Lower Columbia Salmon Recovery
And
Fish & Wildlife Subbasin Plan

Volume II – Subbasin Plan
Chapter H – Lower Columbia Tributaries: Bonneville and Salmon

Salmon-Washougal and Lewis Rivers (WRIAS 27-28)

Watershed Management Plan

Chapter 6 – Management of Fish Habitat Conditions

Lower Columbia Fish Recovery Board

December 15, 2004

Preface

This is one in a series of volumes that together comprise a Recovery and Subbasin Plan for Washington lower Columbia River salmon and steelhead:

--	Plan Overview	*Overview of the planning process and regional and subbasin elements of the plan.*
Vol. I	Regional Plan	*Regional framework for recovery identifying species, limiting factors and threats, the scientific foundation for recovery, biological objectives, strategies, measures, and implementation.*
Vol. II	Subbasin Plans	*Subbasin vision, assessments, and management plan for each of 12 Washington lower Columbia River subbasins consistent with the Regional Plan. These volumes describe implementation of the regional plan at the subbasin level.* *II.A. Lower Columbia Mainstem and Estuary* *II.B. Estuary Tributaries* *II.C. Grays Subbasin* *II.D. Elochoman Subbasin* *II.E. Cowlitz Subbasin* *II.F. Kalama Subbasin* *II.G. Lewis Subbasin* *II.H. Lower Columbia Tributaries* *II.I. Washougal Subbasin* *II.J. Wind Subbasin* *II.K. Little White Salmon Subbasin* *II.L. Columbia Gorge Tributaries*
Appdx. A	Focal Fish Species	*Species overviews and status assessments for lower Columbia River Chinook salmon, coho salmon, chum salmon, steelhead, and bull trout.*
Appdx. B	Other Species	*Descriptions, status, and limiting factors of other fish and wildlife species of interest to recovery and subbasin planning.*
Appdx. C	Program Directory	*Descriptions of federal, state, local, tribal, and non-governmental programs and projects that affect or are affected by recovery and subbasin planning.*
Appdx. D	Economic Framework	*Potential costs and economic considerations for recovery and subbasin planning.*
Appdx. E	Assessment Methods	*Methods and detailed discussions of assessments completed as part of this planning process.*

This plan was developed by of the Lower Columbia Fish Recovery Board and its consultants under the Guidance of the Lower Columbia Recovery Plan Steering Committee, a cooperative partnership between federal, state and local governments, tribes and concerned citizens.

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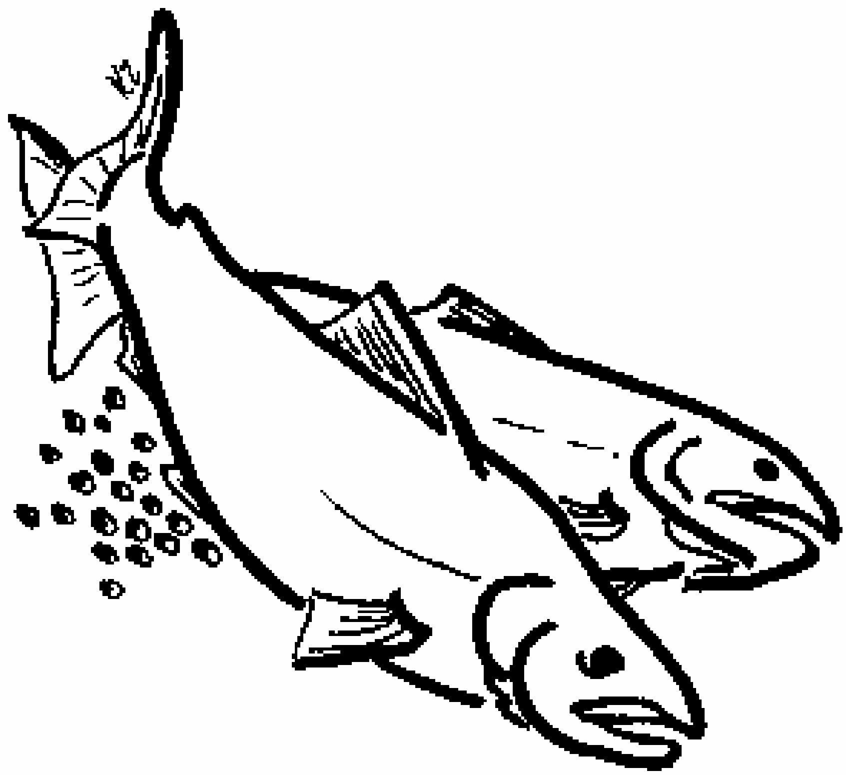
SALMON CREEK



Subbasin Plan Vol. II.H.
Lower Columbia Tributaries Subbasin
– Bonneville Tributaries

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1.0 Bonneville Tributaries – Executive Summary

This plan describes a vision, strategy, and actions for recovery of listed salmon, steelhead, and trout species to healthy and harvestable levels, and mitigation of the effects of the Columbia River hydropower system in Washington lower Columbia River subbasins. Recovery of listed species and hydropower mitigation is accomplished at a regional scale. This plan for the Bonneville Tributaries describes implementation of the regional approach within this basin, as well as assessments of local fish populations, limiting factors, and ongoing activities that underlie local recovery or mitigation actions. The plan was developed in a partnership between the Lower Columbia Fish Recovery Board (Board), Northwest Power and Conservation Council, federal agencies, state agencies, tribal nations, local governments, and others.

The Bonneville Tributaries Basin is part of the Columbia Lower Tributaries Subbasin as defined by the NPPC. The primary streams are Gibbons Creek, Lawton Creek, Duncan Creek, Hardy Creek, and Hamilton Creek. These streams historically supported abundant winter steelhead, chum, coho, and fall chinook. Today, numbers of naturally spawning salmon and steelhead have plummeted to levels far below historical numbers. Chinook, steelhead and chum have been listed as Threatened under the Endangered Species Act and coho is proposed for listing. The decline has occurred over decades and the reasons are many. Freshwater and estuary habitat quality has been reduced by agricultural and forestry practices. Key habitats have been isolated or eliminated by channel and floodplain modifications. Altered habitat conditions have increased predation. Competition and interbreeding with domesticated or nonlocal hatchery fish has reduced productivity. Hydropower construction and operation on the Columbia has altered flows, habitat, and migration conditions. Fish are harvested in fresh and saltwater fisheries.

Bonneville Tributaries winter steelhead, chum, and coho will need to be restored to a high level of viability and fall Chinook to a medium level of viability to meet regional recovery objectives. This means that the populations are productive, abundant, exhibit multiple life history strategies, and utilize significant portions of the subbasin.

In recent years, agencies, local governments, and other entities have actively addressed the various threats to salmon and steelhead, but much remains to be done. One thing is clear: no single threat is responsible for the decline in these populations. All threats and limiting factors must be reduced if recovery is to be achieved. An effective recovery plan must also reflect a realistic balance within physical, technical, social, cultural and economic constraints. The decisions that govern how this balance is attained will shape the region's future in terms of watershed health, economic vitality, and quality of life.

This plan represents the current best estimation of necessary actions for recovery and mitigation based on thorough research and analysis of the various threats and limiting factors that impact Bonneville Tributaries fish populations. Specific strategies, measures, actions and priorities have been developed to address these threats and limiting factors. The specified strategies identify the best long term and short term avenues for achieving fish restoration and mitigation goals. While it is understood that data, models, and theories have their limitations and growing knowledge will certainly spawn new strategies, the Board is confident that by implementation of the recommended actions in this plan, the population goals in the Bonneville Tributaries Basin can be achieved. Success will depend on implementation of these strategies at the program and project level. It remains uncertain what level of effort will need to be invested in each area of impact to ensure the desired result. The answer to the question of precisely how much is enough is currently beyond our understanding of the species and ecosystems and can only be answered through ongoing monitoring and adaptive management against the backdrop of what is socially possible.

1.1 Key Priorities

Many actions, programs, and projects will make necessary contributions to recovery and mitigation in the Bonneville Tributaries Basin. The following list identifies the most immediate priorities.

1. Provide Adequate Water Flows in Bonneville Dam Tailrace for Downstream Habitats

Bonneville Dam flow regimes effect chum and fall Chinook access to spawning habitats in Hamilton and Hardy creeks. The fall and early winter flows also affect the amount of spawning habitat available for chum and fall chinook in the mainstem Columbia near Pierce and Ives islands. The winter and early spring flows at Bonneville Dam are also critical to prevent dewatering and decreased flows through redds during the egg incubation period. Regulating discharge from Bonneville Dam to provide adequate water flow in the fall and early winter for spawning access and in the winter and early spring for egg incubation is critical for Bonneville area chum and fall Chinook restoration.

2. Restore Floodplain Function, Riparian Function and Stream Habitat Diversity

Many of the streams in this basin are characterized by lowland floodplains just before their confluence with the Columbia River. These floodplains have been isolated or eliminated as a result of development, stream channel diversion, and transportion corridors. These practices have also degraded riparian vegetation. Removing or modifying channel control and containment structures to reconnect streams to their floodplains (where this is feasible and can be done without increasing risks of substantial flood damage) will restore normal habitat-forming processes to reestablish habitat complexity, off-channel habitats, and conditions favorable to fish spawning and rearing. Restoration of riparian function will enhance bank stability, water quality, and channel complexity. These improvements will be particularly beneficial to chum, fall Chinook, and coho, which utilize lower elevation reaches. Partially restoring normal floodplain functions will also provide wetland and riparian habitats critical to other fish, wildlife, and plant species. Existing floodplain function and riparian areas will be protected through local land use ordinances, partnerships with landowners, and the acquisition of land, where appropriate. Restoration will be achieved by working with willing landowners, non-governmental organizations, conservation districts, and state and federal agencies.

2. Manage Growth and Development to Protect Watershed Processes and Habitat Conditions

Human population and development trends vary dramatically between the western and eastern portions of the basin. The western portion of the basin is a populated area adjacent to the expanding city of Washougal, WA. The eastern portion lies within the Columbia River Gorge National Scenic Area (CRGNSA), is less populated, and is subject to land-use controls associated with the provisions of the CRGNSA. The population of the entire basin is projected to grow by at least one third in the next twenty years. Population growth will primarily occur in the western portion of the basin and along the Columbia River in the eastern portion. This growth will result in the conversion of forest, rural residential and agricultural land uses to high-density residential uses, with potential impacts to habitat conditions. Land-use changes will provide a variety of risks to terrestrial and aquatic habitats. Careful land-use planning will be necessary to protect and restore natural fish populations and habitats and will also present opportunities to preserve the rural character and local economic base of the basin.

3. Manage Forest Lands to Protect and Restore Watershed Processes

Much of the basin is managed for commercial timber production and has experienced intensive past forest practices activities. Proper forest management is critical to fish recovery. Past forest practices have reduced fish habitat quantity and quality by altering stream flow, increasing fine sediment, and degrading riparian zones. In addition, forest road culverts have blocked fish passage in small tributary streams. Effective implementation of new forest practices through the Department of Natural Resources' Habitat Conservation Plan (state lands), Forest Practices Rules (private lands), and the Northwest Forest Plan / CRGNSA (federal lands) are expected to substantially improve conditions by restoring passage, protecting riparian conditions, reducing fine sediment inputs, lowering water temperatures, improving flows, and restoring habitat diversity. Improvements will benefit all species, particularly winter steelhead and coho.

4. Restore Passage at Culverts and Other Artificial Barriers

There are several passage issues in the basin related to channel alterations (e.g. Gibbons Creek) and transportation corridors (Highway 14 and the railroad corridor). Correcting passage barriers could open up as many as 6 additional miles of habitat. There have already been some significant accomplishments with respect to passage, including enhancement of passage at lower Duncan Creek. Further assessment and prioritization of passage barriers is needed throughout the basin.

5. Address Immediate Risks with Short-term Habitat Fixes

Restoration of normal watershed processes that allow a basin to restore itself over time has proven to be the most effective strategy for long term habitat improvements. However, restoration of some critical habitats may take decades to occur. In the near term, it is important to initiate short-term fixes to address current critical low numbers of some species. Examples in the Bonneville Tributaries Basin include building chum salmon spawning channels and constructing coho overwintering habitat such as alcoves, side channels, and log jams. Benefits of structural enhancements are often temporary but will help bridge the period until normal habitat-forming processes are reestablished.

6. Align Hatchery Priorities with Conservation Objectives

Hatcheries throughout the Columbia Basin historically focused on producing fish for fisheries as mitigation for hydropower development and widespread habitat degradation. Emphasis of hatchery production without regard for natural populations can pose risks to natural population viability. Hatchery priorities must be aligned to conserve natural populations, enhance natural fish recovery, and avoid impeding progress toward recovery while continuing to provide fishing benefits. There are no hatcheries operating in the Bonneville Tributaries Basin. The Washougal hatchery facility will continue to release chum into Duncan Creek as part of a chum rebuilding program and a risk reduction program for the mainstem Columbia, Hamilton and Hardy Creek chum populations.

7. Manage Fishery Impacts so they do not Impede Progress Toward Recovery

This near-term strategy involves limiting fishery impacts on natural populations to ameliorate extinction risks until a combination of measures can restore fishable natural populations. There is no directed Columbia River or tributary harvest of ESA-listed Bonneville Tributaries salmon and steelhead. This practice will continue until the populations are sufficiently recovered to withstand such pressure and remain self-sustaining. Some Bonneville Tributaries salmon and steelhead are incidentally taken in mainstem Columbia River and ocean mixed stock fisheries for strong wild and hatchery runs of fall Chinook and coho. These fisheries will be managed with strict limits to ensure this incidental take does not threaten the recovery of wild populations including those from the Bonneville Tributaries. Steelhead and chum will continue to be protected from significant fishery impacts in the Columbia River and are not subject to ocean fisheries. Selective fisheries for marked hatchery steelhead and coho (and fall Chinook after mass marking occurs) will be a critical tool for limiting wild fish impacts. State and federal legislative bodies will encouraged to develop funding necessary to implement mass-marking of Fall Chinook, thus enabling a selective fishery with lower impacts on wild fish. State and federal fisheries managers will better incorporate Lower Columbia indicator populations into fisheries impact models.

8. Reduce Out-of-Subbasin Impacts so that the Benefits of In-Basin Actions can be Realized

Bonneville Tributaries salmon and steelhead are exposed to a variety of human and natural threats in migrations outside of the basin. Human impacts include drastic habitat changes in the Columbia River estuary, effects of Columbia Basin hydropower operation on mainstem, estuary, and nearshore ocean conditions, interactions with introduced animal and plant species, and altered natural predation patterns by northern pikeminnow, birds, seals, and sea lions. A variety of restoration and management actions are needed to reduce these out-of-basin effects so that the benefits in-basin actions can be realized. To ensure equivalent sharing of the recovery and mitigation burden, impacts in each area of effect (habitat, hydropower, etc.) should be reduced in proportion to their significance to species of interest.

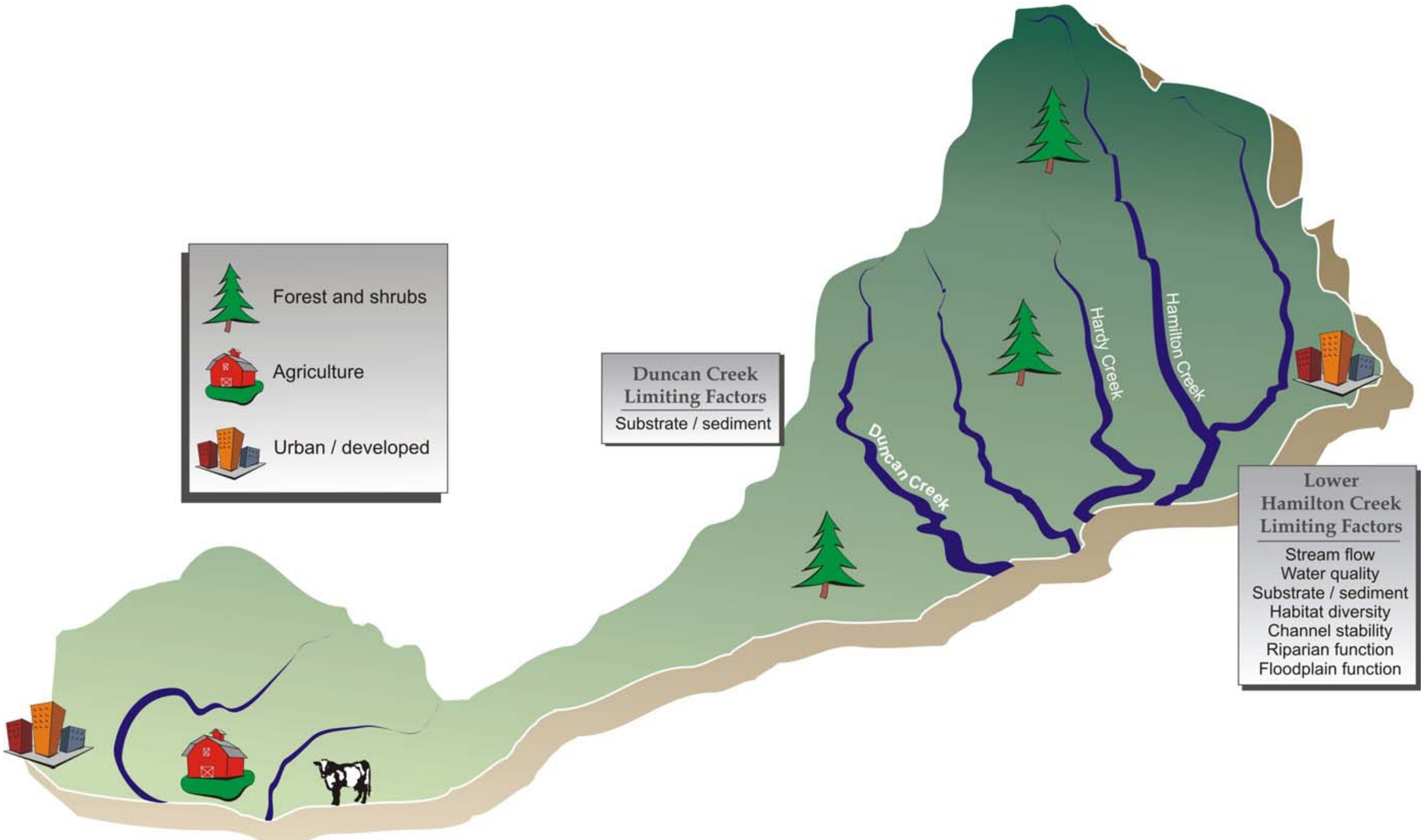


Figure 1. Key features of the Bonneville Tributaries Basin including a summary of limiting fish habitat factors in different areas and the status and relative distribution of focal salmonid species.

2.0 Background

This plan describes a vision and framework for rebuilding salmon and steelhead populations in Washington's Bonneville Tributaries Basin, which is located within the Lower Columbia Tributaries Subbasin as defined by the Northwest Power and Conservation Council (NPCC). The plan addresses subbasin elements of a regional recovery plan for Chinook salmon, chum salmon, coho salmon, steelhead, and bull trout listed or under consideration for listing as Threatened under the federal Endangered Species Act (ESA). The plan also serves as the Subbasin Plan for the NPCC Fish and Wildlife Program to address effects of construction and operation of the Federal Columbia River Power System.

Development of this plan was led and coordinated by the Washington Lower Columbia River Fish Recovery Board (LCFRB). The Board was established by state statute (RCW 77.85.200) in 1998 to oversee and coordinate salmon and steelhead recovery efforts in the lower Columbia region of Washington. It is comprised of representatives from the state legislature, city and county governments, the Cowlitz Tribe, private property owners, hydro project operators, the environmental community, and concerned citizens. A variety of partners representing federal agencies, Tribal Governments, Washington state agencies, regional organizations, and local governments participated in the process through involvement on the LCFRB, a Recovery Planning Steering Committee, planning working groups, public outreach, and other coordinated efforts.

The planning process integrated four interrelated initiatives to produce a single Recovery/Subbasin Plan for Washington subbasins of the lower Columbia:

- Endangered Species Act recovery planning for listed salmon and trout.
- Northwest Power and Conservation Council (NPCC) fish and wildlife subbasin planning for eight full and three partial subbasins.
- Watershed planning pursuant to the Washington Watershed Management Act, RCW 90-82.
- Habitat protection and restoration pursuant to the Washington Salmon Recovery Act, RCW 77.85.

This integrated approach ensures consistency and compatibility of goals, objectives, strategies, priorities and actions; eliminates redundancy in the collection and analysis of data; and establishes the framework for a partnership of federal, state, tribal and local governments under which agencies can effectively and efficiently coordinate planning and implement efforts.

The plan includes an assessment of limiting factors and threats to key fish species, an inventory of related projects and programs, and a management plan to guide actions to address specific factors and threats. The assessment includes a description of the subbasin, focal fish species, current conditions, and evaluations of factors affecting focal fish species inside and outside the subbasin. This assessment forms the scientific and technical foundation for developing a subbasin vision, objectives, strategies, and measures. The inventory summarizes current and planned fish and habitat protection, restoration, and artificial production activities and programs. This inventory illustrates current management direction and existing tools for plan implementation. The management plan details biological objectives, strategies, measures, actions, and expected effects consistent with the planning process goals and the corresponding subbasin vision.

3.0 Assessment

3.1 Subbasin Description

3.1.1 *Topography & Geology*

The Bonneville Tributaries Basin contains the stream systems that drain into the Columbia River between the Washougal River and Bonneville Dam. The basin lies within Clark and Skamania Counties. Streams in the Bonneville Tributaries basin originate on the steep valley walls of the Columbia River Gorge and flow south through Columbia River floodplain terraces before entering the Columbia River. Most of the stream lengths are high gradient and spawning habitat is only available in the lowest reaches. The major streams (from west to east) are Gibbons, Lawton, Duncan, Woodward, Hardy, and Hamilton Creeks. Hamilton Creek has the largest channel length at over 8 miles. Anthropogenic disturbances are related to expanding development (western portion of basin) and transportation corridors that parallel the Columbia River (eastern portion).

Surface geology in the basin is primarily sedimentary, with volcanic material in headwater areas. Lower elevations are underlain by alluvium from catastrophic flooding of the Columbia River during Pleistocene Ice Ages (Bretz Floods) and from more recent floodplain deposits.

3.1.2 *Climate*

The climate is typified by cool, wet winters and warm, dry summers. Temperatures are moderated by mild, moist air flowing up the Columbia from the Pacific. Precipitation levels are high due to orographic effects. Mean annual precipitation is 85 inches at the Skamania Fish Hatchery in the Columbia Gorge. The average annual minimum and maximum temperatures at the Skamania Hatchery are 38°F (3°C) and 62°F (17°C), respectively. Winter temperatures seldom fall below freezing, with very little snowfall (WRCC 2003).

3.1.3 *Land Use, Ownership, and Cover*

The Bonneville Tributaries basin is mostly forested, with a higher degree of residential and agricultural development in the western portion, especially near the town of Washougal. The eastern portion of the basin lies within the Columbia River Gorge National Scenic Area (CRGNSA), where land use and development is limited; however, rural residential and industrial uses are located along the Columbia on the lower reaches of some streams. The State of Washington owns, and the Washington State Department of Natural Resources (DNR) manages the beds of all navigable waters within the subbasin. Any proposed use of those lands must be approved in advance by the DNR. Bonneville Tributaries land ownership and land cover/land use are illustrated by Figure 2 and Figure 3.

3.1.4 *Development Trends*

Human population and development trends vary dramatically between the western and eastern portions of the basin. The western portion of the basin is a populated area adjacent to the expanding city of Washougal, WA. The eastern portion lies within the CRGNSA, is less populated, and is subject to land-use controls associated with the provisions of the CRGNSA. The only population center in the eastern portion of the basin is the town of North Bonneville, situated on the Columbia River just west of Bonneville Dam. The year 2000 population is estimated at approximately 7,000 persons, and is expected to increase to 10,500 by 2020. Population growth will primarily occur in the western portion of the basin and along the Columbia River in the eastern portion. This growth will result in the conversion of forest, rural residential and agricultural land uses to high-density residential uses, with potential impacts to habitat conditions. Land-use changes will provide a variety of risks to terrestrial and aquatic habitats.

