have been part of fish management in Hood Canal since the early 1950s (Myers et al. 1998). Since then, Chinook have been released into most of the major rivers and streams of Hood Canal. Although locations of releases included areas that did not historically support Chinook populations, most releases were focused on the Skokomish River and mid-Hood Canal (Figure 5.1) where historical populations of Chinook occurred (Ruckelshaus et al. 2006). Sources for brood stock have varied, ranging from later-returning stocks from the Trask River (Oregon), Elwha, and Dungeness rivers to early-returning stocks from the Dungeness River and two hybrid stocks, one from Soleduck Hatchery and a second derived from interbreeding Nooksack, Cowlitz, and Umpqua River (Oregon) stocks (Myers et al. 1998, Fuss and Ashbrook 1995). Most releases, however, have been of Green River-origin Chinook salmon, a later-returning stock that has been under culture since 1901 and that is used throughout Puget Sound, although often under different names (Fuss and Ashbrook 1995).

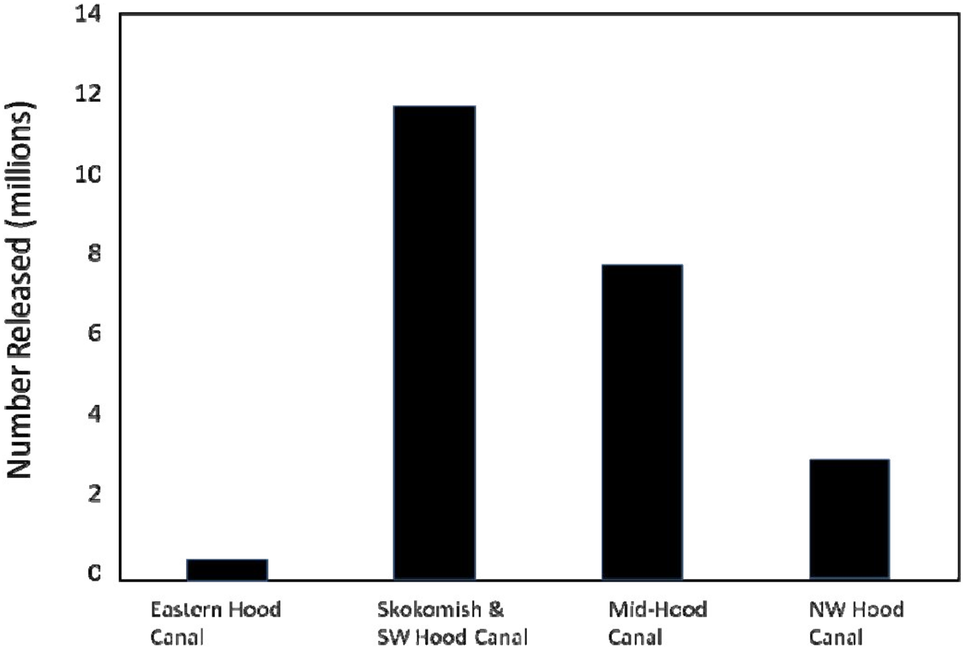

Figure 5.1. Numbers of Chinook released into Hood Canal rivers and streams prior to listing under the Endangered Species Act. Data are from Myers et al. (1998)

More recently, hatchery production of Chinook in the Skokomish River has relied on releasing 3.8 million fingerling fish from the George Adams Hatchery, a facility owned and operated by Washington Department of Fish and Wildlife. The program depends on collecting and spawning returning George Adams brood stock (a derivative of Green River Chinook that were introduced into the watershed). More detail on current operations may be found under "Strategy Implementation" in this plan.

The legacy of hatchery production imposes important constraints on the opportunities and pace for recovering natural, viable population of salmon. A variety of authors have described and evaluated these (see Currens and Busack 1998; Naish et al. 2008). These include genetic affects, such as loss of within-population diversity (which can limit the capacity of populations to adapt to local environmental changes), outbreeding depression and loss of between-population diversity (which reduces local adaptation in individual populations and limits the ability of the species to persist over large geographical areas), domestication (which reduces ability to survive and reproduce because of adaptation and selection in the hatchery environment), and inbreeding depression (which allows rare, deleterious traits affecting survival and reproduction to become more common). Ecological affects may also be important, although they have been less studied. These include behavioral changes, competition with wild fish or other hatchery fish, predation, the potential for hatcheries to amplify endemic diseases, and the potential for hatchery fish to become vectors for the spread of novel disease and parasites.

In many areas – and especially Hood Canal and the Skokomish River - synergistic affects of habitat loss, hatcheries, and harvest led to extinction of wild populations and replacement by hatchery stocks. Beginning in the latter half of the 19th Century, increased harvest on populations that had not been heavily exploited before and loss of salmon habitat as watersheds and streams were being converted for agriculture and industry reduced abundances of wild salmon. Hatchery production appeared to provide an easy way to mitigate for lost natural production (Lichatowich 1999) but it also accelerated extinction of locally adapted wild populations. Releases of large numbers of hatchery fish compared to abundances of wild fish to support fishing led to extinction of the wild populations where they occurred together in fisheries because harvest rates were focused on the most abundant stock (Hilborn 1985; Kope 1992). Where harvest rates were less aggressive, large numbers of hatchery fish escaped the fisheries and exacerbated the potential genetic and ecological affects on wild populations.

Using hatcheries to help reverse these effects requires a fundamental reassessment of how habitat restoration, harvest, and hatcheries are managed and sequenced as a whole. Chapter 8 of this plan briefly reviews these concepts and how these different sectors might be adaptively managed to avoid the pitfalls of the past.

Hatchery Management Objectives

This chapter focuses on four objectives for hatcheries for achieving the goals for Chinook recovery in the Skokomish Watershed:

10. Reintroduce early-timed Chinook salmon sequentially to the upper North Fork and then the upper South Fork of the Skokomish River;
11. Maintain genetic diversity and abundance of early-timed Chinook in the North Fork while promoting local adaptation of early-timed Chinook in the basin using conservation hatchery principles and tools;
12. Maintain genetic diversity of the extant, non-native Chinook stock as source of brood stock to support harvest and to potentially reestablish a late-returning run in the Skokomish River if that becomes necessary; and
13. Continue providing for harvest.

Objective 1: Reintroduce Early-Timed Chinook Salmon

Historically, annual returns of Chinook included late-timed (fall) and early-timed (spring/summer) racial components. Unlike late-timed Chinook, the early-timed component entered the Skokomish River in April through July as river levels rose from melting winter snows. These fish migrated to the upper North Fork and the upper South Fork. They were extirpated from the North Fork watershed by the combined effects of construction of barrier dams for hydroelectric operations in the North Fork and the diversion of stream flows. The altered hydrologic regimes affected the whole river and ultimately also lead to the extinction of the early-timed Chinook in the South Fork.

For years, no opportunity existed to reestablish Chinook in these areas. Recent changes in the legal constraints that had stymied opportunities to address passage and flow in the North Fork, however, now allow for normative seasonal patterns and increased stream flows more like those that existed for the aboriginal run into the North Fork (see Habitat and Hydropower chapters). Restored normative flow volumes and seasonal patterns to the North Fork will also return more water to the mainstem Skokomish River and facilitate passage of early-timed Chinook to the South Fork. It will also substantially improve river entry and passage for later returning Chinook, which are currently supported by the hatchery program.

Reestablishing early-timed Chinook salmon to the Skokomish River would increase the diversity, abundance, and spatial distribution of Chinook salmon in the watershed, the region, and the ESU.

Objective 2: Maintain Genetic Diversity and Abundance of Early-Timed Chinook salmon in the North Fork

This objective aims to ensure that genetic diversity and abundance of early-timed Chinook in the North Fork remain at levels that support progress towards the recovery goals. Although reintroduction of Pacific salmon and trout to areas where they have been extirpated is a goal of many recovery plans throughout western United States, it has yet to be tried in enough places for general concepts, tools, and strategies to be tested, proven, and refined. Uncertainty is great and setbacks are likely. Reintroduction is not a single event but a process. Consequently, maintaining abundance and genetic diversity of early-timed Chinook in the North Fork will allow for failures that can provide lessons about how to be more successful in reintroducing Chinook to the North Fork and later the South Fork. Hatchery production in the North Fork will also be necessary for the longer-term to support production that remains permanently lost from inundation of historical habitat under Lake Cushman and reduced survival because the difficulty of migrating through the lake.

Objective 3: Maintain Genetic Diversity of Extant Chinook Salmon Population to Provide Harvest and as a Contingency

This objective recognizes the need to maintain the potential for adaptation and future uses of the introduced, non-native population by maintaining its genetic diversity. The plan focuses on maintaining genetic diversity because genetic diversity provides the raw material for populations to adapt to changing management needs and environmental conditions.

Genetic data indicate that the later-returning Chinook salmon introduced from Green River hatchery lineage, which is now considered a summer/fall stock, largely replaced the indigenous late-returning population (Myers et al. 1998, Ruckelshaus et al. 2006). Consequently, the extant stock is not a necessary source for recovering Chinook salmon in the watershed or the ESU. Although different in entry timing and genetic characteristics from the indigenous population, the extant, non-native stock is a potential resource for management. This may be important in the Skokomish River for two reasons. First, future harvest opportunities may depend on current or altered characteristics of the stock to meet management needs or constraints. Alternatively, the extant summer/fall stock could provide a contingency source for natural production in the event that efforts to reintroduce early-timed Chinook are unsuccessful and, in such event, if no other source of true late-timed Chinook with appropriate life history characteristics can be found for recovering a late-timed population.

Objective 4: Continue Providing for Harvest

The objective recognizes that appropriate management of the introduced, non-native George Adams and Hoodsport hatchery stocks can maintain harvest in the Skokomish River while minimizing the potential risks to recovery of early-timed Chinook salmon.

Hatcheries can provide salmon for harvest benefits when the ecosystem has been too degraded to provide those services or while the rehabilitation of the ecosystem to provide necessary natural production for harvest progresses. In this regard hatcheries are especially important in meeting tribal treaty obligations. The 1974 landmark court case *United States* v. *Washington* established that without salmon the treaty rights established between the Tribes and the United States government cannot be met and that hatchery fish must be included in meeting treaty rights. In the Skokomish watershed, for example, a conscious decision was made to compensate for the dramatic loss of habitat and natural production, especially on the North Fork Skokomish, by introducing non-native stocks and using artificial propagation to provide fish for harvest. Because of treaty obligations, hatchery and harvest management is now the shared responsibility of the co-managers: the State of Washington and the Skokomish Indian Tribe and other treaty tribes. The co-managers may choose to use the tools of harvest and hatchery management to help natural salmon populations, but until these recover to levels that meet treaty and other legal obligations for harvest, hatchery production will fill that role in a way that complements salmon recovery efforts.

Strategy Implementation

The following discussion examines strategies/actions needed to implement the four strategic objectives. The strategies/actions are grouped according to how they address the strategic objectives. We treat them, therefore, as four separate strategies aimed at achieving the objectives identified above. Aspects of these strategies still need to be determined. In these cases, the chapter describes the steps and analyses. Details of other actions are included in other planning documents such as hatchery and genetic management plans (HGMPs) and the Cushman Settlement Agreement.

Strategy 1: Reintroduce Early-timed Chinook Salmon

The purpose of this program is to reestablish early-timed Chinook to the North and South forks of the Skokomish River. Reintroduction using translocation is a key tool in conserving and recovering many species worldwide (IUCN 1998). Efforts to reintroduce salmon to parts of their historic range are underway in many regions of the Pacific Northwest, including large rivers and tributaries of the Columbia River, the Puget Sound, and the Upper Klamath Basin and San Joaquin rivers in California.

The initial focus is to reintroduce Chinook in the North Fork. After reestablishment in the North Fork, reintroduction will expand to the South Fork to increase overall spatial structure and carrying capacity in the watershed. The North Fork is the first focus because it historically provided the hydrography and habitat for early-returning Chinook salmon AND settlement of long-standing legal challenges to the diversion and damming of the North Fork is providing initiative and funding to restore normative a flow regime and channel forming processes and to support artificial production.

While this is underway, habitat and passage actions in the South Fork (see Habitat chapter) will improve the opportunities for reintroduction to the South Fork. In recent years, for example, Chinook spawning has been limited to the area downstream of Vance Creek because gravel aggradation and low summer stream flows have effectively blocked passage to spawning and rearing areas upstream. However, spawning habitat exists upstream of the canyon (10-15 miles upstream) where the river valley broadens out and the gradient is not as steep as in the canyon. Historically, for example, snow melt in the spring provided access to this area for early-timed Chinook and juvenile outmigration. This habitat has not been used by Chinook since the indigenous early-timed life history was extirpated from the drainage.

Although there is no way of knowing whether South Fork Chinook were historically a different independent population than those in the North Fork (Ruckelshaus et al. 2006), the production in both the North and South forks is important for recovery of early-timed Chinook in the Skokomish River. The North Fork alone is unlikely to support a viable population by itself even under restored normative conditions. A large proportion of the historical spawning and rearing habitat will remain inundated by reservoirs. Lentic conditions could impede passage and outmigration of salmon. Also, the reservoirs may hold large numbers of predators. The remaining habitat is at the upper end of the historic distribution and is unlikely to be as productive the habitat that was lost. Consequently, South Fork habitat is needed to sustain the recovered population and mitigate some of the historical habitat in the North Fork lost to inundation by reservoirs.

The overall reintroduction strategy will be based on IUCN guidelines (IUCN 1998). Table 5.1 outlines key issues for implementation of this strategy, status, and their sequencing in three time frames: 1-5 years; 5-10 years; and 10-20 years. Action has begun or will begin this year on all of the immediate (1-5 year) implementation issues. Key implementation issues are to

- Identify appropriate brood stock for reintroduction;
- Establish hatchery facilities in the North Fork;
- Size the program for reintroduction; and
- Develop and implement monitoring strategies.

Table 5.1. Key **implementation** issues for hatchery strategies.

Issue	Planning phase
Identifying a brood stock strategy to reestablish early-timed Chinook. Main two options are • Use an existing Chinook population as a source. Choice would be based on life-history, genetic, and morphological traits; availability of appropriate numbers of fish to start the program; risks to source populations from removing adults or juveniles, etc. • Artificially select for early return timing using existing George Adams stock. Choice would be based on analyzing the tradeoffs between availability, likelihood of successfully selecting for appropriate return timing with negatively altering correlated life-history traits, and likelihood of local adaptation after artificial selection combined with a century of domestication. This action will begin in 2010.	(1-5 years)
Develop appropriate hatchery facilities in the North Fork. This action is underway with technical support from the Skokomish Tribe, WDFW, and Tacoma Power.	(1-5 years)
Determining the appropriate size of the program over time. Licensing agreements for the hydropower dam on the Skokomish River provide legal commitments for supporting levels for production. Actual production will change over time as the program moves from reintroduction in the North and later in the South Forks to reestablishment and to support breeding in the North Fork.	(1-5 years)
Implementing release strategies to minimize possible negative interactions with other species or hatchery programs in the estuary.	(5-10 years)
Interactions with native and non-native species in the North Fork, including the resident population of Chinook salmon in Lake Cushman and bull trout	(1-20 years)
Initiate monitoring strategies. Technical planning discussions are underway on parts of this, including marking strategies.	(1-5 years)
Identify the appropriate locations, size, and strategies for reintroduction of Chinook salmon to the South Fork.	(10-20 years)
Potential changes in harvest regulations	
• To protect reestablishing early-returning Chinook	(5-10 years)
• To protect other species as North Fork Chinook become available for harvest.	(10-20 years)
Identify funding sources	(1-20 years)

Strategy 2: Maintain Genetic Diversity and Abundance of Early-Returning Chinook Salmon in the North Fork

For the planning horizon of this plan, the roles of hatchery production in the North and South Fork will be different. Hatchery production will begin in the North Fork focused first on reintroduction and later on maintaining the North Fork component until full recovery of the habitat and natural production in the North and South forks. Collection of eggs and incubation of fry will occur from hatchery facilities in the North Fork with fish rearing in net pens in Lake Kokanee supported by the Cushman Settlement. The proportion of hatchery-origin spawners in the wild will be adjusted during the trajectory of recovery as implementation moves from reintroduction to reestablishment to full utilization of rehabilitated habitat using the best available monitoring, research, and modeling to guide decisions. Hatchery production from the North Fork will be used to initiate reintroduction in the South Fork but is not planned after self-sustaining natural spawning is reestablished in the South Fork.

Strategy 3: Maintain Genetic Diversity of Extant Chinook Salmon Population to Provide Harvest and as a Contingency

The operating assumption in implementing this objective is that appropriate management of the introduced, non-native George Adams and Hoodsport hatchery stocks can maintain the existing adaptive potential and future uses of these stocks by maintaining their genetic diversity.

Genetic diversity provides the raw material for populations to adapt to changing management needs and environmental conditions. To maintain N_e at desired levels, brood stock collection, program size, and spawning practices and rearing practices will be adjusted as necessary. Genetic analyses indicate that genetic diversity in the stock, as determined by genetic effective population size (N_e), currently meets or exceeds most conservation guidelines. For example, most conservation guidelines recommend that N_e exceed 500 for natural populations. Estimates of genetic effective size calculated using molecular genetic data from 2005 and algorithms in Migrate 3.0 (Beerli 2008) indicate that the current population has an N_e of 808 (95% CL: 778-838). Likewise, estimates of demographic data assuming a realistic range of sex ratios and variance in family sizes suggest a range of N_e of 702-1053.Although the extant population has a genetic effective population size large enough to maintain existing genetic diversity, other analyses suggest that the existing genetic diversity may limit the opportunities to use this stock for some purposes. Lack of local adaption because the population did not evolve in this watershed and subsequent domestication may limit the potential fitness of these fish in the wild. Based on the FITFISH model (Busack et al. 2005), for example, there is a 95% chance that adaptation to hatchery environments has reduced fitness at least 25% compared to a locally adapted stock and nearly a 50% chance that loss of fitness is 60% or greater. This occurs because both natural and hatchery production of Chinook in the Skokomish River is driven by the large production of the George Adams hatchery stock. In most years, returns to the hatchery far exceed escapement to the river (Figure 4.2) and over 2,000 of these Chinook are used each year for brood stock to produce more hatchery fish.

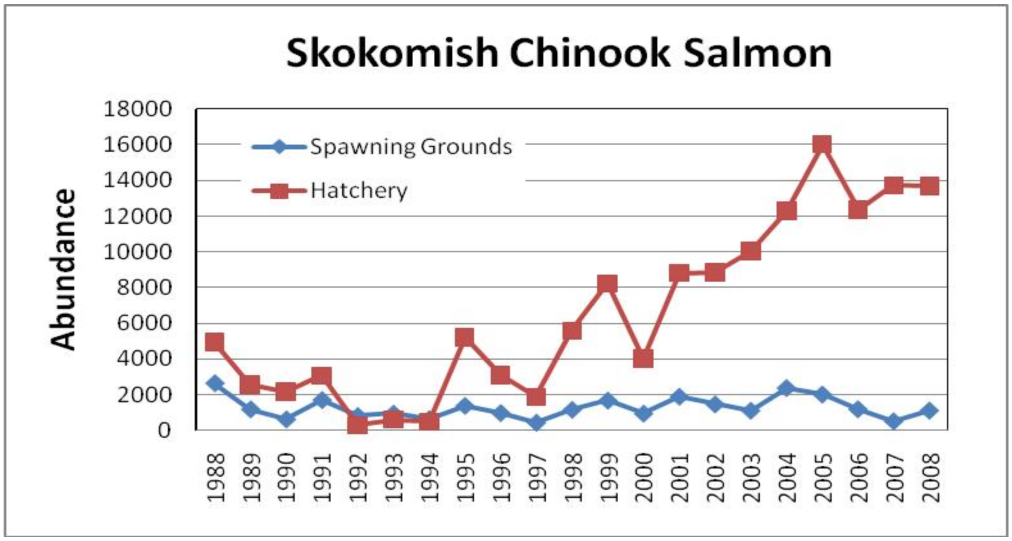

Figure 5.2. Numbers and distribution of Chinook returning to the Skokomish River.

Although domestication effects may be reversible over time, neither of the estimates above account for additional reduced potential fitness because the population is not indigenous and may not have the suite of co-adapted traits necessary for a viable population in that location. As noted in Chapter 2, the life-histories of the extant stock may be ill-suited for survival in the Skokomish River. The practical consequence is that reversal of domestication and waiting for evolution of co-adapted traits may not be realistic over the time frames being considered for recovery. Consequently, hatchery actions for this stock will not be changed to focus on increasing local adaptation. A change to focus on local adaptation of the stock would only be considered if reintroduction for early-timed Chinook salmon fails and no source of ecologically and genetically better suited late-timed Chinook salmon exist in the Puget Sound.

Strategy 4: Continue Providing for Harvest

The Washington Department of Fish and Wildlife raises or supports the release of nearly 7 million fall Chinook salmon in Hood Canal and the Skokomish River watershed to provide for harvest and escapement for natural spawning (Table 4.2). This production program consists of three hatcheries that manage the hatchery and natural spawning components as a composite stock. This approach, known as an *integrated production strategy*, allows artificially propagated fish to spawn in the wild and for natural-origin fish to be included in the brood stock.

Three hatchery facilities in the Skokomish River Watershed focus on fall Chinook production: George Adams, Rick's Pond, and Hoodsport. Detailed descriptions of goals, objectives, operational practices, and monitoring are in the hatchery and genetic management plans.

Table 5.2. Current production of summer/fall Chinook in the Skokomish River watershed for harvest augmentation.

Production facility	No. of summer/fall Chinook		Watershed of release
	Fingerling	Yearling	
George Adams	3,800,000		Skokomish River
Hoodsport	2,800,000	120,000	Finch Creek
Rick's Pond	375,000		Skokomish River
Combined	6,975,000	120,000	

George Adams Hatchery. The Washington Department of Fish and Wildlife owns and operates the George Adams Hatchery located at RM 1.0 on Purdy Creek. The facility was constructed in 1960 and enlarged to its current size in 1977. The physical layout spans 31 acres and relies on raceways and rearing and release ponds for production. The facility produces around 3.8 million Chinook fingerlings annually by collecting and spawning returning George Adams brood stock (a derivative of Green River Chinook salmon that were introduced into the watershed), incubating the eggs, and then releasing them into Purdy Creek (George Adams Fall Chinook HGMP). The hatchery also provides Chinook salmon fry for Rick's Pond on the Skokomish River (see below). In addition, George Adams Hatchery currently rears and releases 300,000 coho salmon yearlings and supports chum salmon production at McKernan and Hoodsport hatcheries.

Rick's Pond Fall Chinook Salmon Program. Rick's Pond is a dirt-bottom rearing and release pond owned and managed by Long Live the Kings (LLTK), a private nonprofit organization. The pond is located near the mouth of an unnamed tributary at RM 2.9 on the Skokomish River mainstem. The facility raised yearlings since 1996 and annually released approximately 120,000 Chinook yearlings through 2008. Beginning in 2009, Rick's Pond rears and releases 375,000 Chinook fingerlings and no yearlings. George Adams Hatchery provides Chinook fry to Rick's Pond and timing of the release is done to minimize impacts to naturally spawned Chinook juveniles (Rick's Pond HGMP).

Hoodsport (Finch Creek) Hatchery. The Hoodsport Hatchery is at the mouth of Finch Creek, approximately five miles north of the Skokomish Estuary. This Washington Department of Fish and Wildlife facility covers slightly over 4 acres and contains a hatchery building with an incubation room and 17 raceways of different sizes. The program has been rearing fall Chinook fingerlings since 1953 and Chinook yearlings since 1995.

The Washington Department of Fish and Wildlife operates the Hoodsport Hatchery as an isolated harvest program. It releases 2.8 million fry and 120,000 yearling Chinook salmon to provide harvest opportunities. Releases occur after April 1 to minimize predation or competition with ESA-listed wild Hood Canal summer chum salmon. The brood stock origin is mixed (Hoodsport Fall Chinook Yearling HGMP 2002 and Hoodsport Fall Chinook Fingerling HGMP 2002). It is possible to operate the Hoodsport program to meet the expected standards of an isolated harvest program.

Other Hatcheries. Three other hatchery facilities—McKernan Hatchery, Enetai Hatchery, and Sund Rock Net Pens—once produced Chinook but no longer do so. However, both McKernan Hatchery and Enetai Hatchery continue to raise and release other species of salmon (see Appendix B). McKernan Hatchery is a satellite facility to George Adams Hatchery that is located two miles west of George Adams Hatchery on Weaver Creek, a tributary of the Skokomish River. Enetai Hatchery is operated by the Skokomish Tribe on Enetai Creek just north of the Skokomish River. The Sund Rock Net Pens was a satellite facility to the Hoodsport Hatchery that was located along the shoreline of Hood Canal. This site was approximately two miles north of the Hoodsport Hatchery. Additionally, new hatchery and net pens facilities are planned for the North Fork of the Skokomish River as part of the Cushman Settlement agreement.

Benefits and Risks of Hatchery Strategies

The four strategies described in this plan should provide immediate short-term and long-term benefits to salmon and the people who depend on them. These benefits are not without risks. A large body of scientific literature documents potentially negative genetic effects on natural production associated with artificial production over time, although the actually reported effects are variable by species, location, and program type (RIST 2009). Other concerns about hatchery fish focus on the potential of disease amplification, predation, and increased competition with wild populations. Such issues could affect the results of recovery activities to reestablish and rebuild natural populations in this watershed.

Experience has shown that these risks cannot be eliminated, but they can be controlled. These lessons have been hard ones learned and an important part of the overall strategy is to use existing tools and advances in hatchery science to maximize the benefits possible by hatcheries while minimizing the potential risks. Even before the co-managers began developing this recovery plan, they reviewed all of their hatchery programs internally for consistency with the Endangered Species Act, participated in an independent review of hatcheries by the Hatchery Scientific Review Group (HSRG), and developed hatchery and genetic management plans (HGMPs) to minimize risk to natural populations and comply with Section 4(d) of ESA.

Chapter 6. Harvest Management Recovery Strategies

The fundamental purpose of fisheries management is to ensure sustainable production of fish stocks, while promoting the economic and social well-being of fishermen and industries that rely on that production (Hilborn and Walters 1992). Harvest of depleted populations must be managed so as not to impede their recovery. There is no doubt that past overharvest contributed, in concert with other factors such as habitat loss, to the demise of the indigenous Chinook life history types produced in the Skokomish watershed. This chapter describes harvest management-related strategies that will promote the recovery of Skokomish early-timed Chinook.

The best prospect for recovering a Skokomish Chinook population, at least in the near-term, has been determined to be for the early-timed racial group. Recovery necessitates a re-introduction of a suitable early-timed stock to the watershed. Once this has been accomplished, the plan has been developed to treat the re-introduced stock as the listed Chinook in the watershed. As the plan goes forward, and as progress is made in restoring key habitats in the lower valleys, the potential for expanding recovery efforts to include the late-timed racial group will be re-evaluated. Failure to make significant progress toward recovering the early-timed group over the next 10 to 12 years, however, would be cause to re-examine plan direction and possibly reset the priority to the late-timed life history group.

During the past century, Skokomish Chinook were harvested throughout their migration pathway, in mixed-stock fisheries operating in coastal marine waters between California and Southeast Alaska, as well as in the Puget Sound. Total harvest rates exceeded 70 percent during the late 1970s and early 1980s. Since then, harvest management evolved to consider broadly declining abundance, and to protect individual stocks, particularly those listed under the ESA.

Drawing from many strategies to conserve weakened salmon stocks, this plan defines harvest management objectives and strategies for Skokomish Chinook that are consistent with recovery, and suited to their distinct life histories.

This chapter is organized into the following sections:
- The fisheries – past and present;
- Harvest management processes;
- Harvest management objectives;
- Harvest management strategies.

The Fisheries – Past and Present

This section presents a short overview of the fisheries that have affected indigenous Skokomish Chinook, and fisheries that are operative today, as context for understanding current status and management.

Pre-Treaty Era

In times past, fish and fishing were the lifeblood of the aboriginal peoples of the Puget Sound region. The salmon was most important. In the Hood Canal region fishing occurred in marine and freshwater areas, but principally in the Skokomish River (Elmendorf and Kroeber 1992). The Skokomish group of the Twana people used weirs, traps, nets, and spears to harvest fish at various places. As noted in Chapter 1, the two waterfalls on the North Fork (Figure 1.2) were favored places to harvest early-timed Chinook as the fish gathered there to make their ascent to the upper reaches (James 1980).

Tribal customs, ceremonies, myths, and taboos defined their management of harvest and limited the scale of fishing (Lichatowich 1999). Cohen (1986) described Puget Sound tribal practices:

> "Indian practice, enforced by belief, would not permit fishermen to catch more salmon than they needed. When the fish were running, the fishermen periodically opened their traps and weirs to let spawners escape upstream. Traps sometimes washed out, as well, allowing more fish through. Perhaps most important, once the Indians had met their needs, they stopped fishing."

Tribal fisheries recognized clearly defined property rights. In some cases, these rights resided in the tribe as a whole; in other cases in families or individuals; sometimes in a mixture of the two (Barsh 1977; Higgs 1982). This system maintained consistency in how the fisheries operated over time.

Salmon were highly productive in pristine watersheds, and in most years, abundant, but freshwater and marine survival undoubtedly varied (Lichatowich 1999; Montgomery 2003). Lichatowich (1999) concluded that while the tribes possessed the skills, technology, and knowledge to more fully exploit the salmon runs, their form of management led them to live within the productive limits of the resource. An ecological balance existed between people and salmon.

Post-Treaty Era

The signing of treaties between the Puget Sound tribes and the Federal Government in the mid 1850s coincided with the onset of rapid changes in the Skokomish and other Puget Sound watersheds, as described in Chapter 4. For several decades following the signing of the treaties, Indian people continued to harvest fish for themselves and for trade with the growing number of immigrants.

In the late 1800s, canneries and related business enterprises proliferated in Puget Sound and their production peaked in 1913. There were indications that salmon stocks were in decline by this time, due to high harvest rates and habitat deterioration (Netboy 1973). Chinook catch in Puget Sound peaked in 1918 (Crutchfield and Pontecorvo 1969).

As innovations in commercial fishing gear and boats developed in the early 20th century, and recreational fisheries expanded in the 1920s, harvest rates on salmon populations increased.

Fishery groups competed with one another, resulting in much controversy and political maneuvering (Crutchfield and Pontecorvo 1969; Higgs 1982). This led to passage of Initiative Measure No. 77 in 1934, which banned all fixed gear (traps) in Puget Sound and closed certain areas to commercial salmon fishing, including Hood Canal.

By mid century, it was believed that Skokomish Chinook were in severe decline (WDF 1957b). The Skokomish Tribe's in-river commercial fishery for Chinook was closed in 1946 and remained so for a number of years (Smoker et al. 1952). The Cushman Project was believed to be the primary reason for loss of Chinook production (WDF 1957b), though hindsight shows that several factors contributed. In the 1950s, WDF and the City of Tacoma reached agreement to construct a new hatchery at Purdy Creek in the lower Skokomish River, to help mitigate the loss in salmon production. The George Adams Hatchery began operation in 1961 using Chinook broodstock of Green River lineage.

Between 1950 and the mid 1970s, commercial and recreational fishing effort in marine waters from California to Alaska increased. During the mid-1950s, the Canadian troll fishery off the west coast of Vancouver Island expanded rapidly, taking large numbers of U.S. - origin Chinook and coho. Soon after, sport fisheries in marine waters increased in both U.S. and Canadian waters. Exploitation rates on some Puget Sound Chinook populations, including Skokomish Chinook, exceeded 70 percent during the period from 1970 through the early 1990's, based on analysis of George Adams Hatchery CWTs (PSC 2009).[32] These high harvest rates likely contributed to the demise of indigenous Chinook stocks in the Skokomish River.

Harvest rates were probably at their highest level at the same time that habitat quality was rapidly deteriorating in the streams utilized by various life stages of early-timed and late-timed native Chinook. During the mid 1900s, the Skokomish watershed was undergoing an enormous transformation as the forests were cut, the North Fork was dammed and diverted, and the floodplains and delta were diked. Alterations to the upper South Fork associated with timber harvest were occurring at their most rapid rate in the 1960s and 1970s. The rates of aggradation and flooding in the lower river were increasing during this period.

Hatchery Chinook production at Hood Canal hatcheries increased during the period to offset lost natural production and to meet the increasing demand for fishing opportunity.[33] Hood Canal was re-opened to commercial salmon fishing to enable the affected treaty tribes to once again exercise their right to harvest salmon there. Non-treaty commercial fishing was also re-initiated. Treaty and non-treaty fisheries expanded in Hood Canal during the mid 1970s and into the 1980s.

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[32] It cannot be known with certainty what the ocean distribution and exploitation rates were for the native Skokomish Chinook. Total exploitation rates in all fisheries combined exceeded 70 percent on George Adams Hatchery Chinook from the late 1970's until the early 1990's (PSC 2009).

[33] / It is noted that hatchery practices during much of the 20th century, which usually relied on non-indigenous stocks, did not consider the risk to indigenous populations. This is especially evident when viewed in the light of current understanding of the ecological and genetic interactions of natural and hatchery production. The primary goal of those hatchery practices was to enhance fisheries, most frequently to mitigate for lost production due to severe habitat constraints that had developed.

Current Harvest Management

Salmon fisheries along the entire west coast of North America are today constrained by a variety of catch limits, harvest rates, time-area closures and restrictions, or species and size retention limits that are designed to achieve conservation objectives for wild salmon stocks (PFMC Framework Plan or Amendment, PST 2008 Chinook Agreement).

State and tribal co-managers developed the Puget Sound Salmon Management Plan (PSSMP) in 1985 and the Hood Canal Salmon Management Plan (HCSMP) in 1986, establishing management units and escapement goals to guide annual management of fisheries. Hood Canal hatchery Chinook stocks were designated as the "primary" management units by the HCSMP, so commercial Chinook fisheries in Hood Canal during the 1980s were managed to achieve sufficient escapement to perpetuate production at the George Adams and Hoodsport hatcheries. Natural Chinook stocks were designated as "secondary" management units in the HCSMP, so fisheries were not managed to achieve a specific number of natural spawners.

Terminal-area fisheries in the marine areas of Hood Canal (primarily in Areas12C and 12H) and in the Skokomish River target Chinook fish produced in the George Adams Hatchery and Hoodsport Hatchery. Treaty commercial and non-treaty sport fisheries occur in the lower reaches of the river. The fisheries that target Chinook operate during the months of August and September when the fish return to the river. The fisheries transition to target coho at the end of September.

Consistent with the PSSMP and HCSMP, the co-managers established multi-year fishery agreements in 2001-2004 (e.g., Puget Sound Chinook Comprehensive Chinook Management Plan (PSCHMP)) that established exploitation rate ceilings for natural Hood Canal Chinook in southern United States pre-terminal fisheries, and with terminal fishery constraints designed to achieve a natural spawning escapement of at least 1,200 to the Skokomish River.

A primary objective of the PSCHMP was to limit fisheries to the degree necessary to ensure rebuilding of natural Chinook populations in the Puget Sound ESU. The PSCHMP was intended to work in concert with recovery actions addressing other factors affecting Chinook, such as habitat and hatcheries, being implemented throughout the Hood Canal region and in other Puget Sound regions.

Recognizing its non-local origin, the extant Skokomish stock was classified as Category 2 (i.e., a composite stock in that hatchery production contributes substantially to natural spawning). The PSCHMP did not define the Skokomish Chinook minimum escapement objective with respect to hatchery or natural origination.

Notwithstanding the ESA mandate to conserve the naturally produced Chinook in the Skokomish River, it is generally recognized that indigenous Skokomish life histories are extinct (Ruckelshaus et al 2006). Natural spawners were found to be genetically indistinguishable from the George Adams hatchery stock (Marshall 2000) and their migratory timing and life history patterns mirror those of the hatchery fish (see Chapter 2). Estimates of escapement since 1988 indicate the majority of naturally spawning Chinook in the river are first-generation hatchery strays (K. Ryding and T. Johnson, *personal communications*).

The updated 2010 PSCHMP (PSIT and WDFW 2010) superseded previous versions of the PSCHMP. The updated PSCHMP defines a schedule of actions with immediate attention on early-timed Chinook, while also recognizing the need to maintain future options for recovery of the late-timed Chinook. To maintain options for use of the extant stock for recovery, the Plan defines a total exploitation rate ceiling (of 50 percent) on its natural component, with further constraints on fisheries if natural escapement is forecasted to be below 800. Future options for recovery of a late-timed population depend upon the success of efforts to recover early-timed Chinook.

Harvest Management Processes

The annual harvest management process is a cycle of pre-season planning, in-season implementation, and post-season assessment. Each step of the process reflects defined elements of the Puget Sound Chinook Harvest Management Plan.

The pre-season planning step develops the fishing regime in Washington waters for the forthcoming season, referring to the forecasted abundance of all coastal Chinook stocks originating in California, Oregon, Washington, and B.C., and expected catch in Alaska and British Columbia. All fisheries-related mortality is accounted, including low levels of incidental Chinook mortality that occur in fisheries directed at sockeye, pink, coho, chum and hatchery Chinook salmon.

During the initial phase of the program to establish an early-timed Chinook population, pre-season planning will qualitatively consider constraining fisheries likely to have direct impacts, based primarily on migration characteristics of the donor stock. Quantitative methods for management fisheries for the early-timed population, such as forecasting abundance and incorporating time and area distributions into harvest simulation modeling, will be developed as requisite time series of exploitation patterns and escapement information accumulates.

Salmon fisheries in Puget Sound (i.e., which in this context include those in the Strait of Juan de Fuca, Georgia and Rosario Straits, and all associated terminal marine and freshwater areas) are planned concurrently with coastal fisheries, which are managed under the jurisdiction of the Pacific Fisheries Management Council. Since the PSCHMP has been authorized by the NMFS as compliant with the conservation standards of the ESA, the Council approves coastal fisheries regimes after assessing compliance with harvest guidelines for Puget Sound Chinook (stated in the PSCHMP) using the FRAM simulation model. However, southern U.S. ocean fisheries exert relatively small impacts on Puget Sound Chinook; exploitation rates estimated for Skokomish Chinook in recent seasons have been only 2 to 3 percent.

Harvest conservation agreements reached under the Pacific Salmon Treaty have a direct bearing on co-managers' decisions regarding management of Skokomish Chinook. The 2008 Chinook Chapter of the Treaty defines abundance-based harvest limits on Canadian and Alaskan fisheries that are intended to conserve depressed stocks, including the Skokomish or Mid Hood Canal Chinook.

Post-season harvest management performance assessment is prescribed by the PSCHMP (see Chapter 7 of that plan for details), and involves annual comparison of expected and observed catch and escapement for all stocks, and periodic, retrospective assessment of stock status trends and the effectiveness of management measures implemented by the co-managers. Related information about harvest and abundance of Skokomish early-timed Chinook will be incorporated in these reports as it becomes available.

Harvest Management Objectives

The purpose of the harvest-related strategies presented in this plan is to ensure that fishery-related mortality will not impede recovery of early-timed Chinook in the watershed. Further, fisheries will be managed to maintain future options for recovery of late-timed Chinook should that need develop. As the plan goes forward, the potential for expanding recovery efforts to include the late-timed racial group will be re-evaluated based on progress of efforts aimed at recovering an early-timed population (see Chapter 1).

Fisheries will be planned and implemented to achieve the following objectives related to early-timed Skokomish Chinook:

5. Protect and conserve the abundance and life history diversity of a locally adapted, self-sustaining, early-timed population during and after its recovery.

6. Manage fisheries to preserve the opportunity to harvest surplus production from other species and populations, including those produced in hatcheries (e.g., George Adams and Hoodsport hatchery-origin Chinook, re-introduced sockeye, hatchery-origin and wild coho, and fall chum).

7. Adhere to the principles of the Puget Sound Salmon Management Plan and the Hood Canal Salmon Management Plan, and other legal mandates pursuant to *U.S. v. Washington* to ensure equitable sharing of harvest opportunity, and among treaty and non-treaty fishers.

8. Account for all sources of fishery-related mortality occurring in the U.S. (including Alaska) and Canada. By implementing CWT or other assessment tools, develop means to quantify harvest distribution and fisheries-specific mortality for the introduced early stock. Initial analysis to better inform harvest management is expected after three to five brood years of early-timed Chinook are fully recruited

9. Recognizing the importance of ceremonial and subsistence (C&S) tribal fisheries, prioritize C&S fisheries over any other fisheries targeting the Skokomish River early-timed Chinook during all stages of recovery.

Harvest objectives and guidelines for Skokomish early-timed Chinook will be incorporated in subsequent revisions of the Puget Sound Chinook Harvest Management Plan.

Harvest Management Strategies

Harvest management strategies embody specific actions designed to achieve the objectives stated above. Management will address uncertainty regarding impacts of pre-terminal fisheries on early timed Chinook with a program to collect stock-specific information on their run timing, distribution, and fishery-specific harvest mortality. Terminal harvest will be more certain, due to the unique run timing of early-timed Chinook and the ability to identify hatchery-origin returns. Known life history and migration characteristics of the donor stock will provide a basis for controlling fisheries to provide sufficient protection to meet recovery objectives. Ultimately, harvest objectives will be revised to reflect the productivity and abundance of early-timed Chinook as they colonize and adapt to habitat in the North Fork, and later, the South Fork.

In order to maximize spawning escapement in the early stages of this process, except for limited ceremonial and subsistence harvest, terminal fisheries targeting early-timed Chinook will not be implemented. As abundance increases, opportunities for expanding terminal fishing opportunities will be evaluated and implemented if consistent with management objectives. Fisheries will be focused on hatchery-origin early-timed adults and other harvestable populations. Additional fishing opportunities will occur once the population is recovered.

The following strategies will be implemented to control harvest:

1. Conduct limited treaty C&S fisheries in the Skokomish River on re-introduced early-timed Chinook during all stages of recovery.

2. Develop expected run timing, harvest distribution, and fishery-specific harvest rates, based on known characteristics of the donor early-timed Chinook stock, to inform management until these characteristics of the introduced early-timed stock are understood based on CWT, genetic, or other stock identification data.

3. Pre-terminal fisheries will involve incidental mortality of early-timed Chinook returning to the Skokomish River. It is expected that recent constraints on pre-terminal fisheries in Washington, which have been driven by concern for weak Puget Sound stocks, will be sufficient to meet the conservation and protection objectives of this Plan for early-timed Skokomish Chinook. When harvest distribution and fishery impacts for the early-timed Chinook are sufficiently quantified, management objectives for this population may be reconsidered to incorporate pre-terminal as well as terminal area fishery impacts.

4. Develop and implement criteria (e.g. ER and/or harvest rate ceilings, catch targets, or escapement thresholds) for expanding fishing opportunity targeting early-timed Chinook and other stronger populations having harvestable numbers, as progress is made toward recovery of the early-timed population.

5. Implement a 50 percent ER ceiling on the extant naturally produced component of the summer/fall stock for management years 2010–2014 and other harvest conservation measures stated in the 2010 Puget Sound Harvest Plan. After the 2010-2014 time period, this strategy will be shaped to remain consistent with provisions of an updated Puget Sound Harvest Plan.

6. Provide fisheries that can effectively harvest surplus George Adams and Hoodsport Hatchery production while maintaining future options for recovering a late-timed Chinook population should that need develop.

Chapter 7. Hydropower Management Recovery Strategy

This plan documents how various threats and related issues have influenced the physical and biological processes of the Skokomish watershed over the past 150 years. The cumulative effect of all of these changes caused the extinctions of the aboriginal life histories of Skokomish Chinook. The single most influential event on the watershed and its processes was the construction of the Cushman Hydroelectric Project. It has had a major role in shaping the watershed's environment, salmon resources, and human communities over the past 80 years (see Chapter 4 for details).

This chapter presents the strategy that will employ the Cushman Project to help achieve recovery. The chapter is organized into the following sections:

- The role of hydropower management in recovery;
- History of events leading to the Cushman Settlement and a new license; and
- Components of the strategy.

The Role of Hydropower Management in Recovery

The Cushman Project will continue to have a major role in the Skokomish watershed over at least the next 40 years. On July 15, 2010, the Federal Energy Regulatory Commission (FERC) issued a new license to the City of Tacoma to operate the Cushman Project. License articles call for the implementation of a variety of measures aimed at restoring normative watershed functions and salmon life histories adapted to the watershed, as spelled out in the Cushman Settlement. Tacoma is required to fund and implement these measures over the life of the license.

As Tacoma had a role in the demise of the aboriginal salmon life histories, it now has an important role in their recovery. The actions specified in the new license call for the re-establishment of early-timed Chinook in the upper North Fork, which is a foundational part of the rest of this recovery plan.

History of Events Leading to the Cushman Settlement and A New License

This section provides an overview and chronology of the major events that led to the Cushman Settlement. It serves to give context for understanding the important role that it has in the recovery plan.

In 1926 the City of Tacoma completed the construction of a hydroelectric dam on the north fork of the Skokomish River to provide electricity to the people of the City of Tacoma. The dam was built without any fish passage facilities and the lake formed by the dam inundated 9.6 miles of prime spawning and rearing habitat. In 1930, Tacoma completed the construction of a second dam on the north fork 2 miles downstream of dam number 1. The powerhouse for dam number 2 was located __ miles away from the dam along the shores of Hood Canal. The North Fork flows were diverted completely out of the watershed through pipes to the powerhouse. Together these dams and associated facilities are known as the Cushman Hydroelectric Project. It operated from 1926 through 1996 without any mitigation requirements for the damage caused to the habitat and the fish and wildlife that live there.

As early as 1915, members of the Skokomish Tribe had opposed the construction of the Cushman Project for fear that it would damage tribal resources and the Skokomish Reservation, which is located downstream. The Tribe sought help from the Bureau of Indian Affairs (BIA), the U.S. Department of Interior (DOI) and the U.S. Department of Justice. The Federal Government debated this issue between agencies and ultimately decided not to take any legal action to stop or otherwise limit construction or operation of the Project. The Tribe filed suit against Tacoma in the Federal District Court but the Court ruled that the Tribe did not have standing to bring the suit itself. If the case was to go forward, the Federal Government would have to pursue it on behalf of the Tribe and the suit was then dismissed. Intervention was not pursued by the Federal Government. The Cushman Project was allowed to go forward.

The original license for the operation of the Project expired in 1974. FERC allowed Tacoma to keep operating the Project on annual licenses until a new license was issued in 1998 and amended in 1999. During this period, the Skokomish Tribe, DOI, Federal and State natural resource agencies intervened in the license proceedings. Legal and administrative appeals were filed by the Tribe and the agencies seeking to have mitigation actions imposed by FERC on Tacoma. In 1996 the DOI developed license conditions designed to mitigate for damages caused by the nearly 75 years of operation of the Project. These conditions were developed under section 4(e) of the Federal Power Act. FERC did not accept these conditions and developed their own set of conditions, which were less restrictive, that were attached to the new license issued in 1998. The Tribe, Tacoma and the agencies then appealed the license issuance, each for various reasons. The Tribe then filed suit in Federal District Court against Tacoma and the Federal Government for damages caused by the Project. The District and Ninth Circuit Court of Appeals ruled against the Tribe and dismissed its claims against Tacoma but transferred the Tribes claims against the Federal Government into the Federal Court of Claims.

In 2006, the D.C. District Court issued a ruling in the appeal of the 1998 license. In that decision the Court determined that under the Federal Power Act only DOI has the authority to develop license conditions to protect the Skokomish Reservation and to mitigate for damage to the Skokomish River caused by the operation of the Project, and that FERC could not reject those conditions. The Court remanded the case back to FERC for modifications to the new license to include the conditions developed by DOI. The Tribe then filed a request with the District Court to amend language in its decision in the damages case to be consistent with language in the Ninth Circuit's decision. When the District Court refused, the Tribe appealed to the Ninth Circuit. The Ninth Circuit offered to provide a mediator if the Tribe and Tacoma were willing to try and settle this latest dispute. Mediation was accepted by the parties.

The Tribe and Tacoma reached agreement on the principal elements of an agreement that would settle all of the disputes between them. DOI and the State and Federal natural resource agencies were then brought in to the process to help craft the language for the license conditions for submittal to FERC. Provisions for a license were agreed to by the Tribe, Tacoma, BIA, NOAA Fisheries, U.S. Forest Service, U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife and the Washington Department of Ecology. The agreement was then signed in a ceremony in Tacoma in January of 2009. This settled disputes over license conditions, damages, water rights, illegal trespass, and the Coastal Zone Management Act.

The license conditions to be submitted to FERC were developed with two primary objectives: (1) to restore normative flows to the North Fork, and (2) to restore salmon species and their life histories that had been extirpated or reduced by the operation of the Project. Together, the license conditions are designed to restore the form and function of the North Fork, restore the channel capacity in the lower Skokomish River, restore access for fish to the upper reaches of the North Fork, and re-establish fish runs in the North Fork. The length of the license period would be 40 years. Tacoma would be required to implement the mitigation measures in the license over the license period. In July, 2010, FERC accepted all of the articles for inclusion into the new license.

Components of The Strategy

This section provides an brief overview of the major license conditions that were developed to improve the aquatic habitat and fish populations in the Skokomish River. Details of the license pertaining to this recovery plan are contained in Appendix B. Elements of these conditions as they will affect habitat, including flow, and the use of hatcheries in recovery are described further in Chapter 4 (habitat) and Chapter 5 (hatcheries).

Normative Flow Regime

The new flow regime to be implemented has three components: base flows governed by a water budget, channel formation flows and sediment transport flows. Together these components are designed to help restore normative fish habitat characteristics and the channel flow conveyance capacity in the Skokomish River.

Fish Passage

A fish passage program and facilities are to be designed and implemented to provide fish passage upstream and downstream of the Cushman dams. The effectiveness of the passage facilities is to meet NMFS fish passage standards.

Habitat Restoration

A fund will be established with an initial deposit of $3.5 million to be used for aquatic and riparian habitat restoration projects in the North Fork. Tacoma will add $300,000 each year beginning in year 5 for the remainder of the length of the 40 year license.

Fish Supplementation and Re-Introduction Program

A program will be developed and operated to re-establish early-timed Chinook in the North Fork through re-introduction using a donor stock. Hatchery technology is to be employed. Other species to be re-introduced using similar technologies are sockeye, coho, and steelhead. Indigenous coho and steelhead from the Skokomish watershed are to be used. A donor stock for sockeye will be required. On-going supplementation technology will be required due to the limitations of the upper North Fork habitat as a result of inundation by the reservoir.

Monitoring and Evaluation

The license requires a significant amount of monitoring to assess how the mitigation measures are performing over the life of the license. Tacoma is to develop the monitoring plans with the help of the Tribe, DOI and the Federal and State agencies. Tacoma will be responsible for implementing the plans. Data collected from the monitoring plans will be used to evaluate the effectiveness of mitigation and the various restoration actions in the watershed. Modification and improvements can be made to the actions using an adaptive management approach in conjunction with monitoring. These monitoring plans will be designed to compliment monitoring work being conducted in the South Fork and estuary of the Skokomish River through the efforts of the Tribe and other entities. A brief list of the monitoring elements to be addressed by Tacoma is provided below. A more detailed description of monitoring requirements is contained in the new Cushman license (Appendix B).

<u>Operational and Flow Monitoring Plan</u> - This plan will document how Tacoma Power will: (1) monitor impoundment water surface elevations in Lake Cushman; (2) monitor stream flows in the Skokomish River downstream of the Project; (3) ensure compliance with the minimum flow requirements; and (4) improve mainstem flow and flood forecasting.

<u>Fish Habitat and Monitoring Plan</u> – This plan is to address the following elements:

- Sediment transport and channel morphology in the lower North Fork and mainstem
- Fish habitat composition and distribution in the North Fork and lower Skokomish River
- Productivity of Lake Cushman
- Water temperatures
- Fish population abundance in the North Fork
- Juvenile production, distribution, and habitat utilization in the lower North Fork
- Fish distribution and habitat utilization in the upper North Fork
- Resident fish in Lake Kokanee
- Genetic monitoring of specific populations.

<u>Fish Passage Monitoring Plan</u> – This plan is to address the following elements:

- Juvenile emigrant survival through the reservoir, fishways and transport mechanisms
- Adult passage effectiveness
- Compliance with survival standards and passage effectiveness as stipulated by NMFS

<u>Hatchery Monitoring Plan</u> – This plan is to address the following elements:

- Best management practices for supplementation facilities

- Size at release, growth rates and survival in hatcheries
- Disease profile
- Spawn timing and condition
- Homing/straying
- Coded-wire tagging program
- Stock inventory
- Number of fish released
- Water temperature at facilities
- Water quality parameters required by permits

Chapter 8. Integration of Habitat, Hatchery, & Harvest Strategies

Challenges of Integrating Habitat, Harvest, and Hatchery Strategies

Integration is the coordinated combination of actions among all the different management sectors (habitat, harvest, hatcheries, and hydroelectric) that together work to achieve the goal of recovering self-sustaining, harvestable salmon runs. Because many actions in these sectors fundamentally require tradeoffs between what people want and what salmon need, "H-integration" involves balancing biological effectiveness in moving towards salmon recovery (e.g. the greatest sustainable improvements in the shortest amount of time) and fairness in providing competing benefits for people. (It should be noted that we have considered the hydroelectric strategy as contained in the habitat and hatchery strategies for simplification.)

The most biologically effective combination of activities is unlikely to be successful, for example, because it may require costs to communities that are perceived as unfair and therefore are not politically sustainable. These actions would likely not get implemented and consequently are not useful for restoration. Likewise, trying to please everyone may be ineffective and costly in recovering salmon (Figure 8.1).

Sequencing, Duration, Location

Practically, integrating the different actions in habitat, hatchery managements, and fishery management means implementing the actions at the best time, in the appropriate sequence, in appropriate locations, and at the necessary levels to be most effective. Figure 8.2 illustrates likely sequences, durations, and magnitudes of actions and their predicted effects for Skokomish River Chinook.

The most important step is beginning the habitat restoration strategy and activities that will allow improve the productivity of naturally spawning Chinook. To protect the investments in habitat restoration, habitat protection likewise needs to increase. Hatchery Strategy No. 1, reintroducing early-timed Chinook to the North and South Forks, depends not only on gaining adequate flows and passage in the watershed but also on choice of an appropriate strategy for the brood stock and enough time for local adaptation to occur. Reintroduction will occur sequentially, first in the North Fork and later in the South Fork. Closely related is Hatchery Strategy No. 2, maintaining genetic diversity and abundance in the North Fork, which is a key foundation for monitoring and adapting the reintroduction efforts early in Strategy 1 and in allowing time for habitat to respond to restoration and protection in the different forks. Hatchery Strategy No. 3, in contrast, allows for harvest and provides a possible contingency source for use of later-returning production in the watershed.

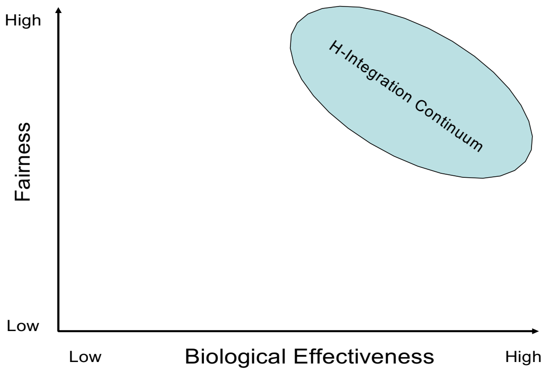

Figure 8.1. Achieving integration of actions in different management sectors (habitat, fisheries, hatcheries, and hydroelectric power) is a balance between fairness and the continuum of biological effectiveness in achieving salmon recovery goals.

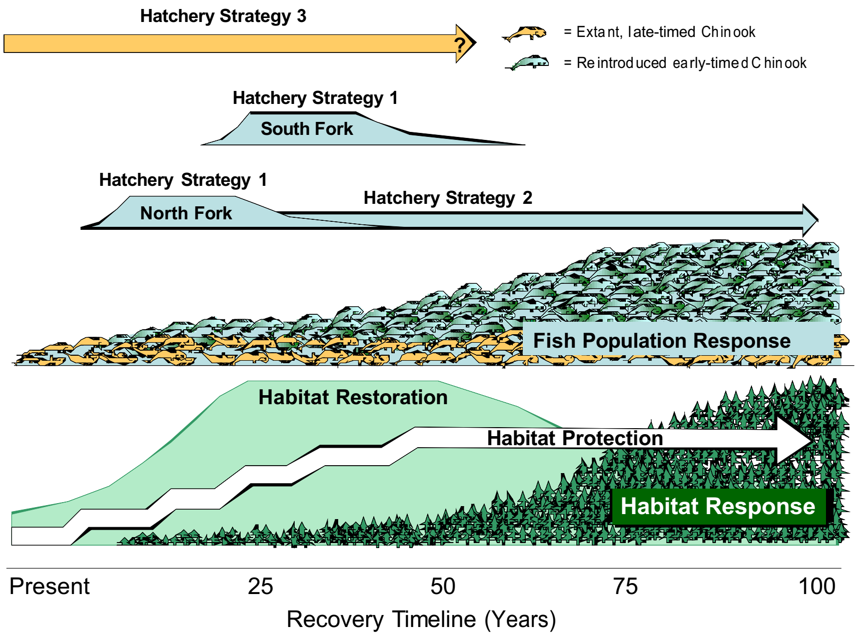

Figure 8.2. Conceptual illustration of sequencing of hatchery strategies in the Skokomish River in relation to habitat restoration and protection actions and the response of the fish populations. The height of the strategies and fish and habitat responses over time indicates the expected magnitude.

Using or developing the appropriate scientific tools to help inform these choices is also an important part of the sequencing. For example, as natural production increases in response to habitat and hatchery strategies, harvest management will need to have adequate tools and data to continue to provide for harvest while protecting natural-origin fish.

Next Steps in Integration

As illustrated above, integration involves four key steps

1. Using the best available information and analyses to understand and predict the combined effects of the individual H-sector actions on VSP characteristics of the population. This begins with comparing the effects of the actions for their directionality (+ or -), magnitude, time lag, and persistence.
2. Choosing actions that are complementary in their effects.
3. Implementing the actions.
4. Utilize monitoring and adaptive management to address probabilities and uncertainties (see Chapter 9)

Recovery planning for Skokomish Chinook has focused on qualitative analyses of these steps and this has provided the general direction and priorities for integration in this recovery plan. Quantitative analyses provide an additional way of refining these analyses and testing for unexpected results that may not be apparent in qualitative analyses. Quantitative analyses require gathering appropriate data and selecting or developing appropriate models for the analysis and this is just beginning for Skokomish Chinook.

An important use of these analyses will be to set the framework for adaptive management (Chapter 9). For example, Table 8.1 shows how results from the analyses can be organized. The major actions from one time period (e.g., current) have expected outcomes at other time periods (e.g., 5, 10, and 20 years), which in turn suggest whether actions need to change at those time periods. The expected outcomes also become the triggers for adaptive management. For example, if the expected outcome does not occur at 5 years, it makes sense to ask why. Were these the right actions? Were they implemented? Was the monitoring inadequate to detect the response? Did something else unexpected happen in the watershed to explain the results? Does the model need to be refined? Answering these questions then leads to refining the sequence, location, timing and duration of the next set of restoration actions.

Table 8.1. Summary of integrated restoration actions.

	Time Frame for Actions			
Management Sector	**Current**	**5 yr**	**10 yrs**	**20 yr**
Habitat	Major Actions	Major Actions	Major Actions	Major Actions
Harvest	Major Actions	Major Actions	Major Actions	Major Actions
Hatcheries	Major Actions	Major Actions	Major Actions	Major Actions
Hydroelectric	Major Actions	Major Actions	Major Actions	Major Actions
VSP Characteristic	**Expected Effects of Actions**			
Abundance	Results from modeling (including uncertainty)	Results from modeling	Results from modeling	Results from modeling
Productivity	Results from modeling	Results from modeling	Results from modeling	Results from modeling
Spatial Structure	Results from modeling	Results from modeling	Results from modeling	Results from modeling
Diversity	Results from modeling	Results from modeling	Results from modeling	Results from modeling

Chapter 9. Adaptive Management and Monitoring

Adaptive management is a science-based management approach of adjusting management actions and/or directions based on new information. It is an essential part of managing salmon recovery to address uncertainties about the future, including the responses of the environment and the biota to recovery actions. Adaptive management is not managing by trial and error—it requires that purposeful actions be taken, then monitored and scientifically evaluated so that policy, management, and actions become more effective in salmon recovery over time (Joint Natural Resources Cabinet 1999).

Adaptive management and monitoring are linked. Without monitoring, there is no scientifically valid way of assessing progress and knowing whether investments in actions are beneficial. Well-designed monitoring should (1) indicate whether the restoration measures were designed and implemented properly, (2) determine whether the restoration results met the objectives, and (3) give us new insights into ecosystem function and response (Kershner 1997). Hence, besides measuring progress of the plan, monitoring also serves a research role in addressing critical uncertainties.

This chapter describes the major elements of the adaptive management and monitoring components of this recovery plan. These elements will be part of the larger adaptive management effort being developed for the Puget Sound Chinook ESU.

This chapter is organized into two sections:

- The adaptive management cycle;
- Monitoring and evaluation framework.

The elements of monitoring contained in this chapter do not in themselves constitute a monitoring plan for recovery. Instead, they would be woven into monitoring efforts either already underway, soon to be implemented, or to be undertaken in the future as funding becomes available. The Cushman Settlement, for example, calls for long-term, comprehensive monitoring of various environmental and biological responses in the North Fork and, to some degree, in the lower Skokomish River. While the components of that monitoring plan have been agreed upon, specific details remain to be worked out during 2010 and 2011. The General Investigation (GI) being carried out by the USCOE in the lower valleys of the Skokomish River and South Fork is also providing important monitoring and research information. It is expected that one benefit of the GI will be to continue to provide an important monitoring function in the lower river valleys for years to come. Other monitoring efforts are also underway in the basin, as noted in this chapter.