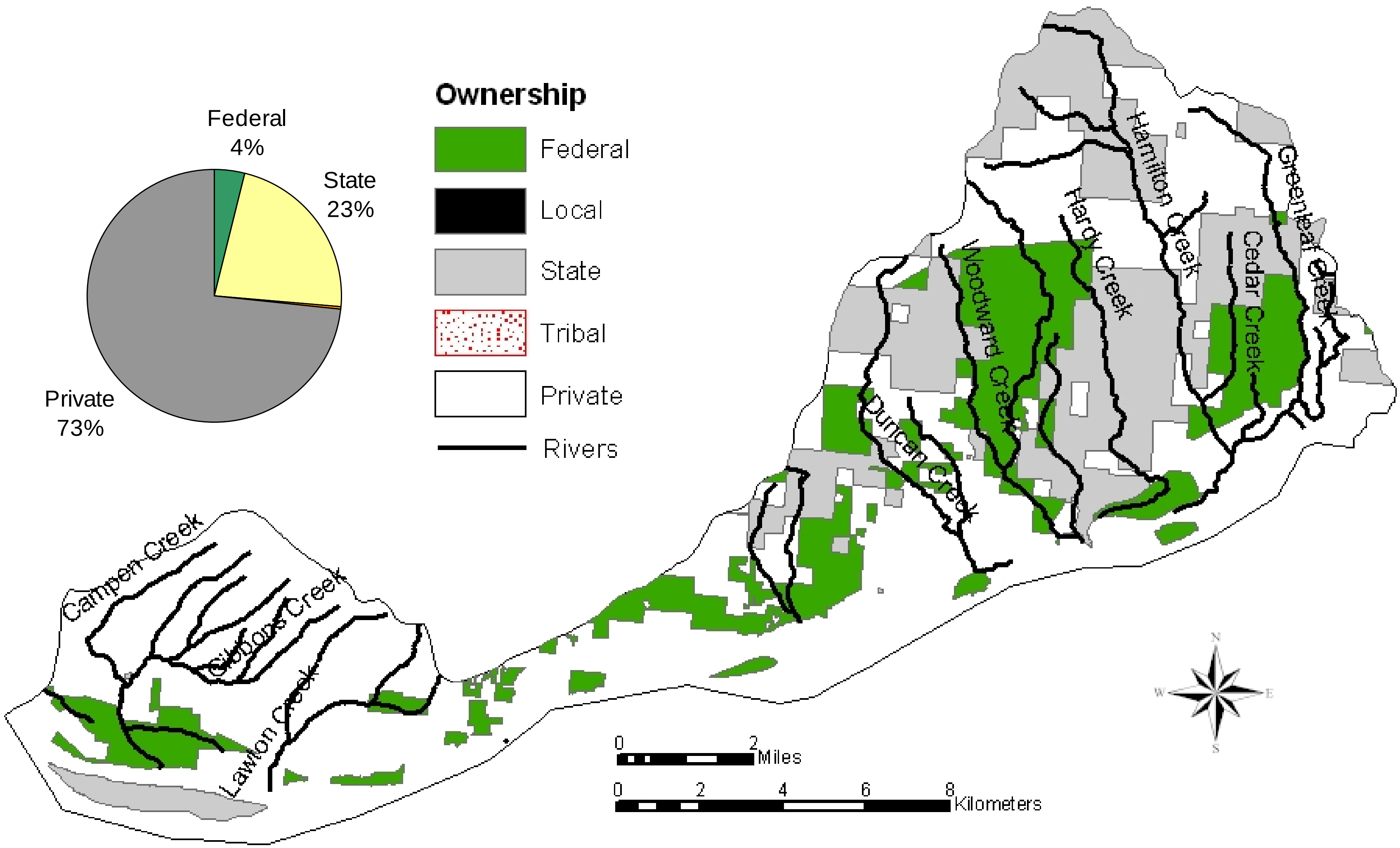


Figure 2. Landownership within the Bonneville Tributaries Basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

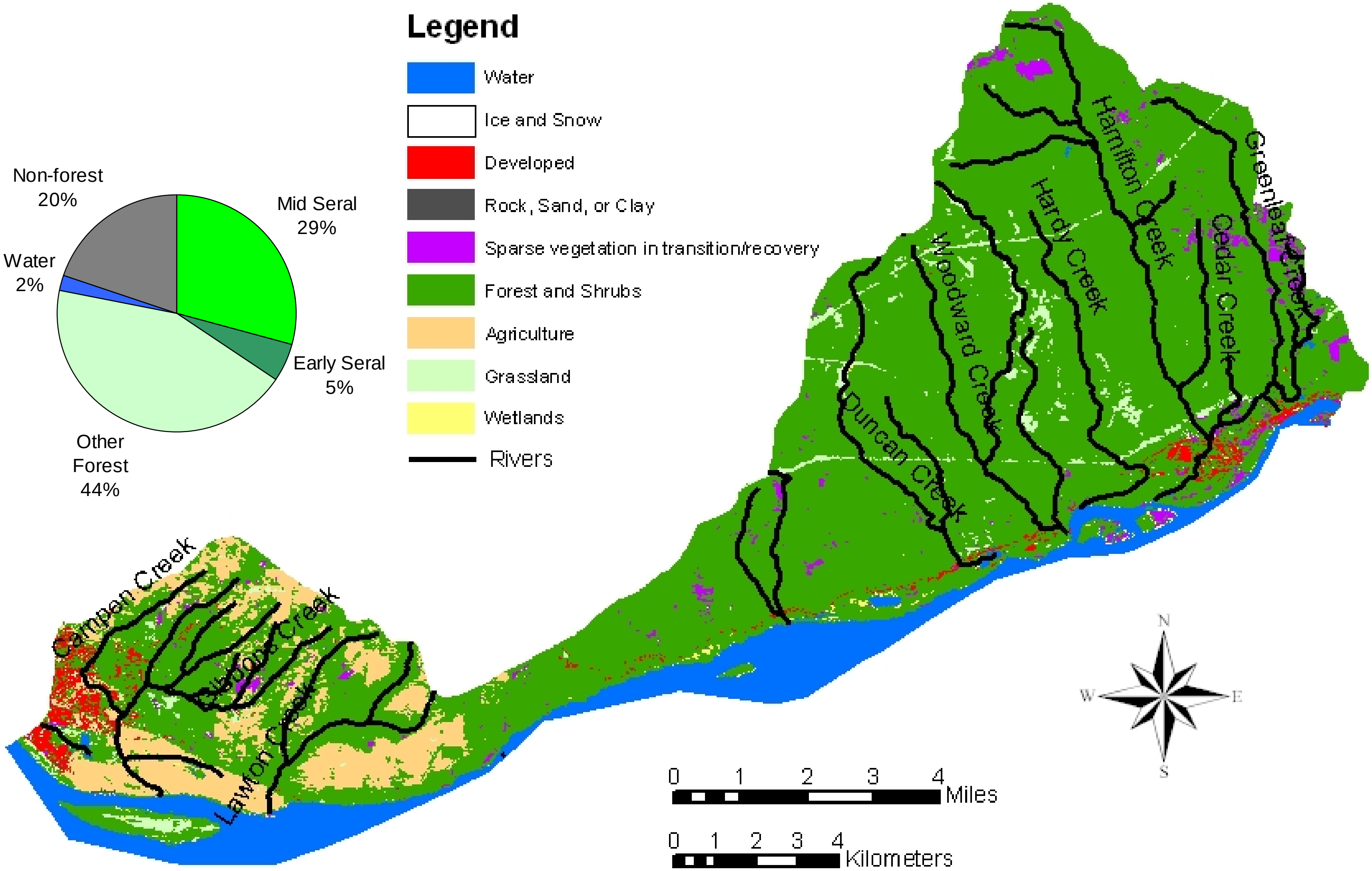


Figure 3. Land cover within the Bonneville Tributaries basin. Vegetation cover (pie chart) derived from Landsat data based on methods in Lunetta et al. (1997). Mapped data was obtained from the USGS National Land Cover Dataset (NLCD).

3.2 Focal and Other Species of Interest

Listed salmon, steelhead, and trout species are focal species of this planning effort for the Bonneville Tributaries Basin. Other species of interest were also identified as appropriate. Species were selected because they are listed or under consideration for listing under the U.S. Endangered Species Act or because viability or use is significantly affected by the Federal Columbia Hydropower system. The Federal hydropower system effects spawning and incubation of Bonneville Tributary salmon with flow operations at Bonneville Dam and migrating juveniles are subject to effects in the Columbia River, estuary, and nearshore ocean. The Bonneville Tributaries ecosystem supports and depends on a wide variety of fish and wildlife in addition to designated species. A comprehensive ecosystem-based approach to salmon and steelhead recovery will provide significant benefits to other native species through restoration of landscape-level processes and habitat conditions. Other fish and wildlife species not directly addressed by this plan are subject to a variety of other Federal, State, and local planning or management activities.

Focal salmonid species in Bonneville Tributaries watersheds include winter steelhead, chum, coho, and fall Chinook. Bull trout do not occur in the basin. Salmon and steelhead numbers have declined to only a fraction of historical levels (Table 1). With the exception of chum, extinction risks are significant for all focal species – the current health or viability of Bonneville tributary salmonids ranges from low for fall Chinook, coho and winter steelhead to medium+ for chum. Returns of Bonneville Tributaries chum include both natural and hatchery produced fish.

Table 1. Status of focal salmond and steelhead populations in the Bonneville Tributaries Basin.

Focal Species	ESA Status	Hatchery Component[1]	Historical numbers[2]	Recent numbers[3]	Current viability[4]	Extinction risk[5]
Bonneville						
Fall Chinook	Threatened	No	300-3,000	100	Low	50%
Chum	Threatened	Yes	9,000-40,000	1,000-6,000	Med+	20%
Coho	Proposed	No	300-13,000	<100	Low	70%
Winter Steelhead	Threatened	No	600-4,000	200-300	Low+	40%

[1] Significant numbers of hatchery fish are released in the basin.
[2] Historical population size inferred from presumed habitat conditions using Ecosystem Diagnosis and Treatment Model and NOAA back-of-envelope calculations..
[3] Approximate current annual range in number of naturally-produced fish returning to the basin.
[4] Propsects for long term persistence based on criteria developed by the NOAA Technical Recovery Team.
[5] Probability of extinction within 100 years corresponding to estimated viability

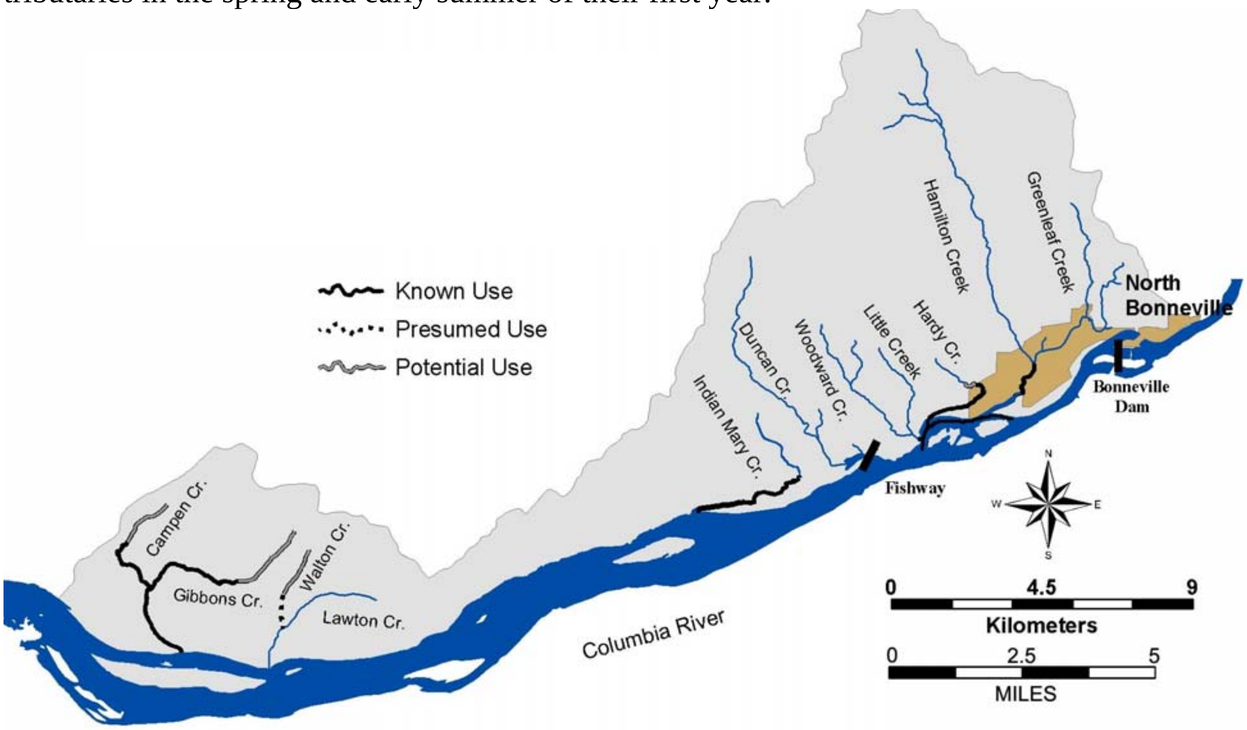
Other species of interest in the Bonneville Tributaries Basin include coastal cutthroat trout and Pacific lamprey. These species have been affected by many of the same habitat factors that have reduced numbers of anadromous salmonids.

Brief summaries of the population characteristics and status follow. Additional information on life history, population characteristics, and status assessments may be found in Appendix A (focal species) and B (other species).

3.2.1 *Fall Chinook—Lower Columbia Tributaries Subbasin (Bonneville Tributaries)*

ESA: Threatened 1999	**SASSI: Unknown 2002**

The historical Bonneville tributary adult tule fall chinook population is estimated from 300-3,000 fish. The current natural spawning number in the tributaries is about 100 tule fall chinook. However, there are significant numbers of upriver bright stock fall Chinook (not part of the lower Columbia ESU) that spawn primarily in the mainstem Columbia near the Bonneville tributaries. Natural spawning of tule fall chinook occurs primarily in the lower reaches of Hamilton and Hardy creeks. Access in the early fall is dependent on mainstem Columbia and tributary flow conditions. Spawning time in the tributaries peaks in October. Juvenile rearing occurs near and downstream of the spawning areas. Juveniles migrate from the Bonneville tributaries in the spring and early summer of their first year.

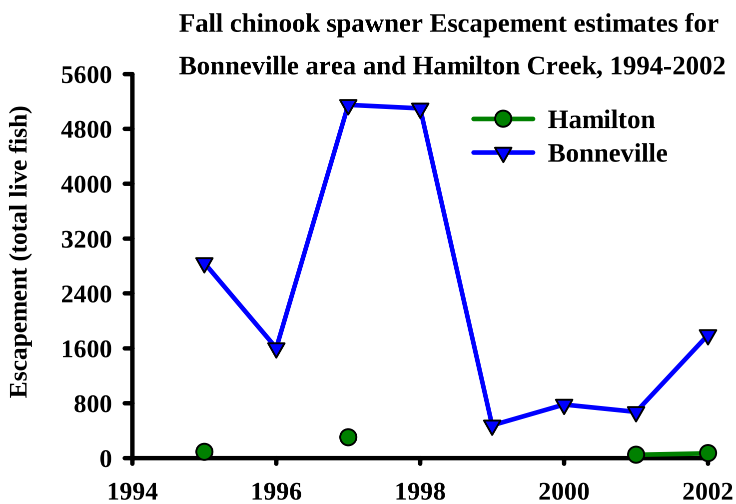


Distribution

- Fall Chinook have recently been observed in the mainstem Columbia River from the upper end of Pierce Island to the lower end of Ives Island, along the Washington shore in Hamilton Slough, between the mouths of Duncan and Hardy Creeks, and in the lower reaches of Hardy and Hamilton Creeks; available spawning habitat depends on the spill regime at Bonneville Dam

Life History

- Fall chinook upstream migration in the Columbia River begins in early August or September, depending on early rainfall
- Spawning in the mainstem Columbia River and Bonneville tributaries occurs from mid-October to late November
- Age ranges from 2 year-old jacks to 6 year-old adults, with dominant adult ages of 3 and 4
- Fry emerge around early April, depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the summer as sub-yearlings



Diversity

- Early spawning components are considered part of the tule population in the lower Columbia River Evolutionary Significant Unit (ESU)
- Bonneville upriver bright fall chinook stock spawning was discovered in 1994 in the mainstem Columbia immediately below Bonneville Dam; stock origin remains unknown; stock was designated based on distinct spawning distribution
- Allozyme analysis indicate that late bright fall chinook, spawning in the mainstem Columbia below Bonneville Dam, are genetically distinct from other Columbia River bright fall chinook stocks although they resemble Yakima bright fall chinook and upriver bright fall chinook maintained at the Little White Salmon National Fish Hatchery and Bonneville Hatchery

Abundance

- Hamilton Creek spawning escapements from 1995-2001 ranged from 47-300 (average 144)
- Bonneville area spawning escapements from 1994-2001 ranged from 477-5,151 (average 2,143)

Productivity & Persistence

- Productivity data is limited for Bonneville area fall chinook
- Seining operations conducted by the WDFW and ODFW have shown consistent juvenile production from late spawning adults in the mainstem Columbia River below Bonneville Dam

Hatchery

- The Spring Creek National Fish Hatchery near the White Salmon River released, 50,160 fall chinook into Hamilton Creek in 1977

Harvest

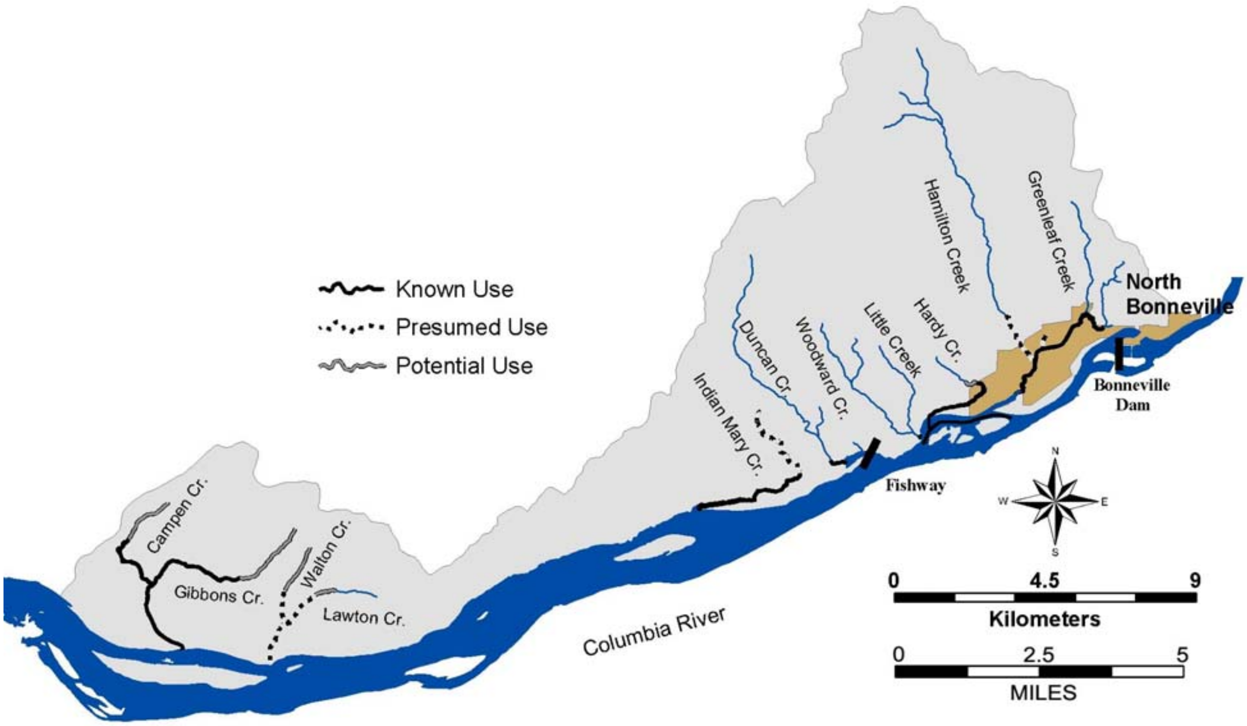
- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska and Columbia River commercial gill net and sport fisheries
- No specific CWT data is available for these populations, however migration patterns and harvest of the bright chinook populations is likely similar to upriver bright (URB) fall chinook and the tule populations similar to lower Columbia hatchery tule chinook

- Columbia River URB chinook harvest is limited to 31.29% based on Endangered Species Act (ESA) limits on Snake River wild fall chinook; however, lower river URB chinook are harvested at a lower rate as they do not pass through the Treaty Indian fishery
- Combined ocean and Columbia River tule fall chinook harvest is currently limited to 49% as a result of ESA limits on Coweeman tule fall chinook
- A popular sport fishery has developed in the mainstem Columbia in late September and early October, targeting on the late spawning bright chinook

3.2.2 *Chum—Lower Columbia Tributaries Subbasin (Bonneville Tributaries)*

ESA: Threatened 1999	SASSI: 2002

The historical Bonneville tributary adult population is estimated from 9,000-40,000. Current natural spawning returns range from 1,000-6,000, including tributary and mainstem Columbia spawning. Spawning occurs in the lower 1.0 miles of Hardy and Hamilton creeks, Hamilton Slough, Duncan Creek, and in the mainstem Columbia near Ives and Pierce islands. Spawning occurs from late November through December. Natural spawning chum in the Bonneville tributaries are all naturally produced as no hatchery chum are released in the area. Juveniles rear in the lower reaches for a short period in the early spring and quickly migrate to the Columbia.



Distribution

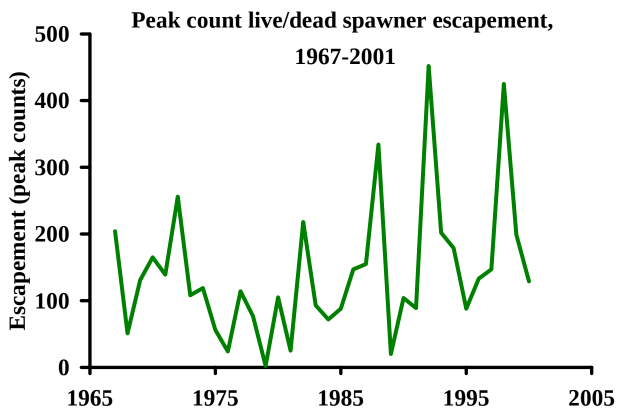
- Spawning occurs in the lower 1.0 miles of Hardy Creek and Hamilton Creeks, Hamilton Slough, Duncan Creek, and in the mainstem Columbia at Ives and Pierce Islands.

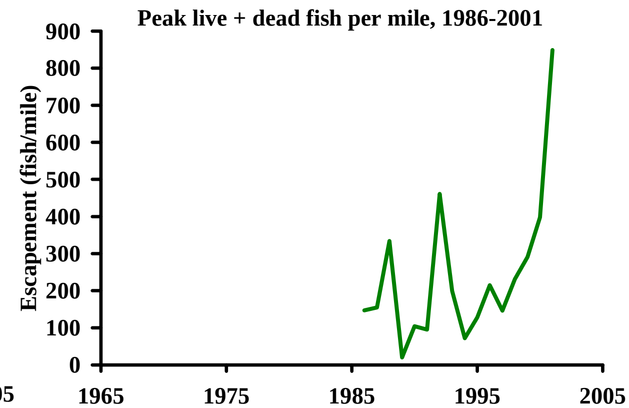
Life History

- Adults enter the lower Columbia tributaries from mid-October through November
- Peak spawning occurs in mid-December, but continues into January
- Dominant adult ages are 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts with little freshwater rearing time

Diversity

- One of two genetically distinct populations in the Columbia River ESU
- Stock designated based on spawning distribution and genetic composition; allozyme and DNA analyses indicate that chum from Hardy Creek, Hamilton Creek, and the mainstem Columbia below Bonneville Dam are one stock (Bonneville chum) and distinct from other Washington Chum stocks





Abundance

- Adult fish/mile ranges from 20-849 for Bonneville chum from 1986-2001 as estimated from peak live/dead escapement ground spawner surveys.
- In 2002, WDFW estimated 2,256 adult chum spawned in Hamilton, Hardy, and Duncan creeks and another 3,209 chum in the mainstem Columbia River near Ives and Pierce islands

Productivity & Persistence

- NMFS Status Assessment indicated a 0.0 risk of 90% decline in 25 years and a 0.01 risk of 90% decline in 50 years for Hardy Creek and a 0.4 risk of 90% decline in 25 years and a 0.86 risk of 90% decline in 50 years for Hamilton Creek; the risk of extinction was not applicable
- Hardy and Hamilton Creeks population forms one of the most productive populations remaining in the Columbia basin
- A chum habitat restoration and enhancement program is currently underway in Duncan Creek

Hatchery

- Hatchery releases have not occurred on Hardy or Hamilton Creeks; USFWS maintains and artificial spawning channel in Hardy Creek to increase chum spawning habitat
- Washougal Hatchery is currently rearing Hardy Creek stock chum to enhance returns to Duncan Creek

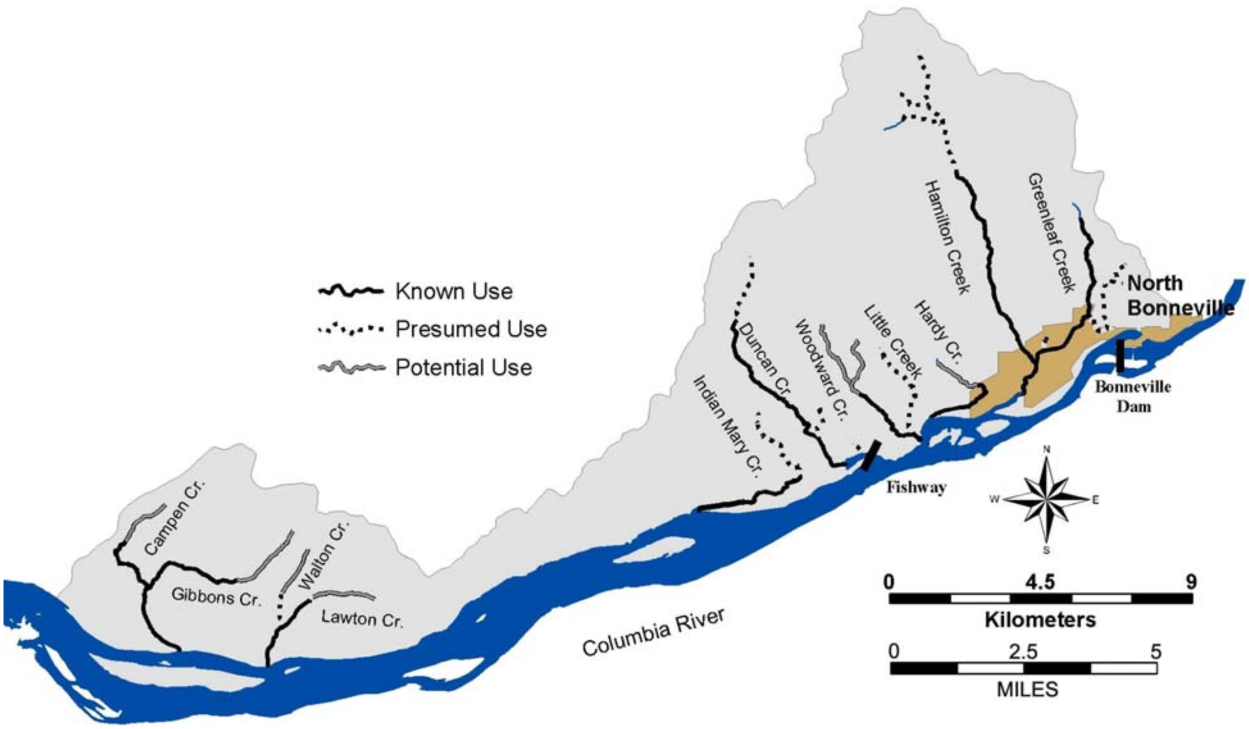
Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less then 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less then 5% of the annual return

3.2.3 *Coho—Lower Columbia Subbasin*

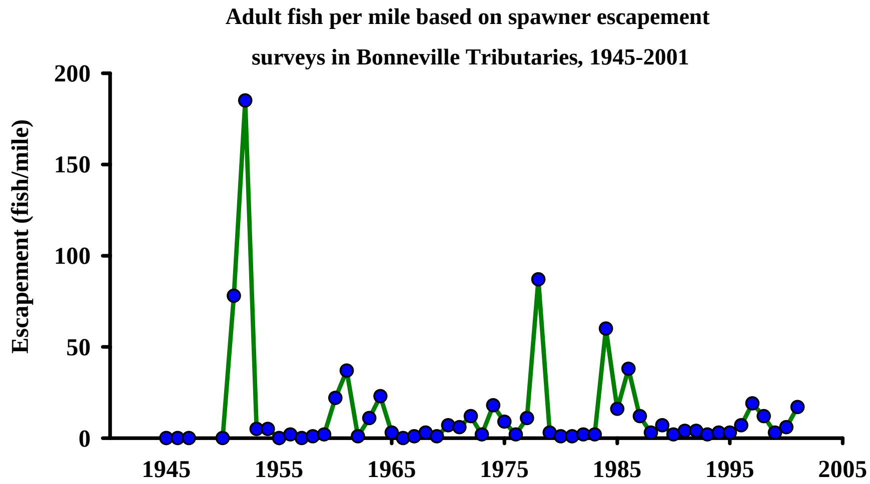
ESA: Candidate 1995	SASSI: Bonneville Tributaries—Depressed 2002; Salmon Creek—Unknown 2002

The historical Bonneville tributary adult population is estimated from 300-13,000, with both early and late stock coho produced. Current natural spawning returns are presumed to be 100 fish or less. There is no hatchery production in the Bonneville tributaries. Natural spawning can occur in Hamilton, Greenleaf, Hardy, Woodard, Duncan, Gibbons and Lawton creeks. Early coho spawning occurs from mid October to mid-November and late coho from mid-Novenber to March. Juvenile rearing occurs upstream and downstream of spawning areas. Juveniles rear for a full year in the Bonneville tributaries before migrating as yearlings in the spring.



Distribution

- Managers refer to late stock coho as Type N due to their ocean distribution generally north of the Columbia River
- Managers refer to early stock coho as Type S due to their ocean distribution generally south of the Columbia River
- Hamilton, Hardy, Woodward, and Duncan Creeks are small Columbia River tributaries located just downstream of Bonneville Dam; Greenleaf Creek is a tributary of Hamilton Creek
- Gibbons, Lawton, and St. Cloud Creeks are located upstream of the Washougal River



Life History

- Adults enter the Columbia River from mid-September through mid-December
- Peak spawning occurs in December to early January for late stock coho
- Peak spawning occurs in late October to mid November for early stock
- Adults return as 2-year old jacks (age 1.1) or 3-year old adults (age 1.2)
- Fry emerge in the spring, spend one year in fresh water, and emigrate as age-1 smolts the following spring

Diversity

- Native population in the Bonneville tributaries (Duncan, Hardy, and Hamilton Creeks) were late stock coho (or type N)
- Other tributaries with historical coho production include: Gibbons Creek, Lawton Creek, St. Cloud Creek, Woodward Creek, and Greenleaf Creek (a tributary of Hamilton Creek)
- Columbia River early and late stock coho produced at Washington hatcheries are genetically similar

Abundance

- Wild coho runs in these Bonneville area small tributaries are believed to be a fraction of historical size
- WDFW (1951) estimated a coho escapement of 2,050 for Salmon Creek and the small tributaries between the Washougal River and Bonneville Dam combined
- Escapement surveys from 1945-2001 on Duncan, Hardy, Hamilton, and Greenleaf Creeks documented a range of 0-185 fish/mile

Productivity & Persistence

- Natural coho spawning is presumed to be very low
- Chum recovery efforts in Duncan, Hardy, and Hamilton creeks should improve coho production potential

Hatchery

- There are no hatcheries on any of these tributaries
- Washougal Hatchery late coho were planted in Duncan and Greenleaf Creeks in 1983

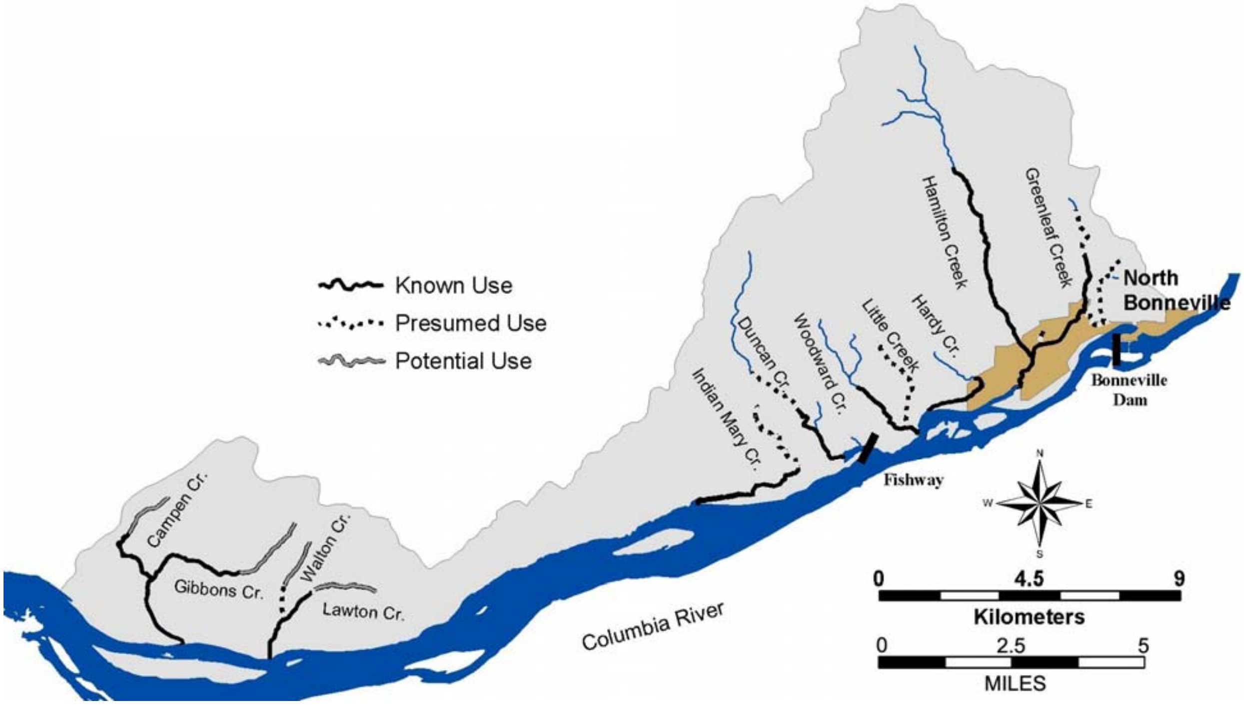
Harvest

- Until recent years, natural produced coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% from 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations
- Columbia River commercial coho fisheries in November were eliminated in the 1990s to reduce harvest of late Clackamas River coho
- Since 1999, Columbia River hatchery coho returns have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Naturally-produced lower Columbia coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon coastal coho and Oregon listed Clackamas and Sandy coho
- During 1999-2002, harvest rates on ESA listed coho were less than 15% each year
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho is constrained in September by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during peak abundance of late hatchery coho
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early hatchery coho, but late hatchery coho harvest can also be substantial
- There is no sport harvest in these tributaries
- Harvest of coho produced in these lower Columbia tributaries is assumed to be similar to Oregon’s Clackamas and Sandy coho, which were harvested at less then 15% during 1999-2002
- There are no adipose fin-clipped hatchery fish released in these tributaries

3.2.4 *Winter Steelhead—Lower Columbia Tributaries Subbasin (Bonneville Tributaries)*

ESA: Threatened 1998	SASSI: Unknown 2002

The historical Bonneville adult population is estimated from 600-4,000 fish. Current natural spawning returns are 200-300 fish. Spawning occurs primarily in the lower 2 miles of Hamilton Creek. Spawning time is early March to early June. Juvenile rearing occurs both downstream and upstream of the spawning areas. Juveniles rear for a full year or more before migrating from the Bonneville tributaries.



Distribution

- Winter steelhead are distributed throughout the lower reaches of Hamilton Creek (~2 mi)

Life History

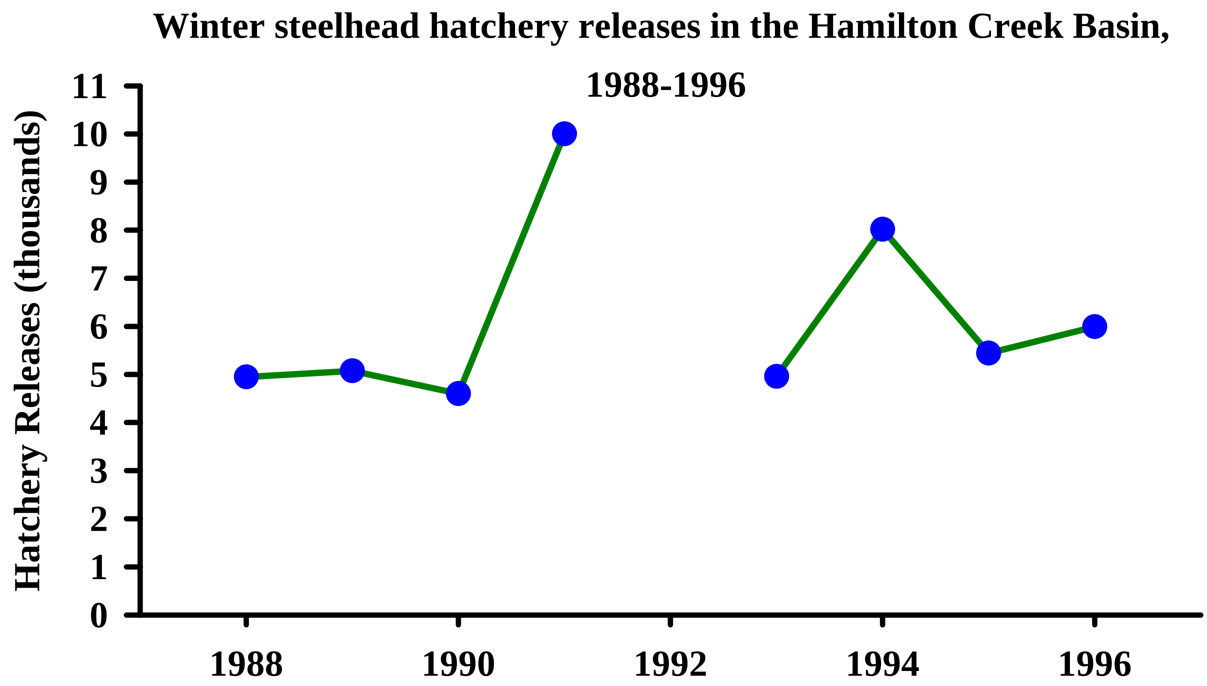
- Adult migration timing for Hamilton Creek winter steelhead is from December through April
- Spawning timing on Hamilton Creek is generally from early March to early June
- Age composition data for Hamilton Creek winter steelhead are not available
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

Diversity

- Hamilton Creek winter steelhead stock is designated based on distinct spawning distribution
- Wild stock interbreeding with Skamania and Beaver Creek Hatchery brood stock is a potential concern

Abundance

- In 1936, steelhead were reported in Hamilton Creek during escapement surveys
- Wild winter steelhead escapement estimates for Hamilton Creek are not available



Productivity & Persistence

- Winter steelhead natural production is expected to be low

Hatchery

- There are no hatcheries on Hamilton Creek; hatchery winter steelhead from the Skamania (Washougal) and Beaver Creek (Elochoman) Hatcheries have been planted in the basin since 1958; release data are displayed from 1988-1991
- Hatchery fish contribute little to natural winter steelhead production in the Hamilton Creek basin

Harvest

- No directed commercial or tribal fisheries target Hamilton Creek winter steelhead; incidental mortality currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur in the Hamilton Creek basin
- Winter steelhead sport harvest (hatchery and wild) in Hamilton Creek from 1977-1986 averaged 21 fish; since 1992, regulations limit harvest to hatchery fish only
- ESA practice limits fishery impact on Hamilton Creek wild winter steelhead in the mainstem Columbia River and in Hamilton Creek

3.2.5 *Other Species*

Pacific lamprey – Information on lamprey abundance is limited and does not exist for Columbia lower tributary populations. However, based on declining trends measured at Bonneville Dam and Willamette Falls it is assumed that Pacific lamprey have declined in the Columbia Lower Tributaries Subbasin also. Adult lamprey return from the ocean to spawn in the spring and summer. Juveniles rear in freshwater up to seven years before migrating to the ocean.

3.3 Subbasin Habitat Conditions

This section describes the current condition of aquatic and terrestrial habitats within the basin. Descriptions are included for habitat features of particular significance to focal salmonid species including watershed hydrology, passage obstructions, water quality, key habitat availability, substrate and sediment, woody debris, channel stability, riparian function, and floodplain function. These descriptions will form the basis for subsequent assessments of the effects of habitat conditions on focal salmonids and opportunities for improvement.

3.3.1 *Watershed Hydrology*

The Bonneville Tributary basins have not had substantial impacts to hydrologic regimes, as much of the area is steep and is now protected by the provisions of the Columbia River Gorge National Scenic Area legislation. There are no permanent stream gages in the basin and little information exists on flow conditions. The streams follow the same general pattern as precipitation due to a lack of storage in the form of impoundments or permanent snowpacks.

The operation of Bonneville Dam has altered flow regimes to some degree in lower Greenleaf and Hamilton Creeks due to reduced connections to overflow channels (Wade 2001). Manipulation of stream flow occurs in a couple of streams. In lower Gibbons Creek, flow exceeding 70 cfs is diverted out of the elevated, artificial channel and into a remnant channel. In Duncan Creek, flow is impounded at the dam near the mouth during the summer months to provide a recreational pond for area residents. Flows are released through the dam at other times of the year to provide adequate passage flows for fish.

Hydrologic (runoff) conditions were investigated as part of the Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter. The IWA results indicate that watershed conditions in 3 of the 7 subwatersheds are “impaired” with respect to conditions that influence runoff; 3 are “moderately impaired”; and only 1 is rated as “functional” (upper Hamilton Creek). The greatest impairments are located in the Lawton Creek, Hardy/Woodward Creek, Duncan Creek, and Indian Mary Creek basins. Runoff impairment in the basin is related primarily to low quantities of mature forest and high road densities. Nearly 60% of the land cover in the Gibbons and Lawton Creek basins is in either non-forest (i.e. urban, agriculture) or other (i.e. cleared, scrub) cover. Over 46% of the land cover in the Duncan, Woodward, Hardy, Hamilton, and Greenleaf Creek basins is in these categories. Land cover conditions, combined with moderate-to-high road densities (>2 mi/mi^2), increase the risk of elevated peak flows and reduced base flows.

An instream flow study utilizing the toe-width method was conducted in 1998 on Gibbons, Lawton, Duncan, Woodward, Hardy, Greenleaf, and Hamilton Creeks. Spot flow measurements were taken at three different times in the fall to compare to optimal flows for salmon and steelhead. Results suggested that for all streams, the flows were well below optimum for both salmon and steelhead spawning and rearing from the first part of September to

November (Caldwell et al. 1999). Summer low flow problems have also been observed at the mouths of several streams and may possibly restrict fish passage and strand juvenile fish (Wade 2001).

Current and projected future consumptive water use in the basin is believed to represent a threat to instream flows where development may occur. Surface water rights appropriation has not been closed for these streams (LCFRB 2001).

3.3.2 *Passage Obstructions*

An historical wetland complex on Gibbons Creek was modified in 1966, creating fish passage problems. Fish passage restoration efforts completed in 1992 resulted in an elevated artificial channel with a fish ladder structure at the mouth. Observations in the summer of 2000 suggest that there may be some passage problems associated with the fish ladder and low flows at the mouth area. Passage problems are also associated with the structure that diverts water into the elevated channel at the head of the historical wetland complex. Bedload buildup during stormflows restricts overflow through a screened intake that feeds the wetlands, overwhelming the diversion channel and spilling fish into adjacent fields, where they become stranded (Wade 2001). Several culverts and other artificial barriers also block passage within the Gibbons Creek basin. Details are given in Wade (2001).

Culverts under State Route 14 and the railroad corridor provide various levels of passage concerns on Mary Creek, Woodward Creek, and Hardy Creek. Passage has been blocked on Greenia Creek (Hardy Creek tributary) to prevent fish access to a wetland managed as a western pond turtle refuge. On many of the streams, there are concerns with low flow problems associated with sediment buildup where the streams enter the Columbia. Flow becomes subsurface at times during the summer.

In the past, an earthen dam near the mouth of Duncan Creek restricted anadromous passage to this important chum spawning stream. Restoration of passage has been accomplished with the installation of a dam and fishway that allow for passage at critical migration periods, but retain recreational lake levels during the summer months.

3.3.3 *Water Quality*

Gibbons Creek is listed on the state 303(d) list for violation of fecal coliform standards. Fecal coliform levels are believed to originate from failing septic systems and small livestock operations. The greatest proportion of the fecal coliform load comes from the Gibbons Creek tributary Campen Creek (Post 2000). Temperature monitoring in the Gibbons Creek basin in the late 1990s showed regular exceedances of the state standard (64°F [18°C]) in lower Gibbons Creek and lower Campen Creek. This likely is a result of the low riparian canopy cover levels in these reaches. Water temperatures exceeded 68°F (20°C) in lower Hardy Creek on a few summer days in 1998 and 1999. Water temperature information is generally lacking for other streams.

The USFWS conducted a benthic macroinvertebrate survey at 4 sites on Gibbons and Campen Creek using the Benthic Index of Biotic Integrity (B-IBI). This survey methodology uses the presence of particular benthic macroinvertebrate communities as an indicator of overall stream health (Kerans and Karr 1994). Results revealed poor riffle and pool habitat in Campen Creek along the golf course and fair to excellent riffle and pool habitat conditions at the other locations (Wade 2001).

Nutrient deficiencies are an assumed problem due to low anadromous salmonid escapement levels compared to historical conditions. Low returns can reduce the input of carcass derived nutrients into stream systems.

3.3.4 *Key Habitat Availability*

State Highway 14 and the Burlington Northern Santa Fe Railroad impact channel morphologies in the lower reaches of most streams. Pool habitat was found to be lacking in 13 out of 19 surveyed reaches in Woodward, Duncan, Good Bear, Hardy, Hamilton, and Greenleaf Creeks. Eight of 11 surveyed reaches in the Gibbons Creek basin had less than 15% of the stream surface area in pools, though a few pools in the basin have considerable area and depth that may provide adequate habitat (Wade 2001).

The presence of side channel habitats is limited to only the lower portions of most of the streams. State Route 14, the railroad, and other development have isolated some of the historical side channels. There is some good side channel and off-channel habitat in lower Hamilton Creek, including the Hamilton Springs chum spawning channel. Minimal side or off-channel habitat exists in Woodward, Good Bear, Hardy, Duncan, or Greenleaf Creeks. Historically abundant side channel habitat was eliminated in Gibbons Creek as a result of modifications to wetlands in the lower reaches. The stream currently courses though an elevated artificial channel in its lower mile (Wade 2001).

3.3.5 *Substrate & Sediment*

USFWS surveys indicate that fine sediment is a problem throughout the Gibbons Creek basin, with all of the 11 surveyed reaches having greater than 18% fines. Only a few reaches in the upper Gibbons Creek basin had substrates suitable for salmonids. USFS surveys revealed that only the 2 upper reaches of Woodward Creek suffered from embedded substrates and that most surveyed streams consisted primarily of gravels. Local experts have expressed a concern over fine sediments in spawning areas in Hardy Creek. While Hamilton Creek does not suffer from fine sediment problems, there are concerns with the effect of bedload instability on chum production (Wade 2001). Many streams deposit large amounts of coarse sediment as they emerge from steep canyons in the Gorge. Some of this material does not reach important spawning areas due to artificial obstructions and it also creates problematic changes to channel morphology as it is routed through culverts and diversions.

Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. The IWA rated all the subwatersheds in the basin as “moderately impaired” with respect to landscape conditions that influence sediment supply. Sediment supply impairments are related to steep slopes and moderately high road densities. Average road densities in the basin fall between 2-3 mi/mi2, considered moderate by most standards.There are a total of approximately 26 miles of stream-adjacent roads and an average of over four stream crossings per mile. These conditions may serve to increase sediment production and delivery to stream systems.

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes

3.3.6 *Woody Debris*

USFS surveys noted low LWD levels in Woodward, Duncan, Good Bear, Hamilton, and Greenleaf Creeks, with a general increase in LWD levels in the upstream direction. All surveyed reaches had less than 0.2 pieces of LWD/meter of stream. Lower Hamilton and Greenleaf Creeks had the lowest amounts. Medium and large LWD is also lacking in the Gibbons Creek basin, with all surveyed reaches receiving a poor rating. LWD levels are also considered low in Hardy and Indian Mary Creeks (Wade 2001).

3.3.7 *Channel Stability*

Information on bank stability is largely lacking. USFS surveys between 1994 and 1996 revealed generally good bank stability conditions on Hamilton and Greenleaf Creeks, except for a couple of portions of lower Hamilton Creek. Lower Woodward Creek is considered very unstable below the railroad. USFS surveys found moderately high width/depth ratios on many of the lower reaches of streams, indicating the potential for lateral bank erosion (Wade 2001).

3.3.8 *Riparian Function*

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, riparian conditions are "moderately impaired" in all but 1 of the 7 subwatersheds in the basin. Only the upper Hamilton Creek subwatershed received a rating of "functional". These results are consistent with an analysis of georeferenced Landsat satellite imagery data, which revealed that less than 10% of the riparian forests in the basin were in mid- to late-seral stages, and most of these were located in upper tributaries above the extent of anadromous habitats (Lewis County GIS 2000). Surveys by the USFS in the mid-1990s also revealed generally poor riparian conditions; only 5 of 18 surveyed reaches contained any large trees and most of the riparian areas were dominated by shrub/seedling, pole/sapling, or small tree associations. Riparian areas lack coniferous cover along lower Lawton Creek where Himalayan blackberry dominates. The Woodward Creek basin has experienced extensive logging and the riparian areas are dominated by deciduous species. Despite generally poor riparian conditions throughout the basin, surveys of canopy density in the Gibbons Creek basin showed good (>75%) cover in all but 2 reaches. These are lower Gibbons Creek (65%), where the stream flows in the artificial diversion channel, and lower Campen Creek (64%), where the stream flows through a golf course (Wade 2001).

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

3.3.9 *Floodplain Function*

Most of the Bonneville tributaries emerge from steep canyons in the Columbia Gorge and historically contained only short sections with floodplains just upstream of their confluence with the Columbia. State Route 14, the railroad corridor, and other developments have largely eliminated floodplain connection and function (Wade 2001).

An historical wetland complex on lower Gibbons Creek was diked, drained, and diverted in the 1960s and fish passage problems were created. In an effort to restore the wetlands and fish passage, an artificial, elevated channel was constructed that provides access to spawning grounds further upstream. As a result, the stream has been disconnected from its floodplain in the lower mile, and fish access has been blocked to off-channel habitats that once existed in the Gibbons

Creek and Columbia River floodplains (Wade 2001). On the Gibbons Creek tributary Campen Creek, a golf course has reduced the availability of complex floodplain habitats.

Floodplain connection has been disrupted on various other streams due to dikes, filling, gravel mining operations, channelization, and diversion. See Wade (2001) for a complete description.

3.4 Stream Habitat Limitations

A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Bonneville Tributaries steelhead, chum, fall chinook and coho. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Appendix E.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

3.4.1 *Population Analysis*

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed for winter steelhead, fall chinook, chum and coho in the lower Columbia Gorge basins of Hardy, Hamilton, and Duncan Creeks. Salmon and steelhead use has also been documented in several other small lower Gorge tributaries (i.e. Gibbons and Lawton Creeks), but abundance in these streams is believed to be low. Although the EDT model was run independently for Hardy, Hamilton, and Duncan Creeks (HHD), the model outputs of these streams have been combined.

Model results indicate that adult productivity has declined for all species (Table 2). Both chum and winter steelhead have seen the sharpest decline in productivity, with current estimates at approximately 30% of historical levels. Adult abundance has also declined for all species in the HHD basins (Figure 4). Fall chinook and winter steelhead abundance has declined by 45% and 56% from historical levels, respectively. Chum and coho abundance has declined more significantly, to 14% and 20% of historical levels, respectively. Species diversity (as measured by the diversity index) has remained relatively constant for chum but has decreased by 47% for winter steelhead, by 50% for fall chinook, and by 63% for coho (Table 2).

Smolt productivity numbers are also lower for each species, except chum (Table 2). In the case of chum, this seems counter-intuitive due to the fact that chum adult abundance has declined the most out of the four species. This relatively higher smolt productivity is an artifact of the way the EDT model calculates productivity. That is, the higher productivity of chum smolts is because HHD chum now have many less trajectories (life history pathways) that are viable (those that result in return spawners); but the few trajectories that remain have higher productivities than historical trajectories (many of which were only marginally viable). Smolt abundance numbers have also declined for all species (Table 2). Current smolt abundance estimates range from 19% of historical levels for coho to 69% of historical levels for winter steelhead.

Model results indicate that restoration to PFC conditions would produce substantial benefits for all species (Table 2). Adult returns of winter steelhead and fall chinook would increase by an estimated 11% and 36%, respectively, while adult returns of chum and coho would increase by an estimated 144% and 117%, respectively. Similar results would be seen for smolt abundance (Table 2).

Table 2. Bonneville Tributaries— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**
Fall Chinook	124	168	225	4.4	5.9	7.0	0.44	0.44	0.88	36,961	52,311	64,512	817	1,040	1,130
Chum	797	1,943	5,842	3.5	8.5	11.4	0.97	1.00	1.00	80,161	121,877	166,842	164	164	137
Coho	57	123	280	5.1	7.5	10.2	0.37	0.44	0.98	1,663	3,760	8,528	154	234	313
Winter Steelhead	244	270	556	15.7	19.0	45.8	0.40	0.47	0.76	2,400	2,628	3,496	188	233	344

[1] Estimate represents historical conditions in the basin and current conditions in the mainstem and estuary.

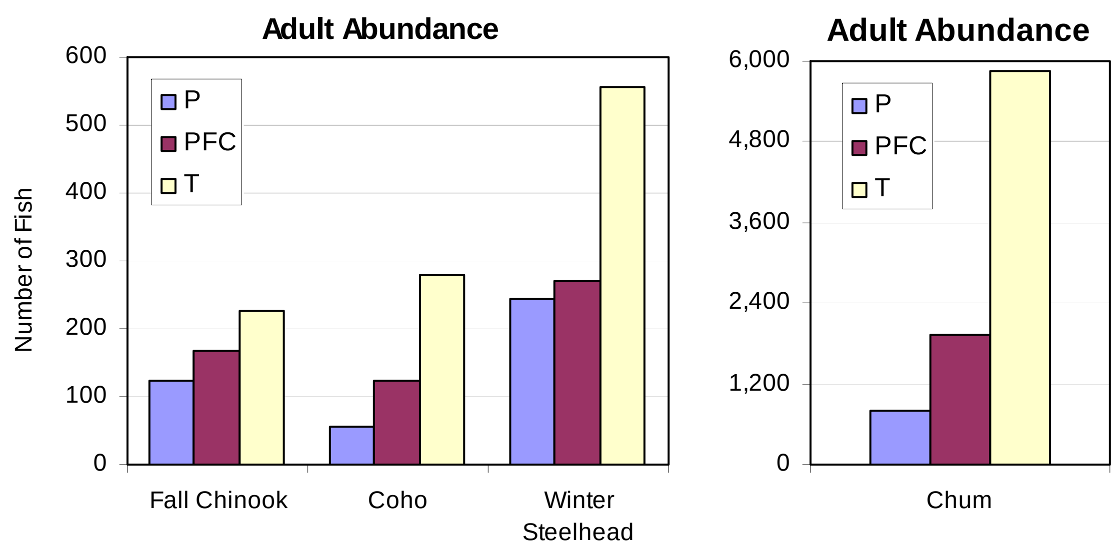


Figure 4. Adult abundance of Bonneville tributary fall chinook, coho, winter steelhead, and chum based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

3.4.2 *Stream Reach Analysis*

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given basin.

The lower Gorge tributaries of Hardy, Hamilton, and Duncan Creeks were divided into numerous individual reaches. These reaches represent the low gradient, lower portions of these systems that are accessible to anadromous fish. Upstream of these reaches, gradients increase dramatically where the stream valleys carve through the steep valley walls of the Columbia Gorge. Hamilton Creek has the greatest length and capacity for fish, and also has the longest tributary, Greenleaf Creek. See Figure 5 for a map of stream reaches within the HHD basins.

Important areas for chum include the Duncan Lake outlet (reach Lake outlet), lower Hamilton (Hamilton 1A, Hamilton 2 and Hamilton Springs) and Hardy Creeks (Hardy 2) (Figure 6). These reaches include some of the most productive chum spawning and rearing areas in the basin. These reaches (especially Lake Outlet) show a strong habitat preservation emphasis.

There was only one high priority reach for fall chinook, located in lower Hamilton Creek (Hamilton 1A) (Figure 7). This high priority reach has a combined habitat preservation and restoration emphasis.

High priority reaches for coho are located in Hamilton and Duncan Creeks (Hamilton 2 and Duncan 1) (Figure 8). Although these areas are considered important spawning reaches, the available habitat has been somewhat degraded. As a result, both high priority reaches show a restoration emphasis. Reach Hamilton 2 has the highest restoration potential of any coho reach modeled in the three basins.

As for fall Chinook, there was only one high priority reach for winter steelhead; located in upper Hamilton Creek (Hamilton 4) (Figure 9). This reach is important for steelhead spawning, and appears to be the least degraded. This reach has the strongest habitat preservation emphasis of any winter steelhead reach in the three basin.

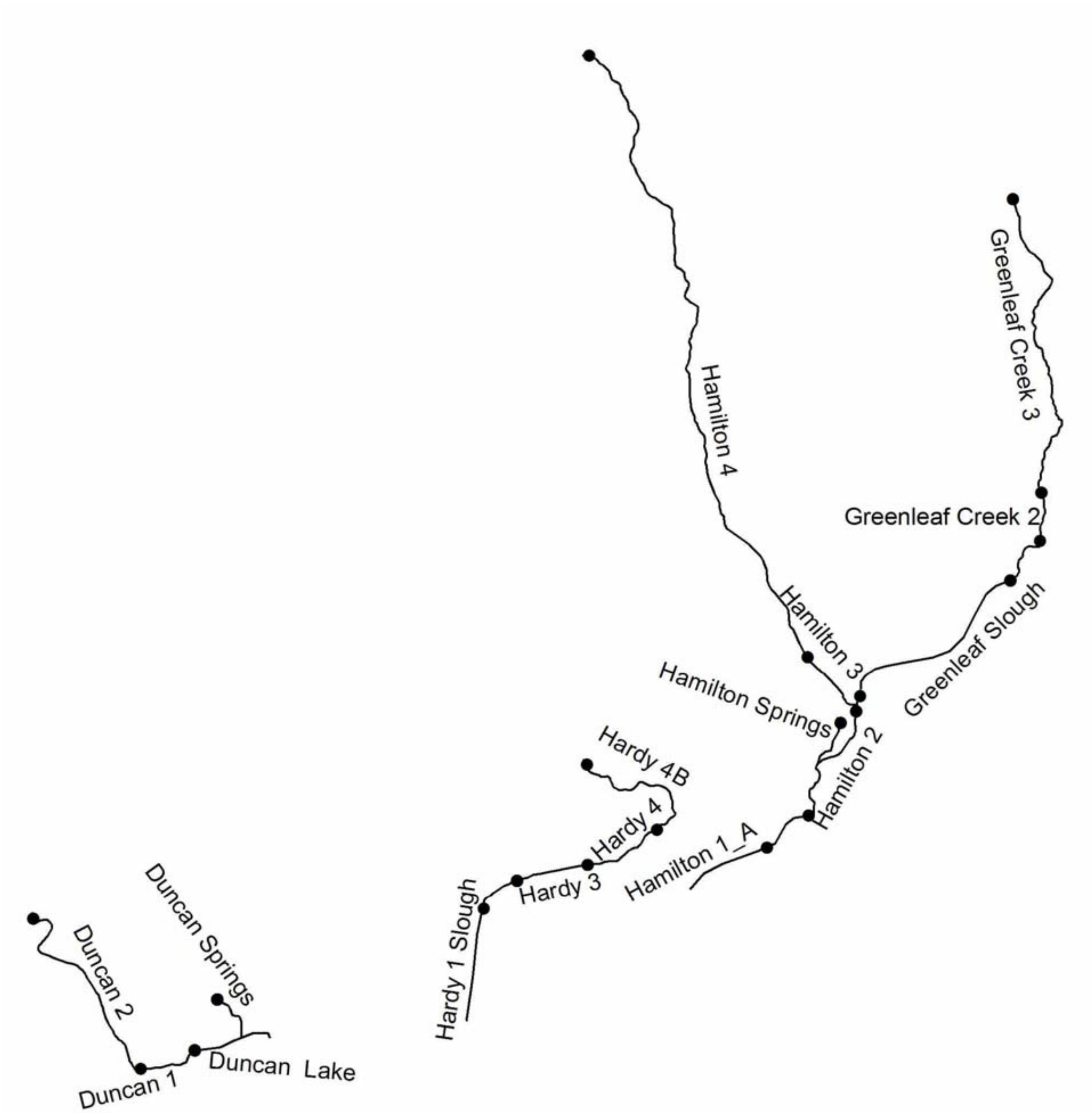


Figure 5. Bonneville Tributaries EDT reaches. Some reaches are not labeled for clarity.

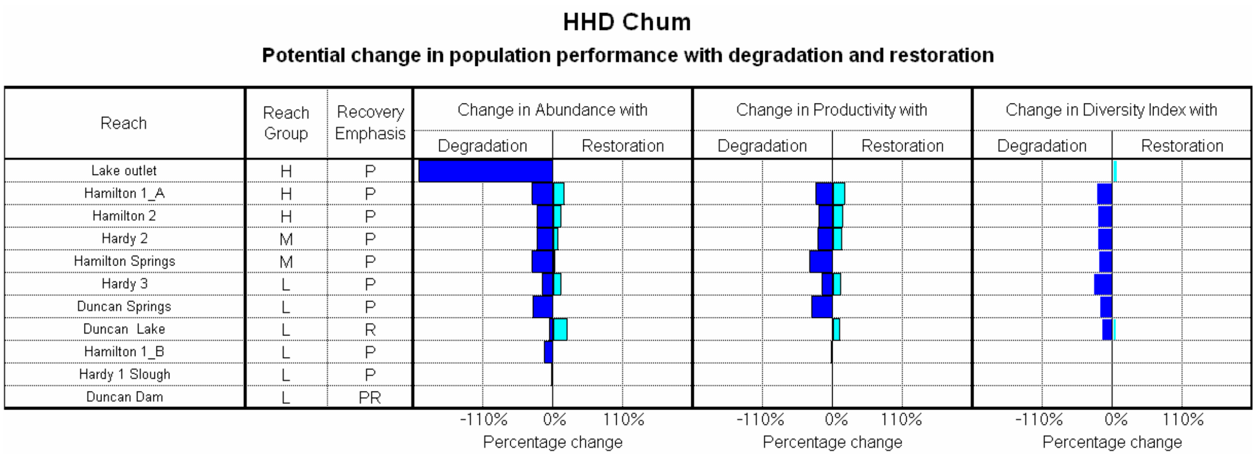


Figure 6. Bonneville Tributaries chum ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. See Appendix E Chapter 6 for more information on EDT ladder diagrams. Percentage change values are expressed as the change per 1000 meters of stream length within the reach.

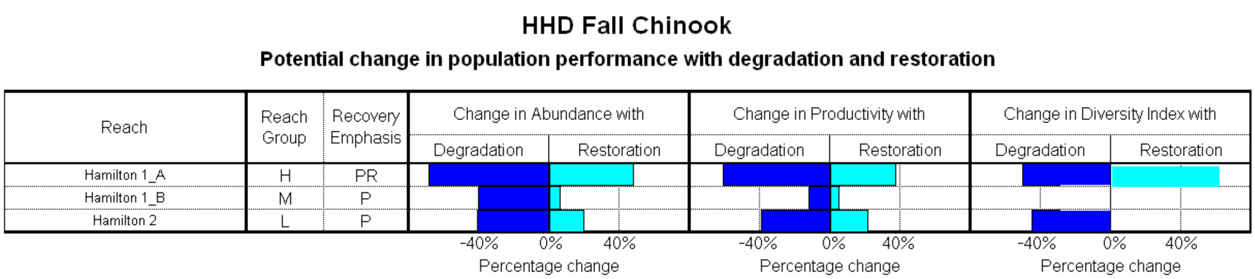


Figure 7. Bonneville Tributaries fall chinook ladder diagram.

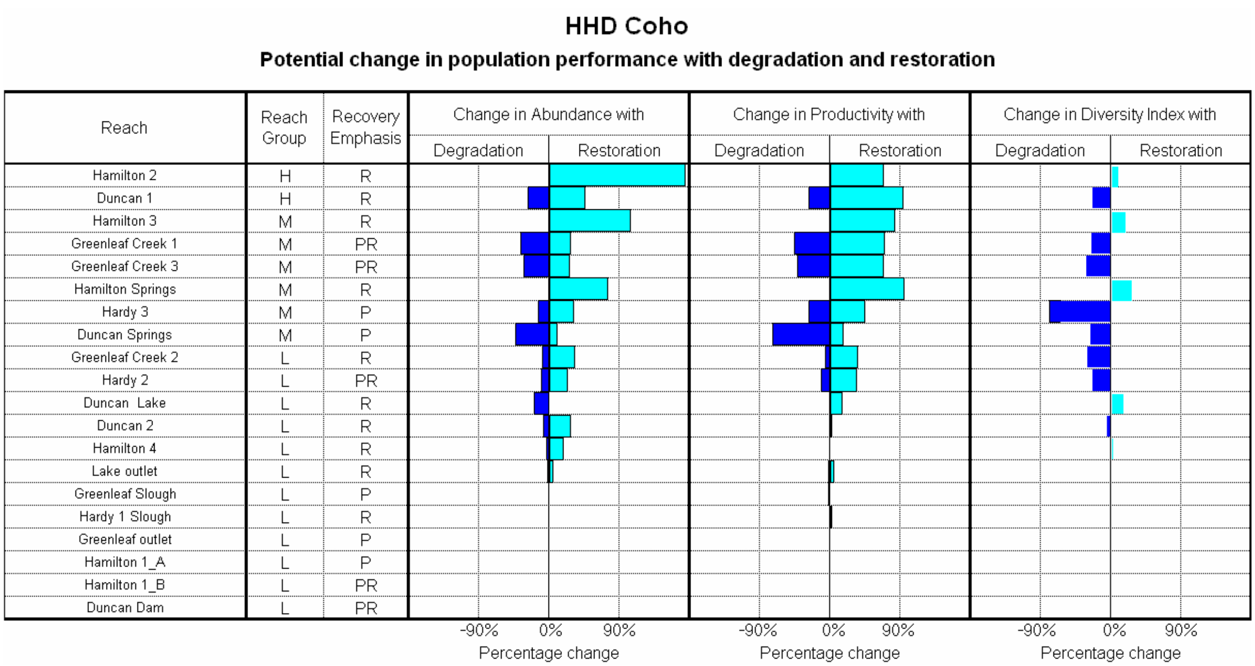


Figure 8. Bonneville Tributaries coho ladder diagram.

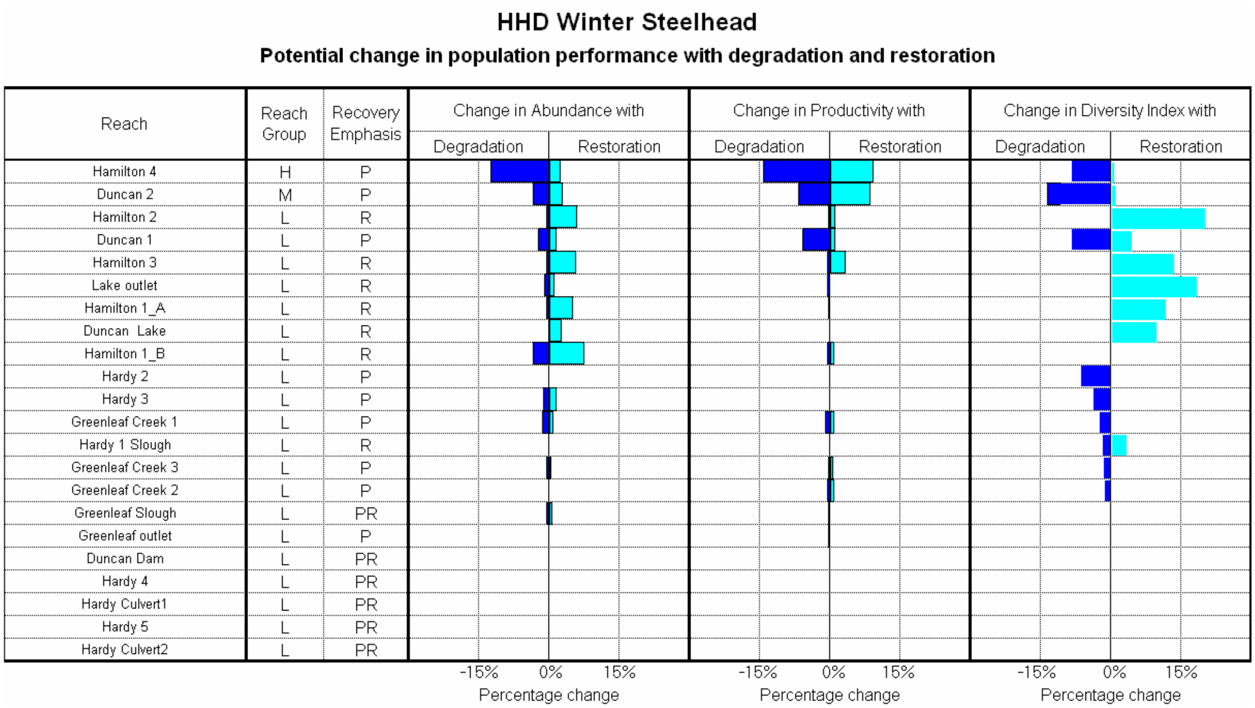


Figure 9. Bonneville Tributaries winter steelhead ladder diagram.

3.4.3 *Habitat Factor Analysis*

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the habitat factor analysis compares current/patient and historical/template habitat conditions. For each reach, EDT generates what is referred to as a "consumer reports diagram", which identifies the degree to which individual habitat factors are acting to suppress population performance. The effect of each habitat factor is identified for each life stage that occurs in the reach and the relative importance of each life stage is indicated. For additional information and examples of this analysis, see Appendix E. Inclusion of the consumer report diagram for each reach is beyond the scope of this document. A summary of the most critical life stages and the habitat factors affecting them are displayed for each species in Table 3.

Table 3. Summary of the primary limiting factors affecting life stages of focal salmonid species. Results are summarized from EDT Analysis.

Species and Lifestage		*greatest limiting factor*	*secondary factor*	*tertiary factor*
Bonneville Tributaries Chum				
most critical	Egg incubation	sediment	channel stability, harassment, key habitat	
second	Prespawning holding	habitat diversity, harassment, key habitat	temperature	
third	Spawning	habitat diversity, harassment	temperature	
Bonneville Tributaries Winter Steelhead				
most critical	Egg incubation	sediment	temperature	
second	0-age summer rearing	flow, temperature		
third	Fry colonization	flow		
Bonneville Tributaries Fall Chinook				
most critical	Spawning	temperature	key habitat	
second	Prespawning migrant	key habitat		
third	Prespawning holding	flow, habitat diversity, harassment, temperature, key habitat		
Bonneville Tributaries Coho				
most critical	0-age summer rearing	temperature	competition (hatchery), flow, food, habitat diversity	predation
second	Egg incubation	sediment	channel stability	
third	Fry colonization	flow, food, habitat diversity		

The consumer reports diagrams have also been summarized to show the relative importance of habitat factors by reach. The summary figures are referred to as habitat factor analysis diagrams and are displayed for each species below. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

All reaches modeled for fall Chinook were in Hamilton Creek. These areas have been negatively impacted by a loss of key habitat, increased sediment, and altered temperature regimes (Figure 10). Habitat diversity and key habitat are low due to low quantities of instream LWD and channel incision/floodplain disconnection. Sediment impacts originate primarily from upstream hillslope and channel sources. Temperature alteration is due to a lack of riparian shading and increased channel widths.