The Adaptive Management Cycle

Will habitat, harvest, hatchery, and hydroelectric strategies recover Chinook salmon in the Skokomish River? The answer hinges on many things that are still uncertain. For example, do we understand the physical and biological processes operating in the watershed that limit salmon recovery well enough to make effective choices? Will there be enough funds to implement the most effective actions? Will the goals, objectives, and strategies outlined in the recovery plan be successfully implemented? Will agencies with regulatory authorities use them to protect existing watershed functions so that recovery actions can provide net improvements?

Adaptive management is a tool for managing these types of uncertainty. It refers to an explicit process of making decisions based on the best available information, implementing them, learning from the results of the implementation, and adjusting the decisions as necessary to achieve a goal. This process can be seen as a management cycle comprised of four key steps (Figure 9.1):

1. Develop goals and objectives;
2. Develop a framework for assessing progress in recovery;
3. Prepare and implement a plan to get the important information;
4. Decide how to use the new information.

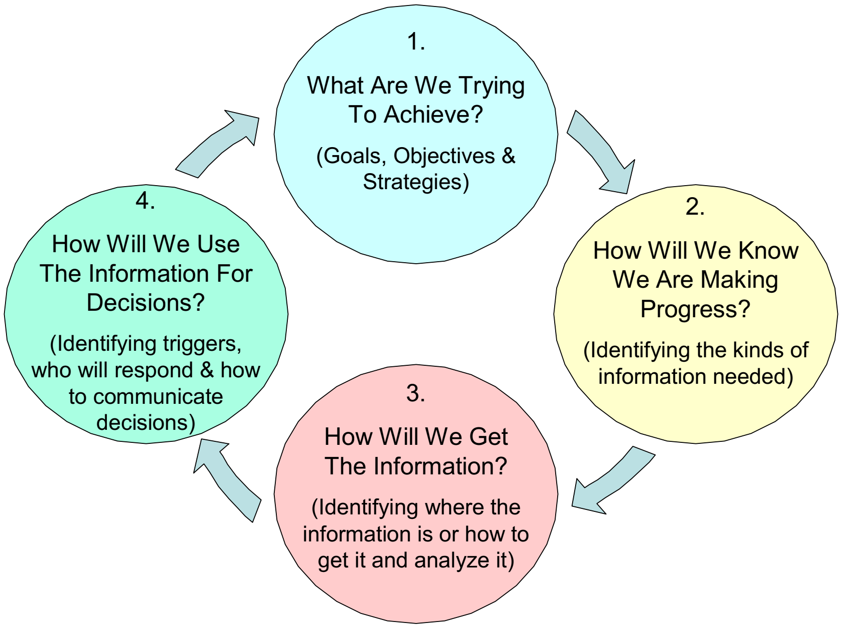

Figure 9.1. The adaptive management cycle (adapted from the Ecosystem Management Initiative Evaluation Cycle, University of Michigan).

An important characteristic of this cycle is that improvements can and should occur in all the steps of the evaluation cycle over time. This allows us to begin taking actions without waiting for a perfect monitoring or decision making system, because through the evaluation process monitoring, analyses, and strategic decision making are examined for how they can be refined and improved.

The scale and scope of this plan are extensive; therefore, it is imperative that the participants in the adaptive management cycle be broadly defined. Watershed-scale protection and restoration involve multiple specialists, including tribal and non-tribal agency personnel, and non-agency partners. Taking an interdisciplinary approach and utilizing multiple agencies and other entities will help integrate the four H's. All of the involved agencies and personnel should actively participate in setting objectives, study design, and analysis.

The adaptive management cycle envisioned in this plan is not another management process being added to an already full slate of management activities involving the Skokomish River, its resources, and the many active personnel. To be useful in a timely manner, we envision that its elements need to be integrated into as many of the various management processes that already exist or will be soon.

Monitoring and Evaluation Framework

This section presents the monitoring and evaluation framework around which the adaptive management cycle will be structured. The framework encompasses the four primary types of monitoring that will need to occur to assess progress toward recovery (Figure 9.2). It is adapted from the status decision framework formulated by NMFS in its guidance document to help recovery planners address monitoring (NMFS 2007).

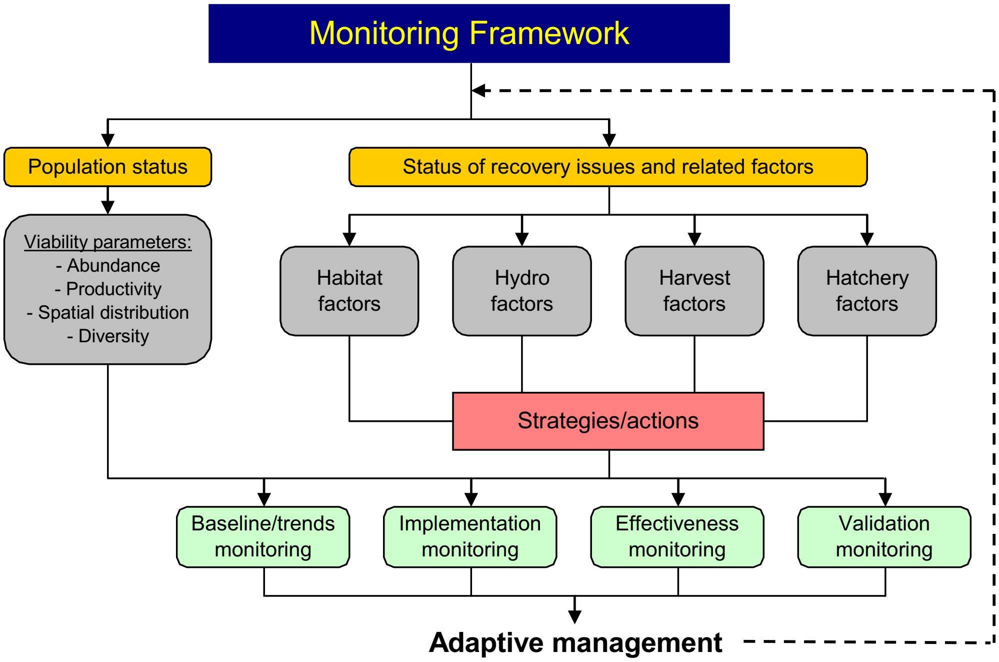

Figure 9.2. Monitoring and evaluation framework (adapted from NMFS 2007).

Definitions of the four types of monitoring, adapted from Joint Natural Resources Cabinet (1999), Botkin et al. (2000), and NMFS (2007), are given below:

> *Baseline/trends monitoring* involves tracking changes in fish populations and habitat conditions over time. This monitoring is critical to the interpretation of effectiveness and validation monitoring activities. It includes establishing a baseline for future comparisons.
>
> *Implementation monitoring* determines progress in implementing the planned recovery strategies/actions. Has an action been implemented? This monitoring is generally carried out as an administrative review, which can include site visits. It does not directly link restoration actions to physical, chemical, or biological responses, as none of these parameters are measured.
>
> *Effectiveness monitoring* assesses how effective actions are in achieving their objectives. The effectiveness of actions directed at affecting the physical environment is usually most directly assessed by determining whether targeted watershed processes or habitat characteristics are altered. For example, did a flow regime action facilitate sediment transport through the lower river? Monitoring directed at answering this question will often yield useful information in a few years. In contrast, the effectiveness of such an action in improving salmon performance can often only be determined over a much longer period of monitoring (Lichatowich and Cramer 1979) and may be best considered as validation monitoring (Botkin et al. 2000). Variability in biological response to altered environmental characteristics is usually much greater than variability in habitat metrics, making it more difficult to conclude cause and effect in biological response (Lestelle et al. 1996; Botkin et al. 2000). However, some effectiveness monitoring directed at certain habitat issues, such as providing fish passage at dams or natural falls, is measured by directly assessing fish response, which, in this case, can normally be determined relatively rapidly.
>
> *Validation monitoring* seeks to validate basic assumptions about how actions contribute to the recovery of the target population (Botkin et al. 2000). Because the ultimate goal of this plan is to re-establish a natural population of early-timed Chinook, then the best measure of the success of various actions toward achieving this goal is the number of naturally-produced, self-sustaining fish produced as a result of those actions. The contributions of some actions toward recovery, particularly those aimed at restoring watershed processes, can be extremely difficult to validate in the short-term (Lestelle et al. 1996). In these cases, modeling can be useful to help validate underlying assumptions contained in the recovery plan until longer-term monitoring results become available.

The elements of the monitoring framework are described below within the context of each of the four steps in the adaptive management cycle (Figure 1). Many of the monitoring elements are defined through the use of two terms, *benchmarks* and *triggers*, which were applied by the Shared Strategy in its presentation of the recovery plan for the ESU. The terms have the same meaning herein. Benchmarks define how progress or change is to be measured for each type of monitoring associated with specific strategies. For implementation monitoring, for example, the benchmarks identify targets against which progress is to be measured to verify actual implementation. Triggers are meant as a type of checklist to help gauge the rate of progress. In implementation monitoring, the triggers can indicate when actions should be initiated or when progress might be occurring too slowly consistent with other aspects of the plan.

Step 1. Develop goals and objectives

This step establishes clear goals and objectives. The objectives define a strategy's or specific project's purpose and determine the type and extent of restoration/protection that is desired. Objectives need to be measurable or quantifiable in some manner, and are defined by indicators to be assessed through monitoring. It is important to define the temporal and spatial scale so monitoring objectives can be identified and prioritized. When the temporal and spatial scales are clearly defined, the study design and sampling protocols can be developed.

Step 2. How will we know if we are making progress?

This step involves designing monitoring to detect change. Utilizing standard principles for conducting environmental or biological field studies, information should be collected on physical, biological, or chemical characteristics before implementing actions or before altering actions, such as altering the flow regime, so changes resulting from the restoration/protection can be documented.

We will know if we are making progress toward recovery if we know that recovery actions are being implemented, and if we see expected changes in watershed processes and the performance of the target salmon population. Chapters 4-7 identify recovery strategies for each of the threat categories or other recovery issues. Chapter 8 outlines a way of organizing the expected, combined effects of all of the strategies.

Four kinds of information, corresponding to each of the monitoring types, are needed for Step 2:

1) Baseline and trends information for relevant indicators. Information on relevant environmental indicators is needed to define the baseline set of conditions throughout the watershed or within specific restoration areas, as well as to monitor trends over time. Some of the environmental indicators are miles of moderate/high risk roads by stream drainage, significant sediment sources that need to be addressed, miles and locations of streams by riparian condition, density of LWD by stream reach, habitat type composition, streambed scour/stability indices, among many others. Relevant indicators are the same as those listed in Tables 9.1 and 9.2.

   Information on salmon performance is also essential. Indicators of salmon performance that are critical for status and trends monitoring are spawners abundances, juvenile production, and survival indices measured at key locations in the watershed as well as in the marine environment.

2) Progress in achieving implementation benchmarks. Monitoring will occur to assess progress in implementing the strategies as defined by the implementation benchmarks and corresponding indicators identified in Table 9.1. The table also identifies triggers to help gauge the rate of progress in implementation or status of the strategies. The benchmarks, indicators, and triggers combined provide the means of evaluating implementation progress.

3) Assessment of action effectiveness. Monitoring will occur to assess the effectiveness of recovery strategies and actions in meeting objectives as defined by the effectiveness benchmarks in Table 9.2. Some of the benchmarks identified in Table 9.2 measure effectiveness as changes in key environmental indicators, while others focus directly on changes in salmon performance during one or more life stages. Examples of environmental changes due to actions include reductions in rates of mass wasting, channel stability indices increasing in the upper South Fork, channel flow capacity increasing in the lower river valleys, increases in stable log jams, and indices of riparian quality improving, among many others. Examples of improved performance of Chinook due to action effectiveness include improved ability of adults to navigate cataracts in the South Fork gorge, achievement of NOAA fish passage standards both upstream and downstream at the Cushman Dams, post-release survival of early-returning hatchery produced Chinook in the North and South forks, successful natural breeding of hatchery-produced Chinook in the North and South forks and normative survival of their progeny, among other benchmarks.

4) Validation of key assumptions and assessment of changes in population performance. Monitoring activities will occur to validate the basic assumptions that underlie this plan and to assess changes in population status as the plan goes forward. Both near-term and longer-term validation benchmarks are identified in Table 9.3. Near-term benchmarks are meant to provide information in the early years of the plan about how well the various strategies might be contributing to recovery. Use of modeling is expected to help validate the plan during the early years. EDT is one model that can be used in this manner (Blair et al. 2009; Thompson et al. 2009). To actually validate that the plan is indeed making significant progress toward recovery will require relatively long-term collections of empirical data due to environmental variability and related survivals in both fresh and salt water. Ultimately, monitoring of status and trends for both the population and the threats (recovery issues) will be used to validate the plan and recovery.

Step 3. How will we collect the information?

Various agencies and non-agency partners will participate in collecting the information needed to monitor the progress of this plan. Key aspects of baseline and trends monitoring useful for this plan have been occurring for several years and will soon expand as the Cushman Settlement is implemented. Some of these monitoring activities also will be the basis for implementation, effectiveness, and validation monitoring. New efforts directed at implementation, effectiveness, and validation monitoring is also expected to soon be initiated, though other efforts will need to wait funding.

The Skokomish Tribe and WDFW annually assess spawner abundance and composition for all salmon species in key areas of the watershed, including the lower North Fork, lower South Fork, and mainstem river. Upon re-introduction of early-timed Chinook into the upper South Fork, the survey effort will be expanded to cover that area.

Table 9.1. Implementation monitoring elements: implementation benchmarks, triggers, and indicators.

Recovery issue	Strategy	Implementation benchmark	Implementation triggers	Indicator
Degraded Upper Watershed Conditions in South Fork and major tributaries	Decommission roads and maintain remaining road & trail network	All moderate and high risk roads decommissioned, stabilized or upgraded to prevent sediment delivery by 2015.	Plans for decommissioning and maintenance on USFS lands and Green Diamond lands agreed on by relevant parties; completed plans being implemented as per RMAP on private lands and the 2000 Road Management Strategy (RMS) and the 2003 Access and Travel Management Plan (ATM) on USFS lands; decommissioning targets not being met on annual or specified schedule; Green Diamond lands targets not being met on specified schedule.	Miles of road decommissioned annualized
	Stabilize sediment sources	Significant sediment sources stabilized with routing and rate of inputs to channels reduced.	High risk or significant sediment sources identified; plans for stabilization by 2015; proposals submitted for funding; funding secured; progress in reducing # of sites or lack thereof.	# of sites identified with plans for stabilization completed; # of sites stabilized
	Expand high quality riparian reserves along mainstem South Fork and tributaries.	Amount of riparian areas preserved by voluntary or regulatory/statutory programs increasing through 2020.	South Fork subbasin-wide riparian targets established by land ownership and subdrainage; comprehensive riparian mgmt plan completed; progress in miles of streams with reserves; steady improvement in quality of riparian forests made evident or lack thereof.	Miles of stream where high quality riparian zones either exist or have been reserved to be established
	Restore riparian conditions	Quality and quantity of riparian areas restored through riparian management programs increasing by 2015, then continuing to improve incrementally thereafter until PFC condition reached.	South Fork subbasin-wide riparian targets established by land ownership and subdrainage; comprehensive riparian mgmt plan completed; progress in miles of streams with reserves; steady improvement in quality of riparian forests made evident or lack thereof	Miles of stream where high quality riparian zones either exist or have been reserved to be established
	Increase woody debris and log jam density	Density of woody debris increasing by 2015 as a result of both passive and active restoration planning, then continuing to improve incrementally thereafter until PFC conditions reached.	Progress or the lack thereof on elements of the HCCC's Three-Year Watershed Implementation Priorities; approval/permitting attained for the South Fork Skokomish Large Wood Enhancement Project on USFS lands in the upper South Fork; South Fork subbasin-wide LWD and logjam targets established by mainstem reach and subdrainage; comprehensive LWD mgmt/restoration plan completed; proposals submitted for actions; funding secured; actions submitted according to plan; progress or lack thereof in density of stable LWD and jams.	Density of LWD by size class and number of stable jams established

Recovery issue	Strategy	Implementation benchmark	Implementation triggers	Indicator
	Silviculture treatments should increase hydrologic maturity on public lands with incentives for doing the same on private lands	Watershed and sub-basin hydrologic maturity on public lands on an increasing trajectory through 2050.	South Fork subbasin-wide targets for hydraulic maturity of stands established for all public lands; plan to achieve targets completed; agreements reached for plan implementation; steady progress in increasing average stand age.	Average stand age; stand age composition steadily increasing.
	Remedial measures taken to improve adult passage at the gorge cascades	Action to improve passage at each of four cataracts in the SF gorge	Cataracts scoped, evaluated; correction actions identified, proposed for action; proposals for funding; funding secured; engineering completed; actions implemented. Early-timed chinook supplementation effort into North Fork implemented and progress on returning fish provides signal for how progress on passage facilities should be progressing.	Progress on site evaluation; proposal for funding; funding secured; engineering; construction.
Altered Flow Regime in North Fork	More normative flow regime created by changes in regulation at Cushman Dam	Component 1 of normative regime implemented; establishes base flow pattern.	FERC license issued 2010; Fisheries and Habitat Committee established and specifics of implementation established.	Flow release magnitude and timing at lower Cushman Dam.
		Component 2 of normative regime implemented; establishes variation in intramonthly flows corresponding to flows at Staircase.	FERC license issued 2010; Fisheries and Habitat Committee established and specifics of implementation established; release triggers at Staircase achieved that signal Component 2 releases.	Flow release magnitude, timing, and variation at lower Cushman Dam.
		Component 3 of normative regime implemented initially in 2011-2018 - channel forming and bed scouring flows corresponding to flood events in lower river.	FERC license issued 2010; Fisheries and Habitat Committee established and specifics of implementation established; release triggers at Potlatch gauge achieved that signal Component 3 releases.	Flow release magnitude and timing at lower Cushman Dam.
Loss of Fish Access to Upper North Fork	Trap and haul fish passage facilities for upstream passage of adult early-timed Chinook at Cushman Dam.	Deployment of fully functional upstream passage facilities at lower Cushman Dam.	FERC license issued 2010; Fisheries and Habitat Committee established; design and engineering completed; facility testing and evaluation; facility upgrades until NOAA criteria achieved.	Design and engineering; construction; testing; monitoring and evaluation.
	Trap and haul fish passage facilities for downstream passage of juvenile early-timed Chinook at Cushman Dam.	Deployment of fully functional downstream passage facilities at upper and lower Cushman Dam.	FERC license issued 2010; Fisheries and Habitat Committee established; design and engineering completed; facility testing and evaluation; facility upgrades until NOAA criteria achieved.	Design and engineering; construction; testing; monitoring and evaluation.

Recovery issue	Strategy	Implementation benchmark	Implementation triggers	Indicator
Degraded Lower Floodplain Conditions, including in-channel, off-channel, and riparian.	Extend CMZ through regulatory, incentive, and education programs	Increases in CMZ as a result of regulatory, incentive, and education programs.	Implementation and progress in Component 3 flows as part of restored normative flow regime; results of evaluation of the same between 2011-2018; progress and completion in the ACOE's General Investigation Study and applicable findings; adoption of measures promoting appropriate CMZs to promote normative channel function and reduce flooding.	Progress in promoting/advancing regulatory, incentive, and education programs for extending CMZ in Skokomish Valley; progress in extending CMZ in the valley.
	Strategically remove impediments to meander, avulsion and channel connectivity	Progress in removing identified impediments to meander, avulsion, and channel connectivity in the lower valleys.	Implementation and progress in Component 3 flows as part of restored normative flow regime; results of evaluation of the same between 2011-2018; progress and completion in the ACOE's General Investigation Study and applicable findings and conclusions regarding measures to achieve normative channel function for Chinook habitat while reducing flooding.	Identification of key impediments that inhibit normative channel function; formulation of plans to correct; securing of funding; implementation of actions.
	Construct ELJs to restore channel complexity and sediment processes	Placement of strategically-located ELJs in the lower valleys to promote island formation, channel complexity, and sediment processes.	Implementation and progress in Component 3 flows as part of restored normative flow regime; results of evaluation of the same between 2011-2018; progress and completion in the ACOE's General Investigation Study and applicable findings and conclusions regarding measures to achieve normative channel function for Chinook habitat while reducing flooding.	Identification of strategic sites for placement of ELJs to promote normative channel function; formulation of plans for construction; securing of funding; implementation of actions.
	Strategically address key sediment deposits and install log jams to improve channel efficiency	Reduction/removal of key sediment deposits in the lower valleys that inhibit normative sediment routing	Implementation and progress in Component 3 flows as part of restored normative flow regime; results of evaluation of the same between 2011-2018; progress and completion in the ACOE's General Investigation Study and applicable findings and conclusions regarding measures to achieve normative channel function for Chinook habitat while reducing flooding.	Identification of sediment deposits that inhibit channel function and sediment routing; formulation of plans for addressing the deposits; securing of funding; implementation of actions.
	Protect riparian lands through regulatory, incentive, and education programs	Improved protection of riparian lands through regulatory, incentive, and education programs.	Comprehensive riparian mgmt plan completed for lower river valleys; progress in miles of streams with expected improvements in protection measures; steady improvement in quality of riparian forests or lack thereof made evident.	Miles of stream increasing with measures in place that will help ensure improved protection of riparian zones.
	Restore effective riparian forest width	Quality and quantity of riparian areas restored through riparian management programs increasing by 2015, then continuing to improve incrementally thereafter until PFC condition reached.	Comprehensive riparian mgmt plan completed for lower river valleys; progress in miles of streams with expected improvements in protection measures; steady improvement in quality of riparian forests or lack thereof made evident.	Miles of stream where high quality riparian zones either exist or have been secured through various programs to be established.

Recovery issue	Strategy	Implementation benchmark	Implementation triggers	Indicator
	Restore riparian forest quality with conifer underplantings	Measured progress in restoring riparian structure and species composition through underplantings of conifers.	Comprehensive riparian mgmt plan completed for lower river valleys; progress in miles of streams with expected improvements in protection measures; steady improvement in quality of riparian forests or lack thereof made evident.	Acres of underplantings with conifers.
	Inventory and control invasives such as knotweed	Measured progress in controlling invasives (such as knotweed) within the riparian corridors.	Comprehensive riparian mgmt plan completed for lower river valleys; progress in miles of streams with expected improvements in protection measures; steady improvement in quality of riparian forests or lack thereof made evident.	Miles of stream corridor or riparian acres treated for controlling invasives.
Degraded Estuarine and Nearshore Conditions	Remove levees and landfill	Progress in the percentages of remaining levees removed or sufficiently breached (as % of the total levees that had been created).	Updating of estuarine restoration plan to incorporate provisions of Cushman Settlement and projects completed through 2010; Another update to be made based on findings and recommendations in the ACOE's General Investigation Study.	Acres or length of levees removed.
	Fill borrow ditches	Progress in reducing the percentage of borrow ditches previously created (as % of the total borrow ditches that were created).	Updating of estuarine restoration plan to incorporate provisions of Cushman Settlement and projects completed through 2010; Another update to be made based on findings and recommendations in the ACOE's General Investigation Study.	Acres of borrow ditches restored.
	Rip compacted road beds	Progress in the percentages of remaining roadbeds removed (as % of total roadbeds that had been created).	Updating of estuarine restoration plan to incorporate provisions of Cushman Settlement and projects completed through 2010; Another update to be made based on findings and recommendations in the ACOE's General Investigation Study.	Acres or length of roadbeds removed.
	Excavate tidal channels where needed	Progress in excavating or restoring tidal channels.	Updating of estuarine restoration plan to incorporate provisions of Cushman Settlement and projects completed through 2010; Another update to be made based on findings and recommendations in the ACOE's General Investigation Study.	Acres or length of tidal channels created or restored.
	Strategically address key sediment deposits and install log jams to improve channel efficiency	Reduction/removal of key sediment deposits within the estuarine zone that inhibit normative sediment routing.	Updating of estuarine restoration plan to incorporate provisions of Cushman Settlement and projects completed through 2010; Another update to be made based on findings and recommendations in the ACOE's General Investigation Study.	Identification of sediment deposits that inhibit channel function and sediment routing; formulation of plans for addressing the deposits; securing of funding; implementation of actions.
	Restore and protect non-natal stream deltas, tidal embayments, and beaches	Progress in the number of sites (by type) restored along the length of Hood Canal.	Progress or lack thereof in protecting or restoring non-natal nearshore habitats used by juvenile salmonids as prioritized in HCCC recovery documents and PNPTC Technical Report 06-1.	# of sites restored and protected.

Recovery issue	Strategy	Implementation benchmark	Implementation triggers	Indicator
Hatcheries	Reintroduce early-returning Chinook to North Fork and South Fork.	Numbers of early-returning fish released to North Fork and South Fork	Donor stock identified; hatchery facilities in North Fork completed; operational plans developed and hatchery & genetic management plan completed; juvenile fish released.	Numbers of early-returning fish released to North Fork and South Fork
	Maintain genetic diversity and abundance of early-returning Chinook in the North Fork	Number of adults, sources (hatchery and wild), & sex ratios used in spawning	Brood stock management objectives identified	Number of adults, sources (hatchery and wild), & sex ratios used in spawning
	Maintain genetic diversity of extant Chinook stock to provide harvest and as a contingency	Number of adults, sources (hatchery and wild), & sex ratios used in spawning	Brood stock management objectives identified	Number of adults, sources (hatchery and wild), & sex ratios used in spawning
	Continue providing for harvest	Production objectives achieved (numbers of fish at size released and marked)	Production objectives defined and implemented.	Production objectives achieved (numbers of fish at size released and marked)
Harvest	Develop and apply a guideline exploitation rate ceiling, based on the expected harvest distribution and run timing of the donor early-timed Chinook stock.	Provisions for harvest protections applied in formulating various pre-terminal and terminal fisheries.	Year of first return of 3-yr olds and thereafter.	Modeled impacts using surrogate indicator stock for initial impact assessment; CWT contributions to all fisheries for hatchery produced fish used to assess actual harvest impacts once CWTs available.
	Pre-terminal fisheries scenarios formulated during pre-season planning will take into account expected impacts on the re-introduced population to minimize potential impacts.	Provisions for harvest protections considered in formulating annual pre-terminal.	Year of first return of 3-yr olds and thereafter.	Modeled impacts using surrogate indicator stock for initial impact assessment; CWT contributions to all fisheries for hatchery produced fish used to assess actual harvest impacts once CWTs available.
	Provide for treaty C&S fisheries in the Skokomish River during all stages of recovery as a recognized high priority in ensuring Indian treaty rights, taking into account the stage of recovery, expected return, and the guideline ER ceiling.	C&S fisheries implemented by Skokomish Tribe beginning with the first return of 3-year old early-timed Chinook.	Year of first return of 3-yr olds and thereafter.	Agreed-upon criteria/guidelines for implementing C&S fisheries; performance of C&S fisheries.
	Develop and implement criteria for expanding opportunity to harvest early-timed Chinook, or other stronger populations having harvestable numbers, as significant progress is made toward recovery of the early-timed population.	Criteria established and implemented for expanding fishing opportunity corresponding to progress in recovery of early-timed Chinook.	Year of first return of 3-yr olds and thereafter.	Agreed-upon criteria/guidelines for implementing expanded fishery opportunity as a function of progress toward recovery of early-timed Chinook.

Recovery issue	Strategy	Implementation benchmark	Implementation triggers	Indicator
	Develop and implement guidelines to limit incidental fishery impacts on early-timed Chinook in extreme terminal fisheries that target harvestable numbers of other populations.	Guidelines established for regulating incidental fishery impacts on early-timed Chinook in in-river fisheries targeting other populations.	Year of first return of 3-yr olds and thereafter.	Agreed-upon guidelines for limiting incidental fishery impacts on early-timed Chinook while targeting other populations.
	Implement the 50% ER ceiling on the extant summer-fall stock for management years 2010 – 2014, and other harvest conservation measures stated in the 2010 Puget Sound Harvest Plan.	For southern U.S. fisheries, agreed-upon fishery regimes by co-managers as part of the annual North of Falcon process.	Year of first return of 3-yr olds and thereafter.	Agreed-upon fisheries for all fisheries managed by co-managers in southern U.S. areas.

Table 9.2. Effectiveness monitoring elements: effectiveness benchmarks and indicators.

Recovery issue	Strategy	Effectiveness benchmarks	Indicator
Degraded Upper Watershed Conditions in South Fork and major tributaries	Decommission roads and maintain remaining road & trail network	Rate of mass wasting by major drainage being reduced; channel stability indices improving; intragravel fines improving; sediment delivery to lower watershed stabilized, then reducing.	# of mass wasting events associated with roads; active channel width; bed scour and channel stability indices; channel cross-sectional changes; intragravel fines.
	Stabilize sediment sources	Progress in stabilizing sediment sources; channel stability indices improving; intragravel fines improving; sediment delivery to lower watershed stabilized, then reducing.	Active channel width; bed scour and channel stability indices; channel cross-sectional changes; intragravel fines.
	Expand high quality riparian reserves along mainstem South Fork and tributaries.	Indices of riparian effectiveness improving, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stabilization, active channel width reduced, side channel stabilization, island formation and stabilization, and habitat composition, and habitat composition; channel stability indices improved, sediment delivery to lower watershed stabilized, then improved.	Riparian forest indicators, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stability, active channel width, side channel stability, island formation and stability; in-channel habitat type composition; channel stability.
	Restore riparian conditions	Indices of riparian effectiveness improving, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stabilization, active channel width reduced, side channel stabilization, island formation and stabilization, and habitat composition; channel stability indices improved, sediment delivery to lower watershed stabilized, then improved.	Riparian forest indicators, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stability, active channel width, side channel stability, island formation and stability; in-channel habitat type composition; channel stability.
	Increase woody debris and log jam density	Indices of terrace and streambank stabilization, active channel width, side channel stability, island formation and stability; mainstem channel stability show steady improvement; sediment delivery to lower watershed stabilized, then improved.	LWD stability; terrace and streambank stability; active channel width; side channel creation and stability; island formation and stability; in-channel habitat type composition; channel stability.
	Silviculture treatments should increase hydrologic maturity on public lands with incentives for doing the same on private lands	Channel stability indices in upper South Fork mainstem improving; sediment delivery to lower watershed stabilized, then reducing.	LWD stability; terrace and streambank stability; active channel width; side channel creation and stability; island formation and stability; in-channel habitat type composition; channel stability.
	Remedial measures taken to improve adult passage at the gorge cascades	Willingness/ability of early-timed chinook adults to pass each of the four gorge cataracts; lack of significant delays at the cataracts and injury of returning chinook at those sites.	Passage of adult early-timed Chinook at each of the four gorge cataracts; rate of injury to Chinook that pass upstream of the gorge.

Recovery issue	Strategy	Effectiveness benchmarks	Indicator
Altered Flow Regime in North Fork	More normative flow regime created by changes in regulation at Cushman Dam	Base flow pattern that mimics natural flow pattern with sufficient spring-time/early summer pulse for adult early-timed chinook passage over Little Falls and return to base of dam.	Similarity of flow regime shape to natural flow pattern with adequate spring pulse; passage of adult early-timed Chinook through the entirety of the lower North Fork and return to the base of dam.
		Normative-type variation introduced into release discharge from Cushman that provides stimuli for salmon migration and in-channel habitat maintenance. Consideration to be given to frequency of events and whether criteria should be changed. Other factors: coordination of flow releases, timeliness of releases to match storm events, not compounding flooding, habitat structure composition in North Fork.	Similarity of flow variation during fall and winter to natural flow regimes in the watershed; reformation and maintenance of normative habitat characteristics in the lower North Fork.
		Component 3 flows implemented as channel capacity maintenance/improvement flows. Evaluation criteria: increases in channel flow capacities of North Fork and lower Skokomish R, amount of bed scour and sediment movement in North Fork and main Skokomish R, habitat structure and composition.	Channel flow capacities of the lower North Fork and mainstem Skokomish River; channel depth; sediment transport rates; frequency of flooding in the lower Skokomish River.
Loss of Fish Access to Upper North Fork	Trap and haul fish passage facilities for upstream passage of adult early-timed Chinook at Cushman Dam.	NOAA criteria for upstream passage as specified in the FERC license; specific measures to be monitored.	Upstream passage effectiveness over the Cushman Dams of early-timed Chinook.
	Trap and haul fish passage facilities for downstream passage of juvenile early-timed Chinook at Cushman Dam.	NOAA criteria for upstream passage as specified in the FERC license; specific measures to be monitored.	Downstream passage effectiveness over the Cushman Dams of early-timed Chinook.
Degraded Lower Floodplain Conditions, including in-channel, off-channel, and riparian.	Extend CMZ through regulatory, incentive, and education programs	Indices of normative channel complexity, bank stability, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity steadily increasing towards interim goal of 13,000 cfs.	Channel complexity; streambank stability; sediment transport and routing; channel flow capacity; flood frequency.
	Strategically remove impediments to meander, avulsion and channel connectivity	Indices of normative channel complexity, bank stability, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity steadily increasing towards interim goal of 13,000 cfs.	Sediment transport and routing; channel flow capacity; flood frequency; habitat type composition.
	Construct ELJs to restore channel complexity and sediment processes	Indices of normative channel complexity, bank stability, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity steadily increasing towards interim goal of 13,000 cfs.	Channel complexity; streambank stability; sediment transport and routing; channel flow capacity; flood frequency; frequency and stability of large logjams; island formation and stability.

Recovery issue	Strategy	Effectiveness benchmarks	Indicator
	Strategically address key sediment deposits and install log jams to improve channel efficiency	Indices of normative channel complexity, bank stability, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity steadily increasing towards interim goal of 13,000 cfs.	Sediment transport and routing; channel flow capacity; flood frequency; habitat type composition.
	Protect riparian lands through regulatory, incentive, and education programs	Indices of riparian effectiveness improving, including species composition, stand age, stand structure, shading, LWD contributions, streambank stabilization, side channel stabilization, island formation and stabilization; channel stability indices improved.	Riparian forest indicators, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stability, active channel width, side channel stability, island formation and stability; in-channel habitat type composition; channel stability.
	Restore effective riparian forest width	Indices of riparian effectiveness improving, including species composition, stand age, stand structure, shading, LWD contributions, streambank stabilization, side channel stabilization, island formation and stabilization; channel stability indices improved.	Riparian forest indicators, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stability, active channel width, side channel stability, island formation and stability; in-channel habitat type composition; channel stability.
	Restore riparian forest quality with conifer underplantings	Indices of riparian effectiveness improving, including species composition, stand age, stand structure, shading, LWD contributions, streambank stabilization, side channel stabilization, island formation and stabilization; channel stability indices improved.	Riparian forest indicators, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stability, active channel width, side channel stability, island formation and stability; in-channel habitat type composition; channel stability.
	Inventory and control invasives such as knotweed	Indices of riparian effectiveness improving, including species composition, stand age, stand structure, shading, LWD contributions, streambank stabilization, side channel stabilization, island formation and stabilization; normative channel stability characteristics more evident consistent with more normative avulsion characteristics.	Riparian forest indicators, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stability, active channel width, side channel stability, island formation and stability; in-channel habitat type composition; channel stability.
Degraded Estuarine and Nearshore Conditions	Remove levees and landfill	Changes in size of the tidal prism; indices of normative channel complexity, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity steadily increasing towards interim goal of 13,000 cfs.	Size and distribution of tidal prism; channel complexity; sediment routing; channel flow capacity; flood frequency.

Recovery issue	Strategy	Effectiveness benchmarks	Indicator
	Fill borrow ditches	Changes in size of the tidal prism; indices of normative channel complexity, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity steadily increasing towards interim goal of 13,000 cfs.	Size and distribution of tidal prism; channel complexity; sediment routing; channel flow capacity; flood frequency.
	Rip compacted road beds	Changes in size of the tidal prism; indices of normative channel complexity, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity steadily increasing towards interim goal of 13,000 cfs.	Size and distribution of tidal prism; channel complexity; sediment routing; channel flow capacity; flood frequency.
	Excavate tidal channels where needed	Changes in size of the tidal prism; indices of normative channel complexity, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity steadily increasing towards interim goal of 13,000 cfs.	Size and distribution of tidal prism; channel complexity; sediment routing; channel flow capacity; flood frequency.
	Strategically address key sediment deposits and install log jams to improve channel efficiency	Changes in size of the tidal prism; indices of normative channel complexity, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity steadily increasing towards interim goal of 13,000 cfs.	Size and distribution of tidal prism; channel complexity; sediment routing; channel flow capacity; flood frequency.
	Restore and protect non-natal stream deltas, tidal embayments, and beaches	Percentage of restoration of pristine condition (based on PNPTC Technical Report 06-1) or that achieve full function based on ratings in the same.	# of non-natal habitats and beaches with habitat rating values reflecting PFC conditions (as inferred from PNPTC Technical Report 06-1).
Hatcheries	Reintroduce early-returning Chinook to North Fork and South Fork.	Demonstrating that released individuals survive (post-release survival of early-returning fish in North Fork and South Fork); breeding by the released generation and their offspring (number of fish returning to North and South Forks to spawn (wild and in hatchery)	Numbers of early-returning fish released to North and South fork; numbers of returning fish; post-release survivals; reproductive success (in hatchery and natural environments) levels.
	Maintain genetic diversity and abundance of early-returning Chinook in the North Fork	Indices of genetic diversity (heterozygosity; allelic diversity; genetic effective population size); life history trait variation (returning timing and juvenile age at migration); and desired gene flow rates maintained	Numbers of early-returning fish released to North and South fork; numbers of returning fish; post-release survivals; reproductive success (in hatchery and natural environments) levels; sex ratios; age structure.
	Maintain genetic diversity of extant Chinook stock to provide harvest and as a contingency	Indices of genetic diversity (heterozygosity; allelic diversity; genetic effective population size); life history trait variation (returning timing and juvenile age at migration); and desired gene flow rates maintained	Numbers of George Adams fish at hatchery; numbers of returning fish; post-release survivals; reproductive success; sex ratios; age structure.
	Continue providing for harvest	See Harvest Monitoring	Harvest contributions based on CWT analysis, catch accounting; projections using harvest models.

Recovery issue	Strategy	Effectiveness benchmarks	Indicator
Harvest	Develop and apply a guideline exploitation rate ceiling, based on the expected harvest distribution and run timing of the donor early-timed Chinook stock.	CWT contributions to all fisheries with consideration as done for other tagged populations in the ESU.	Total exploitation rate on the early-timed Chinook stock measured by CWT analysis and/or projections based on modeling.
	Pre-terminal fisheries scenarios formulated during pre-season planning will take into account expected impacts on the re-introduced population to minimize potential impacts.	CWT contributions to all fisheries with consideration as done for other tagged populations in the ESU.	Harvest impact estimates on the early-timed Chinook stock measured by CWT analysis and/or projections based on modeling.
	Provide for treaty C&S fisheries in the Skokomish River during all stages of recovery as a recognized high priority in ensuring Indian treaty rights, taking into account the stage of recovery, expected return, and the guideline ER ceiling.	Thorough accounting of C&S fisheries; performance of C&S fisheries compared to pre-season projections of how fisheries would be performed.	Catch records documenting C&S impact levels.
	Develop and implement criteria for expanding opportunity to harvest early-timed Chinook, or other stronger populations having harvestable numbers, as significant progress is made toward recovery of the early-timed population.	CWT contributions to all fisheries with consideration as done for other tagged populations in the ESU.	Harvest impact estimates on the early-timed Chinook stock measured by CWT analysis and/or projections based on modeling.
	Develop and implement guidelines to limit incidental fishery impacts on early-timed Chinook in extreme terminal fisheries that target harvestable numbers of other populations.	Thorough accounting of all incidental fishery impacts occurring during fisheries targeting other populations returning to the Skokomish River.	Catch records and creel census data documenting impacts on early-timed Chinook in extreme terminal areas.
	Implement the 50% ER ceiling on the extant summer-fall stock for management years 2010 – 2014, and other harvest conservation measures stated in the 2010 Puget Sound Harvest Plan.	Modeling using FRAM or other agreed upon tools; CWT contributions to all fisheries with consideration as done for other tagged populations in the ESU.	Harvest impact estimates on the extant summer-fall projected using harvest models.

Table 9.3. Validation monitoring elements: validation benchmarks in near and long-term time periods and indicators.

Recovery issue	Strategy	Validation benchmarks - near-term	Validation benchmarks - long-term	Indicator
Degraded Upper Watershed Conditions in South Fork and major tributaries	Decommission roads and maintain remaining road & trail network	Modeled (EDT) spawner (egg) to juvenile emigrant survival levels consistent with performance needed to achieve recovery goals for early-timed Chinook.	Empirical spawner (egg) to smolt survival levels consistent with performance needed to achieve recovery goals for early-timed Chinook. May need independent measure of stock fitness.	Natural spawner abundance; hatchery/natural composition of spawners; juvenile emigrant abundance; modeled estimates of spawners and juvenile emigrants with updated environmental attribute conditions.
	Stabilize sediment sources	Modeled (EDT) spawner (egg) to juvenile emigrant survival levels consistent with performance needed to achieve recovery goals for early-timed Chinook.	Empirical spawner (egg) to smolt survival levels consistent with performance needed to achieve recovery goals for early-timed Chinook. May need independent measure of stock fitness.	Natural spawner abundance; hatchery/natural composition of spawners; juvenile emigrant abundance; modeled estimates of spawners and juvenile emigrants with updated environmental attribute conditions.
	Expand high quality riparian reserves along mainstem South Fork and tributaries.	Modeled (EDT) spawner (egg) to juvenile emigrant survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for early-timed Chinook.	Empirical spawner (egg) to emigrant juvenile and pre-spawning survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for early-timed Chinook; May need independent measure of stock fitness.	Natural spawner abundance; hatchery/natural composition of spawners; juvenile emigrant abundance; modeled estimates of spawners and juvenile emigrants with updated environmental attribute conditions.
	Restore riparian conditions	Modeled (EDT) spawner (egg) to juvenile emigrant survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for early-timed Chinook.	Empirical spawner (egg) to emigrant juvenile and pre-spawning survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for early-timed Chinook; May need independent measure of stock fitness.	Natural spawner abundance; hatchery/natural composition of spawners; juvenile emigrant abundance; modeled estimates of spawners and juvenile emigrants with updated environmental attribute conditions.
	Increase woody debris and log jam density	Modeled (EDT) spawner (egg) to juvenile emigrant survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for early-timed Chinook.	Empirical spawner (egg) to emigrant juvenile and pre-spawning survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for early-timed Chinook; May need independent measure of stock fitness.	Natural spawner abundance; hatchery/natural composition of spawners; juvenile emigrant abundance; modeled estimates of spawners and juvenile emigrants with updated environmental attribute conditions.
	Silviculture treatments should increase hydrologic maturity on public lands with incentives for doing the same on private lands	Modeled (EDT) spawner (egg) to juvenile emigrant survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for early-timed Chinook.	Empirical spawner (egg) to smolt and pre-spawning survival levels consistent with performance needed to achieve recovery goals for early-timed Chinook. May need independent measure of stock fitness.	Natural spawner abundance; hatchery/natural composition of spawners; juvenile emigrant abundance; modeled estimates of spawners and juvenile emigrants with updated environmental attribute conditions.

Recovery issue	Strategy	Validation benchmarks - near-term	Validation benchmarks - long-term	Indicator
	Remedial measures taken to improve adult passage at the gorge cascades	Modeled (EDT) passage effectiveness values consistent with performance needed to achieve recovery goals for early-timed Chinook.	Willingness/ability of early-timed chinook adults to pass each of the four gorge cataracts; lack of significant delays at the cataracts and injury of returning chinook at those sites.	Passage effectiveness over cataracts; modeled population performance with and without passage improvements.
Altered Flow Regime in North Fork	More normative flow regime created by changes in regulation at Cushman Dam	Modeled (EDT) migration effectiveness values consistent with performance needed to achieve recovery goals for early-timed Chinook.	Willingness/ability of early-timed chinook adults to migrate through the lower North Fork to the base of the lower dam, including ability to ascend Little Falls.	Passage effectiveness through the lower North Fork by returning adults; modeled population performance with and without effective passage to the lower dam.
		Modeled (EDT) juvenile and adult survival and abundance levels in the lower North Fork and lower Skokomish River consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in lower North Fork and lower Skokomish River by juvenile and adult migrant early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
		Modeled (EDT) juvenile and adult survival and abundance levels in the lower North Fork and lower Skokomish River consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in lower North Fork and lower Skokomish River by juvenile and adult migrant early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
Loss of Fish Access to Upper North Fork	Trap and haul fish passage facilities for upstream passage of adult early-timed Chinook at Cushman Dam.	Modeled (EDT) adult passage values (projected) consistent with performance needed to achieve recovery goals for early-timed Chinook.	NOAA criteria for upstream passage as specified in the FERC license; specific measures to be monitored.	Upstream passage effectiveness over the Cushman Dams of early-timed Chinook.
	Trap and haul fish passage facilities for downstream passage of juvenile early-timed Chinook at Cushman Dam.	Modeled (EDT) juvenile passage values (projected) consistent with performance needed to achieve recovery goals for early-timed Chinook.	NOAA criteria for downstream passage as specified in the FERC license; specific measures to be monitored.	Downstream passage effectiveness over the Cushman Dams of early-timed Chinook.
Degraded Lower Floodplain Conditions, including in-channel, off-channel, and riparian.	Extend CMZ through regulatory, incentive, and education programs	Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
	Strategically remove impediments to meander, avulsion and channel connectivity	Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.

Recovery issue	Strategy	Validation benchmarks - near-term	Validation benchmarks - long-term	Indicator
	Construct ELJs to restore channel complexity and sediment processes	Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
	Strategically address key sediment deposits and install log jams to improve channel efficiency	Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
	Protect riparian lands through regulatory, incentive, and education programs	Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
	Restore effective riparian forest width	Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
	Restore riparian forest quality with conifer underplantings	Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
	Inventory and control invasives such as knotweed	Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
Degraded Estuarine and Nearshore Conditions	Remove levees and landfill	Modeled (EDT) juvenile and adult survival and abundance levels in the estuarine zone consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the estuarine zone by juvenile early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.

Recovery issue	Strategy	Validation benchmarks - near-term	Validation benchmarks - long-term	Indicator
	Fill borrow ditches	Modeled (EDT) juvenile and adult survival and abundance levels in the estuarine zone consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the estuarine zone by juvenile early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
	Rip compacted road beds	Modeled (EDT) juvenile and adult survival and abundance levels in the estuarine zone consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the estuarine zone by juvenile early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
	Excavate tidal channels where needed	Modeled (EDT) juvenile and adult survival and abundance levels in the estuarine zone consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the estuarine zone by juvenile early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
	Strategically address key sediment deposits and install log jams to improve channel efficiency	Modeled (EDT) juvenile and adult survival and abundance levels in the estuarine zone consistent with performance needed to achieve recovery goals for early-timed Chinook.	Habitat utilization rates and patterns of utilization in the estuarine zone by juvenile early-timed Chinook consistent with those observed in healthy rivers.	Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
	Restore and protect non-natal stream deltas, tidal embayments, and beaches			Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions.
Hatcheries	Reintroduce early-returning Chinook to North Fork and South Fork.	Modeled persistence (e.g. probability of extinction) meets desired levels	Persistence a re-established run to desired to North Fork and South Fork	Numbers of early-returning fish released to North and South fork; numbers of returning fish; post-release survivals; reproductive success (in hatchery and natural environments) levels.
	Maintain genetic diversity and abundance of early-returning Chinook in the North Fork	Heterozygosity; allelic diversity; genetic effective population size; key life history traits such as returning timing and juvenile age at migration	Indices of genetic diversity; life history trait variation; and desired gene flow rates maintained	Numbers of early-returning fish released to North and South fork; numbers of returning fish; post-release survivals; reproductive success (in hatchery and natural environments) levels; sex ratios; age structure.

Recovery issue	Strategy	Validation benchmarks - near-term	Validation benchmarks - long-term	Indicator
	Maintain genetic diversity of extant Chinook stock to provide harvest and as a contingency	Heterozygosity; allelic diversity; genetic effective population size; key life history traits such as returning timing and juvenile age at migration	Indices of genetic diversity; life history trait variation; and desired gene flow rates maintained	Numbers of George Adams fish at hatchery; numbers of returning fish; post-release survivals; reproductive success; sex ratios; age structure.
	Continue providing for harvest	See Harvest Monitoring	See Harvest Monitoring	Harvest contributions based on CWT analysis, catch accounting; projections using harvest models.
Harvest	Develop and apply a guideline exploitation rate ceiling, based on the expected harvest distribution and run timing of the donor early-timed Chinook stock.	Modeled (EDT) life cycle performance with projected productivity and abundance parameters (given habitat characterizations with actions) and expected harvest rates is consistent with achieving recovery goals.	CWT contributions to all fisheries consistent with sustainable harvest regimes developed under the plan, resulting in building run size to river and achievement of recovery goals.	Total exploitation rate on the early-timed Chinook stock measured by CWT analysis and/or projections based on modeling.
	Pre-terminal fisheries scenarios formulated during pre-season planning will take into account expected impacts on the re-introduced population to minimize potential impacts.	Modeled (EDT) life cycle performance with projected productivity and abundance parameters (given habitat characterizations with actions) and expected harvest rates is consistent with achieving recovery goals.	CWT contributions to all fisheries consistent with sustainable harvest regimes developed under the plan, resulting in building run size to river and achievement of recovery goals.	Harvest impact estimates on the early-timed Chinook stock measured by CWT analysis and/or projections based on modeling.
	Provide for treaty C&S fisheries in the Skokomish River during all stages of recovery as a recognized high priority in ensuring Indian treaty rights, taking into account the stage of recovery, expected return, and the guideline ER ceiling.	Modeled (EDT) life cycle performance with projected productivity and abundance parameters (given habitat characterizations with actions) and expected harvest rates is consistent with achieving recovery goals.	CWT contributions to all fisheries consistent with sustainable harvest regimes developed under the plan, resulting in building run size to river and achievement of recovery goals.	Catch records documenting C&S impact levels.
	Develop and implement criteria for expanding opportunity to harvest early-timed Chinook, or other stronger populations having harvestable numbers, as significant progress is made toward recovery of the early-timed population.	Modeled (EDT) life cycle performance with projected productivity and abundance parameters (given habitat characterizations with actions) and expected harvest rates is consistent with achieving recovery goals.	CWT contributions to all fisheries consistent with sustainable harvest regimes developed under the plan, resulting in building run size to river and achievement of recovery goals.	Harvest impact estimates on the early-timed Chinook stock measured by CWT analysis and/or projections based on modeling.
	Develop and implement guidelines to limit incidental fishery impacts on early-timed Chinook in extreme terminal fisheries that target harvestable numbers of other populations.	Modeled (EDT) life cycle performance with projected productivity and abundance parameters (given habitat characterizations with actions) and expected harvest rates is consistent with achieving recovery goals.	CWT contributions to all fisheries consistent with sustainable harvest regimes developed under the plan, resulting in building run size to river and achievement of recovery goals.	Catch records and creel census data documenting impacts on early-timed Chinook in extreme terminal areas.

Recovery issue	Strategy	Validation benchmarks - near-term	Validation benchmarks - long-term	Indicator
	Implement the 50% ER ceiling on the extant summer-fall stock for management years 2010 – 2014, and other harvest conservation measures stated in the 2010 Puget Sound Harvest Plan.	Modeled (EDT) life cycle performance with projected productivity and abundance parameters (given habitat characterizations with actions) and expected harvest rates is consistent with achieving recovery goals.	CWT contributions to all fisheries consistent with sustainable harvest regimes developed under the plan, resulting in building run size to river and achievement of recovery goals.	Harvest impact estimates on the extant summer-fall projected using harvest models.

Tacoma's new operating license for the Cushman Project requires a significant amount of monitoring to assess the effects of the license conditions on the watershed and on its fish and wildlife populations. To do this, specific monitoring plans will be developed through the Fisheries and Habitat Committee (FHC), which is charged with monitoring oversight. The FHC will be made up of representatives from the various agencies who participated in the settlement process. Monitoring details are to be developed into statistically sound monitoring plans. Some of the elements to be contained in those plans are listed in Table 9.2. It is worth noting the level of biological monitoring to be aimed at assessing salmon response in the North Fork. Tacoma is responsible to fund annual assessments of spawners and juvenile production in the North Fork subbasin—both in the upper North Fork and lower North Fork.[34] Those efforts will include operation of fish passage facilities at the Cushman Dams. The facilities will be used to annually assess the number of Chinook adults that return to the base of the lower dam and are passed into the upper North Fork. The fish will be identified as being hatchery or naturally-produced. The facilities will also assess the number of juveniles that successfully pass downstream out of Lake Cushman.

Much environmental baseline information has been collected in recent years, including channel characteristics and habitat composition in the lower North Fork by Tacoma and in the upper South Fork by the USFS. Additional baseline and on-going trends monitoring information on channel and habitat characteristics will be performed by Tacoma in the lower North Fork and mainstem Skokomish River under provisions of the new Cushman license. Key characteristics of the lower South Fork and mainstem Skokomish River have been assessed, or are currently being assessed, by the U.S. Bureau of Reclamation and U.S. Army Corps of Engineers as part of the General Investigation. Effectiveness monitoring on environmental indicators will be performed by Tacoma and the USCOE as part of activities associated with the Cushman license and the GI, respectively. Also, the USFS will perform effectiveness monitoring in the upper South Fork as part of restoration actions that it is implementing (e.g., USFS 2010).

Agencies or entities known or expected to be involved in some form of monitoring by geographic area within and beyond the watershed are listed below:

- Upper South Fork and associated tributaries
  - USFS
  - Skokomish Tribe
  - Washington State agencies
  - HCCC
- Lower South Fork and associated tributaries
  - Mason County
  - Skokomish Tribe
  - Washington State agencies
  - HCCC
  - Green Diamond Resource Company
- Cushman Project related
  - City of Tacoma
  - Skokomish Tribe
  - WDFW

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[34] / Annual assessments are to occur for the life of the Cushman Project license, i.e., 40 years.

    - NMFS
    - USFWS
- Lower North Fork and associated tributaries
    - City of Tacoma
    - Skokomish Tribe
    - Washington State agencies
    - Green Diamond Resource Company
    - Mason County
    - HCCC
- Mainstem Skokomish River
    - Skokomish Tribe
    - Washington State agencies
    - City of Tacoma
    - USCOE
    - Mason County
    - HCCC
- Skokomish estuary
    - Skokomish Tribe
    - Washington State agencies
    - USCOE
    - Mason County
    - HCCC
- Hood Canal marine areas
    - Washington State agencies
    - Skokomish Tribe
    - Point No Point Treaty Tribes
    - Mason County
    - Kitsap County
    - Jefferson County
    - HCCC
- Pre-terminal fisheries
    - Co-Managers

Step 4. How will the information be used for making decisions?

Information collected through the monitoring elements described above will be used in a variety of management processes that concern the Skokomish watershed and its fish populations. Many different groups, ranging from individual landowners, county and state regulator agencies, Skokomish Tribe, other tribes, City of Tacoma, and federal land and natural resource agencies, make or influence decisions through these processes that affect the Skokomish watershed or its fish. To be effective, the elements of this recovery plan need to be integrated into the relevant management processes and related forums. As the primary authors of this plan, the Skokomish Tribe and WDFW are committed to providing leadership in this regard.

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Chapter 11. Appendices

Appendix A

Related Information on Hatchery Management Actions

This appendix provides additional information on the use of hatcheries in and near the Skokomish watershed relevant to recovery planning.

Other Hatchery Programs in the Skokomish Watershed

Brief descriptions of current and proposed Chinook salmon programs are in Chapter 5. The Hatchery and Genetic Management Plan (HGMP) for each program provides more detail regarding the goals, strategies, operations, and facilities.[35] The co-managers have developed recovery program HGMPs in conjunction with the development of recovery plans.

Current Production of Other Species

Hatchery programs in the Skokomish River do not operate independently of programs for other species. Hatchery operations in the Skokomish River Watershed also produce coho salmon, fall chum salmon, pink salmon, and steelhead. The annual hatchery production goals of these species, excepting steelhead, are shown in Table A.1. These programs often share facilities and released fish can, and often do, interact in the wild.

Table A.1. Hatchery production of non-Chinook species of salmon in the Skokomish River.

	Species				
Production Facility	Coho	Fall chum	Pink	Release Location	Purpose
George Adams	300,000			Skokomish R.	Harvest
McKernan		10,000,000		Skokomish R.	Harvest
Enetai		2,500,000		Enetai Cr.	Harvest
Hoodsport		12,000,000	500,000	Finch Cr.	Harvest

Washington State's long-term Hood Canal hatchery steelhead program was discontinued after 2004. A large-scale test of steelhead supplementation of local populations in Hood Canal was initiated beginning in 2007 (Berejikian et al. 2006). The supplementation program includes the collection of embryos from redds constructed by natural steelhead in the South Fork Skokomish River and the rearing and release of 34,500 age-1 and/or age-2 smolts and 400 adults (age-3 and/or age-4).

Future Production of Other Species

The Cushman Hydroelectric project had major impacts on fish species in the Skokomish River and to the Skokomish Tribe that depended on the river. As part of the new FERC license issued

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[35] Available at http://wdfw.wa.gov/hat/hgmp/#pugetsound

on July 15, 2010, Tacoma Power is required to provide for supplementation releases of artificially propagated salmon and steelhead into the upper North Fork. The specifics of those requirements are provided in Appendix B of this plan (see Article 417).

Other Hatchery Actions Relevant to Recovery Planning

Guidelines, Evaluations, and Adaptive Management

As affirmed in the co-managers' RMP and the HGMPs, hatchery programs in the Skokomish River follow a number of guidelines, policies and permit requirements in order to operate. The intent of these rules is to limit adverse effects on cultured fish, wild fish, and the environment. Operational objectives and standards include brood stocking and production targets, fish spawning, rearing and transfer protocols, minimizing negative interactions with listed species (i.e., natural Chinook, summer chum, and bull trout), maintaining stock integrity and genetic diversity, maximizing survival and controlling fish pathogens, and ensuring compliance with state and federal water quality standards. Some of the manuals and guidelines used by WDFW or the tribes are listed in Table A.2.

The co-managers regularly evaluate the risks and benefits of hatchery programs as part of their effort to adaptively manage and improve hatcheries. Tools used to evaluate hatchery programs are continually being improved. Some of the most current ones are listed in Tables A.3 and A.4.

Table A.2. Guidelines and manuals used for hatchery operations.

Guidelines	Explanation
Genetic Manual and Guidelines for Pacific Salmon Hatcheries in Washington (Hershberger and Iwamoto 1981)	Defines practices that promote maintenance of genetic variability in propagated salmon.
Spawning Guidelines for Washington Department of Fisheries Hatcheries (Seidel 1983)	Defines spawning criteria to be used to maintain genetic variability within the hatchery populations
Stock Transfer Guidelines (WDF 1991)	Guidance in determining allowable stocks for release for each hatchery
Fish Health Policy of the Co-managers of Washington State (NWIFC and WDFW 2006)	Designates zones limiting the transfer of eggs and fish in Puget Sound thereby limiting spread of fish pathogens between watersheds
National Pollutant Discharge Elimination System Permit Requirement	Sets allowable discharge criteria for hatchery effluent and defines acceptable practices to ensure the quality of receiving waters and ecosystems

Table A.3. Models used for evaluating hatchery actions for salmon recovery.

Model	**Description**
AHA	All-“H”-Analyzer—Uses a Beaverton-Holt spawner-recruit model, assumptions about habitat capacity and productivity, hatchery production information, and a genetic model for loss of fitness in hatchery fish to predict the relative numbers of fish returning to the wild, the hatchery, and harvest.
BRAP	Benefit Risk Assessment Procedure—a qualitative model for assessing genetic and ecological impacts of hatchery fish on wild populations.
EDT population	Ecosystem Diagnosis and Treatment model—This version incorporates harvest and hatchery information into the well-used original model, which used information about the habitat quality of stream reaches to predict the impacts of habitat actions on salmon abundance, productivity, and diversity.
RAMP models	Easy to use quantitative models of genetic impacts
• FITFISH	Models loss of fitness from domestication
• TUFTO-HINDAR	Models genetic effective population size with one or more interacting populations to assess risk of losing genetic diversity through genetic drift
• PCD-RISK	Bioenergetic model of the impacts of predation and competition between hatchery and natural fish in freshwater.
Managing for Success	This is database which is still under development by the co-managers, tracks the implementation of hatchery reform recommendations arising from the assessments using the models above and the recommendations of independent reviews, such as the HSRG.

Table A.4. Tools and processes used to assess hatchery operations and their consistency with the co-managers' General Principles (from WDFW and PSTT 2004).