For chum, the important reaches have suffered negative impacts from a loss of habitat diversity, loss of key habitat, increased sedimentation, and harassment (Figure 11). A lack of riparian function and low LWD levels contribute to habitat diversity problems. Sediment and key habitat impacts are similar to those discussed above for fall Chinook. There are no impacts in the Lake Outlet reach because this reach is most important for preservation.

Important reaches for coho are located in Hamilton, Duncan, and Greenleaf Creeks. A suite of factors has negatively impacted these areas, including impairments related to sediment, key habitat, temperature, flow, food, and habitat diversity (Figure 12). The causes of these impacts are similar to those discussed above for fall Chinook.

In the priority areas for winter steelhead, key habitat, sediment, and temperature have the largest impacts (Figure 13). Key habitat has been reduced by loss of side channels and by subsurface flow conditions that reduce available summer rearing and holding habitat. Sediment, which originates primarily from upper basin sources, settles out in these low gradient reaches, impacting egg incubation and fry emergence. Flow alterations are also due to upper basin conditions, whereas temperature concerns are related to a lack of shade from riparian tree canopies.

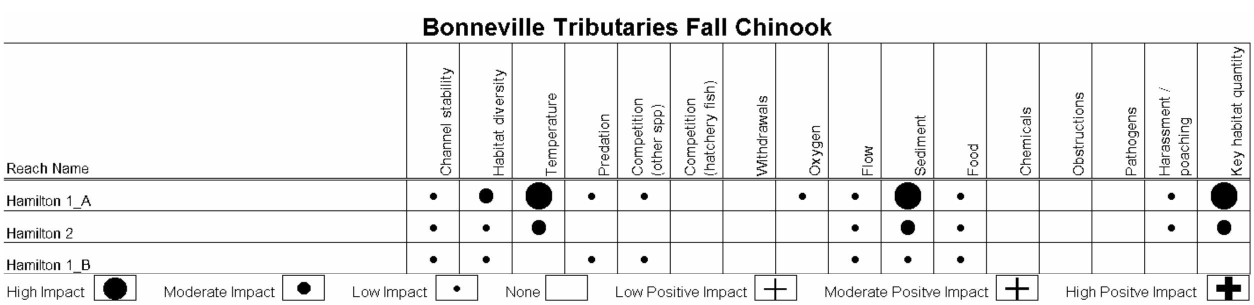


Figure 10. Bonneville Tributaries fall chinook habitat factor analysis. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Appendix E Chapter 6 for more information on habitat factor analysis diagrams. Some low priority reaches are not included for display purposes.

Bonneville Tributaries Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Lake outlet																
Hamilton 1_A	Low	High	Low	Moderate	Low				Moderate	Moderate	Moderate				High	High
Hamilton 2	Low	High	Low						Low	Moderate	Low				High	High
Hardy 2	Low	High		Moderate	Low				Low	Moderate	Low					Low Positive
Hamilton Springs																
Hardy 3	Low	High							Moderate	Moderate	Low					High
Duncan Springs																
Duncan Lake	Low	Moderate	Low Positive	Moderate	Low				Low	High	Moderate			Moderate	High	High Positive
Hamilton 1_B																
Hardy 1 Slough										Low						
Duncan Dam																

High Impact ● Moderate Impact ● Low Impact • None Low Positive Impact + Moderate Positve Impact + High Positve Impact ✚

Figure 11. Bonneville Tributaries chum habitat factor analysis.

Bonneville Tributaries Coho

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Hamilton 2	Moderate	High	High	Low		Moderate		Low	High	High	Moderate			Low	Low	High
Duncan 1	Low	Moderate	Moderate	Low		Moderate			Moderate	High	Moderate			Low		Moderate
Hamilton 3	Moderate	Low	High	Low		Moderate			Moderate	High	Moderate			Low		Moderate
Greenleaf Creek 1	Low	Low	Moderate	Low		Low			Moderate	High	Moderate					Low
Greenleaf Creek 3	Low	Low	Moderate	Low		Low			Moderate	High	Moderate			Low		Low
Hamilton Springs									High		High					Moderate
Hardy 3	Low	Moderate	Moderate						Moderate	Moderate	Low					Moderate
Duncan Springs				Low		Moderate			Low		Moderate			Low		
Greenleaf Creek 2	Low	Moderate	Moderate			Low			Moderate	Moderate	Moderate					Moderate
Hardy 2	Low	Moderate	Low	Moderate	Low				Low	Moderate	Low			Low		Low
Duncan Lake																
Duncan 2	Low	Moderate	Moderate						Low	Moderate	Low					Moderate
Hamilton 4	Low	Moderate	Low						Low	Low	Low					Moderate
Lake outlet		Low		Low												
Greenleaf Slough																
Hardy 1 Slough										Low						
Greenleaf outlet																
Hamilton 1_A																
Hamilton 1_B																
Duncan Dam																

High Impact ● Moderate Impact ● Low Impact • None Low Positive Impact + Moderate Positve Impact + High Positve Impact ✚

Figure 12. Bonneville Tributaries coho habitat factor analysis.

Bonneville Tributaries Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Hamilton 4	Low	Moderate	Moderate	Low					Moderate	High	Low			Low		High
Duncan 2	Low	Moderate	High	Low					Moderate	High	Low			Low		High
Hamilton 2	Moderate	Moderate	High	Moderate		Low		Low	Moderate	High	Moderate			Moderate	Low	High
Duncan 1	Low	Low	Moderate	Low		Low			Low	Moderate	Low			Low		Low
Hamilton 3	Low	Low	High	Moderate		Low			Moderate	High	Low			Moderate		High
Lake outlet	Low	Low	Low	Moderate		Low			Low		Low			Low		Low Positive
Hamilton 1_A	Low	Moderate	Moderate	Moderate	Low	Low		Low	Moderate	Low	Low			Moderate		High
Duncan Lake		High	Low	Moderate		Low					Low			Low		
Hamilton 1_B	Low	Moderate	High	High	Low	Moderate		Low	Moderate	Low	Low			Moderate		
Hardy 2																
Hardy 3		Moderate	Moderate	Low					Moderate	High	Low			Low		Low
Greenleaf Creek 1		Low	Moderate	Low					Low	High	Low			Low		
Hardy 1 Slough																
Greenleaf Creek 3			Low	Low					Low	Moderate	Low			Low		
Greenleaf Creek 2			Low							Moderate						
Greenleaf Slough		Low	Low	Low							Low			Low		
Greenleaf outlet																
Duncan Dam																
Hardy 4																
Hardy Culvert1																
Hardy 5																
Hardy Culvert2																

High Impact ● Moderate Impact • Low Impact · None Low Positive Impact + Moderate Positve Impact + High Positve Impact ✚

Figure 13. Bonneville Tributaries winter steelhead habitat factor analysis diagram.

3.5 Watershed Process Limitations

This section describes watershed process limitations that contribute to stream habitat conditions significant to focal fish species. Reach level stream habitat conditions are influenced by systemic watershed processes. Limiting factors such as temperature, high and low flows, sediment input, and large woody debris recruitment are often affected by upstream conditions and by contributing landscape factors. Accordingly, restoration of degraded channel habitat may require action outside the targeted reach, often extending into riparian and hillslope (upland) areas that are believed to influence the condition of aquatic habitats.

Watershed process impairments that affect stream habitat conditions were evaluated using a watershed process screening tool termed the Integrated Watershed Assessment (IWA). The IWA is a GIS-based assessment that evaluates watershed impairments at the subwatershed scale (3,000 to 12,000 acres). The tool uses landscape conditions (i.e. road density, impervious surfaces, vegetation, soil erodability, and topography) to identify the level of impairment of 1) riparian function, 2) sediment supply conditions, and 3) hydrology (runoff) conditions. For sediment and hydrology, the level of impairment is determined for local conditions (i.e. within subwatersheds, not including upstream drainage area) and at the watershed level (i.e. integrating the entire drainage area upstream of each subwatershed). See Appendix E for additional information on the IWA.

The Bonneville Tributaries watershed is comprised of several independent tributaries to the Columbia River, including Hamilton Creek, Hardy Creek, and Duncan Creek. IWA results for the Bonneville Tributaries watershed are shown in Table 4. A reference map showing the location of each subwatershed in the basin is presented in Figure 14. Maps of the distribution of local and watershed level IWA results are displayed in Figure 15.

3.5.1 *Hydrology*

Current Conditions.— The upper Hamilton Creek subwatershed (70102) is rated as functional for hydrology, with the remaining six subwatersheds split equally between moderately impaired and impaired ratings. Except for lower Hamilton Creek (70101), all subwatersheds in the area are terminal (i.e., having no upstream subwatersheds); thus, the watershed level results are the same as the local level results.

Functional hydrology conditions in upper Hamilton Creek are driven by relatively extensive mature forest coverage (64%) and moderate road densities (2.0 mi/sq mi). Impervious surface areas are low in this lightly developed area. Over half (53%) of upper Hamilton Creek is in public lands, administered by WDNR and Beacon Rock State Park.

Hydrologic conditions are rated moderately impaired in the lower Hamilton/Greenleaf Creek subwatershed (70101). Lower Hamilton Creek is rated as moderately impaired, based on moderate mature forest coverage levels (43%) and moderately high road densities (4.2 mi/sq mi). Roads in the lower Hamilton Creek/Greenleaf Creek subwatershed are concentrated around the Bonneville Dam facilities, which are located in the low lying areas of the watershed. Road densities in the upland areas of this subwatershed are considerably lower. Thus, the moderately impaired hydrology rating for subwatershed 70101 most likely overstates actual conditions, which may be closer to functional. In the lower Hamilton/Greenleaf Creek subwatershed, 19% is publicly owned (WDNR, state parks, and USACE). Development and land use regulations are relatively strict in the Columbia Gorge National Scenic Area.

Hydrologic conditions in Hardy and Duncan Creeks (70201, 70202) are rated impaired. Duncan Creek subwatershed (70201) has low mature forest coverage (17%) and moderately high road densities (3.4 mi/sq mi). As with lower Greenleaf Creek, a significant portion of road length in these subwatersheds is concentrated in the low-lying areas adjacent to the Columbia River. Therefore, the hydrologic conditions rating may overstate actual conditions, which may lean more towards moderately impaired. Several powerline right of ways traverse these drainages, affecting forest cover.

Hydrologic conditions in Lawton Creek subwatershed (70402) are impaired and are moderately impaired in Gibbons Creek (70401) and in 70302. Impairments here are related to young forests and high road densities (>3 miles/mi2).

Predicted Future Trends.— Given the relatively high percentage of public lands in upper Hamilton Creek and upper Greenleaf Creek, combined with the land management regulations of the CRGNSA, the extent of hydrologically mature forest coverage in subwatersheds 70101 and 70102 is expected to expand over time with only limited increases in road density and development. Hydrologic conditions are therefore predicted to trend towards gradual improvement as forest cover matures.

Given the land management regulations of the CRGNSA, the extent of hydrologically mature forest cover in Hardy and Duncan Creek subwatersheds (70201, 70202) is expected to expand over time with only limited increases in road density and development. Hydrologic conditions are therefore predicted to trend towards gradual improvement as forest cover matures.

Table 4. IWA results for the Bonneville Tributaries Watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
70101	M	M	M	M	M	70102
70102	F	M	F	F	M	none
70201	I	M	M	I	M	none
70202	I	M	M	I	M	none
70301	M	M	M	M	M	none
70401	M	M	M	M	M	none
70402	I	M	M	I	M	none

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800030#####.
[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:
F: Functional
M: Moderately impaired
I: Impaired
[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.
[d] Subwatersheds upstream from this subwatershed.

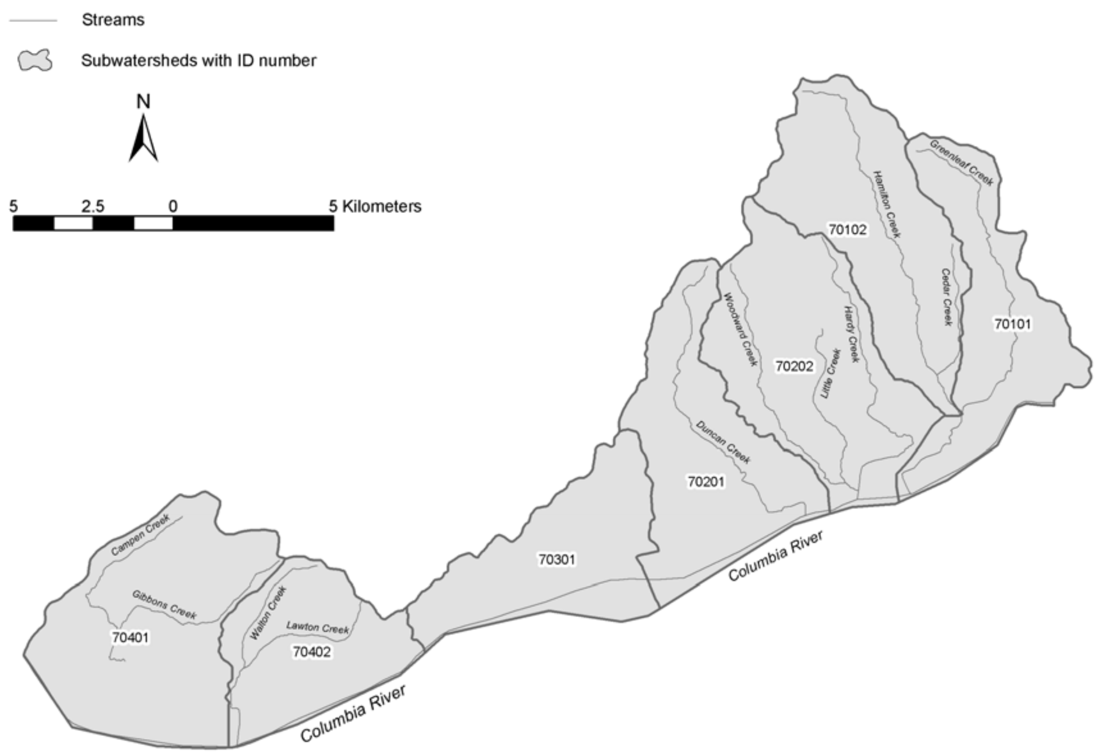


Figure 14. Map of the Bonneville Tributaries Basin showing the location of the IWA subwatersheds.

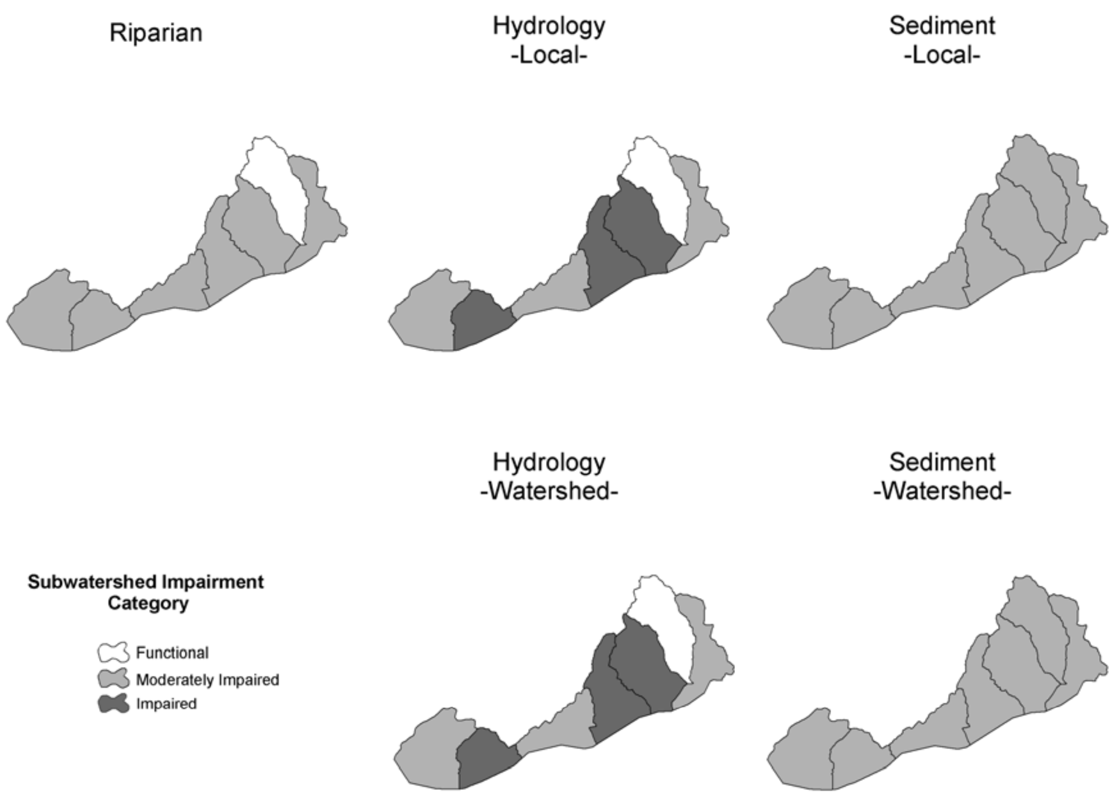


Figure 15. IWA subwatershed impairment ratings by category for the Bonneville Tributaries Basin.

3.5.2 *Sediment Supply*

Current Conditions.— Sediment conditions in the Bonneville Tributaries watershed are rated as moderately impaired. As with hydrology, local and watershed level impairments are the same.

Erodability ratings for upper Hamilton Creek (70102) are low, whereas lower Hamilton/Greenleaf Creek (70101) is rated moderately low (7 and 26, respectively, on a scale of 0-126). The sediment supply rating for upper Hamilton Creek is borderline functional, only slightly above the threshold for a moderately impaired rating. Ratings for lower Hamilton/Greenleaf Creek are driven by high road densities on erodable geology in the low lying areas. Sediment conditions in the uplands are expected to be similar to upper Hamilton Creek, leaning towards functional. Streamside roads, which represent a significant potential source of erosion, are relatively infrequent (averaging less than 0.2 miles/mile of stream). This average is skewed by the high concentration of roads adjacent to the Columbia River and associated with Bonneville Dam facilities. Averages in the upstream areas are probably closer to 0.1 miles/stream mile.

Sediment conditions in Hardy and Duncan Creeks (70201, 70202) are rated as moderately impaired. Natural erodability ratings in this drainage are moderately low. The moderately impaired ratings are primarily driven by high road densities on erodable geology in the lowlands. Upland areas of the drainage have higher road densities relative to Hamilton Creek, exceeding 3 mi/sq mi. Streamside road densities in Duncan Creek are moderately high, approaching 0.5 miles/stream mile. Again, this average is skewed somewhat by the high density of roads adjacent to the Columbia River.

Sediment supply conditions are moderately impaired in Lawton Creek (70402), Gibbons Creek (70401), and subwatershed 70301. Road densities exceed 3 mi/mi2 in 70402 and 70401.

Predicted Future Trends.— Given the extent of state park lands within both Hamilton Creek subwatersheds (70101 and 70102) and the low likelihood of expanding development or increasing forest road densities, sediment conditions are expected to trend stable in these subwatersheds.

Based on the high road densities and higher proportion of unsurfaced roads in the upper areas of the Duncan and Hardy Creek subwatersheds (70201, 70702), sediment conditions are predicted to trend stable over the next 20 years.

3.5.3 *Riparian Condition*

Current Conditions.— Riparian conditions range from functional to moderately impaired. Upper Hamilton Creek (70102) is the only subwatershed rated as functional. Riparian conditions in lower Hamilton and Greenleaf Creek (70101) and Duncan Creek (70201) are rated as moderately impaired. These conditions track well with the hydrologically mature forest cover in these subwatersheds. Moderately impaired riparian conditions in Gibbons and Lawton Creek subwatersheds (70401, 70402) are related to residential and agricultural development.

Predicted Future Trends.— Given the restrictive development regulations in the CRGNSA and the emphasis on restoration of riparian zones, riparian conditions in upper and lower Hamilton Creek, Duncan Creek, and Hardy Creek subwatersheds (70101, 70102, 70201, 70202) are predicted to trend towards improvement over the next 20 years. Conditions are expected to trend stable in Gibbons and Lawton Creek subwatersheds (70401, 70402).

3.6 Other Factors and Limitations

3.6.1 *Hatcheries*

Hatcheries currently release over 50 million salmon and steelhead per year in Washington lower Columbia River subbasins. Many of these fish are released to mitigate for loss of habitat. Hatcheries can provide valuable mitigation and conservation benefits but may also cause significant adverse impacts if not prudently and properly employed. Risks to wild fish include genetic deterioration, reduced fitness and survival, ecological effects such as competition or predation, facility effects on passage and water quality, mixed stock fishery effects, and confounding the accuracy of wild population status estimates. This section describes hatchery programs in the Bonneville Tributaries Basin and discusses their potential effects.

There are no hatcheries in the Bonneville area tributaries. Sporadic hatchery releases of fall chinook, coho salmon, and winter steelhead have occurred over time. Hatchery winter steelhead from Skamania (Washougal) and Beaver Creek (Elochoman) stocks have been planted in Hamilton Creek beginning in 1958 and continued into the 1990s. In 1977, the Spring Creek NFH released approximately 50,000 tule fall chinook in Hamilton Creek. In 1983, the Washougal Hatchery released late-run coho in Duncan and Greenleaf creeks. More specific information regarding the hatchery programs that have released fish into the Bonneville area tributaries is available in the appropriate sections presenting information on each hatchery.

A spawning population of upriver bright fall chinook was discovered in 1994 in the mainstem Columbia River immediately downstream of Bonneville Dam. The population is considered to have originated from hatchery strays from the Bonneville Hatchery in Oregon and the Little White Salmon NFH in Washington. Allozyme analysis indicated that this population was genetically distinct from other Columbia River bright fall chinook stocks, although the population resembles Yakima bright fall chinook and upriver bright fall chinook produced at the Little White Salmon NFH and the Bonneville Hatchery. This population is not considered part of the LCR Chinook salmon ESU.

A chum salmon hatchery program was recently started at the Washougal Hatchery with releases beginning in 2003. The program uses Hardy Creek chum for broodstock; the program goal is to enhance chum returns to Duncan Creek. The hatchery program occurs in conjunction with habitat restoration efforts in Duncan Creek. This program also acts as a safety-net in the event that mainstem Columbia flow operations severely limit the natural spawning of chum salmon in Hamilton and Hardy creeks and the Ives Island area below Bonneville.

Table 5. Bonneville tributaries hatchery Production

Hatchery	Release Location	Chum
Washougal	Duncan Creek	100,000

<u>Biological Risk Assessment</u>

The evaluation of hatchery programs and implementation of hatchery reform in the Lower Columbia is occurring through several processes. These include: 1) the LCFRB recovery planning process; 2) Hatchery Genetic Management Plan (HGMP) preparation for ESA permitting; 3) FERC releated plans on the Cowlitz River and Lewis River; and 4) the federally mandated Artificial Production Review and Evaluation (APRE) process. Through each of these processes, WDFW is applying a consistent framework to identify the hatchery program enhancements that will maximize fishing-related economic benefits and promote attainment of regional recovery goals. Developing hatcheries into an integrated, productive, stock recovery tool requires a policy framework for considering the acceptable risks of artificial propagation, and a scientific assessment of the benefits and risks of each proposed hatchery program. WDFW developed the Benefit-Risk Assessment Procedure (BRAP) to provide that framework. The BRAP evaluates hatchery programs in the ecological context of the watershed, with integrated assessment and decisions for hatcheries, harvest, and habitat. The risk assessment procedure consists of five basic steps, grouped into two blocks:

Policy Framework

- Assess population status of wild populations
- Develop risk tolerance profiles for all stock conditions
- Assign risk tolerance profiles to all stocks

Risk Assessment

- Conduct risk assessments for all hatchery programs
- Identify appropriate management actions to reduce risk

Following the identification of risks through the assessment process, a strategy is developed to describe a general approach for addressing those risks. Building upon those strategies, program-specific actions and an adaptive management plan are developed as the final steps in the WDFW framework for hatchery reform.