General Principles	Concerns Addressed	HGMP	Benefit-Risk Assessment Procedure	Section 7 consultation	HSRG Review
• Goals, objectives, performance standards	Inappropriate management decisions	Sections 1.6, 1.7, 1.8, 1.9, 1.10	Uses HGMP	Yes	Yes—Important focus of review
• Priorities for brood stock collection	Brood stock mining, minimizing "take"	Sections 6.2.1 and 6.2.2	Genetic Hazard, Demographic Hazard	Yes	Yes
• Protocols to manage risks associated with hatchery operations	Loss of genetic variation, disease, demographic losses from catastrophic facility failures	Sections 7, 8, 9, and 10; Sections 7.8 and 5.8	Uses HGMP and supplemental information	Yes	Yes
• Assess and manage ecological and genetic risks to natural populations	Loss of genetic variation, reproductive success, competition, predation	Sections 4.2, 5.8, 6.2.4, 6.3, 7.2, 7.9, 8, 9.1.7, 9.2.10, 10.11, 11.2	Genetic Hazard 1-3; Ecological Hazard 1-3; Demographic Hazard 1-2; Facility Effect Hazard 1-3.	Yes	Yes
• Coordination with fishery management programs	Genetic effects, demographic effects	Sections 3.1, 3.2, and 3.3	Uses HGMP	Yes	Yes
• Adequate facilities	Catastrophic facility failures, disease, domestication	Section 4, 5, 7.6, 9.2.9, and 9.2.10	Genetic Hazard 2; Ecological Hazard 1; Facility Effect Hazard 1.	Yes	Yes—Important focus of review
• Adaptive management and monitoring & evaluation	Inappropriate management decisions; monitoring, evaluation, and research effects	Sections 1.9, 1.10, and 11	Intent is to use risk assessment results to identify areas for monitoring, evaluation and research	Yes	Yes
• Monitor "take" of listed fish	All of the above	To be included	Not directly addressed	To be done	No

Other Recent Actions

There have been numerous hatchery management actions implemented in Hood Canal since the listing of Puget Sound Chinook under the ESA in 1999. Those actions to help achieve Chinook salmon recovery goals include:

- Implementing measures for hatchery Chinook and non-Chinook programs to minimize negative affects on natural Chinook populations, such as reducing potential ecological interactions in freshwater and estuarine areas by controlling size, time, and location of release;
- Discontinuing the importation of non-local hatchery Chinook stocks in 1991 and thereby allowing for local adaptation and increase in diversity;
- Reducing or eliminating some hatchery programs, such as the termination of yearling releases from saltwater net pens to reduce potential straying and spawning by hatchery Chinook in natural spawning areas;
- Improving monitoring, assessment and adaptive management programs to meet hatchery objectives and standards and ultimately the recovery goals; and
- Coordinating management actions among the management entities.

Actions for George Adams Hatchery Program

- WDFW will continue to use gametes procured from fall Chinook salmon adults volunteering to the George Adams Hatchery for this program.
- WDFW will limit, as the management intent, annual production of summer/fall Chinook salmon for on-station release at George Adams Hatchery to a total, maximum of 3,800,000 fingerlings or sub-yearlings.
- WDFW will, as a management intent, apply an identifiable mark to the summer/fall Chinook salmon sub-yearlings released through the hatchery program each year to allow monitoring and evaluation of the hatchery program fish releases and adult returns. Except for the designated Chinook production utilized for double-index tagging all George Adams hatchery origin fish will be visibly marked by removal of the adipose fin. This objective was phased in for Chinook and fully implemented with the 2007 brood year production.
- WDFW will apply coded-wire tags to a portion of the sub-yearling fall Chinook salmon production at George Adams Hatchery to allow for evaluation of fishery contribution and survival rates, and of straying levels to other Puget Sound watersheds.
- The co-managers will monitor Chinook salmon escapement to the Skokomish River to estimate the number of hatchery-origin and natural-origin Chinook escaping to the river each year. This monitoring will allow for assessment of the status of the natural population.

Currently, some Chinook production is coded-wire tagged at George Adams Hatchery and it has been a Pacific Salmon Treaty index station since 1985. In addition, since 1995 George Adams Hatchery has released Double-Index Tag (DIT) groups of 225,000 adipose-fin clip/coded-wire tagged Chinook fingerlings and 225,000 coded-wire tagged Chinook fingerlings (with no adipose-fin clip). Tag groups provide data on hatchery Chinook catch contributions, run timing, total survival, migration patterns and straying into other watersheds and the DIT groups each provide an index group for Hood Canal wild fingerling summer/fall Chinook. In addition, adipose fin-clipping of Chinook fingerling production increased beginning with brood year 2005, as described above, to allow additional monitoring and evaluation of the hatchery program.

Actions at Rick’s Pond Fall Chinook Salmon Program

- WDFW will continue to use gametes procured from fall Chinook salmon adults volunteering to the George Adams Hatchery for this program.

- WDFW will limit, as the management intent, annual production of summer/fall Chinook for on-station release at Rick's Pond to a total of 375,000 sub-yearlings.

- WDFW and the Tribes have agreed to adipose-clip 100% of the summer/fall Chinook salmon released through the hatchery program each year to allow monitoring and evaluation of the hatchery program fish releases and adult returns.

- The co-managers will monitor Chinook salmon escapement to the Skokomish River sites to estimate the number of hatchery-origin and natural-origin Chinook escaping to the river each year. This monitoring will allow for assessment of the status of the natural population.

Actions for Hoodsport Hatchery Fall Chinook Salmon Program

- WDFW will continue to use gametes procured from summer/fall Chinook salmon adults volunteering to the Hoodsport Hatchery for this program. The intent is to collect localized hatchery-origin broodstock at this location.

- WDFW will limit, as the management intent, annual production of summer/fall Chinook salmon for on-station release at Hoodsport Hatchery to a total, maximum of 2,800,000 fingerlings or sub-yearlings and 120,000 yearlings.

- WDFW will, as a management intent, agree on an identifiable mark with the tribes and apply it to 100% of the fall Chinook salmon sub- yearlings and yearlings released through the hatchery program each year to allow monitoring and evaluation of the hatchery program fish releases and adult returns.

- WDFW will apply coded-wire tags to a portion of the sub-yearling and yearling summer/fall Chinook salmon production at Hoodsport Hatchery to allow for evaluation of fishery contribution and survival rates, and of straying levels to other Puget Sound watersheds.

- Currently, some Chinook production at Hoodsport Hatchery is coded-wire tagged. Tag groups provide data on catch contributions, run timing, total survival, migration patterns and straying into other watersheds. In addition, WDFW and the Tribes have agreed to mass mark Chinook fingerling and yearling production and all Chinook have been adipose-clipped beginning with brood year 2004. In addition, each year there will be combined adipose fin-clipping and coded-wire tagging for 200,000 subyearling Chinook and 100,000 yearling Chinook.

The guidelines listed above for Chinook hatchery programs also apply to non-Chinook hatchery programs. For example, coho and steelhead programs include the provision of delaying release until after April 15 to reduce potential predation on the ESA-listed species of Chinook and summer chum salmon. The expectation is that the delay in release of the larger coho and steelhead yearlings (age 1+) will provide the opportunity for the smaller ESA listed Chinook and ESA listed summer chum juvenile emigrants (age 0+) to move out of the river and estuary in time to avoid becoming prey to the larger fish. The fall chum and pink salmon programs include the provision of delaying release until after April 1 to reduce potential adverse impacts due to competition and/or behavioral modifications to natural summer chum in the watershed and Hood Canal marine areas. All programs are also managed to control potential disease pathogens that might affect the natural salmonid populations in the watershed. Details of the Hood Canal non-Chinook hatchery programs are described in the respective HGMPs and in the non-Chinook RMP (PSTT and WDFW 2004) and are consistent with guidelines in the Summer Chum Salmon Conservation Initiative (WDFW and PNPTT 2000).

Appendix B.

Proposed License Articles for the Cushman Hydroelectric Project, FERC No. 460

Article 201(c) (substitute for existing language): The Licensee shall pay the Skokomish Tribe an annual charge of $20,000 based on 2008 dollars and adjusted annually according to the U.S. Department of Labor, Bureau of Labor Statistics Consumer Price Index, All Urban consumers, for Seattle-Tacoma-Bremerton (CPI-U), for the use of reservation lands. The first payment will be made within 60 days after issuance of the Amended License and annually for the term of the Amended License and any subsequent annual licenses.

Articles 202-205, 301-303: Unchanged.

Article 401: Article proposed for deletion. See explanation in the Joint Explanatory Statement.

Article 402: Unchanged.

Article 403: Channel Conveyance Capacity

The Licensee shall implement the measures described in this license article as its contribution to regional efforts to enhance the channel conveyance capacity of the mainstem Skokomish River for the reduction of risks to human health and welfare from flooding.

1. Skokomish River Basin Ecosystem Restoration and Flood Damage Reduction General Investigation: The Licensee shall annually provide 25% of the funds necessary for the Army Corps of Engineers to conduct the Skokomish River Basin Ecosystem Restoration and Flood Damage Reduction General Investigation (General Investigation). The Licensee's funding obligations shall not exceed $400,000 in any year, and shall not exceed $1.2 million in total. The Licensee shall implement this obligation through a cost-sharing agreement with either the Army Corps of Engineers or Skokomish Tribe as appropriate.

2. Mainstem Channel Restoration (MCR) Plan: If by year fifteen (15) after issuance of the Amended License, Congress has not appropriated sufficient funds to substantially implement measures that address mainstem Skokomish River channel capacity, the Licensee shall file with the Commission for approval, a Mainstem Channel Restoration (MCR) Plan.

The MCR Plan shall: (1) identify and prioritize appropriate measures that are capable of being implemented by the Licensee to enhance mainstem channel capacity; (2) include individual implementation schedules and cost estimates for each measure; and (3) identify provisions for creating and managing the MCR Account, as described in section 3. Any measures identified in the MCR Plan for implementation in a location that is both: (a) outside the North Fork Skokomish sub-basin and (b) outside of the then existing Project boundary will be limited to actions that do not result in an expansion of the Project boundary.

The Licensee shall develop the MCR Plan in consultation with the Fisheries and Habitat Committee and shall seek approval of the National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the Bureau of Indian Affairs. The Licensee shall also seek the comments and recommendations of the Corps of Engineers, the Federal Emergency Management Agency, the U.S. Environmental Protection Agency, and Mason County. The Licensee shall allow a minimum of thirty (30) days for comments and recommendations before submitting the MCR Plan for approval to NMFS, USFWS, and BIA. When filing the plan with the Commission, the Licensee shall include documentation of consultation, copies of comments and recommendations, and specific descriptions of how comments and recommendations from Fisheries and Habitat Committee members, the Corps, the Federal Emergency Management Agency, the U.S. Environmental Protection Agency, and Mason County are accommodated by the Licensee's Plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the MCR Plan with the Commission without first obtaining the approval of NMFS, USFWS and BIA, the Licensee shall include specific reasons for doing so.

The Commission reserves the right to require changes to the proposed MCR Plan. The Licensee's funding of the MCR Plan pursuant to section 3 shall commence when the Licensee is notified by the Commission that the filing is approved.

3. <u>MCR Channel Restoration Account</u>: The Licensee shall deposit $600,000 into an interest-bearing account within thirty (30) days after Commission approval of the MCR Plan.

In addition, so long as Congress has not appropriated funds to substantially implement measures that address Mainstem Skokomish River channel capacity, the Licensee shall deposit $600,000 every five (5) years for the term of the Amended License and $120,000 for each subsequent annual license to fund priority measures identified in the MCR Plan. The last five year payment during the license term shall be reduced based upon a pro rata calculation of the number of years remaining in the license. All funds identified in this section shall be based on 2008 dollars and adjusted annually according to the U.S. Department of Labor, Bureau of Labor Statistics Consumer Price Index, All Urban consumers, for Seattle-Tacoma-Bremerton (CPI-U). The Licensee shall use this account to fund projects identified in the MCR Plan. The Licensee shall not use the funds provided within this section for its administration and oversight of these projects. The Licensee's obligation to fund measures identified in the MCR Plan shall continue until Congress has appropriated funds to substantially implement measures that address Mainstem Skokomish River channel capacity or until the fund is fully expended, whichever comes first.

The Licensee shall develop a proposed budget for each project. The Licensee shall use the funds provided within this section to implement only those projects specified, budgeted for, and approved by NMFS, BIA, and USFWS after consultation with the Fisheries and Habitat Committee. Use of any funds in excess of amounts budgeted for such activities must be approved by NMFS, BIA, and USFWS after consultation with the Fisheries and Habitat Committee. Provided, however, the funds shall not be used to cover any additional costs incurred by the Licensee in completing the projects developed pursuant to this article, due to the negligence or other fault of the Licensee or the Licensee's contractor, unless otherwise approved by the Fisheries and Habitat Committee.

Article 404: Proposed for deletion because provisions are incorporated in Article 407.

Article 405: Impoundment Elevations

Upon approval of the Operational and Flow Monitoring Plan required to monitor surface water elevations required by Article 406, the Licensee shall maintain a minimum impoundment elevation (Tacoma Datum) in Lake Cushman of between 735 feet and 738 feet from Memorial Day weekend through Labor Day weekend. The License shall also maintain a minimum impoundment elevation in Lake Cushman of 690 feet from November 1 through March 31.

The purposes of maintaining these minimum elevation levels are to protect and enhance the land-use, recreation, aesthetic, and socio-economic value of Lake Cushman's shoreline, and to provide for the interests of dam safety and flood mitigation. Moreover, the Licensee shall maintain impoundment elevations in Lake Kokanee between 474 feet Tacoma Datum and 480 feet Tacoma Datum at all times, except for maintenance requirements of the intake or spillway.

These minimum impoundment surface elevations may be temporarily modified if required by operating emergencies beyond the control of the Licensee, or upon approval of the Fisheries and Habitat Committee. If the impoundment water surface elevation is so modified, the Licensee shall notify the members of the Fisheries and Habitat Committee as soon as possible, but no later than two (2) business days after each such incident. The Licensee shall notify the Commission as soon as possible, but no later than ten (10) days after each such incident.

Changes to this article's impoundment surface elevations can be made through the provisions outlined in the Fisheries and Habitat Monitoring Plan and fishery reports required in Article 413. If the information in the fishery reports, prepared pursuant to Article 413, indicates that changes in impoundment levels are needed to protect and enhance the fishery and aquatic habitat in the North Fork of the Skokomish River, the Commission may direct the Licensee to file with the Commission an amendment to the license to change the Project's impoundment surface elevation requirements.

Article 406: Operational and Flow Monitoring Plan

Within 180 days of issuance of the Amended License, the Licensee shall file with the Commission, for approval, a comprehensive Operational and Flow Monitoring Plan (OFM Plan). This OFM Plan will document how the Licensee shall: (1) monitor impoundment water surface elevations, as required by Article 405; (2) monitor stream flows in the Skokomish River downstream from the Project, as required by Article 407; (3) ensure compliance with the minimum instream flow requirements; (4) improve mainstem flow and flood forecasting; and (5) address water use issues, specifically from Lake Cushman, when refill, Project operations, flow releases and Lake Cushman water surface elevations may conflict.

The OFM Plan shall include, but not be limited to: (1) the use of the three existing North Fork Skokomish River U.S. Geological Survey (USGS) streamflow gages (USGS Gage Nos. 12056500, 12058790 and 12059500) and one mainstem gage (12061500); (2) the use of and/or the installation of new staff gages, impoundment water surface level monitoring devices, and flow measurement and recording equipment, as needed, to determine instantaneous water surface elevations, flows in the Skokomish River downstream from Cushman Dam No. 2, and to effectively implement the flow regime in Article 407; (3) a provision that describes the priorities in operating the Project when refill, Project operations, flow releases and Lake Cushman water surface elevations may conflict; (4) the proposed location, design, and calibration (including methods and schedule) of the monitoring equipment; (5) the relative extent of manned versus automatic operation of the monitoring equipment; (6) the methods for recording and maintaining flow data; (7) the methods for recording and maintaining surface impoundment elevation data; (8) the mechanism(s) for providing impoundment elevation data and telemetered real-time flow data to the Fisheries and Habitat Committee, Save the Lakes Coalition, and USGS; and (9) a schedule for: (a) implementation of the OFM Plan, (b) consultation with the appropriate federal and state agencies regarding the monitoring data, and (c) filing the data, agency comments, and the Licensee's response to agency comments with the Commission.

The Licensee shall develop the OFM Plan in consultation with the Fisheries and Habitat Committee and shall seek approval of the National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the Bureau of Indian Affairs. The Licensee shall involve a representative of Save the Lakes Coalition in development of the OFM Plan provisions that describe the priorities in operating the Project when refill, Project operations, flow releases and Lake Cushman water surface elevations may conflict. The Licensee shall allow a minimum of thirty (30) days for comments and recommendations by Fisheries and Habitat Committee members and Save the Lakes Coalition, before submitting the OFM Plan for approval to USFWS, BIA and NMFS. When filing the Plan with the Commission, the Licensee shall include documentation of consultation, copies of comments and recommendations, and specific descriptions of how comments and recommendations from Fisheries and Habitat Committee members and Save the Lakes Coalition are accommodated by the Licensee's plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the OFM Plan with the Commission without first obtaining the approval of NMFS, USFWS and BIA, the Licensee shall include specific reasons for doing so.

The Commission reserves the right to require changes to the OFM Plan. Changes to Project operations shall not commence until the Licensee is notified by the Commission that the Plan is approved. Upon Commission approval, the Licensee shall implement the Plan.

Article 407: Minimum Flows

The Licensee shall release flows from the Cushman Project into the Lower North Fork of the Skokomish River ("North Fork"), in accordance with all components of the flow regime required by this Article. The purposes of this Article are: 1) to protect, mitigate, and enhance fish and wildlife resources, riparian vegetation, aesthetic resources, and water quality in the North Fork, 2) to provide safe, timely and effective fish passage in the North Fork; and 3) to improve sediment transport in the North Fork and the Mainstem of the Skokomish River ("Mainstem"). The flow regime required by this Article has three components, described as follows:

1. Component 1: The Licensee shall provide an annual water budget of 160,000 acre-feet for release from the Cushman Project into the Lower North Fork of the Skokomish River. The Licensee shall release 115,835 acre-feet of the annual 160,000 acre-foot water budget as instantaneous minimum flows from the Cushman Project, into the Lower North Fork of the Skokomish River, in accordance with the following schedule:

Month:	Instantaneous Minimum Flow Release Schedule:
January:	150 cfs
February:	150 cfs
March:	180 cfs
April:	180 cfs
May:	180 cfs
June:	170 cfs
July:	100 cfs
August:	100 cfs
September:	170 cfs
October:	180 cfs
November:	180 cfs
December:	180 cfs

In addition to the instantaneous minimum flow releases described above, the Licensee shall release the remaining 44,165 acre-feet of the annual 160,000 acre-feet water budget in accordance with a release schedule developed prior to each water budget year (July 1 – June 30) in consultation with the Fisheries and Habitat Committee. By no later than ninety (90) days prior to the beginning of each water budget year, the Licensee shall prepare and distribute to the Fisheries and Habitat Committee a preliminary Flow Report containing a recommended release schedule for the 44,165 acre-feet for the upcoming water budget year. Following consultation with the Fisheries and Habitat Committee, the Licensee shall modify the Flow Report to document the final release schedule determined by the Fisheries and Habitat Committee and shall file the finalized Flow Report with the Commission for informational purposes by no later than fifteen (15) days prior to the beginning of each water budget year. The Fisheries and Habitat Committee may change the above schedule to the USGS water year (October 1 – September 30).

If, during the course of a water budget year, but not more than once every ninety (90) days unless exceptional circumstances exist, the Fisheries and Habitat Committee determines that the release schedule described in the Flow Report requires interim modification consistent with the purposes of this Article, the Licensee shall notify the Commission and implement the revised release schedule within seven (7) days of providing such notice, unless otherwise directed by the Commission. Additionally, during the first three water budget years after license amendment, but not more than once every thirty (30) days, if the Fisheries and Habitat Committee determines that additional interim modifications are necessary for the purposes of this Article, the Licensee shall notify the Commission and implement the revised schedule within seven (7) days of providing such notice unless otherwise directed by the Commission.

In the event that the Fisheries and Habitat Committee is unable to reach consensus regarding the release of the 44,165 acre-feet by fifteen (15) days prior to the beginning of the water budget year, the following flow regime will be implemented beginning the first day of the water budget year:

Month:	Default Instantaneous Flow Release Schedule:
January:	230 cfs
February:	215 cfs
March:	215 cfs
April:	220 cfs
May:	240 cfs
June:	230 cfs
July:	220 cfs
August:	200 cfs
September:	200 cfs
October:	210 cfs
November:	225 cfs
December:	235 cfs

The Licensee shall discharge water to the North Fork Skokomish River to meet the scheduled flow releases in this Article. Water releases exceeding the planned flows shall not be charged to the water budget.

For compliance purposes, the Licensee is allowed temporary fluctuations of up to five percent (5%) of the scheduled flow release as measured at USGS Gage No. 12058790 to account for monitoring imprecision and release equipment variability.

2. Component 2: In addition to the flow releases required by Component 1 of this Article 407, the Licensee shall increase flow releases from the Cushman Project, into the Lower North Fork of the Skokomish River to: (a) 500 cfs whenever the daily average flow at the North Fork Skokomish River/Staircase Rapids U.S. Geological Survey (USGS) streamflow Gage No. 12056500 ("Staircase Rapids Gage") exceeds 3000 cfs; (b) 750 cfs whenever the daily average flow at the Staircase Rapids Gage exceeds 4000 cfs; and (c) 1000 cfs whenever the daily average flow at the Staircase Rapids Gage exceeds 5000 cfs. Commencing in the sixth year after the issuance of the Amended License, and every five (5) years thereafter, the Licensee shall increase the initial flow releases of 500, 750, and 1000 cfs described herein by five percent (5%) of the previous flow and implement these flows as stated above.

The Licensee shall maintain the flow releases provided for in this component for the same duration of time that the flow at the Staircase Rapids Gage exceeds the applicable trigger of 3000, 4000, or 5000 cfs. The Licensee may delay the commencement of the flow releases required by this component by up to seven (7) days after the initial exceedance at the Staircase Rapids Gage if necessary to avoid flood impacts or to allow time for necessary water release notifications.

3. Component 3: In addition to the flow releases required by Components 1 and 2 of this Article, the Licensee shall increase flow releases from the Cushman Project, into the Lower North Fork of the Skokomish River, up to 2,200 cfs for forty-eight (48) consecutive hours whenever the daily average flow at the Skokomish River/Potlatch USGS stream flow Gage No. 12061500 exceeds 9800 cfs, or fifteen percent (15%) above flood stage, whichever is greater, between October 1 and February 15 of each year. The purpose of the flows required in this component is to test whether sediment transport is significantly improved in the Mainstem by extending the duration of the high Mainstem flow events at slightly less than bank-full capacity.

If a flood event triggers the flow releases in this Component within 2 days of the Staircase Rapids Gage exceeding the trigger flows described in Component 2, releases described in this Component will eliminate the requirement for Component 2 flows for that flood event.

The Licensee shall release the flows required by this Component as soon as practicable after the Mainstem drops below flood stage. Once the release has commenced, the Licensee shall continue the flow release for forty-eight (48) consecutive hours. The Licensee shall control the flow release to extend the duration of the high flow event in the Mainstem at or near bank-full capacity in a continuous manner, without exceeding flood stage, until reaching the maximum 2,200 cfs release. If a Component 3 release is triggered during the delay of a required Component 2 release, the Component 2 flow release will be initiated immediately following completion of the Component 3 release. The Licensee shall comply with ramping rates provided for in Article 411 of the Amended License when implementing these flows.

4. Sediment Transport Adaptive Management

Based upon the sediment transport studies provided in Article 413, in year five of this Amended License, and every five (5) years thereafter, the Licensee shall file a Component 3 effectiveness report with the Commission for its approval, after consultation with the Fisheries and Habitat Committee and seeking the approval of the National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the Bureau of Indian Affairs. The report shall evaluate the effectiveness of the flows provided in Component 3 for the purpose of improving sediment transport in the Mainstem Skokomish River. The report shall discuss whether modifications to the flow trigger, the timing of the flows, and the duration of the flows are necessary to improve sediment transport; however, any modification to the quantity of the flow release provided for in this component shall be limited to no more than a five percent (5%) increase in the total quantity of each Component 3 flow release in each five-year evaluation period beginning in year eleven. The report shall also analyze the impacts to meeting the Article 405 refill requirements and the potential benefit to improving sediment transport in the Mainstem of extending the Component 3 seasonal period through March 31. If the analysis demonstrates that extending the seasonal period will not adversely impact refill and will improve sediment transport, the Fisheries and Habitat Committee may extend the seasonal period through March 31.

5. Component 3 Flow Alternative

5.1 Flood Damage Reduction and Mitigation Plan

If the Fisheries and Habitat Committee determines based on best available information that the flows required by Component 3 are not effective at improving sediment transport in the Mainstem Skokomish River, it may request that the Licensee develop and implement a Flood Damage Reduction and Mitigation Plan (FDRM Plan). If so requested, the Licensee shall develop this Plan and file it with the Commission within 180 days of receiving notice to do so by the Fisheries and Habitat Committee.

The Licensee shall develop the FDRM Plan in consultation with the Fisheries and Habitat Committee and shall seek approval of NMFS, USFWS, and BIA. The Licensee shall allow a minimum of thirty (30) days for comments and recommendations by Fisheries and Habitat Committee members before submitting the FDRM Plan for approval to the USFWS, BIA and NMFS. When filing the FDRM Plan with the Commission, the Licensee shall include documentation of consultation, copies of comments and recommendations, and specific descriptions of how comments and recommendations from Fisheries and Habitat

Committee members are accommodated by the Licensee's FDRM Plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the Flood Damage Reduction and Mitigation Plan with the Commission without first obtaining the approval of NMFS, USFWS and BIA, the Licensee shall include specific reasons for doing so.

The FDRM Plan shall: (1) include the rationale for proposing a cessation of Component 3 flows; (2) identify an initial list of projects in order of priority to be implemented by the Licensee over the first five (5) years of plan implementation either to enhance channel conveyance capacity or reduce or mitigate flood damage in the Skokomish River basin; (3) identify provisions for creating a Flood Damage Reduction and Mitigation Fund to cover the costs of plan implementation, consistent with paragraph 5.2; and (4) include provisions for resuming Component 3 flow releases. The Licensee shall update the list of projects every five (5) years on the anniversary of the Commission's approval, following the same procedures discussed above for consultation with the Fisheries and Habitat Committee, seeking approval by NMFS, USFWS, and BIA, and filing with the Commission.

Any measures identified in the FDRM Plan for implementation in a location that is both: (a) outside the North Fork Skokomish sub-basin and (b) outside of the then existing Project boundary, will be limited to actions that do not result in an expansion of the Project boundary.

The Commission reserves the right to require changes to the FDRM Plan and the updated project lists. Component 3 flows shall be provided by the Licensee until the Licensee is notified by the Commission that the FDRM Plan is approved. Upon Commission approval, the Licensee shall discontinue Component 3 flows and implement the FDRM Plan.

5.2 Flood Damage Reduction and Mitigation Fund

The Licensee shall deposit $150,000 into an interest bearing account within thirty (30) days after Commission approval of the Flood Damage Reduction and Mitigation Plan. In addition, the Licensee shall deposit $150,000 into an interest bearing account every year thereafter for the term of the Amended License, and $150,000 for each subsequent annual license, on the anniversary date of the Commission's approval of the Plan. All funds deposited into the Flood Damage Reduction and Mitigation Fund shall be based on 2008 dollars and adjusted annually according to the U.S. Department of Labor, Bureau of Labor Statistics Consumer Price Index, All Urban consumers, for Seattle-Tacoma-Bremerton (CPI-U). The Licensee shall use this account to fund projects developed pursuant to this

License Article. The Licensee shall not use the funds provided within this paragraph for its administration and oversight of these projects.

The Licensee shall develop a proposed budget for each project. The Licensee shall use the funds provided within this section to implement only those projects specified, budgeted for, and approved by NMFS, BIA, and USFWS after consultation with the Fisheries and Habitat Committee. Use of any funds in excess of amounts budgeted for such activities must be approved by NMFS, BIA, and USFWS after consultation with the Fisheries and Habitat Committee. Provided, however, the funds shall not be used to cover any additional costs incurred by the Licensee in completing the projects developed pursuant to this Article, due to the negligence or other fault of the Licensee or the Licensee's contractor, unless otherwise approved by the Committee.

6. General Provisions: The Licensee shall notify the Skokomish Indian Tribe no less than twenty-four (24) hours in advance of any increased flow releases provided for in Components 2 and 3 of this Article 407. Article 407 flows may be temporarily modified if required by operating emergencies beyond the control of the Licensee. If flows are so modified, the Licensee shall notify the members of the Fisheries and Habitat Committee as soon as possible, but no later than forty-eight (48) hours after each such incident. The Licensee shall notify the Commission no later than ten (10) days after each such incident.

The Licensee shall include, in any report prepared pursuant to this Article 407, documentation of its consultation with the Fisheries and Habitat Committee, copies of the comments and recommendations on the report after it has been prepared and provided to the Fisheries and Habitat Committee, and specific descriptions of how the comments and/or recommendations of the Fisheries and Habitat Committee are accommodated by and incorporated into the report. The Licensee shall allow a minimum of thirty (30) days for the Fisheries and Habitat Committee members to provide comments and recommendations before filing the report with the Commission. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information.

Article 408: Minimum Flow Plan. Proposed for deletion because article is related to implementation of minimum flow originally required by Article 407 which has now been superseded.

Article 409. Deleted by 1999 Rehearing Order. *City of Tacoma, Wash.*, 86 FERC ¶ 61,311 (1999).

Article 410. Within 180 days of issuance of the Amended License, the Licensee shall file with the Commission, for approval, a water quality enhancement plan to protect and enhance water quality, recreation, and aesthetics in the North Fork of the Skokomish River.

The plan shall include, but not be limited to the following provisions:

(1) Installing emergency intake shutoff valves on all penstock intakes: The Licensee shall provide design drawings, and describe the guidelines under which the valves will be operated, as well as a schedule for installing the valves.

(2) Improving Staircase Road in a manner consistent with U.S.D.A. Forest Service (USFS) stipulations to protect water quality: The Licensee shall include a mechanism and a schedule for contributing an amount not to exceed $750,000 as matching dollars for Federal or other grants, if the USFS determines that it will facilitate jurisdiction of Staircase Road (USFS Road No. 24) being assumed by a public road management agency. If jurisdiction is not transferred within three (3) years after issuance of the Amended License and upon the request of the USFS, instead of contributing $750,000 (2008 dollars), adjusted annually by the U.S. Department of Labor, Bureau of Labor Statistics Consumer Price Index, All Urban consumers, for Seattle-Tacoma-Bremerton (CPI-U), as matching dollars the Licensee shall apply a double thickness bituminous surface treatment (BST - asphalt emulsion and chip rock) and additional aggregate base to accommodate anticipated traffic loading from MP 10.1 to MP 14.08. This initial application shall be supplemented with an additional (third) surface course of asphalt and aggregate to be applied within the first five (5) years of the original placement, the specific timing to be determined by the USFS, to keep the structural integrity of the surface. Subsequent operations, maintenance and treatment activities are to be done pursuant to Article 427.

(3) Monitoring dissolved gases (*e.g.* nitrogen) at all powerhouse outfalls and spillways during spill events: The Licensee shall describe: (a) all the mechanisms and structures used to monitor dissolved gases; (b) the methods for recording and maintaining data on dissolved gases, and providing relevant data to the Commission and the appropriate agencies for review; and (c) the schedule for implementing the monitoring program. The Licensee shall also describe reasonable enhancement measures, developed in consultation with appropriate agencies, to address nitrogen levels that deviate from Washington's standards due to the operation of the Project.

The Licensee shall prepare the water quality enhancement plan after consultation with U.S. Fish and Wildlife Service, National Marine Fisheries Service, Bureau of Indian Affairs, National Park Service, USFS, Washington Department of Fish and Wildlife, Washington Department of Ecology, and the Skokomish Indian Tribe. The Licensee shall include with the plan documentation of consultation, and copies of comments and recommendations on the Licensee's proposed plan after it has been prepared and provided to the agencies and the Tribe.

Article 411: Ramping Rate Conditions

The Licensee shall operate the Project within the following ramping rate restrictions as measured at North Fork Skokomish River U.S. Geological Survey (USGS) Streamflow Gage No. 12058790.

1. Downramping Rates

Downramping rate refers to the rate of allowable stage decline. The following rates apply to flows less than the critical flow, which is currently estimated to be 500 cfs.

Time of Year	Daylight Rates	Night Rates
February 16 to June 15	No Ramping	2 inches per hour
June 16 to October 31	1 inch per hour	1 inch per hour
November 1 to February 15	2 inches per hour	2 inches per hour

Daylight is defined as one hour before sunrise to one hour after sunset. Night is defined as one hour after sunset to one hour before sunrise.

At flows greater than the critical flow, currently estimated to be 500 cfs, the Licensee shall attempt to limit the downramping rate to no more than 0.5 feet per hour unless flows are exacerbating downstream flood conditions that would warrant a more rapid reduction of flows.

The Licensee shall modify the critical flow and down ramping rate restrictions upon recommendation of the Fisheries and Habitat Committee, and approval by the Commission.

2. Upramping Rates

Upramping rate refers to the rate of allowable stage increase. The Licensee shall limit the upramping rate to no more than 1 foot per hour unless required by an operating emergency.

Article 412: Fish Habitat Enhancement and Restoration Plan

Within twelve (12) months of issuance of the Amended License, the Licensee shall file with the Commission, for approval, a comprehensive Fish Habitat Enhancement and Restoration Plan (FHER Plan) to enhance fish habitat in the North Fork of the Skokomish River basin. The purpose of the FHER Plan is to guide the implementation of projects designed to enhance aquatic habitat in the North Fork of the Skokomish River and McTaggert Creek and to provide access to spawning habitat in tributaries of Lake Cushman.

The Licensee shall develop the FHER Plan in consultation with the Fisheries and Habitat Committee, and shall seek approval of the National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the Bureau of Indian Affairs. The Licensee shall also seek the comments and recommendations of the National Park Service when developing the plan. The Licensee shall allow a minimum of thirty (30) days for comments and recommendations before submitting the plan for approval to the USFWS, BIA and NMFS. When filing the FHER Plan with the Commission, the Licensee shall include documentation of consultation, copies of comments and recommendations, and specific descriptions of how comments and recommendations from Fisheries and Habitat Committee members and the National Park Service are accommodated by the Licensee's plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the FHER Plan with the Commission without first obtaining the approval of NMFS, USFWS and BIA, the Licensee shall include specific reasons for doing so.

The Commission reserves the right to require changes to the proposed FHER Plan. Implementation of the FHER Plan shall not commence until the Licensee is notified by the Commission that the filing is approved. Upon Commission approval, the Licensee shall implement the FHER Plan.

The FHER Plan shall consist of the following actions:

(1) Habitat Restoration Account (HRA): The Licensee shall deposit $3.5 million into an interest bearing account within thirty (30) days after issuance of the Amended License. In addition, starting five (5) years after issuance of the Amended License and annually for the term of the Amended License and any subsequent annual licenses, the Licensee shall deposit $300,000 into this account. All funds are based on 2008 dollars and adjusted annually according to the U.S. Department of Labor, Bureau of Labor Statistics Consumer Price Index, All Urban consumers, for Seattle-Tacoma-Bremerton (CPI-U). The Licensee shall use this account to fund projects developed pursuant to this License Article, other than removing the McTaggert Creek Diversion Structure and implementing the threatened species take minimization measures referenced in Paragraph 3 below. The Licensee shall not use the funds provided within this section for its administration and oversight of these projects.

The Licensee shall develop a proposed budget for each project. The Licensee shall use the funds provided within this section to implement only those projects specified, budgeted for, and approved by NMFS, BIA, and USFWS after consultation with the Fisheries and Habitat Committee. Use of any funds in excess of amounts budgeted for such activities must be approved by NMFS, BIA, and USFWS after consultation with the Fisheries and Habitat Committee. Provided, however, the funds shall not be used to cover any additional costs incurred by the Licensee in completing the projects developed pursuant to this article, due to the negligence or other fault of the Licensee or the Licensee's contractor, unless otherwise approved by the Committee.

(2) Habitat Enhancement and Restoration Projects. Throughout the term of the Amended License and any subsequent annual licenses, the Licensee shall, in consultation with the Fisheries and Habitat Committee and with the approval of NMFS, USFWS, and BIA develop and implement, specific HRA-funded aquatic habitat enhancement and restoration projects within and adjacent to the North Fork of the Skokomish River. Such projects shall include, but not be limited to (a) instream structure enhancements, (b) side-channel habitat development, and (c) the removal of existing barriers to upstream migration in upper Big Creek and Dow Creek at River Mile 0 (other than any barrier underlying the state highway). If the monitoring provided in Article 413 indicates that augmenting gravel below Cushman Dam No. 2 is necessary to increase anadromous fish spawning habitat, the Licensee in consultation with the Fisheries and Habitat Committee will implement appropriate gravel augmentation projects.

The Licensee, in consultation with the Fisheries and Habitat Committee, shall use funds from the Habitat Restoration Account established in Paragraph (1) to implement the types of projects identified in this section. In addition, throughout the term of the Amended License, if available funds remain within the Account, the Licensee will implement other appropriate aquatic habitat enhancement and restoration projects developed by the Fisheries and Habitat Committee within the Skokomish River Basin; however, any measures identified in the FHER Plan for implementation in a location that is both: (a) outside the North Fork Skokomish sub-basin and (b) outside of the then-existing Project boundary, will be limited to actions that do not result in an expansion of the Project boundary.

(3) Threatened Species Take Minimization Measures: The Licensee shall implement measures to minimize the take of Puget Sound Chinook salmon, Puget Sound Steelhead, Hood Canal summer-run chum, and bull trout associated with in-water work during development of any physical structures and facilities, consistent with the agencies' incidental take statements [attached as Appendices __ and __ to this order]. The Licensee shall not use funds from the Habitat Restoration Account to implement such measures.

(4) FHER Plan Implementation Schedule: The Licensee shall include a schedule for implementing the FHER Plan, evaluating the success of the enhancement and restoration projects, and modifying the plan, if needed.

(5) FHER Report: The Licensee shall file with the Commission by June 30 of each year an annual report fully describing its implementation of the FHER Plan during the previous calendar year and a list of planned projects for the current calendar year. The Fisheries and Habitat Committee shall have at least thirty (30) days to review and comment on the draft report prior to filing with the Commission. The Licensee shall provide copies of the annual report to the Fisheries and Habitat Committee.

(6) McTaggert Creek Diversion Structure: Notwithstanding the FHER Plan, within twelve (12) months of issuance of the Amended License, the Licensee shall remove the McTaggert Creek diversion structure and restore the affected areas. In addition, the

Licensee shall replace the existing USFS culvert underlying the USFS road crossing on McTaggert Creek (River Mile 4.3), in the event that such culvert is not replaced prior to issuance of the Amended License. The Licensee shall not use funds from the Habitat Restoration Account to complete these tasks.

Article 413: Fish Habitat and Monitoring Plan

Within twelve (12) months after issuance of the Amended License, the Licensee shall file with the Commission, for approval, a Fisheries and Habitat Monitoring Plan (FHM Plan) for the North Fork of the Skokomish River (North Fork) and the Mainstem of the Skokomish River below the confluence of the North and South Forks (Mainstem). The Licensee shall implement the FHM Plan throughout the term of the Amended License and any subsequent annual licenses, in consultation with Fisheries and Habitat Committee.

The Licensee shall develop the FHM Plan in consultation with the Fisheries and Habitat Committee, and shall seek approval of the National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the Bureau of Indian Affairs. The Licensee shall also seek the comments and recommendations of the National Park Service when developing the FHM Plan. The Licensee shall allow a minimum of thirty (30) days for comments and recommendations before submitting the plan for approval to the USFWS, BIA and NMFS. When filing the plan with the Commission, the Licensee shall include documentation of consultation; copies of comments and recommendations; and specific descriptions of how comments and recommendations from Fisheries and Habitat Committee members and the National Park Service are accommodated by the Licensee's plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the FHM Plan with the Commission without first obtaining the approval of NMFS, USFWS and BIA, the Licensee shall include specific reasons for doing so.

The purpose of the FHM Plan is to inform the implementation of Articles 407 and 412 and, as appropriate, the adaptive management provisions within Articles 414, 415, and 417. The FHM Plan shall include a schedule for the Licensee's: (1) implementation of the plan consistent with this license article; (2) consultation with the Fisheries and Habitat Committee regarding the results of the monitoring and a schedule for providing preliminary monitoring data; and (3) filing of results, comments, and the Licensee's response to these comments with the Commission.

The Commission reserves the right to require changes to the FHM Plan. Implementation of the plan shall not commence until the Licensee is notified by the Commission that the filing is approved. Upon Commission approval, the Licensee shall implement the plan.

The Licensee shall file with the Commission, by June 30 of each year, an annual report fully describing the monitoring efforts of the previous calendar year and activities required under the plan for the following year. The Fisheries and Habitat Committee shall have at least thirty (30) days to review and comment on the draft report prior to filing with the Commission. The Licensee shall provide copies of the annual report to the Fisheries and Habitat Committee.

As provided below, the Fisheries and Habitat Committee may modify the monitoring program methods and frequencies of data collection and reporting requirements to more effectively meet the specific purpose of a monitoring activity.

The following guidelines shall be used in developing and implementing the FHM Plan: (a) monitoring and studies shall be relevant to the Amended License, (b) monitoring and studies shall be chosen and conducted so that they provide useful information for project management decisions or establishing compliance with Amended License conditions, and (c) monitoring and studies shall be cost-effective in meeting the specific purpose of the monitoring activity.

For purposes of implementing the FHM Plan, each year is defined on a calendar year basis (i.e., January through December). Except as provided in Articles 416, 417, and 418, this Plan covers monitoring and studies to be conducted by the Licensee during all years through the term of the Amended License and in any subsequent annual licenses. Monitoring of Article 412 habitat projects shall be addressed within the Plan for such projects. Where years are specified, Year 1 is the first year after the Plan is approved.

The FHM Plan shall consist of monitoring the following:

1. <u>Sediment Transport and Channel Morphology in the lower North Fork and Mainstem</u>

The Licensee shall monitor channel morphology and substrate composition in the lower North Fork and mainstem Skokomish River to document the effects of the flow regime prescribed in License Article 407 on channel shape and substrate composition.

1.1 <u>Purpose</u>

The purpose of sediment transport and channel morphology monitoring is to determine: (a) the magnitude of flows that initiate transport of spawning-sized gravel in the North Fork Skokomish River downstream of Cushman Dam No. 2; (b) the extent to which the high flow releases prescribed in Article 407 (Component 2 and Component 3) result in changes in substrate composition and changes in channel cross sections in the North Fork Skokomish River downstream of Cushman Dam No. 2; and (c) the extent to which high flow releases prescribed in Article 407 result in changes in channel cross sections and channel aggradation in the mainstem Skokomish River downstream of the confluence with the North Fork.

1.2 Method

The Licensee shall identify study reaches based on geomorphic channel types.

The Licensee shall monitor the North Fork to determine the flows at which gravel is mobilized.

The License shall establish representative cross sections in each study reach taking advantage of USGS stream gage locations where possible.

The Licensee shall collect channel profile and substrate data at each cross section during low flow periods, including channel characteristics, redd scour, and substrate composition.

In the case of mainstem channel modification, the Licensee shall modify the Plan to provide for additional monitoring.

1.3 Frequency

For Year 1 through Year 5 and every five years thereafter, the Licensee shall monitor the North Fork transects during the summer low flow period to determine channel shape and bedload composition. In the event that gravel augmentation occurs pursuant to Article 412, the Licensee shall resume monitoring on an annual basis for five years after such augmentation.

For Year 1 through Year 10, the Licensee shall monitor the Mainstem channel during the summer low flow period following any year in which Mainstem Capacity Enhancement Flows are released. Thereafter, the Licensee shall resurvey mainstem transects every five (5) years during the summer low flow period.

In the case of Mainstem channel modification, the Licensee shall modify the FHM Plan to provide for additional monitoring frequency.

2. Fish and Fish Habitat in the North Fork and Mainstem Skokomish River

2.1 Riverine Habitat

2.1.1 Purpose

The purpose of the riverine fish habitat monitoring program is to characterize and quantify habitat types in the lower North Fork and mainstem Skokomish Rivers to determine how habitat restoration efforts and Project operations affect fish habitat conditions over the life of the Amended License.

2.1.2 Method

The Licensee shall assess the quantity and quality of fish habitat by employing standard Timber, Fish and Wildlife (TFW) Agreement or Oregon Department of Fish and Wildlife (ODFW) methods in both the lower North Fork (below Cushman 2) and the Mainstem Skokomish River. The Licensee shall assess habitat units, such as pools, riffles and glides, substrate composition, gradient, channel exposure, woody debris, bank stability, and riparian vegetation content. The Licensee shall use a statistically-valid approach consistent with the TFW or ODFW methods in assessing both the quantity and quality of habitat, and in enabling detection of changes to habitat condition between sampling events. The Licensee shall also make photo documentation at permanent photo points.

The Licensee shall conduct surveys to assess conditions in late summer, but these are to be augmented by additional surveys during mid winter (to be associated with representative flows at that time) to assess seasonal side channel and off-channel habitats.

The river channel of interest is to be divided into distinct reaches based on habitat types consistent with existing baseline habitat information. Analysis and data summarization will be performed consistent with these reach boundaries.

2.1.3 Frequency

During Year 1, the Licensee shall perform an initial habitat survey. During Year 2 through Year 12, if there is a high flow event or other major events causing change, the Licensee shall perform annual habitat surveys. From Year 13 throughout the term of the Amended License and any subsequent annual licenses, the Licensee shall perform habitat surveys once every five (5) years (starting in Year 18) unless the frequency of such surveys is modified by the Fisheries and Habitat Committee.

2.2 Lake Productivity

2.2.1 Purpose

The purpose of assessing productivity of Lake Cushman is to determine the effects of lake productivity on juvenile sockeye survival, growth, age and size at smolt emigration, and smolt carrying capacity.

2.2.2 Method

The Licensee shall assess lake productivity by measuring zooplankton abundance (density and biomass by species). Unless modified by the Fisheries and Habitat Committee, the upstream third, the middle third, and the downstream third of the reservoir will be routinely sampled.

Vertical sampling of the water column will occur in each third of the reservoir in such a way as to ensure collection of zooplankton across their entire depth profiles. Samples will be analyzed by species for density and biomass—the latter metric requiring determination of zooplankton size by sample. The Licensee shall use standard methods and a statistically valid approach in sampling and sample analysis consistent with Koenings et al (1987).[1]

Sampling is to occur at three or more sites in each upstream, middle, and downstream third of the reservoir (as discussed above) during the first year. In subsequent years, at least two sites will be sampled in each third of the reservoir.

2.2.3 Frequency

The Licensee shall assess lake productivity for two years prior to the first planned release of sockeye into Lake Cushman and for 12 years after the initial release of sockeye. The sampling frequency following the fourteenth year of sampling will be determined by the Fisheries and Habitat Committee. The Fisheries and Habitat Committee may reduce the number of years sampled based on progress of the program.

Sampling will occur on a bi-weekly (i.e., two times per month) schedule from the beginning of March through the end of October each year.

During the first year of implementation, the Licensee shall also sample to determine the diurnal cycles and the depth distributions of zooplankton at each location as part of the above sampling. Unless modified by the Fisheries and Habitat Committee, the

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[1] Koenings, J. P., J. A. Edmundson, G. B. Kyle, and J. M. Edmundson. 1987. Limnology field and laboratory manual: methods for assessing aquatic production. Alaska Department of Fish and Game, FRED Division Report 71, Juneau.

Licensee shall conduct this more intensive sampling one time per month at each of the three locations between May and September.

2.3 Water Temperature

2.3.1 Purpose

The purpose of water temperature monitoring is to document temperature regimes in the lower North Fork Skokomish River, Lake Cushman and Lake Kokanee, and the upper North Fork. These data are needed to help analyze the biological information collected through separate monitoring efforts (i.e., spawning timing, emergence timing, juvenile size or growth rates, distribution, habitat utilization, and species interactions).

2.3.2 Method

The Licensee shall monitor water temperatures on an hourly basis in the North Fork and Lakes Cushman and Kokanee.

- Lower North Fork

The Licensee shall install, operate and maintain a thermistor at the base of Cushman No. 2 dam.

The Licensee shall install, operate and maintain a thermistor at USGS Gage No. 12059500 (North Fork near Potlatch) located at approximately River Mile 1.1.

- Lake Cushman

The Licensee shall install, operate and maintain a vertical thermistor array near the log boom by the dam.

- Lake Kokanee

The Licensee shall install, operate and maintain a vertical thermistor array near the log boom by the dam.

- Upper North Fork

The Licensee shall install, operate and maintain a thermistor at or near USGS Gage No. 12056500 (North Fork Skokomish River below Staircase Rapids) – subject to the approval of the National Park Service (if the thermistor is to be installed on NPS lands).

2.3.3 Frequency

- Lower North Fork

The Licensee shall deploy, operate and maintain the above-listed thermistors in the Lower North Fork continuously throughout the term of the Amended License and any subsequent annual licenses.

- Lake Cushman

The Licensee shall deploy, operate and maintain thermistors continuously in Lake Cushman for the first three years.

The Licensee shall monitor the location of the thermocline in Lake Cushman throughout the term of the Amended License and any subsequent annual licenses.

- Lake Kokanee

The Licensee shall deploy, operate and maintain thermistors for the first three years, in addition to any water temperature monitoring required pursuant to Article 417.

- Upper North Fork

The Licensee shall deploy, operate and maintain thermistors in the Upper North Fork continuously throughout the term of the Amended License and any subsequent annual licenses.

3. Fish Populations in the North Fork

3.1 Spawner Abundance, Distribution, and Timing

3.1.1 Purpose

The purpose of assessing spawner abundances, distributions, and timing is to evaluate performances of all populations of concern over the term of the Amended License and any subsequent annual licenses.

3.1.2 Method

The Licensee shall conduct surveys using standard methods in the region to assess spawner abundances, spawner distributions, spawning timing, species composition, and sample marked fish for chinook (fall and spring), coho, sockeye, steelhead, and bull trout in both the lower and upper North Fork systems (including tributaries). The Licensee shall collect similar information for pink and chum during the course of the chinook (fall and spring), coho, sockeye, steelhead, and bull trout surveys.

Such surveys shall enumerate redds and/or fish (live and dead) depending on species and location within the river. Such surveys shall be conducted using one or more of the following techniques depending on species and location within the river: foot surveys, raft surveys, and snorkel surveys. It is expected that methods and procedures that work best to achieve the purpose will be evaluated during the first several years of the Amended License. Once the methods have been evaluated and the most appropriate ones selected, they will be applied consistently over the term of the Amended License and any subsequent annual licenses, unless modified by the Fisheries and Habitat Committee.

The Licensee shall use standard methods when conducting carcass sampling and for retrieval and processing of tags.

The Licensee shall collect, compile, and report the following: (1) spawner abundance by species, production origin (hatchery versus wild), and location (upper North Fork and lower North Fork); (2) species distribution (by reach or at a finer scale depending on species and issue, such as to address possible interactions between bull trout and coho or sockeye); and (3) spawning timing.

The Licensee shall include in the FHM Plan provisions for appropriate and reasonable analysis of data from the above surveys. The Licensee shall implement such provisions.

3.1.3 Frequency

The Licensee shall conduct assessments annually during the spawning seasons for each species throughout the term of the Amended License and any subsequent annual licenses.

The Licensee shall conduct surveys once every 7-10 days, weather and river conditions permitting over the entirety of the species-specific periods of spawning, as specified in the plan.

3.2 Juvenile Production, Distribution, and Habitat Utilization in the Lower North Fork

3.2.1 Purpose

The purpose of assessing juvenile production, distribution, and habitat utilization in the lower North Fork is to evaluate performances of populations of concern at the juvenile stage over the term of the Amended License and any subsequent annual licenses.

3.2.2 Method

The Licensee shall install and operate a juvenile trap in the lower North Fork Skokomish River to assess natural salmonid production in the lower North Fork. Methods of operation and data collection shall follow those methods applied by the Washington Department of Fish and Wildlife in juvenile trap assessments made by that agency. These methods include frequency of operation, fish sampling, and estimation of trap efficiency.

The Licensee shall collect, compile, analyze and report the following juvenile trap data by species and life stages: numbers of fish caught, timing, fish population estimates, hatchery and wild composition, size distribution, and trap efficiency.

Under circumstances defined in the monitoring plan, the Licensee shall conduct supplemental assessments using snorkeling and/or backpack electroshocker surveys to evaluate such things as rearing, fish distributions, relative abundance, habitat utilization, size, and life stage survival.

3.2.3 Frequency

The Licensee shall operate the juvenile trap to assess juvenile production annually in the North Fork for the term of the Amended License and any subsequent annual licenses.

The Licensee shall operate the trap during the period that juveniles are expected to emigrate from the North Fork. During years one and two, the Licensee shall operate the trap beginning January 20 through November 10. Based upon the results obtained during years one and two, thresholds to reduce sampling days and periods will be developed by the Fisheries and Habitat Committee for subsequent years. Following two generations of naturally-spawning introduced early-time Chinook, the juvenile trapping period will be increased to assess the timing of the reintroduced stock.

The Licensee shall operate the trap 7 days per week based on the standard procedures employed by WDFW, except that the trap will not be operated during severe flow events. This operation schedule may be adjusted by the Fisheries and Habitat Committee if an alternative sampling schedule produces acceptable data for assessing juvenile production. Also, during periods when few fish are emigrating, such as is expected during late summer, trapping frequency can be reduced to fewer days per week. Exact scheduling will be determined by the Fisheries and Habitat Committee.

3.3 Fish Distribution and Habitat Utilization in the Upper North Fork Watershed

3.3.1 Purpose

The purpose of assessing the distribution, size or age class, and habitat utilization of salmonids in the upper North Fork and tributaries upstream of Cushman Dam No. 1 is to evaluate performance and species interactions of populations of concern as related to available habitat, species composition, hatchery supplementation, and spawner abundances.

3.3.2 Method

The Licensee shall assess juvenile and sub-adult fish distributions, relative abundance, habitat utilization, and size (when electrofishing) or age class at representative sites within each designated reach (as delineated for habitat surveys noted below) using snorkeling and/or backpack electroshocker. The principal method of assessment would be snorkeling, following the same procedures used in past years by the National Park Service to monitor juvenile fish distribution and habitat utilization.

As part of this work, the Licensee shall assess the quantity and quality of fish habitat by employing standardTFW or ODFW methods in the upper North Fork system (including accessible and significant tributaries) and Big Creek. These methods are designed to assess habitat units, such as pools, riffles and glides, substrate composition, gradient, channel exposure, woody debris, bank stability, and riparian vegetation content. The Licensee shall use a statistically valid approach consistent with the TFW or ODFW methods in assessing both the quantity and quality of habitat, and in enabling detection of changes to habitat condition between sampling events. The Licensee shall also make photo documentation at permanent photo points.

The Licensee shall conduct surveys to assess conditions in late summer, and again at moderate fall or winter flows.

3.3.3 Frequency

The Licensee shall assess juveniles and sub-adult fish distributions, habitat utilization, and size or age class in late spring, late summer, and mid winter annually beginning two years prior to expected presence of re-introduced species in the upper North Fork system, then continuing annually for 12 years after reintroduction, or as specified by the Fisheries and Habitat Committee based on the times of arrival and abundances of introduced species.

The Licensee shall assess habitat in the first year of the fish distribution assessment, then at an expected interval of every 3-5 years, depending on changes to habitats in the upper river system due to storm events. The Fisheries and Habitat Committee will periodically evaluate the need for re-assessment of habitat.

3.4 Resident Fish in Lake Kokanee

3.4.1 Purpose

The purpose is to evaluate the contribution of the rainbow trout stocking program to the recreational fishery by monitoring harvest of resident fish in Lake Kokanee.

3.4.2 Method

The Licensee shall conduct a creel census at Lake Kokanee to evaluate the contribution of the rainbow trout stocking program to the recreational fishery.

3.4.3 Frequency

The Licensee shall monitor for the first three years and once every five years thereafter.

3.5 Genetic Monitoring of Specific Populations

The Licensee shall include in the FHM Plan and shall implement provisions for appropriate and reasonable genetic monitoring of bull trout, steelhead, and Chinook salmon to inform supplementation and fish passage decisions.

Article 414: Downstream Passage

The Licensee shall provide safe, timely, and effective downstream fish passage at the Cushman Project for the term of this Amended License and any subsequent annual licenses. Such passage facilities shall use attraction flow, guidance, trapping, sorting, handling, holding, and hauling facilities located on Lake Cushman and other operations and facilities as necessary for the Project.

The Licensee shall develop and implement the downstream fish passage program in consultation with the Fisheries and Habitat Committee.

1. Downstream Fish Passage Plan

Within 180 days after issuance of the Amended License, the Licensee shall file with the Commission, for approval, a Downstream Fish Passage Plan (DFP Plan) for the installation, operation, and maintenance of downstream fish passage facilities at the Project for juvenile salmon, steelhead smolts and kelts, and bull trout. The DFP Plan shall include, but is not limited to: (1) functional design drawings of the Licensee's proposed downstream fish passage facilities; (2) quantification of the flows required to operate the proposed facilities; (3) a preliminary operation and maintenance plan; (4) a schedule for installing the facilities; (5) provisions for short and long-term monitoring, and modifying facilities as needed to meet performance standards, design criteria, and general requirements of safe, timely, and effective passage; and (6) dates for completion of each provision of the plan.

The Licensee shall develop the DFP Plan in consultation with the Fisheries and Habitat Committee, and shall seek approval of the National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the Bureau of Indian Affairs. The Licensee shall allow a minimum of thirty (30) days for members of the Fisheries and Habitat Committee to comment and make recommendations before submitting the DFP Plan for approval to USFWS, BIA and NMFS. When filing the plan with the Commission, the Licensee shall include documentation of consultation; copies of comments and recommendations; and specific descriptions of how comments and recommendations from Fisheries and Habitat Committee members are accommodated by the Licensee's Plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the DFP Plan with the Commission without first obtaining the approval of NMFS, USFWS and BIA, the Licensee shall include specific reasons for doing so.

The Commission reserves the right to require changes to the DFP Plan. Upon Commission approval, the Licensee shall implement the DFP Plan.

2. FSC Requirements

The Licensee's DFP Plan and detailed design for downstream fish passage facilities shall utilize a Floating Surface Collector (FSC). The Licensee shall develop the FSC in up to two phases, with the first phase having 250 cfs attraction flow and the second phase having 500 cfs.

3. Floating Surface Collector (FSC) Development

3.1 Phase One: The FSC shall produce a minimum 250 cfs attraction flow. During the Phase One Demonstration Period, the Licensee may operate the Phase One FSC for up to nine demonstration years to satisfy Performance Standards. If, in any of these nine (9) years, the FSC satisfies either of the Performance Standards, the Licensee will enter a two-year verification period to verify that the Performance Standard is sustained as described in the paragraph below. If performance is not achieved during a demonstration year or not sustained during a verification period, then the Licensee shall make non-attraction-flow improvements in consultation with the Fisheries and Habitat Committee. Phase One includes up to, but no more than, two verification periods. The Licensee has a minimum of nine years to operate the FSC at 250 cfs, and a maximum of thirteen (13) years if the verification periods are triggered. The Licensee may opt to move to Phase Two at any time prior to expiration of the time limit for operation within Phase One.

When the FSC demonstrates for one season that a Performance Standard is satisfied, it will begin a Verification Period. The purpose of the Verification Period is to operate the FSC in the same condition for two consecutive years to determine if the FSC's performance on average, based upon the demonstration year and the two verification years, continues to satisfy that Performance Standard. If, after the first year of verification, it is impossible for the FSC's performance to satisfy this three-year performance average, then the FSC reverts to the Demonstration Period. If the FSC's average performance does not satisfy that Performance Standard after the second year of verification, then FSC reverts to the Demonstration Period. The Licensee shall attempt to improve FSC performance during the Demonstration Period through non-attraction-flow measures that are reviewed and approved by the Fisheries and Habitat Committee.

Verification shall be measured at a 90% confidence level with a standard error of the estimate that shall be not more than plus or minus 5% (i.e., 10% error), unless otherwise agreed to by the Fisheries and Habitat Committee.

If neither of the Performance Standards are demonstrated and verified within the timeframes provided for the Phase One Demonstration and Verification Periods, Phase One will end. If Phase One ends, the Phase Two FSC will be installed and operational prior to the start of the second fish passage season after Phase One ends. If, however, NMFS, USFWS and BIA believe that one or more of the extenuating factors listed below is likely the cause of the FSC not meeting the performance standards, then NMFS, USFWS, and BIA may approve continued operation of the collector at 250 cfs until such factors are addressed. Extenuating factors may include: (1) environmental conditions (such as predation or disease mortality) that prevent the collector from attaining System Survival (SS) or Fish Collection Efficiency (FCE); (2) technical issues related to measurement of SS or FCE; or (3) other similar surface collection systems not meeting performance criteria.

If FCE is demonstrated and verified but SS is not demonstrated and verified, the Licensee shall continue to operate the Phase One FSC and not develop Phase Two so long as FCE is maintained (*see* Performance Standard Monitoring, section 7). As long as FCE is maintained, increases in FSC discharge will not be required. However, within twelve (12) months of verifying FCE, the Licensee shall develop a plan for determining factors which may be limiting its ability to demonstrate and verify SS, in consultation with the Fisheries and Habitat Committee, and shall implement appropriate measures for improving SS as soon thereafter as possible.

If SS is demonstrated, verified and maintained but FCE is not, the Licensee shall make non-attraction flow modifications to the FSC as determined necessary by the Fisheries and Habitat Committee.