Table 6 identifies hazard levels associated with risks involved with hatchery programs in the Bonneville Tributaries Basin. Table 7 identifies preliminary strategies proposed to address risks identified in the BRAP for the same populations.

The BRAP risk assessments and strategies to reduce risk have been key in providing the biological context to develop the hatchery recovery measures for lower Columbia River sub-basins.

Table 6. Preliminary BRAP for hatchery programs affecting populations in the Bonneville Tributaries Basin.

Symbol	Description
○	Risk of hazard consistent with current risk tolerance profile.
(?)	Magnitude of risk associated with hazard unknown.
●	Risk of hazard exceeds current risk tolerance profile.
[shaded]	Hazard not relevant to population

Bonneville Tributary Population	Hatchery Program: Name	Hatchery Program: Release (millions)	Risk Assessment of Hazards: Genetic: Effective Population Size	Genetic: Domestication	Genetic: Diversity	Ecological: Predation	Ecological: Competition	Ecological: Disease	Demographic: Survival Rate	Demographic: Reproductive Success	Facility: Catastrophic Loss	Facility: Passage	Facility: Screening	Facility: Water Quality
Fall Chinook	Washougal Chum (Duncan Cr.)	0.080	[shaded]	[shaded]	[shaded]	○	○	○	[shaded]	[shaded]	[shaded]	○	○	○
Spring Chinook	Washougal Chum (Duncan Cr.)	0.080	[shaded]	[shaded]	[shaded]	○	○	○	[shaded]	[shaded]	[shaded]	○	○	○
Chum	Washougal Chum (Duncan Cr.)	0.080	○	○	○	○	○	○	○	(?)	○	○	○	○
Winter Steelhead	Washougal Chum (Duncan Cr.)	0.080	[shaded]	[shaded]	[shaded]	○	○	○	[shaded]	[shaded]	[shaded]	○	○	○

Table 7. Preliminary strategies proposed to address risks identified in the BRAP for Bonneville Tributaries Basin populations.

Bonneville Tributary Population	Hatchery Program: Name	Hatchery Program: Release (millions)	Risk Assessment of Hazards: Address Genetic Risks: Mating Procedure	Address Genetic Risks: Integrated Program	Address Genetic Risks: Segregated Program	Address Genetic Risks: Research/ Monitoring	Address Genetic Risks: Broodstock Source	Address Ecological Risks: Number Released	Address Ecological Risks: Release Procedure	Address Ecological Risks: Disease Containment	Address Ecological Risks: Research/ Monitoring	Address Demographic Risks: Culture Procedure	Address Demographic Risks: Research/ Monitoring	Address Facility Risks: Reliability	Address Facility Risks: Improve Passage	Address Facility Risks: Improve Screening	Address Facility Risks: Pollution Abateme
Fall Chinook	Washougal Chum (Duncan Cr.)	0.080	[shaded]	[shaded]	[shaded]	[shaded]	[shaded]										
Spring Chinook	Washougal Chum (Duncan Cr.)	0.080	[shaded]	[shaded]	[shaded]	[shaded]	[shaded]										

Impact Assessment

The potential significance of negative hatchery impacts within the subbasin on natural populations was estimated with a simple index based on: 1) intra-specific effects resulting from depression in wild population productivity that can result from interbreeding with less fit hatchery fish and 2) inter-specific effects resulting from predation of juvenile salmonids of other species. The index reflects only a portion of net hatchery effects but can provide some sense of the magnitude of key hatchery risks relative to other limiting factors. Fitness effects are among the most significant intra-specific hatchery risks and can also be realistically quantified based on hatchery fraction in the natural spawning population and assumed fitness of the hatchery fish relative to the native wild population. Predation is among the most significant inter-specific effects and can be estimated from hatchery release numbers by species. This index assumed that equilibrium conditions have been reached for the hatchery fraction in the wild and for relative fitness of hatchery and wild fish. This simplifying assumption was necessary because more detailed information is lacking on how far the current situation is from equilibrium. The index does not consider the numerical benefits of hatchery spawners to natural population numbers, ecological interactions between hatchery and wild fish other than predation, or out-of-basin interactions, all of which are difficult to quantify. Appendix E contains a detailed description of the method and rationale behind this index.

Because there are no hatcheries in the Bonneville tributaries, the indexed potential for negative impacts of hatchery spawners on wild population fitness in the Bonneville Tributaries is quite low. The greatest potential fitness impact is for coho, which have a fitness impact potential of 46%. However, the incidence of coho hatchery spawners straying to these tributaries suggests that the fitness of natural and hatchery fish is probably quite similar and natural populations might decline substantially without continued hatchery subsidy under current habitat conditions. Inter specific impacts from predation is estimnated to be 0% for all species.

Table 8. Presumed reductions in wild population fitness as a result of natural hatchery spawners and survival as a result of interactions with other hatchery species for Bonneville salmon and steelhead populations.

Population	Annual releases[a]	Hatchery fraction[b]	Fitness category[c]	Assumed fitness[d]	Fitness impact[e]	Interacting releases[f]	Interspecies impact[g]
Fall Chinook	0	NA	0	0.7	NA	0	0
Chum	100,000[h]	0.05	1	0.9	0.005	0	0
Coho	0[i]	0.91	3	0.5	0.46	0	0
Winter Steelhead	0	na	na	na	na	0	0

[a] Annual release goals.
[b] Proportion of natural spawners that are first generation hatchery fish.
[c] Broodstock category: 1 = derived from native local stock, 2 = domesticated stock of native local origin, 3 = originates from same ESU but substantial divergence may have occurred, 4 = out-of-ESU origin or origin uncertain
[d] Productivity of naturally-spawning hatchery fish relative to native wild fish prior to significant hatchery influence. Because population-specific fitness estimates are not available for most lower Columbia River populations, we applied hypothetical rates comparable to those reported in the literature and the nature of local hatchery program practices.
[e] Index based on hatchery fraction and assumed fitness.
[f] Number of other hatchery releases with a potential to prey on the species of interest. Includes steelhead and coho for fall chinook and coho. Includes steelhead and spring chinook for chum.
[g] Predation impact based on interacting releases and assumed species-specific predation rates.
[h] Hardy Creek origin chum reared at Washougal Hatchery and released into Duncan Creek.
[i] Hatchery coho salmon are no longer released in the basin; hatchery fish in these basins appear to be strays from other programs..

3.6.2 *Harvest*

Fishing generally affects salmon populations through directed and incidental harvest, catch and release mortality, and size, age, and run timing alterations because of uneven fishing on different run components. From a population biology perspective, this can result in fewer spawners and can alter age, size, run timing, fecundity, and genetic characteristics. Fewer spawners result in fewer eggs for future generations and diminish marine-derived nutrients delivered via dying adults, now known to be significant to the growth and survival of juvenile salmon in aquatic ecosystems. The degree to which harvest-related limiting factors influence productivity varies by species and location.

Most harvest of wild Columbia River salmon and steelhead occurs incidental to the harvest of hatchery fish and healthy wild stocks in the Columbia estuary, mainstem, and ocean. Fish are caught in the Canada/Alaska ocean, U.S. West Coast ocean, lower Columbia River commercial and recreational, tributary recreational, and in-river treaty Indian (including commercial, ceremonial, and subsistence) fisheries. Total exploitation rates have decreased for lower Columbia salmon and steelhead, especially since the 1970s as increasingly stringent protection measures were adopted for declining natural populations.

Current fishing impact rates on lower Columbia River naturally-spawning salmon populations ranges from 2.5% for chum salmon to 45% for tule fall Chinook (Table 9). These rates include estimates of direct harvest mortality as well as estimates of incidental mortality in catch and release fisheries. Fishery impact rates for hatchery produced spring Chinook, coho, and steelhead are higher than for naturally-spawning fish of the same species because of selective fishing regulations. These rates generally reflect recent year (2001-2003) fishery regulations and quotas controlled by weak stock impact limits and annual abundance of healthy targeted fish. Actual harvest rates will vary for each year dependent on annual stock status of multiple west coast salmon populations, however, these rates generally reflect expected impacts of harvest on lower Columbia naturally-spawning and hatchery salmon and steelhead under current harvest management plans.

Table 9. Approximate annual exploitation rates (% harvested) for naturally-spawning lower Columbia salmon and steelhead under current management controls (represents 2001-2003 fishing period).

	AK./Can. Ocean	West Coast Ocean	Col. R. Comm.	Col. R. Sport	Trib. Sport	**Wild Total**	Hatchery Total	Historic Highs
Spring Chinook	13	5	1	1	2	**22**	53	65
Fall Chinook (Tule)	15	15	5	5	5	**45**	45	80
Fall Chinook (Bright)	19	3	6	2	10	**40**	Na	65
Chum	0	0	1.5	0	1	**2.5**	2.5	60
Coho	<1	9	6	2	1	**18**	51	85
Steelhead	0	<1	3	0.5	5	**8.5**	70	75

Columbia River fall Chinook are subject to freshwater and ocean fisheries from Alaska to their rivers of origin in fisheries targeting abundant Chinook stocks originating from Alaska, Canada, Washington, Oregon, and California. Columbia tule fall Chinook harvest is constrained by a Recovery Exploitation Rate (RER) developed by NOAA Fisheries for management of Coweeman naturally-spawning fall Chinook. Some in-basin sport fisheries (like the Bonneville Tributaries) are closed to the retention of Chinook. Harvest of lower Columbia bright fall Chinook is managed to achieve an escapement goal of 5,700 natural spawners in the North Fork Lewis.

Rates are very low for chum salmon, which are not encountered by ocean fisheries and return to freshwater in late fall when significant Columbia River commercial fisheries no longer occur. Chum are no longer targeted in Columbia commercial seasons and retention of chum is prohibited in Columbia River and Colulmbia lower tributary sport fisheries. Chum are impacted incidental to fisheries directed at coho and winter steelhead.

Harvest of Columbia lower tributary coho occurs in the ocean commercial and recreational fisheries off the Washington and Oregon coasts and Columbia River. Wild coho impacts are limited by fishery management to retain marked hatchery fish and release unmarked wild fish. The Bonneville Tributaries are closed to fishing for coho

Steelhead, like chum, are not encountered by ocean fisheries and non-Indian commercial steelhead fisheries are prohibited in the Columbia River. Incidental mortality of steelhead occurs in freshwater commercial fisheries directed at Chinook and coho and freshwater sport fisheries directed at hatchery steelhead and salmon. All recreational fisheries are managed to selectively harvest fin-marked hatchery steelhead and commercial fisheries cannot retain hatchery or wild steelhead.

Access to harvestable surpluses of strong stocks in the Columbia River and ocean is regulated by impact limits on weak populations mixed with the strong. Weak stock management of Columbia River fisheries became increasingly prevalent in the 1960s and 1970s in response to continuing declines of upriver runs affected by mainstem dam construction. In the 1980s coordinated ocean and freshwater weak stock management commenced. More fishery restrictions followed ESA listings in the 1990s. Each fishery is controlled by a series of regulating factors. Many of the regulating factors that affect harvest impacts on Columbia River stocks are associated with treaties, laws, policies, or guidelines established for the management of other stocks or combined stocks, but indirectly control impacts of Columbia River fish as well. Listed fish generally comprise a small percentage of the total fish caught by any fishery. Every listed fish may correspond to tens, hundreds, or thousands of other stocks in the total catch. As a result of weak stock constraints, surpluses of hatchery and strong naturally-spawning runs often go unharvested. Small reductions in fishing rates on listed populations can translate to large reductions in catch of other stocks and recreational trips to communities which provide access to fishing, with significant economic consequences.

Selective fisheries for adipose fin-clipped hatchery coho (since 1999) and steelhead (since 1984) have substantially reduced fishing mortality rates for naturally-spawning populations and allowed concentration of fisheries on abundant hatchery fish. Selective fisheries occur in the Columbia River and tributaries for steelhead and in the ocean, Columbia River, and tributaries for coho. Columbia River hatchery fall Chinook are not marked for selective fisheries, but likely will be in the future because of recent legislation enacted by Congress.

3.6.3 *Mainstem and Estuary Habitat*

Conditions in the Columbia River mainstem, estuary, and plume affect all anadromous salmonid populations within the Columbia Basin. Juvenile and adult salmon may be found in the mainstem and estuary at all times of the year, as different species, life history strategies and size classes continually rear or move through these waters. A variety of human activities in the mainstem and estuary have decreased both the quantity and quality of habitat used by juvenile salmonids. These include floodplain development; loss of side channel habitat, wetlands and marshes; and alteration of flows due to upstream hydro operations and irrigation withdrawals.

Effects on salmonids of habitat changes in the mainstem and estuary are complex and poorly understood. Effects are similar for Bonneville Tributaries populations to those of most other subbasin salmonid populations. Effects are likely to be greater for chum and fall Chinook which rear for extended periods in the mainstem and estuary than for steelhead and coho which move through more quickly. Estimates of the impacts of human-caused changes in mainstem and estuary habitat conditions are available based on changes in river flow, temperature, and predation as represented by EDT analyses for the NPCC Multispecies Framework Approach (Marcot et al. 2002). These estimates generally translate into a 10-60% reduction in salmonid productivity depending on species (Appendix E). Estuary effects are described more fully in the estuary subbasin volume of this plan (Volume II-A).

3.6.4 *Hydropower Construction and Operation*

There are no hydro-electric dams in the Bonneville Tributaries Basin. However, spawning habitat for salmon is affected by fall and winter flows from Bonneville Dam and migrating fish are affected by changes in the Columbia River mainstem and estuary related to Columbia basin hydropower development and operation. The mainstem Columbia River and estuary provide important habitats for anadromous species during juvenile and adult migrations between spawning and rearing streams and the ocean where they grow and mature. These habitats are particularly important for fall chinook and chum which rear extensively in the Columbia mainstem and estuary. Aquatic habitats have been fundamentally altered throughout the Columbia River basin by the construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control.

The hydropower infrastructure and flow regulation affects adult migration, juvenile migration, mainstem spawning success, estuarine rearing, water temperature, water clarity, gas supersaturation, and predation. Dams block or impede passage of anadromous juveniles and adults. Columbia River spring flows are greatly reduced from historical levels as water is stored for power generation and irrigation, while summer and winter flows have increased. These flow changes affect juvenile and adult migration, and have radically altered habitat forming processes. Flow regulation and reservoir construction have increased average water temperature in the Columbia River mainstem and summer temperatures regularly exceed optimums for salmon. Supersaturation of water with atmospheric gases, primarily nitrogen, when water is spilled over high dams causes gas bubble disease. Predation by fish, bird, and marine mammals has been exacerbated by habitat changes. The net effect of these direct and indirect effects is difficult to quantify but is expected to be less significant for populations originating from lower Columbia River subbasins than for upriver salmonid populations. Additional information on hydropower effects can be found in the Regional Recovery and Subbasin Plan Volume I.

3.6.5 *Ecological Interactions*

Ecological interactions focus on how salmon and steelhead, other fish species, and wildlife interact with each other and the subbasin ecosystem. Salmon and steelhead are affected throughout their lifecycle by ecological interactions with non native species, food web components, and predators. Each of these factors can be exacerbated by human activities either by direct actions or indirect effects of habitat alternation. Effects of non-native species on salmon, effects of salmon on system productivity, and effects of native predators on salmon are difficult to quantify. Strong evidence exists in the scientific literature on the potential for significant interactions but effects are often context- or case-specific.

Predation is one interaction where effects can be estimated although interpretation can be complicated. In the lower Columbia River, northern pikeminnow, Caspian tern, and marine mammal predation on salmon has been estimated at approximately 5%, 10-30%, and 3-12%, respectively of total salmon numbers (see Appendix E for additional details). Predation has always been a source of salmon mortality but predation rates by some species have been exacerbated by human activities.

3.6.6 *Ocean Conditions*

Salmonid numbers and survival rates in the ocean vary with ocean conditions and low productivity periods increase extinction risks of populations stressed by human impacts. The ocean is subject to annual and longer-term climate cycles just as the land is subject to periodic droughts and floods. The El Niño weather pattern produces warm ocean temperatures and warm, dry conditions throughout the Pacific Northwest. The La Niña weather patterns is typified by cool ocean temperatures and cool/wet weather patterns on land. Recent history is dominated by a high frequency of warm dry years, along with some of the largest El Niños on record—particularly in 1982-83 and 1997-98. In contrast, the 1960s and early 1970s were dominated by a cool, wet regime. Many climatologists suspect that the conditions observed since 1998 may herald a return to the cool wet regime that prevailed during the 1960s and early 1970s.

Abrupt declines in salmon populations throughout the Pacific Northwest coincided with a regime shift to predominantly warm dry conditions from 1975 to 1998 (Beamish and Bouillon 1993, Hare et al 1999, McKinnell et al. 2001, Pyper et al. 2001). Warm dry regimes result in generally lower survival rates and abundance, and they also increase variability in survival and wide swings in salmon abundance. Some of the largest Columbia River fish runs in recorded history occurred during 1985–1987 and 2001–2002 after strong El Niño conditions in 1982–83 and 1997–98 were followed by several years of cool wet conditions.

The reduced productivity that accompanied an extended series of warm dry conditions after 1975 has, together with numerous anthropogenic impacts, brought many weak Pacific Northwest salmon stocks to the brink of extinction and precipitated widespread ESA listings. Salmon numbers naturally ebb and flow as ocean conditions vary. Healthy salmon populations are productive enough to withstand these natural fluctuations. Weak salmon populations may disappear or lose the genetic diversity needed to withstand the next cycle of low ocean productivity (Lawson 1993).

Recent improvements in ocean survival may portend a regime shift to generally more favorable conditions for salmon. The large spike in recent runs and a cool, wet climate would provide a respite for many salmon populations driven to critical low levels by recent conditions. The National Research Council (1996) concluded: "*Any favorable changes in ocean conditions—which could occur and could increase the productivity of some salmon populations for a time—should be regarded as opportunities for improving management techniques. They should not be regarded as reasons to abandon or reduce rehabilitation efforts, because conditions will change again*". Additional details on the nature and effects of variable ocean conditions on salmonids can be found in the Regional Recovery and Subbasin Plan Volume I.

3.7 Summary of Human Impacts on Salmon and Steelhead

Stream habitat, estuary/mainstem habitat, harvest, hatchery and ecological interactions have all contributed to reductions in productivity, numbers, and population viability. Pie charts in Figure 16 describe the relative magnitude of potentially-manageable human impacts in each category of limiting factor for Bonneville Tributaries Basin salmon and steelhead. Impact values were developed for a base period corresponding to species listing dates. This depiction is useful for identifying which factors are most significant for each species and where improvements might be expected to provide substantial benefits. Larger pie slices indicate greater significance and scope for improvement in an impact for a given species. These numbers also serve as a working hypothesis for factors limiting salmonid numbers and viability.

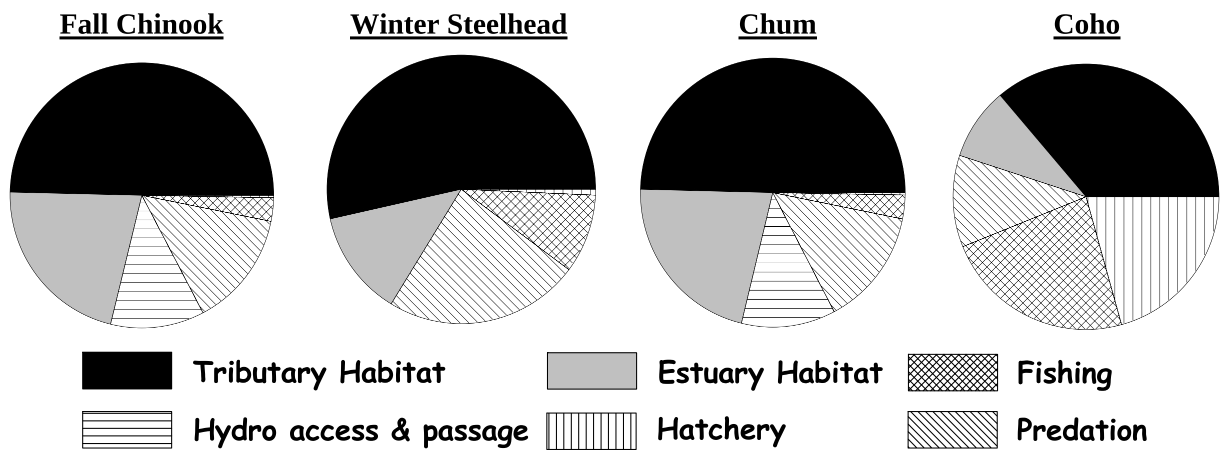


Figure 16. Relative contribution of potentially manageable impacts on Bonneville Tributaries salmonid populations.

This assessment indicates that current salmonid status is the result of large impacts distributed among several factors. No single factor accounts for a majority of effects on all species. Thus, substantial improvements in salmonid numbers and viability will require significant improvements in several factors.

In the Bonneville tributaries subbasin, loss of tributary habitat quality and quantity accounts for the largest relative impact on all species. Loss of estuary habitat quality and quantity is also relatively important for all species, but less so for coho. Harvest has a sizeable effect on coho, but is relatively minor for chum and fall Chinook; harvest impact on winter steelhead is intermediate. Coho are the only species heavily impacted by hatcheries in the basin. Predation impacts are substantial for winter steelhead and moderate for all other species. Hydrosystem access and passage impacts are important for fall Chinook and chum yet relatively minor for all other species.

Impacts were defined as the proportional reduction in average numbers or productivity associated with each effect. Subbasin and estuary habitat impacts are the differences between the pre-development historical baseline and current conditions. Hydro impacts identify the percentage of historical habitat blocked by impassable dams and the mortality associated with juvenile and adult passage of other dams. Fishing impacts are the direct and indirect mortality in ocean and freshwater fisheries. Hatchery impacts include the equilibrium effects of reduced natural population productivity caused by natural spawning of less-fit hatchery fish and also effects of inter-specific predation by larger hatchery smolts on smaller wild juveniles. Hatchery impacts do not include other potentially negative indirect effects or potentially beneficial effects of augmentation of natural production. Predation includes mortality from northern pikeminnow, Caspian terns, and marine mammals in the Columbia River mainstem and estuary. Predation is not a direct human impact but was included because of widespread interest in its relative significance. Methods and data for these analyses are detailed in Appendix E.

Potentially-manageable human impacts were estimated for each factor based on the best available scientific information. Proportions are standardized to a total of 1.0 for plotting purposes. The index is intended to illustrate order-of-magnitude rather than fine-scale differences. Only the subset of factors we can potentially manage were included in this index – natural mortality factors beyond our control (e.g. naturally-occuring ocean mortality) are excluded. Not every factor of interest is included in this index – only readily-quantifiable impacts are included.

4.0 Key Programs and Projects

This section provides brief summaries of current federal, state, local, and non-governmental programs and projects pertinent to recovery, management, and mitigation measures and actions in this basin. These descriptions provide a context for descriptions of specific actions and responsibilities in the management plan portion of this subbasin plan. More detailed descriptions of these programs and projects can be found in the Comprehensive Program Directory (Appendix C).

4.1 Federal Programs

4.1.1 *NOAA Fisheries*

NOAA Fisheries is responsible for conserving, protecting and managing pacific salmon, ground fish, halibut, marine mammals and habitats under the Endangered Species Act, the Marine Mammal Protection Act, the Magnusen-Stevens Act, and enforcement authorities. NOAA administers the ESA under Section 4 (listing requirements), Section 7 (federal actions), and Section 10 (non-federal actions).

4.1.2 *US Army Corps of Engineers*

The U.S. Army Corps of Engineers (USACE) is the Federal government's largest water resources development and management agency. USACE programs applicable to Lower Columbia Fish & Wildlife include: 1) Section 1135 – provides for the modification of the structure or operation of a past USACE project, 2) Section 206 – authorizes the implementation of aquatic ecosystem restoration and protection projects, 3) Hydroelectric Program – applies to the construction and operation of power facilities and their environmental impact, 4) Regulatory Program – administration of Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act.

4.1.3 *Environmental Protection Agency*

The Environmental Protection Agency (EPA) is responsible for the implementation of the Clean Water Act (CWA). The broad goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters so that they can support the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water. The CWA requires that water quality standards (WQS) be set for surface waters. WQS are aimed at translating the broad goals of the CWA into waterbody-specific objectives and apply only to the surface waters (rivers, lakes, estuaries, coastal waters, and wetlands) of the United States.

4.1.4 *United States Forest Service*

The Unites States Forest Service (USFS) manages federal forest lands within the Gifford Pinchot National Forest (GPNF) and the Columbia River Gorge National Scenic Area (CRGNSA). The GPNF operates under the Gifford Pinchot Forest Plan (GPFP). Management prescriptions within the GPFP have been guided by the 1994 Northwest Forest Plan, which calls for management of forests according to a suite of management designations including Reserves (e.g. late successional forests, riparian forests), Adaptively-Managed Areas, and Matrix Lands. Most timber harvest occurs in Matrix Lands. The GPNF implements a wide range of ecosystem restoration activities. The CRGNSA was established in 1986 to protect and provide for the enhancement of the scenic, cultural, recreational and natural resources of the Gorge; and to protect and support the economy of the Columbia River Gorge area. CRGNSA lands designated as General Management Area are subject to review of new development and land use.

4.1.5 *Natural Resources Conservation Service*

Formerly the Soil Conservation Service, the USDA Natural Resources Conservation Service (NRCS) works with landowners to conserve natural resources on private lands. The NRCS accomplishes this through various programs including, but not limited to, the Conservation Technical Assistance Program, Soil Survey Program, Conservation Reserve Enhancement Program, and the Wetlands Reserve Program. The NRCS works closely with local Conservation Districts; providing technical assistance and support.

4.1.6 *Northwest Power and Conservation Council*

The Northwest Power and Conservation Council, an interstate compact of Idaho, Montana, Oregon, and Washington, has specific responsibility in the Northwest Power Act of 1980 to mitigate the effects of the hydropower system on fish and wildlife of the Columbia River Basin. The Council does this through its Columbia River Basin Fish and Wildlife Program, which is funded by the Bonneville Power Administration. Beginning in Fiscal Year 2006, funding is guided by locally developed subbasin plans that are expected to be formally adopted in the Council's Fish and Wildlife Program in December 2004.

4.2 State Programs

4.2.1 *Washington Department of Natural Resources*

The Washington Department of Natural Resources governs forest practices on non-federal lands and is steward to state owned aquatic lands. Management of DNR public forest lands is governed by tenets of their proposed Habitat Conservation Plan (HCP). Management of private industrial forestlands is subject to Forest Practices regulations that include both protective and restorative measures.

4.2.2 *Washington Department of Fish & Wildlife*

WDFW's Habitat Division supports a variety of programs that address salmonids and other wildlife and resident fish species. These programs are organized around habitat conditions (Science Division, Priority Habitats and Species, and the Salmon and Steelhead Habitat Inventory and Assessment Program); habitat restoration (Landowner Incentive Program, Lead Entity Program, and the Conservation and Reinvestment Act Program, as well as technical assistance in the form of publications and technical resources); and habitat protection (Landowner Assistance, GMA, SEPA planning, Hydraulic Project Approval, and Joint Aquatic Resource Permit Applications).

4.2.3 *Washington Department of Ecology*

The Department of Ecology (DOE) oversees: the Water Resources program to manage water resources to meet current and future needs of the natural environment and Washington's communities; the Water Quality program to restore and protect Washington's water supplies by preventing and reducing pollution; and Shoreline and the Environmental Assistance program for implementing the Shorelines Management Act, the State Environmental Protection Act, the Watershed Planning Act, and 401 Certification of ACOE Permits.

4.2.4 *Washington Department of Transportation*

The Washington State Department of Transportation (WSDOT) must ensure compliance with environmental laws and statutes when designing and executing transportation projects. Programs that consider and mitigate for impacts to salmonid habitat include: the Fish Passage Barrier Removal program; the Regional Road Maintenance ESA Section 4d Program, the

Integrated Vegetation Management & Roadside Development Program; Environmental Mitigation Program; the Stormwater Retrofit Program; and the Chronic Environmental Deficiency Program.

4.2.5 *Interagency Committee for Outdoor Recreation*

Created through the enactment of the Salmon Recovery Act (Washington State Legislature, 1999), the Salmon Recovery Funding Board provides grant funds to protect or restore salmon habitat and assist related activities with local watershed groups known as lead entities. SRFB has helped finance over 500 salmon recovery projects statewide. The Aquatic Lands Enhancement Account (ALEA) was established in 1984 and is used to provide grant support for the purchase, improvement, or protection of aquatic lands for public purposes, and for providing and improving access to such lands. The Washington Wildlife and Recreation Program (WWRP), established in 1990 and administered by the Interagency Committee for Outdoor Recreation, provides funding assistance for a broad range of land protection, park development, preservation/conservation, and outdoor recreation facilities.

4.2.6 *Lower Columbia Fish Recovery Board*

The Lower Columbia Fish Recovery Board encompasses five counties in the Lower Columbia River Region. The 15-member board has four main programs, including habitat protection and restoration activities, watershed planning for water quantity, quality, habitat, and instream flows, facilitating the development of an integrated recovery plan for the Washington portion of the lower Columbia Evolutionarily Significant Units, and conducting public outreach activities.

4.3 Local Government Programs

4.3.1 *Clark County*

Clark County is conducting Comprehensive Planning under the State's Growth Management Act. Clark County manages natural resources under various programs including Critical Areas Ordinance, ESA Program, Road Operations, Parks Operations, Stormwater Management, and the Conservation Futures Program.

4.3.2 *Skamania County*

Skamania County is not planning under the State's Growth Management Act in its Comprehensive Planning process. Skamania County manages natural resources primarily through a Critical Areas Ordinance. Skamania County has adopted special land use and environmental regulations implementing the Columbia River Gorge National Scenic Area Act for some areas within their jurisdiction.

4.3.3 *Clark Conservation District*

Clark Conservation District provides technical assistance, cost-share assistance, and project monitoring in Clark County. Clark CD assists agricultural landowners in the development of farm plans and in the participation in the Conservation Reserve Enhancement Program. Farm plans optimize use, protect sensitive areas, and conserve resources.

4.3.4 *Underwood Conservation District*

The Underwood CD provides technical assistance, cost-share assistance, project and water quality monitoring, community involvement and education, and support of local stakeholder groups within the district. UCD implements a wide variety of programs, including conservation and restoration projects, water quality monitoring, a spring tree sales program, education and outreach activities, and support for local watershed committees.

4.4 Non-governmental Programs

4.4.1 *Columbia Land Trust*

The Columbia Land Trust is a private, non-profit organization founded in 1990 to work exclusively with willing landowners to find ways to conserve the scenic and natural values of the land and water. Landowners donate the development rights or full ownership of their land to the Land Trust. CLT manages the land under a stewardship plan and, if necessary, will legally defend its conservation values.

4.4.2 *Lower Columbia Fish Enhancement Group*

The Washington State Legislature created the Regional Fisheries Enhancement Group Program in 1990 to involve local communities, citizen volunteers, and landowners in the state's salmon recovery efforts. RFEGs help lead their communities in successful restoration, education and monitoring projects. Every group is a separate, nonprofit organization led by their own board of directors and operational funding from a portion of commercial and recreational fishing license fees administered by the WDFW, and other sources. The mission of the Lower Columbia RFEG (LCFEG) is to restore salmon runs in the lower Columbia River region through habitat restoration, education and outreach, and developing regional and local partnerships.

4.5 NPCC Fish & Wildlife Program Projects

Re-introduction of Lower Columbia River Chum Salmon into Duncan Creek (Project 200105300)

Abstract: 2003 - Monitor and evaluate the success of the recently restored spawning channels for chum salmon at Duncan Creek. If necessary, jump start the population by collecting brood stock from adjacent populations. 2001 - Enhance spawning areas historically used by chum salmon in Duncan Creek. Jump-start the population by incubating eggs from adjacent stocks at this site. Conduct annual spawning ground counts and estimate fry production. Funding Status: funded 2001, 2002, recommended 2003

Evaluate factors limiting Columbia River gorge chum salmon populations (Project 200001200)

Abstract: 2003 - Evaluate factors limiting chum salmon production in Hardy Creek, Hamilton Springs, and Columbia River side-channel. 2001 - Evaluate factors limiting chum salmon production, spawning group relationships, population dynamics, and biological and ecological characteristics of chum in tributaries and mainstem below Bonneville Dam; evaluate chum movements above Bonneville Dam. Funding Status: funded 2000, 2001, 2002, recommended for funding 2003

4.6 Washington Salmon Recovery Funding Board Projects

Type	Project Name	Subbasin
Restoration	Wood's Landing Chum Spawning Site	Lower Gorge-Bonneville Tribs
Restoration	Hardy Creek Spawning and Rearing Channel	Lower Gorge-Bonneville Tribs
Restoration	Duncan Creek Dam Fish Passage	Lower Gorge-Bonneville Tribs
	Duncan Creek Dam Fish Restoration	Lower Gorge-Bonneville Tribs

5.0 Management Plan

5.1 Vision

Washington lower Columbia salmon, steelhead, and bull trout are recovered to healthy, harvestable levels that will sustain productive sport, commercial, and tribal fisheries through the restoration and protection of the ecosystems upon which they depend and the implementation of supportive hatchery and harvest practices.

The health of other native fish and wildlife species in the lower Columbia will be enhanced and sustained through the protection of the ecosystems upon which they depend, the control of non-native species, and the restoration of balanced predator/prey relationships.

The Bonneville Tributaries Basin will play a key role in the regional recovery of salmon and steelhead. Natural populations of fall Chinook will be restored to a medium viability level and winter steelhead, chum, and coho will be restored to high levels of viability by significant reductions in human impacts throughout the lifecycle. Salmonid recovery efforts will provide broad ecosystem benefits to a variety of subbasin fish and wildlife species. Recovery will be accomplished through a combination of improvements in subbasin, Columbia River mainstem, and estuary habitat conditions as well as careful management of hatcheries, fisheries, and ecological interactions among species.

Habitat protection or restoration will involve a wide range of Federal, State, Local, and non-governmental programs and projects. Success will depend on effective programs as well as a dedicated commitment to salmon recovery across a broad section of society.

Some hatchery programs will be realigned to focus on protection, conservation, and recovery of native fish. The need for hatchery measures will decrease as productive natural habitats are restored. Where consistent with recovery, other hatchery programs will continue to provide fish for fishery benefits for mitigation purposes in the interim until habitat conditions are restored to levels adequate to sustain healthy, harvestable natural populations.

Directed fishing on sensitive wild populations will be eliminated and incidental impacts of mixed stock fisheries in the Columbia River and ocean will be regulated and limited consistent with wild fish recovery needs. Until recovery is achieved, fishery opportunities will be focused on hatchery fish and harvestable surpluses of healthy wild stocks.

Columbia basin hydropower effects on Bonneville Tributaries salmonids will be addressed by mainstem Columbia and estuary habitat restoration measures. Hatchery facilities in the Lower Columbia River will also be called upon to produce fish to help mitigate for hydropower impacts on upriver stocks where compatible with wild fish recovery.

This plan uses a planning period or horizon of 25 years. The goal is to achieve recovery of the listed salmon species and the biological objectives for other fish and wildlife species of interest within this time period. It is recognized, however, that sufficient restoration of habitat conditions and watershed processes for all species of interest will likely take 75 years or more.

5.2 Biological Objectives

Biological objectives for Bonneville Tributaries salmonid populations are based on recovery criteria developed by scientists on the Willamette/Lower Columbia Technical Recovery Team convened by NOAA Fisheries. Criteria involve a hierarchy of ESU, Strata (i.e. ecosystem areas within the ESU – Coast, Cascade, Gorge), and Population standards. A recovery scenario describing population-scale biological objectives for all species in all three strata in the lower Columbia ESUs was developed through a collaborative process with stakeholders based on biological significance, expected progress as a result of existing programs, the absence of apparent impediments, and the existence of other management opportunities. Under the preferred alternative, individual populations will variously contribute to recovery according to habitat quality and the population's perceived capacity to rebuild. Criteria, objectives, and the regional recovery scenario are described in greater detail in the Regional Recovery and Subbasin Plan Volume I.

Focal populations in the Bonneville Tributaries are targeted to improve to a level that contributes to recovery of the species. The scenario differentiates the role of populations by designating primary, contributin, and stabilizing categories. *Primary populations* are those that would be restored to high or better probabilities of persistence. *Contributing populations* are those where low to medium improvements will be needed to achieve stratum-wide average of moderate persistence probability. *Stabilizing populations* are those maintained at current levels.

The Bonneville Tributaries Basin was identified as one of the most significant areas for salmon recovery among Washington Gorge subbasins based on fish population significance and realistic prospects for restoration. Recovery goals call for restoring Bonneville tributary chum, coho, and winter steelhead to a high viability level. This level will provide for a 95% or better probability of population survival over 100 years. Recovery goals call for restoring Bonneville tributary fall Chinook to a medium viability level, providing for a 75-95% chance of persistence over 100 years.

Cutthroat will benefit from improvements in stream habitat conditions for anadromous species. Lamprey are also expected to benefit from habitat improvements in the estuary, Columbia River mainstem, and Columbia Lower Tributaries Subbasin although specific spawning and rearing habitat requirements are not well known. Bull trout do not occur in the basin.

Table 10. Current viability status of Bonneville Tributaries populations and the biological objective status that is necessary to meet the recovery criteria for the Gorge strata and the lower Columbia ESU.

	ESA	Hatchery	Current		Objective	
Species	Status	Component	Viability	Numbers	Viability	Numbers
Fall Chinook	Threatened	No	Low	100	Medium[C]	100-1,400
Winter steelhead	Threatened	Yes	Low+	200-300	High[P]	200
Chum	Threatened	Yes	Med+	1,000-6,000	High+[P]	2,600-3,100
Coho	Proposed	Yes	Low	unknown	High[P]	600

P = primary population in recovery scenario
C = contributin population in recovery scenario
S = stabilizing population in recovery scenario

5.3 Integrated Strategy

An Integrated Regional Strategy for recovery emphasizes that: 1) it is feasible to recover Washington lower Columbia natural salmon and steelhead to healthy and harvestable levels; 2) substantial improvements in salmon and steelhead numbers, productivity, distribution, and diversity will be required; 3) recovery cannot be achieved based solely on improvements in any one factor; 4) existing programs are insufficient to reach recovery goals, 5) all manageable effects on fish and habitat conditions must contribute to recovery, 6) actions needed for salmon recovery will have broader ecosystem benefits for all fish and wildlife species of interest, and 7) strategies and measures likely to contribute to recovery can be identified but estimates of the incremental improvements resulting from each specific action are highly uncertain. The strategy is described in greater detail in the Regional Recovery and Subbasin Plan Volume I.

The Integrated Strategy recognizes the importance of implementing measures and actions that address each limiting factor and risk category, prescribing improvements in each factor/threat category in proportion to its magnitude of contribution to salmon declines, identifying an appropriate balance of strategies and measures that address regional, upstream, and downstream threats, and focusing near term actions on species at-risk of extinction while also ensuring a long term balance with other species and the ecosystem.

Population productivity improvement increments identify proportional improvements in productivity needed to recover populations from current status to medium, high, and very high levels of population viability consistent with the role of the population in the recovery scenario. Productivity is defined as the inherent population replacement rate and is typically expressed by models as a median rate of population increase (PCC model) or a recruit per spawner rate (EDT model). Corresponding improvements in spawner numbers, juvenile outmigrants, population spatial struction, genetic and life history diversity, and habitat are implicit in productivity improvements.

Improvement targets were developed for each impact factor based on desired population productivity improvements and estimates of potentially manageable impacts (see Section 3.7). Impacts are estimates of the proportional reduction in population productivity associated with human-caused and other potentially manageable impacts from stream habitats, estuary/mainstem habitats, hydropower, harvest, hatcheries, and selected predators. Reduction targets were driven by the regional strategy of equitably allocating recovery responsibilities among the six manageable impact factors. Given the ultimate uncertainty in the effects of recovery actions and the need to implement an adaptive recovery program, this approximation should be adequate for developing order-of-magnitude estimates to which recovery actions can be scaled consistent with the current best available science and data. It is anticipated that objectives and targets will be refined during plan implementation based on new information and refinements in methodology.

The following table identifies population and factor-specific improvements consistent with the biological objectives for this subbasin. Per factor increments are less than the population net because factor affects are compounded at different life stages and density dependence is largely limited to freshwater tributary habitat. Thus, productivity of Bonneville Tributaries chum must increase by 90% to reach population viability goals which requires impact reductions equivalent to an 11% improvement in productivity or survival for each of six factor categories. For instance, tribuary habitat potential must increase from 77% of the historical potential (23% impact) to 85% of the historical potential (15% impact).

Table. Productivity improvements consistent with biological objectives for the Bonneville Tributaries subbasin.

Species	Net increase	Per factor	Baseline impacts					
			Trib.	Estuary	Hydro.	Pred.	Harvest	Hatch.
Fall Chinook	10%	3%	0.44	0.28	.19	0.24	0.63	0.28
Winter steelhead	20%	8.5%	0.51	0.12	0	0.23	0.09	0.01
Chum	90%	11%	0.77	0.33	.18	0.22	0.04	0.00
Coho	na	na	na	na	na	na	na	na

5.4 Tributary Habitat

Habitat assessment results were synthesized in order to develop specific prioritized measures and actions that are believed to offer the greatest opportunity for species recovery in the subbasin. As a first step toward measure and action development, habitat assessment results were integrated to develop a multi-species view of 1) priority areas, 2) factors limiting recovery, and 3) contributing land-use threats. For the purpose of this assessment, limiting factors are defined as the biological and physical conditions serving to suppress salmonid population performance, whereas threats are the land-use activities contributing to those factors. Limiting Factors refer to local (reach-scale) conditions believed to be directly impacting fish. Threats, on the other hand, may be local or non-local. Non-local threats may impact instream limiting factors in a number of ways, including: 1) through their effects on habitat-forming processes – such as the case of forest road impacts on reach-scale fine sediment loads, 2) due to an impact in a contributing stream reach – such as riparian degradation reducing wood recruitment to a downstream reach, or 3) by blocking fish passage to an upstream reach.

Priority areas and limiting factors were determined through the technical assessment, including primarily EDT analysis and the Integrated Watershed Assessment (IWA). As described later in this section, priority areas are also determined by the relative importance of subbasin focal fish populations to regional recovery objectives. This information allows for scaling of subbasin recovery effort in order to best accomplish recovery at the regional scale. Land-use threats were determined from a variety of sources including Washington Conservation Commission Limiting Factors Analyses, the IWA, the State 303(d) list, air photo analysis, the Barrier Assessment, personal knowledge of investigators, or known cause-effect relationships between stream conditions and land-uses.

Priority areas, limiting factors and threats were used to develop a prioritized suite of habitat measures. Measures are based solely on biological and physical conditions. For each measure, the key programs that address the measure are identified and the sufficiency of existing programs to satisfy the measure is discussed. The measures, in conjunction with the program sufficiency considerations, were then used to identify specific actions necessary to fill gaps in measure implementation. Actions differ from measures in that they address program deficiencies as well as biophysical habitat conditions. The process for developing measures and actions is illustrated in Figure 17 and each component is presented in detail in the sections that follow.

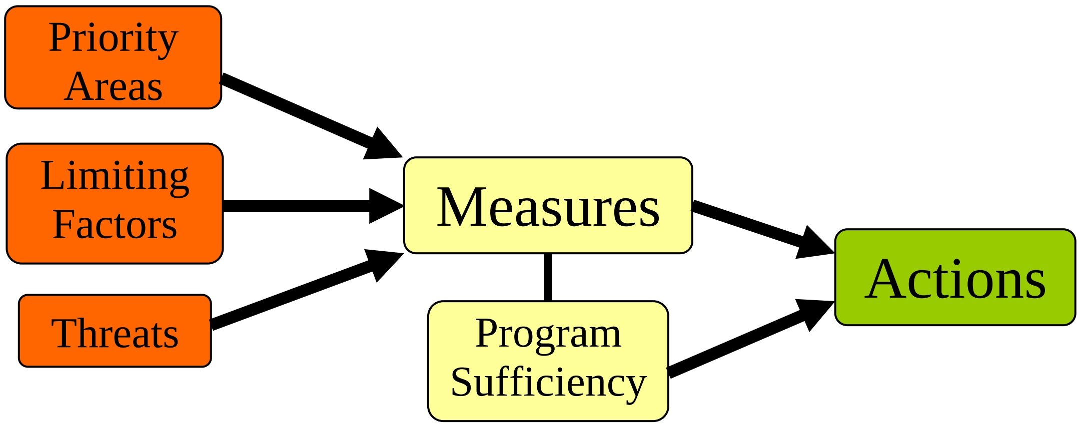


Figure 17. Flow chart illustrating the development of subbasin measures and actions.

5.4.1 *Priority Areas, Limiting Factors and Threats*

Priority habitat areas and factors in the subbasin are discussed below in two sections. The first section contains a generalized (coarse-scale) summary of conditions throughout the basin. The second section is a more detailed summary that presents specific reach and subwatershed priorities.

Summary

Decades of human activity in the Bonneville Tributaries Basin have significantly altered watershed processes and reduced both the quality and quantity of habitat needed to sustain viable populations of salmon and steelhead. Moreover, stream habitat conditions within the Bonneville Tributaries have a high impact on the health and viability of salmon and steelhead relative to other limiting factors. The following bullets provide a brief overview of each of the priority areas in the basin. These descriptions are a summary of the reach-scale priorities that are presented in the next section. These descriptions summarize the species most affected, the primary limiting factors, the contributing land-use threats, and the general type of measures that will be necessary for recovery. A tabular summary of the key limiting factors and land-use threats can be found in Table 11.

- **Lower Hamilton Creek** *(reaches Hamilton 1A, 2; Hamilton Springs)* – Lower Hamilton Creek contains potentially good spawning habitat but conditions have been impacted by development around the town of North Bonneville and by the Hwy 14 crossing. The artificially created Hamilton Springs spawning channel provides important chum spawning habitat. Effective recovery measures here will include riparian and floodplain restoration, in particular addressing channel confinement adjacent to N. Bonneville and associated with the Hwy 14 crossing. Addressing upstream sediment inputs will also help these reaches to recover.
- **Upper Hamilton and Greenleaf Creeks** *(reaches Hamilton 4; Greenleaf 1-3)* – Upper Hamilton and upper Greenleaf creeks contain good quality habitat for winter steelhead and coho. Above reach Hamilton 4, the gradient increases dramatically with several large falls that cannot be ascended. Reach Hamilton 4 currently supports a significant portion of the production for these populations. Preservation is the primary recovery emphasis

for these areas, although restoration of sediment supply conditions will also provide important benefits.

- **Hardy and Duncan Creeks** *(reaches Duncan 1-2; Duncan Springs; Lake Outlet; Hardy 2-3)* – Most of the good spawning habitat in Duncan Creek is located just above Duncan Lake. This area is most important for chum and coho although it is also used by fall Chinook and winter steelhead. Access to spawning areas in Duncan Creek has recently been improved by the construction of a dam that lowers lake levels during salmonid migration periods. Hardy reach 2 and 3 contain the greatest potential in Hardy Creek. Recovery measures in these areas will primarily involve floodplain and riparian restoration.
- **Gibbons & Lawton Creeks** *(no reach priorities specified)* – Gibbons and Lawton creeks were not evaluated using the EDT model and therefore specific reach and limiting factor priorities have not been developed for these streams. Although these streams do not support significant abundance of anadromous salmonids, they nevertheless contain some potentially productive habitat that is in need of restoration and preservation. These streams are threatened primarily by expanding development from the town of Washougal. Effective recovery measures will entail floodplain reconnection, riparian reforestation, and land-use planning that is adequate to protect habitat-forming processes in sensitive areas (i.e., wetlands, riparian areas, floodplains).

Table 11. Salmonid habitat limiting factors and threats in priority areas. Priority areas include the lower Hamilton Creek (LH), upper Hamilton & Greenleaf Creek (UH), Duncan & Hardy Creeks (DU), and Gibbons & Lawton Creek (GI). Linkages between each threat and limiting factor are not displayed – each threat directly and indirectly affects a variety of habitat factors..