3.2 Phase Two: The FSC shall be redesigned to produce a 500 cfs attraction flow, unless otherwise agreed to by NMFS, USFWS, and BIA, provided the total attraction flow shall not exceed 500 cfs. If the Phase Two FSC does not satisfy Performance Standards, the Licensee shall implement appropriate non-attraction flow measures for improving SS and FCE in consultation with the Fisheries and Habitat Committee and based upon the performance monitoring conducted pursuant to Article 416.

4. Final Design

The Licensee shall file the final FSC design with the Commission within eighteen (18) months of this Amended License. Prior to submitting the design to the Commission, the Licensee shall prepare detailed design drawings at the 30% (functional design), 50% and 90% completion stage and consult with the Fisheries and Habitat Committee at each stage. The Licensee shall seek approval of the final design from NMFS, BIA and USFWS at least thirty (30) days prior to filing with the Commission. Construction of downstream fish passage facilities shall not begin until the design is approved by the Commission, USFWS, BIA and NMFS and the Licensee has obtained all necessary permits. No later than twenty-one (21) months after Commission approval of the design and obtaining all necessary permits, the Licensee shall have completed installation and testing, and shall begin operating the FSC. The Phase One Demonstration Period will begin the following fish passage season. The downstream fish passage facilities shall be shown on the as-built drawings filed pursuant to Article 303 of this license.

The design shall conform to the NMFS 2008 Anadromous Salmonid Passage Facility Design, prepared by the NMFS Northwest Region Hydro Division, dated February 8, 2008 (NMFS Design Manual). There may be cases where site constraints or extenuating biological circumstances dictate that certain design features deviate from the NMFS Design Manual. The Licensee shall provide compelling evidence in support of any proposed design features that deviate from the NMFS Design Manual and obtain NMFS approval for any deviation.

5. FSC Requirements

The Licensee's downstream fishway shall include a system of exclusionary guide nets and five FSC modules, which includes the: 1) Net Transitions Module; 2) Capture Module; 3) Screen Module; 4) Collection Module; and 5) Transport Module. In addition to complying with the NMFS Design Manual, the FSC must meet the following requirements:

5.1. Full exclusionary guide netting and panels (the net) will be installed in the forebay of the Cushman Dam No. 1 reservoir and will extend from shoreline to shoreline and from the water surface to the bottom of the reservoir. The net system will be located within the existing boat barrier on Lake Cushman unless hydraulic modeling or fish migration studies indicate another location is better suited.

The net will be made of a knotless mesh with the mesh size not to exceed ¼ inch clear opening and resistant to rot and ultraviolet degradation. To improve the guidance of fish to the FSC, the net in the upper 30 to 50 feet of the water column may incorporate a knotless mess with the mesh size not to exceed 3/32 inch or an impermeable membrane.

5.2. Net Transition Module (NTM): The NTM is a modular unit that provides a transitional dimension and velocity gradient from the guide nets to the capture module. Entrance velocity at the face of the NTM would be the greater of 0.2 fps or 1.1 times the adjacent reservoir ambient velocity at full generation. Based on these criteria the likely initial entrance size would be approximately 35 ft x 35 ft based on 250 cfs/0.2 fps = 1250 sq ft. Water that enters the NTM will gradually accelerate along the length of the module to a capture velocity of 8 fps. Velocity increase through the NTM would be no more than 0.2 fps/ft, but must be steadily increasing or flat, not decreasing. Centerline velocity at the entrance to the capture module will be 8 ft/sec.

5.3. Capture Module: The Capture Module is a modular unit with an initial wetted cross-sectional area of approximately 32 square feet in the 250 cfs attraction flow phase and will provide 20 linear feet of 8 ft/sec velocity between the NTM and the Screen Module to assure capture.

5.4. Screen Module: The Screen Module will provide dewatering while maintaining near 6 fps velocity. At the downstream end of the Screen Module, approximately 3 cfs will discharge fish into the Collection Module where fish will be held for sorting, sampling, and preparation for transfer to a transport vessel. Fish Screens in the Screen Module will be designed to NMFS screen criteria as described in the NMFS Design Manual, unless otherwise specified below. This will be accomplished using hydraulic modeling to aid the design of the screens, baffles, pump manifold, pump size, and locations.

The Screen Module will be designed to ensure no failure of the screen structure, and will include an alarm that is triggered by a change in head pressure between the downstream and upstream sides of the screen. The Screen Module will also be designed such that any debris accumulations are removed before they affect hydraulic design characteristics and potentially compromise fish safety. Unless NMFS approves otherwise, the Screen Module will be constructed with a high pressure water jet cleaning system located behind the screen face to provide complete automated backwash cleaning of the entire screen flow through area, with cleaning automatically triggered by timed interval and by head loss through the screen mesh. The Screen Module and cleaning system will be modified to maintain the hydraulic profile described above as attraction flow is increased.

5.5. Collection Module: The collection module will include up to 3 cfs dewatering capability, sorting mechanisms to effectively separate adult and juvenile fish, and holding areas. The fish would then be distributed according to destination and those destined for downstream would be conveyed in a water-to-water transfer system to a transport vessel. Unless otherwise approved by NMFS, a minimum of two holding areas sized for 2,500 smolts each shall be provided. NMFS Design Manual and WDFW hatchery criteria will be used in designing the fish handling components.

5.6. Transport Module: The transport module will have a minimum capacity of 2,500 smolts. The module may be used to transfer fish to a tank truck or trailer for hauling to the release site, or it may be used as a transport tank placed on a truck or trailer for hauling to the release site. If the transport module is used for hauling the fish, it must be equipped with an on-board oxygen supply. If it is used to transfer fish to a tank truck or trailer, it must be equipped with water-to-water transfer fittings. The module shall be sized such that its loading density does not exceed 0.15 ft^3 per pound of fish. Fish in the module shall be transported as often as necessary so as not to exceed capacity, but at least one time per day.

5.7. Release Site: The release site for collected fish being transported downstream of the dam shall be immediately downstream of Cushman Dam No. 2, or at an appropriate location to be determined by the Fisheries and Habitat Committee. The Licensee shall maintain the release site in a safe and useable condition as determined by the Fisheries and Habitat Committee.

5.8 Phase Two Modifications: The Licensee shall modify the modules described in Sections 5.2, 5.3 and 5.4 to accommodate increased attraction flow. The Licensee shall modify the NTM, Capture Module, and Screen Module to maintain the original design hydraulic characteristics as attraction flow is increased unless deviations are approved by NMFS, USFWS and BIA. The Licensee shall make modifications to other components of the FSC as determined appropriate by the Fisheries and Habitat Committee and approved by NMFS, USFWS and BIA.

5.9 Operation Period: The downstream passage fishway will be capable of operation over the entire range of forebay elevations expected year round. The expected operation period is March 15 through July 31 each year. The Fisheries and Habitat Committee may revise the operation period based on expected fish species occurrence and actual fish collection data.

5.10 Debris and Trash Management: Floating log booms will be installed in the reservoir upstream of the guide nets in order to provide protection to the fishway.

5.11 Inspection, Operations, and Maintenance Plan: The Licensee shall annually inspect and maintain, and allow NMFS to annually inspect the guide nets, screens, cleaning system, and any other mechanical component subject to wear. The Licensee's plan shall also describe how the guide net system will be protected and maintained during extreme flow events.

6. Performance Standards

The Licensee's operation of the downstream fish passage facilities shall be subject to the following Performance Standards:

6.1. System Survival Standard (SS): SS is the percentage of a marked group of smolts released near the upstream end of Lake Cushman that is successfully collected by the FSC and safely passed downstream of the Cushman Project. The SS goal is 95%, and the minimum compliance standard SS is 75%.

6.2. Fish Collection Efficiency Standard (FCE): FCE is the percentage of a tagged (radio, acoustic, or PIT) group of smolts detected at the log boom (approximately 360 feet upstream of the dam) or at another location in the forebay to be determined by the Fisheries and Habitat Committee and are successfully collected in the FSC and safely passed downstream of the Cushman Project. The FCE standard is 95% collection and survival.

Success, for the purposes of FSC development, is attained when either of the Performance Standards is demonstrated and verified. Notwithstanding demonstration and verification of FCE being achieved, the Licensee shall continue to implement non-attraction flow measures to improve fish passage until the SS Performance Standard is achieved. In addition, throughout the term of the Amended License and any subsequent annual licenses, Licensee shall use reasonable efforts to achieve the SS goal of 95%, provided those efforts are likely to improve SS.

7. Performance Standard Monitoring

The Licensee shall monitor SS performance annually for the term of the Amended License and any subsequent annual licenses. The Licensee shall monitor FCE annually during Phase One of FSC development. In addition, if the FCE Performance Standard is demonstrated and verified during Phase One of FSC development, the Licensee shall monitor FCE performance every five (5) years beginning in the fifth year after verification, unless the Fisheries and Habitat Committee determines that monitoring during the fifth year after verification is unnecessary. If FCE monitoring indicates that performance has declined to less than the FCE Performance Standard (95%), the

Licensee shall monitor FCE performance in the following fish passage season. If FCE monitoring verifies that performance is below the FCE Performance Standard, the Fisheries and Habitat Committee shall convene to develop appropriate measures which may include increasing attraction flow up to 500 cfs. The Licensee shall then implement these measures. The Licensee shall monitor FCE every five (5) years during Phase Two for the term of the Amended License and any subsequent annual licenses.

Performance Standard Monitoring shall use marked groups of surrogate hatchery Coho smolts that are collected and mark-sampled at the FSC or by methods determined by the Fisheries and Habitat Committee.

Article 415: Upstream Passage

The Licensee shall provide safe, timely, and effective upstream fish passage at the Cushman Project for the term of the Amended License and any subsequent annual licenses. The Licensee shall install, operate, maintain and monitor, at its own expense, facilities to: protect and mitigate damages to anadromous fisheries; provide access to historic spawning and rearing habitat; and enhance the restoration of anadromous fish to the Skokomish River Basin.

The Licensee shall develop and implement the upstream fish passage program in consultation with the Fisheries and Habitat Committee.

1. Upstream Fish Passage Plan

Within six (6) months after issuance of the Amended License, the Licensee shall file with the Commission, for approval, a plan to install, operate, and maintain upstream trap and haul fish passage facilities at the Cushman Project that includes, but is not limited to: (1) functional design drawings of the Licensee's proposed upstream fish passage facilities; (2) quantification of the flows required to operate the proposed facilities, including a description of the flows needed for in-migration of adult salmonids; (3) a preliminary operation and maintenance plan; (4) a schedule for installing the facilities; (5) provisions for short and long-term monitoring and for modifying the facility as needed to meet criteria and general requirements of safe, timely, and effective passage; and (6) dates for completion of each provision of the plan. The plan shall be consistent with the NMFS Design Manual.

The Licensee shall develop the Upstream Fish Passage Plan in consultation with the Fisheries and Habitat Committee, and shall seek approval of NMFS, USFWS, and BIA. The Licensee shall allow a minimum of thirty (30) days for members of the Fisheries and Habitat Committee to comment and make recommendations before submitting the plan for approval to USFWS, BIA and NMFS. When filing the plan with the Commission, the Licensee shall include documentation of consultation; copies of comments and recommendations; and specific descriptions of how comments and recommendations from Fisheries and Habitat Committee members are accommodated by the Licensee's plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the upstream fish passage plan with the Commission without first obtaining the approval of NMFS, USFWS and BIA, the Licensee shall include specific reasons for doing so.

The Commission reserves the right to require changes to the plan. Upon Commission approval, the Licensee shall implement the plan.

2. Design Review

The Licensee shall file the final design within eighteen (18) months after issuance of the Amended License. Prior to submitting the final design to the Commission, the Licensee shall prepare detailed design drawings at the 30% (functional design), 50% and 90% completion stage and consult with the Fisheries and Habitat Committee at each stage. The Licensee shall seek approval of the design from NMFS, BIA, and USFWS no less than thirty (30) days prior to filing with the Commission. Construction of upstream fish passage facilities shall not begin until the design is approved by the Commission, USFWS, BIA and NMFS and the Licensee has obtained all necessary permits. No later than fifteen (15) months after Commission approval of the design and obtaining all necessary permits, the Licensee shall have completed installation, and shall begin operating the upstream fishway. The upstream fish passage facilities shall be shown on the as-built drawings filed pursuant to Article 304 of the Amended License.

The design shall be consistent with the NMFS Design Manual. There may be cases where site constraints or extenuating biological circumstances dictate that certain design features deviate from the NMFS Design Manual. The Licensee shall provide compelling evidence in support of any proposed design features that deviate from the NMFS Design Manual and obtain NMFS approval for any deviation.

3. Plan Requirements

The Licensee's upstream fish passage plan and design for upstream fish passage facilities, in addition to complying with the NMFS Design Manual, must meet the following requirements:

3.1 Fishway Location

The preferred location for the upstream fishway is near the base of Cushman Dam No. 2. If this location is demonstrated not to be feasible, the Licensee shall in consultation with the Fisheries and Habitat Committee identify an alternate location near the confluence of McTaggert Creek with the North Fork Skokomish River.

3.2 Operational Period

The upstream passage facilities must be operational year-round except for an annual maintenance period as determined in consultation with the Fisheries and Habitat Committee subject to the approval of NMFS, USFWS, and BIA.

3.3 Upstream Passage Facility Design Flow Range

The Licensee must design the trap and haul facilities to provide safe, timely, and effective fish passage over streamflows between 100 and 300 cfs, when upstream migrating fish are normally present at the barrier.

3.4 Barrier Dam

The Licensee must provide a barrier dam to effectively divert upstream migrating fish into the fish trap. Cushman Dam No. 2 may be part of the barrier dam element.

3.5 Trap Holding Pools

The Licensee must provide holding pools of sufficient volume to provide a carrying capacity equal to a projected 1 day peak run of fish (about 1200 fish). Based upon a minimum holding density of .25 ft^3 per pound of fish, the holding pools shall contain a minimum volume of 2,400 ft^3 of water at the low design water surface elevation. Flow into the holding pools must be a minimum of 2 gallons per minute (gpm) per adult fish, up to the carrying capacity of the pools, or a minimum of 2400 gpm (5.4 cfs). A finger weir or V-trap lead must be provided between the ladder and the lower holding pool, and between holding pools such that once fish enter they are not able to fallback downstream. These conditions assume good water quality. If water temperature is greater than 50 degrees Fahrenheit and dissolved oxygen is less than 6 ppm, the Licensee must transport fish more frequently.

3.6 Fish Crowder and Braille Systems

The Licensee must build the upstream passage facilities to include a crowder and braille system in each holding pool as necessary to move fish from the holding pools to the fish lock. When not in use, the crowder should be stored either against the back wall of the holding pool or out of the water entirely. Likewise, the braille should be stored recessed in the floor of the holding pool when not in service. The braille must be sloped and contoured so that fish are guided toward the entrance to the fish lock. Both the crowder and braille must provide fish tight seals (maximum opening of 1/2 inch) against the walls and floors of the holding pool so that no fish can become trapped behind them. The travel speed of both the crowder and braille should be adjustable up to 3 ft per minute. Maximum clear opening between bars in the crowder or braille must be 1/2 inch. When the crowder is in use, a removable barrier will be installed across the fish ladder exit into the holding pool to prevent fish from entering the holding pool. Fish should not come into contact with sharp or abrupt edges (including structural supports) anywhere throughout the system.

The maximum clear opening between bars in the crowder or braille may need to be less than 1/2 inch. Tests will need to be completed at the trap vicinity to determine if there are smaller fish in the vicinity of the trap. The head width of these fish will be measured and a decision as to the permanent spacing of the bars should be determined based on the 50% exceedance level.

3.7 Fish Transport and Sorting

The Licensee shall transport fish from the fish lock in a transport hopper. Loading density of the transport hopper will be limited to 0.15 ft^3 per pound of fish. The volume of the transport hopper should be equal to or less than the volume of the transport trucks (to reduce the possibility of overloading the transport trucks).

The transport hopper should connect via water to water transfer with the fish sorting facility tanks/ponds or the transport trucks/trailers. Transport trucks/trailers will have provisions to supply oxygen to the transport water. Provisions will be made at the release point for the transported fish to acclimate to the receiving water if the temperature difference exceeds 5 degrees C.

The fish sorting facility will provide a receiving pond/tank that accepts full hopper/truck loads of transported fish and sorting/holding pools/pens sufficient to separate each species. The receiving pond/tank will be equipped with a mechanism capable of forcing fish into the sorting flume and raceways. The Licensee will build the receiving pond/tank water supply such that flow will be introduced through a diffuser or series of diffusers located in the floor of the pond/tank. Overflow from the pond/tank will pass over a control weir at a minimum depth of 6 inches and through a short, descending slope separator (screen), allowing excess flow to be drained off and adult fish to be routed into a wetted chute (transport flume) for sorting and routing to sampling tanks, sorting/holding pools, or re-direct loading to a transport truck.

Provisions for PIT tag interrogation must be located upstream of any diverter gate. Provisions must also be included to divert fish to sampling, anesthetic, disease treatment, and recovery tanks; or routed to an appropriate raceway.

Provisions should be made to guarantee a continuous supply of water to the raceways (such as redundant pumps, backup pumps, emergency generator, etc.) and for the emergency release of fish. The entire adult fishway facility will provide a means to evacuate fish back to the Skokomish River, Lake Kokanee or agency designated alternative in the event of the loss of power or water supply.

The Licensee shall check the adult fishway daily during the adult fish migration periods and shall transport adult fish from the fishway as necessary to prevent overcrowding and harm, as determined by USFWS, NMFS and BIA. At a minimum, when only a few fish are present, fish will be transported three times per week, on Monday, Wednesday, and Friday.

3.8 Sample/Anesthetic/Recovery Tanks

The Licensee shall design the sampling, anesthetic, and recovery tanks in consultation with the Fisheries and Habitat Committee subject to the approval of NMFS, USFWS, and BIA. The system must include provisions to move fish to the raceways or return fish to the river after they have fully recovered.

3.9 Auxiliary Power

The Licensee shall provide auxiliary power in the event of a power failure. Full operation of the facility must be restored within 48 hours. Auxiliary power must be sufficient to operate the pumped water supply and all associated apparatus until all fish dependent on pumped water have been processed and removed from the facility.

4. Post Construction

4.1 Post Construction Evaluation: Prior to completion of the upstream fish passage facilities, the Licensee shall develop, in consultation with the Fisheries and Habitat Committee, a Post Construction Evaluation Plan for approval by USFWS, NMFS and BIA. The plan must include hydraulic and biological evaluations to ensure the proper performance of the facilities and that the facility provides safe, timely, and effective fish passage. The Licensee shall implement this plan upon completion of upstream passage facility construction. Based upon evaluations conducted pursuant to this plan, the Licensee shall make appropriate modifications to the upstream passage facilities and their operations to ensure safe, timely, and effective passage throughout the license term as may be determined by the Fisheries and Habitat Committee.

4.2 Future Modifications: The Licensee shall update and modify these facilities as necessary based upon long term monitoring results, changing resource management requirements or as improvements in technology for safe, timely, and effective fish passage becomes available.

4.3 Inspections: The Licensee shall provide access to the upstream passage facilities to any fishery agency or the Skokomish Tribe for immediate inspection of fishway operation and maintenance conditions.

5. Fish Passage at Little Falls

If, based upon fish passage monitoring pursuant to Article 416 and other available information, the Fisheries and Habitat Committee determines that modifications to Little Falls are required to achieve safe, timely, and effective fish passage; the Licensee shall implement such modifications, pursuant to a schedule developed by the Fisheries and Habitat Committee and subject to obtaining any necessary regulatory approval. The

Licensee shall not use funds from the Habitat Restoration Account to make modifications to Little Falls.

Article 416: Fish Passage Monitoring Plan

The Licensee shall implement the following Fish Passage Monitoring Plan, in consultation with the Fisheries and Habitat Committee. The purposes of this plan are to: (1) measure fish survival through the reservoir, fishways and transport mechanisms, (2) assess compliance with survival and performance standards for effective passage, and (3) inform the implementation of Articles 414 and 415. The Licensee shall modify its passage measures based on the information developed pursuant to this plan and on recommendations of the Fisheries and Habitat Committee. The Fish Passage Monitoring Plan shall include a schedule for implementing the plan consistent with this Article and for consulting with the Fisheries and Habitat Committee regarding the monitoring results.

Within twenty-four (24) months after issuance of the Amended License, the Licensee shall file with the Commission, for approval, the Fish Passage Monitoring Plan. The Licensee shall develop the plan in consultation with the Fisheries and Habitat Committee, and seek approval of the National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the Bureau of Indian Affairs. The Licensee shall allow a minimum of thirty (30) days for members of the Fisheries and Habitat Committee to comment and make recommendations before submitting the plan for approval to USFWS, BIA and NMFS. When filing the plan with the Commission, the Licensee shall include documentation of consultation; copies of comments and recommendations; and specific descriptions of how comments and recommendations from Fisheries and Habitat Committee members are accommodated by the Licensee's plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the Fish Passage Monitoring Plan without first obtaining the approval of NMFS, USFWS and BIA, the Licensee shall include specific reasons for doing so.

The Commission reserves the right to require changes to the plan. Implementation of the plan shall commence when the Licensee is notified by the Commission that the filing is approved. Upon Commission approval, the Licensee shall implement the plan.

The Licensee shall file with the Commission, by June 30 of each year, an annual report fully describing the monitoring efforts of the previous calendar year. The Fisheries and Habitat Committee shall have at least thirty (30) days to review and comment on the draft report prior to filing with the Commission. The Licensee shall provide copies of the annual report to the Fisheries and Habitat Committee.

The Fisheries and Habitat Committee may modify methods and frequencies of data collection if the Fisheries and Habitat Committee determines that: (a) there is a more appropriate or preferable method or site to use than that described in the individual elements of the Fish Passage Monitoring Plan; or (b) monitoring may be reduced or terminated because the relevant ecological resource objective has been met or no change in resource response is expected.

The following guidelines shall be used in developing and implementing the Fish Passage Monitoring Plan: (a) monitoring and studies shall be relevant to the Project License; (b) monitoring and studies shall be chosen and conducted so that they provide useful information for project management decisions or establishing compliance with license conditions; and (c) monitoring and studies shall be cost-effective in meeting the specific purpose of the monitoring activity.

1. Monitoring methods

1.1. Downstream juvenile passage

The Licensee shall measure downstream passage survival through the fishway by releasing marked groups of smolts from a point just upstream of the juvenile fishway (FSC) through the last point of contact, which is either stress relief ponds or a prospective release pond at the base of Cushman Dam No. 2. The Licensee shall measure downstream passage survival through the reservoir by releasing marked groups of smolts near the upstream end of Lake Cushman and enumerating their recapture at the FSC. Marks may include, but not be limited to, freeze brands, pit tags, radio tags, and acoustic tags. The Licensee shall monitor passage success of each species that is collected at the FSC in numbers large enough to yield statistical significance, as determined by the Fisheries and Habitat Committee.

1.2. Upstream adult passage

The Licensee shall measure upstream passage survival by marking groups of adult salmonids collected at the base of Cushman Dam No. 2 (or another suitable location as determined by the Fisheries and Habitat Committee) and tracking their survival from a point downstream of the Little Falls to their point of disposition either to hatchery facilities, holding net pens, or release into Lake Cushman. Marks may include, but not be limited to, pit tags, radio tags, and acoustic tags. The size of the marked groups shall include numbers large enough to yield statistical significance, or as determined by the Fisheries and Habitat Committee.

2. Monitoring frequency

2.1 The Licensee shall monitor downstream passage annually for the term of the Amended License using marked groups of juvenile coho salmon. Other species that are numerically sufficient (described above) shall also be monitored, at least twice during the start-up years of the FSC, and then for two (2) years every ten (10) years thereafter. The Licensee shall monitor FCE every five

(5) years during Phase Two for the duration of the Amended License and any subsequent annual licenses.

2.2. The Licensee shall monitor upstream passage survival of coho, Chinook, sockeye and steelhead at least three (3) times during the start-up years of the upstream passage fishway, and then for two (2) years every ten (10) years thereafter.

Article 417: Fish Supplementation Program

Within nine (9) months after issuance of the Amended License, the Licensee shall file with the Commission, for approval, a plan to implement the fish supplementation program. The purposes of the fish supplementation program are to protect, mitigate damages to, and enhance anadromous and resident fisheries. The objectives of the program are: 1) to support the reintroduction, restoration, and long-term maintenance of anadromous fish populations in the North Fork Skokomish watershed; 2) to provide harvest opportunities to treaty Indian and non-treaty fishers; and 3) to provide recreational fishing opportunities.

The Licensee shall develop the Fish Supplementation Plan in consultation with the Fisheries and Habitat Committee, and shall seek approval of the National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the Bureau of Indian Affairs. The Licensee shall also seek the comments and recommendations of the National Park Service. The Licensee shall allow a minimum of thirty (30) days for members of the Fisheries and Habitat Committee and the National Park Service to comment and make recommendations before submitting the plan for approval to the USFWS, BIA and NMFS. When filing the plan with the Commission, the Licensee shall include documentation of consultation; copies of comments and recommendations; and specific descriptions of how comments and recommendations from Fisheries and Habitat Committee members and the National Park Service are accommodated by the Licensee's plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the Fish Supplementation Plan with the Commission without first obtaining the approval of NMFS, USFWS and BIA, the Licensee shall include specific reasons for doing so.

The Commission reserves the right to require changes to the fish supplementation program plan. Implementation of the plan shall commence when the Licensee is notified by the Commission that the filing is approved. Upon Commission approval, the Licensee shall implement the plan.

The plan shall incorporate the guiding principles and program elements of the Cushman Project Fish Supplementation Framework included as Appendix 4 in the Settlement Agreement and consist of the following elements:

1. Species

The fish supplementation program shall include five species: sockeye, spring Chinook, steelhead, coho and rainbow trout.

2. Facilities

2.1 Upstream Fish Passage Facility: The Licensee shall construct, operate and maintain an upstream fish passage facility as described in Article 415. In addition to upstream fish passage, the facility will be used to collect brood stock for the sockeye, spring Chinook, and coho supplementation programs.

2.2 Supplementation Facilities

2.2.1 The Licensee shall construct, operate and maintain an adult holding, spawning, egg incubation, and early rearing facility for the sockeye supplementation program that is capable of producing the number of healthy fry shown in Table 1. The facility shall be located at Tacoma's Saltwater Park property.

Table 1. Sockeye Supplementation Program Production Targets

Species	Type	Number	Fish/Pound	Pounds
Sockeye	Fed fry (May)	200,000	2500	80
	Fed fry (June)	1,000,000	800	1,250
	Fed fry (Sept)	800,000	150	5,333
TOTALS		2,000,000		6,663

2.2.2 The Licensee shall construct, operate and maintain adult holding, spawning, egg incubation, early rearing and net pen rearing facilities for the spring Chinook, steelhead, and coho supplementation programs which are capable of producing the quantity of healthy fish shown in Tables 2, 3 and 4, respectively. These facilities shall be located either at Saltwater Park, in the vicinity of Tacoma's Cushman No. 2 Powerhouse, on the east shore of Lake Kokanee, or some combination of these locations. Prior to and during construction, if these sites are determined to be infeasible, the Licensee will locate facilities at an alternate site. The Licensee shall determine the specific location of the facilities in consultation with the Fisheries and Habitat Committee.

Table 2. Spring Chinook Supplementation Program Production Targets

Species	Type	Number	Fish/Pound	Pounds
Spring	Fingerling	300,000	50	6,000
Chinook	Yearling	75,000	10	7,500
TOTALS		375,000		13,500

Table 3. Winter Steelhead Supplementation Program Production Targets

Species	Type	Number	Fish/Pound	Pounds
Winter	Smolts	15,000	8	1,875
Steelhead	Adults	225	0.125	1,800
TOTALS		15,225		3,675

Table 4. Coho Supplementation Program Production Targets

Species	Type	Number	Fish/Pound	Pounds
Coho	Smolts	10,000 – 35,000	15	666 – 2,333

2

2.3 The Licensee shall construct, operate and maintain net pen rearing facilities in Lake Kokanee adjacent to Cushman Dam No. 2 for spring Chinook, coho, steelhead and rainbow trout. The spring Chinook net pens shall be sized to rear 13,500 pounds of spring Chinook juveniles as described in Table 2. The winter steelhead net pens shall be sized to rear 1,875 pounds of winter steelhead smolts and 1,800 pounds of winter steelhead adults as described in Table 3. The coho net pens shall be sized to rear 2,333 pounds of coho smolts as described in Table 4. The rainbow trout net pens shall be sized to rear 11,667 pounds of catchable rainbow trout.

3. Program Details

3.1 Stock Selection: The Licensee shall, in consultation with the Fisheries and Habitat Committee and the National Park Service, evaluate potential donor stocks for selection and use in developing hatchery production.

3.2 Fish Health and Genetic Fitness: The Licensee shall specify best management practices in the plan and implement these practices to help ensure fish health and maintenance of genetic fitness in all aspects of the supplementation program.

3.3 Sequencing and Phase-In: The Licensee shall develop a schedule in consultation with the Fisheries and Habitat Committee which includes sequencing of steps necessary to implement the supplementation program. The schedule will address when potential donor stocks might be available and when start-up phases for each species can begin. The schedule shall allow for incremental phasing in of the program. Production quantity and schedule changes may be made by the Fisheries and Habitat Committee to accommodate unforeseen circumstances such as donor stock availability.

3.4 Production and Release Strategies: The Licensee's supplementation program shall include production and release strategies in an attempt to achieve the production targets for each species in Tables 1-4.

3.4.1 Sockeye: The Licensee's program shall be targeted to produce and release the sockeye fry quantities as shown in Table 1. The production quantities and release strategies for the facility may be adjusted by the Fisheries and Habitat Committee within the design production capacity of that facility. The initial production will be dependent on the availability of donor stock. The Licensee shall transport and release juvenile sockeye into Lake Cushman or in the North Fork Skokomish River as determined by the Fisheries and Habitat Committee.

3.4.2 Spring Chinook: The Licensee's program shall be targeted to produce and release the spring Chinook fingerling and yearling quantities shown in Table 2. The production quantities and release strategies for those facilities may be adjusted by the Fisheries and Habitat Committee within the design production capacity of those facilities. The Licensee shall rear these fingerling and yearling spring Chinook in Lake Kokanee net pens or, if determined infeasible, in another appropriate location, preferably in the North Fork Skokomish River sub-basin. The Licensee shall release these fish into the pool at the base of Cushman No. 2 Dam as fingerlings/ yearlings.

3.4.3 Steelhead: The Licensee's program shall be targeted to produce and release the Winter Steelhead smolt quantities and adult numbers shown in Table 3. The production quantities and release strategies for those facilities may be adjusted by the Fisheries and Habitat Committee within the design production capacity of those facilities. The Licensee shall rear these winter steelhead smolts and adults in Lake Kokanee net pens or, if determined infeasible, in another appropriate location, preferably in the North Fork Skokomish River sub-basin. The Licensee shall release the winter steelhead smolts into the pool at the base of Cushman No. 2 Dam where they can hold until they are ready to distribute themselves downstream. The Licensee shall release winter steelhead adults into the North Fork Skokomish at locations to be determined by the Fisheries and Habitat Committee that are reasonably accessible by truck.

3.4.4 Coho: The Licensee's program shall be targeted to produce and release the quantity of coho smolts shown in Table 4. The production quantities and release strategies for those facilities may be adjusted by the Fisheries and Habitat Committee within the design production capacity of those facilities. Because the effects of the new flow regime on North Fork coho production are unknown, the Licensee shall rear between 10,000 and 35,000 coho smolts annually as determined by the Fisheries and Habitat Committee. The Licensee shall collect broodstock at the adult collection facility or at an alternate location in the North Fork Skokomish River if necessary and agreed to by the Fisheries and Habitat Committee, and held in a net pen in Lake Kokanee. Egg incubation and early rearing shall occur at the facility described above. After early rearing, the Licensee shall rear these coho in Lake Kokanee net pens or, if determined infeasible, in another appropriate location, preferably in the North Fork Skokomish River sub-basin. The Licensee shall use a portion of these coho smolts as test fish for evaluating the Lake Cushman downstream migrant collection facility. The Licensee shall release the remaining coho smolts into the pool at the base of Cushman No. 2 Dam.

3.4.5 Rainbow Trout: The Licensee shall annually release between 24,000 and 35,000 rainbow trout (8,000 to 11,667 pounds of rainbow trout) into Lake Kokanee. The Licensee shall rear these rainbow trout in Lake Kokanee net pens and release them directly into Lake Kokanee. The Licensee shall consult with WDFW when determining the size and number of rainbow trout and the timing of the releases.

3.5 Hatchery Monitoring Plan

The Licensee shall implement the following Fish Hatchery Monitoring Plan after issuance of the Amended License and through the term of the Amended License and any subsequent annual licenses, in consultation with Fisheries and Habitat Committee.

Within 18 months after issuance of the Amended License, the Licensee shall file with the Commission, for approval, a Hatchery Monitoring Plan. The Licensee shall develop the Hatchery Monitoring Plan in consultation with the Fisheries and Habitat Committee, and shall seek approval of NMFS, USFWS, and BIA. The Licensee shall allow a minimum of thirty (30) days for members of the Fisheries and Habitat Committee to comment and make recommendations before submitting the plan for approval to USFWS, BIA and NMFS. When filing the plan with the Commission, the Licensee shall include documentation of consultation; copies of comments and recommendations; and specific descriptions of how comments and recommendations from Fisheries and Habitat Committee members are accommodated by the Licensee's plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the Hatchery Monitoring Plan with the Commission without first obtaining the approval of NMFS, USFWS and BIA, the Licensee shall include specific reasons for doing so.

The purpose of this plan is to inform implementation of the Hatchery Program. The Licensee shall make any necessary changes to hatchery operations based on the monitoring results. The Hatchery Monitoring Plan shall also include a schedule for the Licensee's implementation of the plan consistent with this Article, consultation with the Fisheries and Habitat Committee regarding monitoring results, and a schedule for providing preliminary monitoring data.

The Hatchery Monitoring Plan shall describe the following parameters: (1) best management practices for the supplementation facilities; (2) size at release, growth rate, and survival in the hatcheries; (3) disease profile; (4) spawn timing and condition; (5) homing/straying; (6) coded-wire tagging program for smolt to adult return rates; (7) stock inventory; (8) number of fish released; (9) water temperature at facilities; and (10) other water quality monitoring parameters required by permits necessary to operate facilities.

The Commission reserves the right to require changes to the plan. Implementation of the plan shall commence when the Licensee is notified by the Commission that the filing is approved. Upon Commission approval, the Licensee shall implement the plan.

The Licensee shall file with the Commission, by June 30 of each year, an annual report fully describing the monitoring efforts of the previous calendar year, and activities required under the plan for the following year. The Fisheries and Habitat Committee shall have at least thirty (30) days to review and comment on the draft report prior to filing with the Commission. The Licensee shall provide copies of the annual report to the Fisheries and Habitat Committee.

Article 418: Tailrace Monitoring Plan

Within sixty (60) months after issuance of the Amended License, the Licensee shall file with the Commission, for approval, a plan to monitor migration delay, injury, and/or mortality at the tailrace during the operation of Powerhouse No. 2. The purpose of the plan is to determine the need for any additional fish protection measures.

The tailrace monitoring plan shall include, but not be limited to: (1) the methods used to monitor migration delay, injury, and/or mortality at the Powerhouse No. 2 tailrace; and (2) a schedule for (a) implementation of the tailrace monitoring plan, and (b) consultation with the Fisheries and Habitat Committee regarding the results of the study and any additional measures needed to protect the fishery resources (i.e., tailrace barrier or other similar device)

The Licensee shall develop the Tailrace Monitoring Plan in consultation with the Fisheries and Habitat Committee, and shall seek approval of the National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the Bureau of Indian Affairs. The Licensee shall allow a minimum of thirty (30) days for members of the Fisheries and Habitat Committee to comment and make recommendations before submitting the plan for approval to USFWS, BIA and NMFS. When filing the plan with the Commission, the Licensee shall include documentation of consultation; copies of comments and recommendations; and specific descriptions of how comments and recommendations from Fisheries and Habitat Committee members are accommodated by the Licensee's plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the Tailrace Monitoring Plan with the Commission without first obtaining the approval of NMFS, USFWS and BIA, the Licensee shall include specific reasons for doing so.

The Commission reserves the right to require changes to the plan. Implementation of the plan shall commence when the Licensee is notified by the Commission that the filing is approved. Upon Commission approval, the Licensee shall implement the plan.

If tailrace monitoring indicates that changes in project structures or operations are necessary to protect fish resources, including any measures identified by the Licensee or the Fisheries and Habitat Committee as a result of the consultation required by this article, the Commission may direct the Licensee to modify project structures or operations accordingly.

Article 419: Reservation of Authority to Construct Fishways. Unchanged.

Article 420: Terrestrial Plan

The Licensee shall file for Commission approval a Terrestrial Resources Protection Plan (Terrestrial Plan). The Terrestrial Plan shall include two components: (1) a Mitigation Plan that includes measures to minimize adverse impacts on terrestrial resources during project construction, and (2) a Monitoring and Protection Plan that includes monitoring and protective procedures for terrestrial resources during Project operation.

The Licensee shall prepare the Terrestrial Plan in consultation with the Washington Department of Fish and Wildlife, U.S. Fish and Wildlife Service, U.S.D.A. Forest Service, the Bureau of Indian Affairs, and the Skokomish Indian Tribe. The Licensee shall allow a minimum of thirty (30) days for comment and recommendation of the agencies and the Tribe before filing the plan with the Commission. The Licensee shall include with the Terrestrial Plan documentation of consultation, copies of comments and recommendations on the plan, and specific descriptions of how the agencies' and the Skokomish Indian Tribe's comments are accommodated by the Licensee's Terrestrial

Plan. If the Licensee does not adopt a recommendation, the Terrestrial Plan shall include the Licensee's reasons, based on Project-specific information.

The Commission reserves the right to require changes to the Terrestrial Plan. Construction shall not begin until the Licensee is notified by the Commission that the filing is approved. Upon Commission approval, the Licensee shall implement the Plan.

Construction Mitigation Plan

Within 1 year after issuance of the Amended Project License, but no later than ninety (90) days before the start of any land-clearing or land-disturbing activities at the site, the Licensee shall file a Construction Mitigation Plan identifying measures to minimize disturbance during construction activities to protect native vegetation and wildlife. The plan shall include, but not be limited to:

a. use of measures such as blast mats and construction activity restrictions during the osprey breeding season;

b. on lands disturbed by removing the McTaggert Creek diversion structure and the Dow Creek fish passage barrier, measures to restrict the development of invasive exotic plants and to enhance native tree and shrub development, to be developed after consultation with the aforementioned agencies and the Simpson Timber Company;

c. if lower North Fork fish habitat enhancements are undertaken, mitigation of vegetation disturbance by: avoiding wetlands and other sensitive areas; scarifying and revegetating cleared access roads and skid trails with herbaceous elk forage; covering excavation spoils with cached topsoil and litter; revegetating disturbed wetlands with native wetland plants, revegetating disturbed streambanks with native shrubs, and other measures proposed by the Licensee; and in conjunction with the Threatened and Endangered Species Plan, constructing lower North Fork instream fish habitat enhancements between May 15th and December 31st to prevent disturbance of wintering bald eagles;

d. on recreation facility improvement sites on the Dry and Copper Creek trails, along Staircase Road, a prohibition on cutting overstory trees greater than sixteen (16) inches diameter breast height (dbh), with the exception of trees that pose a public safety threat;

e. on recreation improvement sites on the Dry and Copper Creek trails, along Staircase Road, at the U.S.D.A. Forest Service Big Creek Campground, and at Lake Cushman State Park, measures such as construction schedule adjustments or other means to prevent disturbance of marbled murrelets and northern spotted owls, in conjunction with the Threatened and Endangered Species Plan; and

f. on Olympic National Park exchange lands, procedures, developed after consultation with the National Park Service, to eliminate or control reed canary grass.

Operational Monitoring and Protection Plan

Within 1 year after issuance of the Amended License, the Licensee shall file a terrestrial resources monitoring and protection plan for National Park Service exchange lands, enhancement parcels, lands leased by Tacoma to Lake Cushman Development Corporation, and other Project lands to protect plant and wildlife resources during the license period. The plan shall include techniques for monitoring and protecting the plant and wildlife resources on these lands, measures to restrict land use and human use, and procedures to enforce the restrictive use measures. The plan shall include a schedule for implementing and evaluating the monitoring and protection program.

Article 421: Comprehensive Wildlife Habitat Enhancement Plan

Within one year after issuance of the Amended License, the Licensee shall file with the Commission, for approval, a Wildlife Habitat Enhancement Plan (WHE Plan) for the Project. The WHE Plan shall address this Article's provisions pertaining to (1) Land Acquisition and (2) Enhancement of Habitat and Wildlife Populations.

The Licensee shall develop the WHE Plan in consultation with the Skokomish Tribe, Washington Department of Fish and Wildlife, U.S.D.A. Forest Service, the Bureau of Indian Affairs, and the U.S. Fish and Wildlife Service. The Licensee shall allow a minimum of thirty (30) days for the WDFW, USFS, USFWS and Skokomish Tribe to comment and make recommendations before submitting the plan for approval to USFWS, USFS and BIA. The Licensee shall include with the WHE Plan documentation of consultation; copies of comments and recommendations; and specific descriptions of how comments and recommendations are accommodated by the Licensee's WHE Plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the WHE Plan with the Commission without first obtaining the approval of USFWS, USFS and BIA, the Licensee shall include specific reasons for doing so.

The WHE Plan shall also be developed in conjunction with the Threatened and Endangered Species Plan.

The Commission reserves the right to require changes to the WHE Plan. Implementation of the WHE Plan shall commence when the Licensee is notified by the Commission that the filing is approved. Upon Commission approval, the Licensee shall implement the WHE Plan.

1. Land Acquisition

The Licensee shall acquire the title to the following parcels for the purpose of enhancing native plants and wildlife populations: (1) the 320-acre Green Diamond-owned site adjacent to Homan Flats (east half of Section 15, Township 22 North, range 5 West, W.M.); and (2) the approximately 430-acre Green Diamond-owned Lake May/Northern Lower North Fork site generally located in the southeast portion of Section 8, western portion of Section 16, eastern portion of Section 17, and northeastern portion of Section 20, Township 22 North, Range 4 West, W.M. and as depicted on the Wildlife Lands map which is attached as Appendix 1 to this Amended License.

The WHE Plan shall contain a description of each parcel and a schedule of dates for acquiring parcels and reporting to the Commission and the agencies on the progress of acquisitions.

The WHE Plan shall also include procedures, including consultation with the Tribe and agencies, to allow the Licensee to acquire appropriate alternative parcels which would provide equivalent or greater habitat benefits as the above described parcels in event that such parcels are identified and available.

2. Enhancement of Habitat and Wildlife Populations

Pursuant to the WHE Plan, the Licensee shall enhance native plants and wildlife populations on the following lands and waters: (1) the Project reservoirs; (2) the Westside, Dow Mountain, Deer Meadow, Brown Creek, Dry Creek, and Homan Flats parcels owned by Tacoma; (3) the approximately 750 acres of Green Diamond acquisition land described above; (4) the Cushman transmission line right of way between Cushman dam No. 1 and Cushman powerhouse No. 2; and (5) the Tacoma-owned approximately 75-acre non-operational land located in sections 27 and 28, Township 22 North, Range 4 West W.M. above the number 2 powerhouse (See Wildlife Lands Map attached as Appendix 1 to the Amended License).

The WHE Plan shall include goals, objectives, and standards for all recommended measures. Enhancement measures shall include, but may not be limited to the following:

a. constructing three osprey nesting structures on the Project reservoirs;

b. protecting and preserving all suitable bald eagle and osprey perching, roosting, and nesting trees on the Cushman wildlife lands located along the North and South Forks of the Skokomish River and Project reservoirs;

c. establishing high density snag areas through creation of 300 snags in conifer-dominated Class 3 forests;

d. scarifying, seeding, planting and other measures needed to successfully remove and revegetate roads not needed for parcel maintenance. Roads needed for maintenance but not for approved recreational access should be gated;

e. improving forage production and tree growth within 200 acres of dense Class 1 or 2 conifer forest through thinning and maintaining target tree densities and forage throughout the term of the license using techniques to be specified in the WHE Plan;

f. installing, maintaining, and monitoring at least 20 wood duck nest boxes at Lake Kokanee, Lake May, and other nearby aquatic areas;

g. installing, maintaining, and monitoring at least seven (7) bat boxes at Lake Cushman, Lake Kokanee, and Lake May vicinity; and

h. constructing, maintaining, and monitoring up to 200 acres of elk forage fields.

Article 422: Estuarine Enhancement Plan

Article proposed for deletion. See discussion in Joint Explanatory Statement.

Article 423: Threatened and Endangered Species Plan

Within one year after issuance of the Amended License, the Licensee shall, develop and file for Commission approval a Threatened and Endangered Species Protection Plan (T&E Plan) for the Project. The T&E Plan shall include measures to protect the Puget Sound Chinook salmon, Puget Sound Steelhead, Hood Canal summer-run chum salmon, bull trout, peregrine falcon, bald eagle, marbled murrelet, and spotted owl during project construction and operation.

The T&E Plan shall include, but not be limited to, the following:

a. measures to protect listed salmon stocks and bull trout, consistent with the requisite provisions of Articles 401 through 407, 410 through 419, and 422 of this license;

b. protective measures such as establishment of buffer zones for future logging or land development, precluding construction during breeding seasons, the protection of existing and potential bald eagle roosting and perching trees, particularly along stream shorelines, and maintaining and enhancing food sources for the bald eagle;

c. a schedule for implementing the measures;

d. a description of the method(s) for monitoring the results of the implemented measures;

e. a monitoring schedule; and

f. a schedule for providing the monitoring results to the National Marine Fisheries Service, U.S. Fish and Wildlife Service, U.S.D.A. Forest Service, Washington Department of Fish and Wildlife, and the Commission.

If any of the measures prove unsuccessful, the Licensee shall prepare a revised plan to include alternative or modified measures, developed in consultation with the National Marine Fisheries Service, U.S. Fish and Wildlife Service, U.S.D.A. Forest Service, and the Washington Department of Fish and Wildlife.

The Licensee shall develop the T&E Plan in consultation with the Fisheries and Habitat Committee, and shall seek approval of NMFS and USFWS. The Licensee shall allow the Fisheries and Habitat Committee members a minimum of thirty (30) days for comments and recommendations before submitting the plan for approval to USFWS and NMFS. When filing the T&E Plan with the Commission, the Licensee shall include documentation of consultation, copies of comments and recommendations, and specific descriptions of how comments and recommendations from Fisheries and Habitat Committee members are accommodated by the Licensee's T&E Plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based on Project-specific information. If the Licensee files the T&E Plan with the Commission without first obtaining the approval of NMFS and USFWS, the Licensee shall include specific reasons for doing so.

The Commission reserves the right to require changes to the T&E Plan. No land-disturbing activities shall begin at the Project until the Licensee is notified by the Commission that the T&E Plan is approved. Upon Commission approval, the Licensee shall implement the T&E Plan.

Article 424: Shoreline Management Plan

Within two (2) years after issuance of the Amended License, the Licensee shall file with the Commission, for approval, a detailed management plan for the use of shoreline Project buffer zone lands. The Shoreline Management Plan, at a minimum, shall include: (1) allowable uses for the buffer zone lands; (2) conditions to be specified for such allowable uses (such as, measures to maintain the aesthetic quality of the reservoir); and (3) any proposed permit system (with a sample permit).

The Licensee shall prepare the Shoreline Management Plan in consultation with the Washington Department of Fish and Wildlife, U.S. Fish and Wildlife Service, U.S.D.A. Forest Service, and Mason County. The Licensee shall allow a minimum of thirty (30) days for comment and recommendation of the agencies before filing the Plan with the Commission. The Licensee shall include with the plan documentation of consultation, copies of comments and recommendations on the Plan, and specific descriptions of how the agencies' comments are accommodated by the Licensee's Plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based upon operation and landscape conditions at the site.

The Commission reserves the right to require changes to the Plan. Upon Commission approval the Licensee shall implement the Plan.

Article 425: Recreation Plan

Within 1 year of issuance of the Amended License, the Licensee shall file with the Commission, for approval, a recreational resources plan detailing measures that the Licensee will undertake to protect and enhance area recreational resources. All plan requirements to be implemented outside the current Project boundary are one-time actions that shall not include maintenance, management, monitoring, or oversight by the Licensee. At a minimum, the plan shall include the following provisions:

1. The Licensee shall improve five existing casual shoreline access sites in the Staircase Road Recreation Area by converting existing informal camp sites to day use only sites (as described in FEIS section 4.7.1.2).

2. The Licensee shall improve the Lake Cushman Viewpoint by providing picnic sites, kiosks, and a toilet, and improve accessibility (as described in FEIS section 4.7.1.2).

3. The Licensee shall relocate the Dry Creek Trail to bypass the portion of the current Dry Creek Trail adjacent to the residences situated along Lake Cushman. The Dry Creek Trailhead shall be relocated to join with the Copper Creek Trailhead and provide improvements to that trailhead (as described in the FEIS sections 4.7.1.2 and 4.7.4.2) or, alternatively, the Licensee shall secure legal public access for the U.S.D.A. Forest Service along the existing Dry Creek trail route or portions thereof. The Licensee shall make improvements to the access road to the Mt. Rose Trailhead, and improve and enlarge the Mt. Rose Trailhead parking area (as described in FEIS section 4.7.1.2).

4. The Licensee shall improve the Lake Kokanee boat ramp facilities by installing a boat loading dock, adding new crushed rock to the parking area, delineating parking stalls, and providing picnic tables and kiosks. The Licensee shall assume the maintenance of the boat ramp facilities including repairing or replacing broken slabs in the ramp, grading the parking area annually, maintaining the concrete vault toilets, removing garbage and litter, and other general maintenance as necessary.

5. The Licensee shall improve the undeveloped portion of Olympic National Forest's Big Creek Campground for organized group overnight and day-use (as described

in FEIS sections 4.7.1.2 and 4.7.4.2). All constructed facilities will be owned by the USFS upon completion.

5.1 To the extent feasible given site constraints, the Licensee shall work with the USFS to add up to thirty (30) group camp RV sites including two kitchen shelters, picnic tables, a group fire circle and two barrier free double vault toilets.

5.2 The Licensee shall provide a new entrance sign for the existing campground, a fee station, informational kiosks, a hand pump well, storage building, wastewater disposal sumps, and miscellaneous signage (as described in the FEIS Section 4.7.1.2). The Licensee shall also rehabilitate one double vault toilet and one hand pump well.

5.3 In addition to the requirements of section 5.1, the Licensee shall construct or reconstruct up to thirty (30) individual campsites (both RV and tent) with picnic tables and fire rings. The Licensee shall also construct a camp host site with on-site sewage system and water for filling trailer holding tanks, and install a well, pump, pumphouse, distribution lines, up to twenty (20) faucets, and drains. Until outside power is available at the site, the camp host site, well, pump, and pumphouse shall be powered by a site battery with a recharging system by either hydro, solar, and/or portable generator. The battery system will not be capable of powering the water distribution lines and thus faucets will not be operable until outside power is available pursuant to section 5.4.

5.4 When outside power is available within one-quarter mile of Big Creek Campground, the Licensee shall extend the power into Big Creek Campground, add lighting to existing facilities such as shelters, kiosks, and the host site, and add lighting and fans to the toilets. The Licensee also shall extend power to the water distribution system (well, pump, pumphouse, distribution lines, up to twenty (20) faucets, and drains).

5.5 After the distribution line is installed and functional, the Licensee shall remove and decommission the existing hand pump wells and well sites.

5.6 The Licensee shall provide hard surfacing (using either concrete or Bituminous Surface Treatment) to the entrance area and campground host site, and shall provide 2" of new crushed surfacing on existing roadway and parking spurs within the campground upon completion of all subsurface work. The new roadways and parking spurs shall be constructed using up to 4" of base material topped with 2" of crushed surfacing.

5.7 The Licensee shall construct an interpretive trail, approximately ¼ mile in length, at Big Creek Campground.

5.8 The Licensee shall provide for a trailer dump station within three miles of the campground.

6. The Licensee shall provide for improvements to Bear Gulch Access by providing 5 picnic tables, toilets and parking (up to twenty (20) vehicles) as described in the FEIS (sections 4.7.1.2, and 4.7.4.2). The Licensee shall also repair or replace the existing toilet.

7. The Licensee shall construct recreational facilities to comply with the Americans with Disabilities Act of 1990.

8. The Licensee shall complete an assessment of the site commonly known as "The Big Rock" in consultation with the U.S. Fish and Wildlife Service, Washington Department of Natural Resources, and Mason County Sheriff to address the continuing incidence of person caused wildfire starts and ensuing investigations in the area and other law enforcement actions attributed to gatherings of people in the area. Such assessment shall include discussion of options to manage public activities in this area, which may include but are not limited to methods to limit access, limit parking opportunities in the area, use of traffic revisions or increased signage and fire prevention patrols.

9. The Licensee shall impose campfire and camping restrictions on Licensee lands along Staircase Road at the request of the U.S.D.A. Forest Service.

10. The plan shall include a schedule for completion of items 1, 2, 3, 4, 5, 6, and 8 within three (3) construction seasons of issuance of the Amended License. The schedule may be modified by agreement with the USFS. The designs for the facilities described in items 1, 3, 5, 6, and 8 shall be developed in consultation with and subject to approval of the USFS.

The Licensee shall prepare the plan after consultation with the USFS, National Park Service, the Bureau of Indian Affairs, Skokomish Indian Tribe, Washington Department of Fish and Wildlife, and the Washington Department of Natural Resources. The Licensee shall include with the plan documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the plan.

The Licensee shall allow a minimum of thirty (30) days for the agencies to comment and make recommendations before filing the plan with the Commission. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons, based on Project-specific information.

The Commission reserves the right to require changes to the proposed plan. Implementation of the recreational management plan shall not begin until the Licensee is notified by the Commission that the filing is approved. Upon Commission approval, the Licensee shall implement the plan.

Article 426: Article proposed for deletion. See discussion in Joint Explanatory Statement.

Article 427: Road Management Plan

Within one year of issuance of the Amended License, the Licensee shall file with the Commission, for approval, a Road Management Plan for USFS Road Nos. 24 and 2451 that addresses Project-related use and protects water quality, recreational, and aesthetic resources as described in the FEIS (sections 4.7.1.2 and 6.4.1).

At a minimum, the Road Management Plan shall include the following components:

1. The License shall include a description of Project induced impacts relevant to the history of the road's development and use.

2. The License shall include a description of projected future use levels.

3. The License shall include a description of public safety.

4. The License shall include a description of year-round access needs.

5. The License shall include a description of winter maintenance.

6. The License shall include a description of objectives for future road standards that may facilitate jurisdiction by public road management agencies.

7. The Licensee shall assume a portion of the responsibility, commensurate with Project related use (including recreational use and water quality protection measures), for operation and maintenance activities of USFS Road No. 24 from Road Mile 10.1 to 14.08 until road jurisdiction is transferred to others or unless otherwise agreed to by the USFS. Operation and maintenance of USFS Road No. 24 consists of: (1) cleaning, removing, reconditioning, installing, or replacing the following: drainage structures (such as culverts, ditches, catch basins), riprap armor, headwalls, water bars, cross ditches, erosion control devices, earth berms, and debris rack; (2) surface maintenance including load, haul and place materials, blading, grading, surface rock, asphalt & BST maintenance and treatment, pothole patching or grading, spot rock surfacing, and road condition surveys; (3) signs and traffic control maintenance; (4) reconditioning, installing or replacement (including graffiti removal) of the following: gates, post, signs, guardrail, jersey barriers, barricades, and pavement markers; and (5) vegetation management such as brushing, danger tree removal, logging out trees, establish vegetation, and seeding and removal of invasive species.

8. The Licensee shall assume a portion of the responsibility, commensurate with Project-related use (including recreational use and water quality protection measures), for operation and maintenance activities of USFS Road No. 2451 from Road Mile 0.00 to Road Mile 1.0 for the duration of the Amended License. Notwithstanding, the Licensee shall not be responsible for any structural damages to USFS Road No. 2451 caused by floods or by Project operations. Operation and maintenance of USFS Road No. 2451 consists of: (1) cleaning, removing, reconditioning, installing, or replacing the following: drainage structures (such as culverts, ditches, and catch basins), water bars, cross ditches, erosion control devices, earth berms, and debris rack; (2) surface maintenance including load, haul and place materials, blading, grading, surface rock, pothole patching or grading, spot rock surfacing, slide or rock onto roadway removal and haul, and road condition surveys; (3) signs and traffic control maintenance; (4) reconditioning, installing or replacement (including graffiti removal) of the following: barricades or gates to close bridge, post, bridge signs, guardrail, jersey barriers, graffiti removal, barricades, and pavement markers; (5) vegetation management such as brushing, danger tree removal, logging out trees, establish vegetation, and seeding and removal of invasive species; and (6) structure maintenance such as bridge guardrail and approach railing maintenance, bridge deck and drain cleaning and maintenance, and patching damaged concrete bridge deck.

The Licensee shall prepare the Plan after consultation with the USFS, National Park Service, Washington State Parks and Recreation Commission, and Washington Department of Natural Resources. The Licensee shall include with the Plan documentation of consultation, copies of comments and recommendations on the completed Plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the Plan.

The Licensee shall allow a minimum of thirty (30) days for the agencies to comment and make recommendations before filing the Plan with the Commission. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons, based on Project-specific information.

The Commission reserves the right to require changes to the proposed Plan. The recreational resources program shall not begin until the Licensee is notified by the Commission that the filing is approved. Upon Commission approval, the Licensee shall implement the Plan.

Article 428: Recreational Use Monitoring Plan

Within one year of completion of improvements required by Article 425, the Licensee, in consultation with the U.S.D.A. Forest Service, National Park Service, Washington State Parks and Recreation Commission, Washington Department of Fish and Wildlife, and Washington Department of Natural Resources, shall implement a study to determine whether existing recreational facilities are meeting Project-related recreational demands. The Licensee shall seek approval by the USFS of the study plan prior to implementing the study. Reporting of the required information is to be in accordance with 18 C.F.R. § 8.11, which requires the filing of the Commission Form No. 80, and the requirements of this Article. This report shall include the following components:

1. annual use figures;

2. a discussion of the adequacy of the Licensee's recreational facilities in the project area to meet recreational demand including boating access;

3. a description of the methodology used to collect all study data; and

4. if there is a need for additional facilities, the Licensee shall develop and implement a recreation plan to accommodate recreational needs in the Project area.

The Licensee shall include with the plan documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the plan.

The Licensee shall allow a minimum of thirty (30) days for the agencies to comment and make recommendations before filing the plan with the Commission. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons, based on Project-specific information.

The Commission reserves the right to require changes to the proposed plan. Implementation of the recreational management plan shall not begin until the Licensee is notified by the Commission that the filing is approved. Upon Commission approval, the Licensee shall implement the plan.

Articles 429: Unchanged

Article 430: Penstock Painting. Proposed for deletion. See explanation in Joint Explanatory Statement.

Article 431: Unchanged

Article 432: Fisheries and Habitat Committee

Within three (3) months after issuance of the Amended License, the Licensee shall establish and convene a Fisheries and Habitat Committee (FHC) for the purpose of consultation with the Licensee as expressly provided in specific license articles and Settlement Agreement Appendix 3.

The Licensee shall arrange, administer, and chair all meetings. Upon request of the other parties, the Licensee shall provide a meeting facilitator. The Licensee, or the facilitator, shall provide no fewer than ten (10) days' prior notice of any meeting, unless otherwise agreed to by the FHC or required in order to meet a license deadline or other emergency circumstance.

The Licensee, or the facilitator, shall provide draft meeting minutes for concurrence by the FHC prior to final distribution. Meeting minutes will include FHC action items, a summary of issues discussed, decisions reached, and member concerns.

The Licensee shall bear all costs associated with conducting meetings.

For purposes of the Amended License, consultation or consult means that the Licensee shall obtain the views of and attempt to reach consensus among the specified parties or specified committee whenever the Amended License requires the Licensee to consult. Consultation shall not mean consultation under section 7 of the Endangered Species Act or other federal laws specifically requiring consultation unless specifically provided.

Article 433: U.S.D.A. Forest Service Reservation of Authority

The U.S.D.A. Forest Service reserves its authority under Section 4(e) of the Federal Power Act as provided in Section 10.5 of the Cushman Off-license Agreement Between Tacoma and the U.S.D.A. Forest Service, dated January 12, 2009, to require the inclusion of conditions in the license for Project No. 460, described in Sections 3 and 7 of the Cushman Off-license Agreement Between Tacoma and the U.S.D.A. Forest Service, even if the Cushman Off-license Agreement between Tacoma and the U.S.D.A. Forest Service terminates.

Article 434: Department of Interior Reservation of Authority

The Licensee shall implement, upon order by the Commission, such additional measures as may be identified by the Secretary of the Interior pursuant to authority provided in Section 4(e) of the Federal Power Act, as necessary to ensure adequate protection and utilization of the Skokomish Indian Reservation.

Unnumbered Appendix B U.S.D.A. Forest Service Recreation Plan

This obligation is proposed for deletion from the license because it has been superseded by Amended Articles 410, 425, 427 and 428.

Unnumbered Appendix B U.S.D.A. Forest Service Fire Plan

This obligation is proposed for deletion from the license because it has been superseded by Amended Articles 410, 425, 427 and 428.

Unnumbered Appendix B U.S.D.A. Forest Service Road Management Plan

This obligation is proposed for deletion from the license because it has been superseded by Amended Articles 410, 425, 427 and 428.