Limiting Factors	LH	UH	DU	GI
Habitat connectivity				
Blockages to off-channel habitats	✓		✓	✓
Habitat diversity				
Lack of stable instream woody debris	✓	✓	✓	✓
Altered habitat unit composition	✓	✓	✓	✓
Loss of off-channel and/or side-channels	✓	✓	✓	✓
Channel stability				
Bed and bank erosion	✓	✓		✓
Channel down-cutting (incision)	✓	✓	✓	✓
Riparian function				
Reduced stream canopy cover	✓	✓	✓	✓
Reduced bank/soil stability	✓	✓	✓	✓
Exotic and/or noxious species	✓		✓	✓
Reduced wood recruitment	✓	✓	✓	✓
Floodplain function				
Altered nutrient exchange processes	✓	✓	✓	✓
Reduced flood flow dampening	✓	✓	✓	✓
Restricted channel migration	✓	✓	✓	✓
Disrupted hyporheic processes	✓	✓	✓	✓
Stream flow				
Altered magnitude, duration, or rate of chng	✓		✓	✓
Water quality				
Altered stream temperature regime	✓	✓	✓	✓
Bacteria				✓
Substrate and sediment				
Excessive fine sediment	✓	✓	✓	✓
Embedded substrates	✓	✓	✓	✓

Threats	LH	UH	DU	GI
Agriculture/grazing				
Clearing of vegetation				✓
Riparian grazing				✓
Floodplain filling				✓
Urban & rural development				
Clearing of vegetation	✓		✓	✓
Floodplain filling	✓	✓	✓	✓
Increased impervious surfaces				✓
Increased drainage network				✓
Roads – riparian/floodplain impacts	✓		✓	✓
Leaking septic systems				✓
Forest practices				
Timber harvests –sediment supply impacts	✓	✓	✓	
Timber harvests – impacts to runoff	✓		✓	
Riparian harvests		✓		
Forest roads – impacts to sediment supply	✓	✓	✓	
Forest roads – impacts to runoff	✓		✓	
Channel manipulations				
Bank hardening	✓			✓
Channel straightening	✓	✓	✓	✓
Artificial confinement	✓	✓	✓	✓
Dredge and fill activities	✓	✓		

Specific Reach and Subwatershed Priorities

Specific reaches and subwatersheds have been prioritized based on the plan's biological objectives, fish distribution, critical life history stages, current habitat conditions, and potential fish population performance. Reaches have been placed into Tiers (1-4), with Tier 1 reaches representing the areas where recovery measures would yield the greatest benefits towards accomplishing the biological objectives. The reach tiering factors in each fish population's importance relative to regional recovery objectives, as well as the relative importance of reaches within the populations themselves. Reach tiers are most useful for identifying habitat recovery measures in channels, floodplains, and riparian areas. Reach-scale priorities were initially identified within individual populations (species) through the EDT Restoration and Preservation Analysis. This resulted in reaches grouped into categories of high, medium, and low priority for each population (see Stream Habitat Limitations section). Within a subbasin, reach rankings for all of the modeled populations were combined, using population designations as a weighting factor. Population designations for this subbasin are described in the Biological Objectives section. The population designations are 'primary', 'contributing', and 'stabilizing'; reflecting the level of emphasis that needs to be placed on population recovery in order to meet ESA recovery criteria.

Spatial priorities were also identified at the subwatershed scale. Subwatershed-scale priorities were directly determined by reach-scale priorities, such that a Group A subwatershed contains one or more Tier 1 reaches. Scaling up from reaches to the subwatershed level was done in recognition that actions to protect and restore critical reaches might need to occur in adjacent and/or upstream upland areas. For example, high sediment loads in a Tier 1 reach may originate in an upstream contributing subwatershed where sediment supply conditions are impaired because of current land use practices. Subwatershed-scale priorities can be used in conjunction with the IWA to identify watershed process restoration and preservation opportunities. The specific rules for designating reach tiers and subwatershed groups are presented in Table 12. Reach tier designations for this basin are included in Table 13. Reach tiers and subwatershed groups are displayed on a map in Figure 18. A summary of reach- and-subwatershed-scale limiting factors is included in Table 14.

Table 12. Rules for designating reach tier and subwatershed group priorities. See Biological Objectives section for information on population designations.

Designation	Rule
Reaches	
Tier 1:	All high priority reaches (based on EDT) for one or more primary populations.
Tier 2:	All reaches not included in Tier 1 and which are medium priority reaches for one or more primary species and/or all high priority reaches for one or more contributing populations.
Tier 3:	All reaches not included in Tiers 1 and 2 and which are medium priority reaches for contributing populations and/or high priority reaches for stabilizing populations.
Tier 4:	Reaches not included in Tiers 1, 2, and 3 and which are medium priority reaches for stabilizing populations and/or low priority reaches for all populations.
Subwatersheds	
Group A:	Includes one or more Tier 1 reaches.
Group B:	Includes one or more Tier 2 reaches, but no Tier 1 reaches.
Group C:	Includes one or more Tier 3 reaches, but no Tier 1 or 2 reaches.
Group D:	Includes only Tier 4 reaches.

Table 13. Reach Tiers in the Bonneville Tributaries Basin.

Tier 1	Tier 2		Tier 4	
Duncan 1	Duncan 2	Hamilton Springs	Duncan Lake	Hamilton 1_B
Hamilton 1_A	Duncan Springs	Hardy 2	Duncan Dam	Hardy 4
Hamilton 2	Greenleaf Creek 1	Hardy 3	Greenleaf Creek 2	Hardy 5
Hamilton 4	Greenleaf Creek 3		Greenleaf outlet	Hardy Culvert 1
Lake Outlet	Hamilton 3		Greenleaf Slough	Hardy Culvert 2

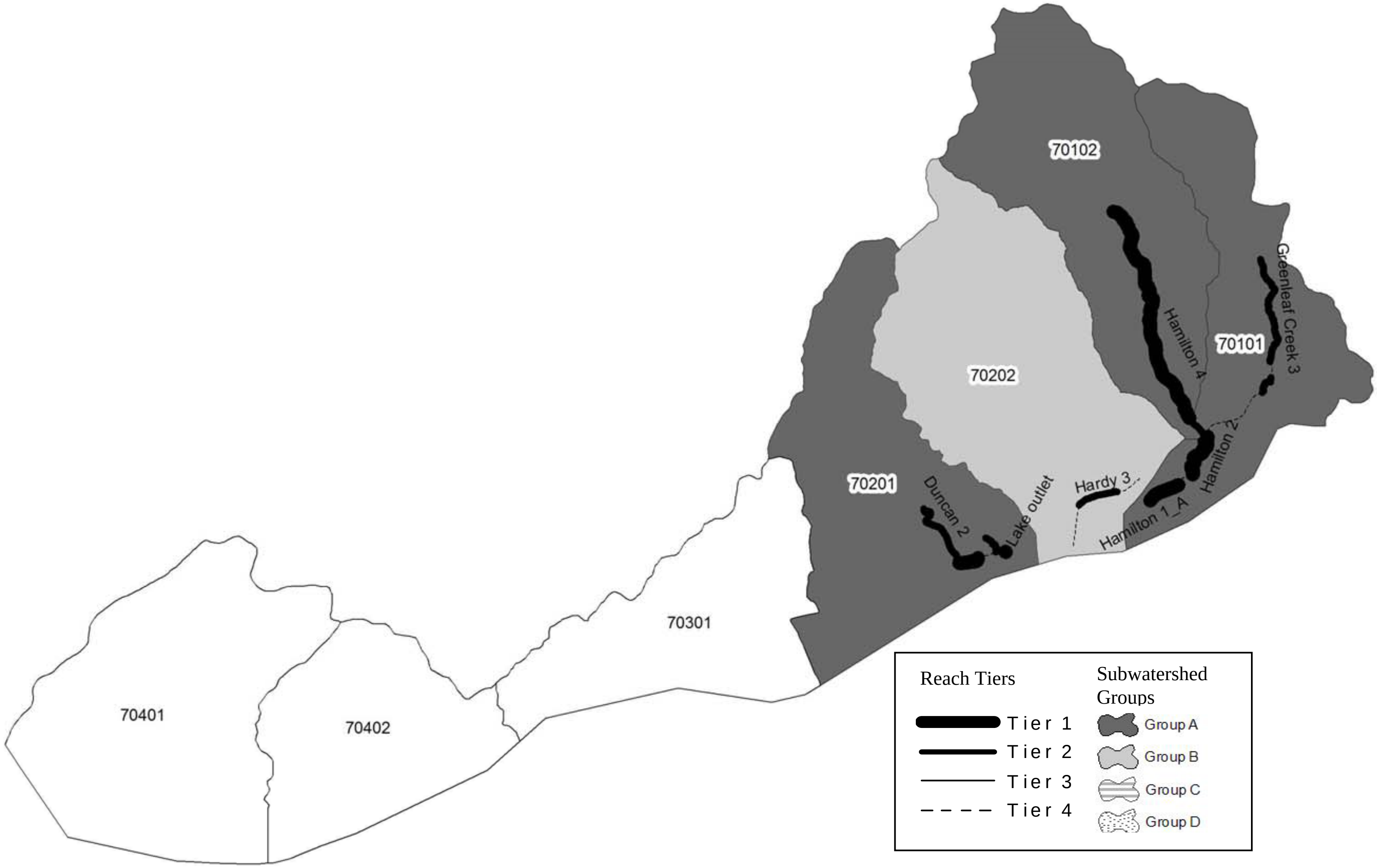


Figure 18. Reach tiers and subwatershed groups in the Bonneville Tributaries Basin. Tier 1 reaches and Group A subwatersheds represent the areas where recovery actions would yield the greatest benefits with respect to species recovery objectives. The subwatershed groups are based on Reach Tiers. Priorities at the reach scale are useful for identifying stream corridor recovery measures. Priorities at the subwatershed scale are useful for identifying watershed process recovery measures. Watershed process recovery measures for stream reaches will need to occur within the surrounding (local) subwatershed as well as in upstream contributing subwatersheds.

Table 14. Summary Table of reach- and subwatershed-scale limiting factors in priority areas. The table is organized by subwatershed groups, beginning with the highest priority group. Species-specific reach priorities, critical life stages, high impact habitat factors, and recovery emphasis (P=preservation, R=restoration, PR=restoration and preservation) are included. Watershed process impairments: F=functional, M=moderately impaired, I=impaired. Species abbreviations: ChS=spring Chinook, ChF=fall Chinook, StS=summer steelhead, StW=winter steelhead.

Sub-watershed Group	Sub-watershed	Reaches within subwatershed	Species Present	High priority reaches by species	Critical life stages by species	High impact habitat factors	Preservation or restoration emphasis	Watershed processes (local) Hydrology	Watershed processes (local) Sediment	Watershed processes (local) Riparian	Watershed processes (watershed) Hydrology	Watershed processes (watershed) Sediment
A	70101	Hamilton 2 Hamilton 1_A Greenleaf Creek 1 Greenleaf Creek 3 Hamilton 3 Hamilton 1_B Greenleaf Creek 2 Greenleaf outlet Greenleaf Slough	ChF	Hamilton 1_A	Spawning Egg incubation Adult holding	temperature sediment key habitat quantity	PR	M	M	M	M	M
			Chum	Hamilton 2 Hamilton 1_A	Spawning Egg incubation Fry colonization Adult holding	habitat diversity harassment key habitat quantity	P					
			StW	none								
			Coho	Hamilton 2	Egg incubation Fry colonization Summer rearing	habitat diversity temperature flow sediment key habitat quantity	R					
	70201	Lake outlet Duncan 1 Duncan 2 Duncan Springs Duncan Lake Duncan Dam	ChF	none				I	M	M	I	M
			Chum	Lake outlet	Fry colonization Adult migrant	none	P					
			StW	none								
			Coho	Duncan 1	Egg incubation Summer rearing Winter rearing	sediment	R					
	70102	Hamilton 4	StW	Hamilton 4	Spawning Egg incubation Fry colonization Adult holding	sediment key habitat quantity	P	F	M	F	F	M
			Coho	none								
B	70202	Hardy 2 Hardy 3 Hardy 1 Slough Hardy 4 Hardy 5	Chum	none				I	M	M	I	M
			StW	none								
			Coho	none								

5.4.2 *Habitat Measures*

Measures are means to achieve the regional strategies that are applicable to the Bonneville Tributaries Basin and are necessary to accomplish the biological objectives for focal fish species. Measures are based on the technical assessments for this subbasin (Section 3.0) as well as on the synthesis of priority areas, limiting factors, and threats presented earlier in this section. The measures applicable to the Bonneville Tributaries Basin are presented in priority order in Table 15. Each measure has a set of submeasures that define the measure in greater detail and add specificity to the particular circumstances occurring within the subbasin. The table for each measure and associated submeasures indicates the limiting factors that are addressed, the contributing threats that are addressed, the species that would be most affected, and a short discussion. Priority locations are given for some measures. Priority locations typically refer to either stream reaches or subwatersheds, depending on the measure. Addressing measures in the highest priority areas first will provide the greatest opportunity for effectively accomplishing the biological objectives.

Following the list of priority locations is a list of the programs that are the most relevant to the measure. Each program is qualitatively evaluated as to whether it is sufficient or needs expansion with respect to the measure. This exercise provides an indication of how effectively the measure is already covered by existing programs, policy, or projects; and therefore indicates where there is a gap in measure implementation. This information is summarized in a discussion of Program Sufficiency and Gaps.

The measures themselves are prioritized based on the results of the technical assessment and in consideration of principles of ecosystem restoration (e.g. NRC 1992, Roni et al. 2002). These principles include the hypothesis that the most efficient way to achieve ecosystem recovery in the face of uncertainty is to focus on the following prioritized approaches: 1) protect existing functional habitats and the processes that sustain them, 2) allow no further degradation of habitat or supporting processes. 3) re-connect isolated habitat, 4) restore watershed processes (ecosystem function), 5) restore habitat structure, and 6) create new habitat where it is not recoverable. These priorities have been adjusted for the specific circumstances occurring in the Bonneville Tributaries Basin. These priorities are adjusted depending on the results of the technical assessment and on the specific circumstances occurring in the basin. For example, re-connecting isolated habitat could be adjusted to a lower priority if there is little impact to the population created from passage barriers.

5.4.3 *Habitat Actions*

The prioritized measures and associated gaps are used to develop specific Actions for the subbasin. These are presented in Table 16. Actions are different than the measures in a number of ways: 1) actions have a greater degree of specificity than measures, 2) actions consider existing programs and are therefore not based strictly on biophysical conditions, 3) actions refer to the agency or entity that would be responsible for carrying out the action, and 4) actions are related to an expected outcome with respect to the biological objectives. Actions are not presented in priority order but instead represent the suite of activities that are all necessary for recovery of listed species. The priority for implementation of these actions will consider the priority of the measures they relate to, the “size” of the gap they are intended to fill, and feasibility considerations.

Table 15. Prioritized measures for the Bonneville Tributaries Basin.

#1 – Protect stream corridor structure and function

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Protect floodplain function and channel migration processes B. Protect riparian function C. Protect access to habitats D. Protect instream flows through management of water withdrawals E. Protect channel structure and stability F. Protect water quality G. Protect the natural stream flow regime	Potentially addresses many limiting factors	Potentially addresses many limiting factors	All Species	Stream corridors in the upper reaches of Hardy, Hamilton, and Duncan Creek Basins are in relatively good condition. Lower reaches are impacted by State Highway 14, the railroad, and development. Stream corridors in the Gibbons and Lawton Creek Basins are impacted by the expanding development from the west. Preventing further degradation of stream channel structure, riparian function, and floodplain function will be an important component of recovery.

Priority Locations

1st- Tier 1 or 2 reaches with functional riparian zones according to the IWA
Reaches: Hamilton 3-4

2nd- Tier 1 or 2 reaches in mixed-use lands at risk of further degradation
Reaches: Duncan 1, 2; Duncan Springs; Lake Outlet (Duncan Creek mouth); Hamilton 1_A; Hamilton Springs; Hardy 2-3

3rd- All remaining reaches

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
NOAA Fisheries	ESA Section 7 and Section 10	✓	
US Army Corps of Engineers (USACE)	Dredge & fill permitting (Clean Water Act sect. 404); Navigable waterways protection (Rivers & Harbors Act Sect, 10)	✓	
USFS	Northwest Forest Plan, Columbia River Gorge National Scenic Area	✓	
Washington State Parks	Beacon Rock State Park	✓	
WA Department of Natural Resources (WDNR)	State Lands HCP, Forest Practices Rules, Riparian Easement Program	✓	
WA Department of Fish and Wildlife (WDFW)	Hydraulics Projects Approval	✓	
Clark County	Comprehensive Planning		✓
Skamania County	Comprehensive Planning		✓
Clark Conservation District / Natural Resources Conservation Service (NRCS)	Landowner technical assistance, conservation planning		✓
Underwood Conservation District / NRCS	Landowner technical assistance, conservation planning		✓
Noxious Weed Control Boards (State and County level)	Noxious Weed Education, Enforcement, Control		✓
Non-Governmental Organizations (NGOs) (e.g. Columbia Land Trust) and public agencies	Land acquisition and easements		✓

Program Sufficiency and Gaps
Alterations to stream corridor structure that may impact aquatic habitats are regulated through the WDFW Hydraulics Project Approval (HPA) permitting program. Other regulatory protections are provided through USACE permitting, ESA consultations, HCPs, USFS programs, and local government ordinances. Riparian areas within private timberlands are protected through the Forest Practices Rules (FPR) administered by WDNR. The FPRs came out of an extensive review process and are believed to adequately protect riparian areas with respect to stream shading, bank stability, and LWD recruitment. The program is new, however, and careful monitoring of the effect of the regulations is necessary, particularly with respect to the effects on watershed hydrology and sediment supply. Land-use conversion and development are increasing in the western portion of the basin and local government ordinances must ensure that new development occurs in a manner that protects key habitats. Conversion of land-use from forest or agriculture to residential use has the potential to increase impairment of aquatic habitat, particularly when residential development is paired with flood control measures. Local governments can limit potentially harmful land-use conversions by thoughtfully directing growth through comprehensive planning and tax incentives, by providing consistent protection of critical areas across jurisdictions, and by preventing development in floodplains. In cases where existing programs are unable to protect critical habitats due to inherent limitations of regulatory mechanisms, conservation easements and land acquisition may be necessary. Public land acquisition should be used as a last resort due to the strong opposition by Skamania County to reducing their tax base in an area that is already overwhelming publicly owned.

#2 – Protect hillslope processes

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Manage forest practices to minimize impacts to sediment supply processes, runoff regime, and water quality B. Manage agricultural practices to minimize impacts to sediment supply processes, runoff regime, and water quality (western portion of basin only) C. Manage growth and development to minimize impacts to sediment supply processes, runoff regime, and water quality	• Excessive fine sediment • Excessive turbidity • Embedded substrates • Stream flow – altered magnitude, duration, or rate of change of flows • Water quality impairment	• Timber harvest – impacts to sediment supply, water quality, and runoff processes • Forest roads – impacts to sediment supply, water quality, and runoff processes • Agricultural practices – impacts to sediment supply, water quality, and runoff processes (western portion of basin only) • Development – impacts to sediment supply, water quality, and runoff processes	All species	Hillslope runoff and sediment delivery processes have been degraded due to past intensive timber harvest and road building. Agriculture and development have further impacted river systems in the western portion of the basin (Lawton and Gibbons Creek Basins). Limiting additional degradation will be necessary to prevent further habitat impairment.

Priority Locations

1st- Functional subwatersheds contributing to Tier 1 or 2 reaches (functional for sediment *or* flow according to the IWA – local rating)
Subwatersheds: 70102 (upper Hamilton Creek)
2nd- All other functional subwatersheds plus Moderately Impaired subwatersheds contributing to Tier 1 or 2 reaches
Subwatersheds: 70201, 70202, 70101
3rd- All other Moderately Impaired subwatersheds plus Impaired subwatersheds contributing to Tier 1 or 2 reaches
Subwatersheds: 70401, 70402, 70301

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDNR	Forest Practices Rules, State Lands HCP	✓	
Washington State Parks	Beacon Rock State Park	✓	
USFS	Northwest Forest Plan, Columbia River Gorge National Scenic Area	✓	
Clark County	Comprehensive Planning		✓
Skamania County	Comprehensive Planning		✓
Clark Conservation District / NRCS	Landowner technical assistance, conservation planning		✓
Underwood Conservation District / NRCS	Landowner technical assistance, conservation planning		✓

Program Sufficiency and Gaps

Hillslope processes on state lands are protected through the State Forest Lands HCP. Federal forest lands are protected through the Northwest Forest Plan. Hillslope processes on private forest lands are protected through Forest Practices Rules administered by the WDNR. These rules, developed as part of the Forests & Fish Agreement, are believed to be adequate for protecting watershed sediment supply, runoff processes, and water quality on private forest lands. Small private landowners may be unable to meet some of the requirements on a timeline commensurate with large industrial landowners. Financial assistance to small owners would enable greater and quicker compliance. On non-forest lands (agriculture and developed), County Comprehensive Planning is the primary nexus for protection of hillslope processes. Counties can control impacts through zoning that protects existing uses, through stormwater management ordinances, and through tax incentives to prevent agricultural and forest lands from becoming developed. These protections are especially important in the western portion of the basin due to expanding growth. There are few to no regulatory protections of hillslope processes that relate to agricultural practices; such deficiencies need to be addressed through local or state authorities. Protecting hillslope processes on agricultural lands would also benefit from the expansion of technical assistance and landowner incentive programs (NRCS, Conservation Districts).

#3 - Restore floodplain function and channel migration processes in the lower reaches of the primary streams

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Set back, breach, or remove artificial confinement structures	• Bed and bank erosion • Altered habitat unit composition • Restricted channel migration • Disrupted hyporheic processes • Reduced flood flow dampening • Altered nutrient exchange processes • Channel incision • Loss of off-channel and/or side-channel habitat • Blockages to off-channel habitats	• Floodplain filling • Channel straightening • Artificial confinement	chum, fall chinook, coho	There has been significant degradation of floodplain connectivity and constriction of channel migration zones along the lower portion of many streams. In the case of Hardy, Hamilton, and Duncan Creeks, this impairment is largely due to State Highway 14 and the railroad corridor as well as development around North Bonneville, which has impacted lower Hamilton Creek. Lower Gibbons Creek has been disconnected from its floodplain as a result of wetland draining and construction of an elevated channel. Re-configuring stream crossings and selective breaching, setting back, or removing confining structures would help to restore floodplain and CMZ function as well as facilitate the creation of off-channel and side channel habitats. There are challenges with implementation due to private lands, existing infrastructure already in place, potential flood risk to property, and large expense.

Priority Locations

1st- Tier 1 reaches with hydro-modifications (obtained from EDT ratings)
Reaches: Duncan 1; Hamilton 1_A, 2

2nd- Tier 2 reaches with hydro-modifications
Reaches: Duncan 2; Hamilton 3; Hardy 2

3rd- Other reaches with hydro-modifications
Reaches: Hardy 1 Slough; Gibbons Creek; Campen Creek (Gibbons Creek trib – golf course impacts)

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDFW	Habitat Program		✓
USACE	Water Resources Development Act (Sect. 1135 & Sect. 206)		✓
Washington State Parks	Habitat Projects		✓
USFS	Habitat Projects		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓

Program Sufficiency and Gaps

There currently are no programs that set forth strategies for restoring floodplain function and channel migration processes in the Bonneville Tributaries Basin. Without programmatic changes, projects are likely to occur only seldom as opportunities arise and only if financing is made available. The level of floodplain and CMZ impairment in the lower reaches of several of the streams put an increased emphasis on restoration. Means of increasing restoration activity include building partnerships with landowners, increasing landowner participation in conservation programs, allowing restoration projects to serve as mitigation for other activities, and increasing funding for NGOs and government entities to conduct projects. Floodplain restoration projects are often expensive, large-scale efforts that require partnerships among many agencies, NGOs, and landowners. Building partnerships is a necessary first step toward floodplain and CMZ restoration.

#4- Restore degraded hillslope processes

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Upgrade or remove problem forest roads B. Reforest heavily cut areas not recovering naturally C. Employ agricultural Best Management Practices with respect to contaminant use, erosion, and runoff (western portion of basin only) D. Reduce watershed imperviousness (western portion of basin only) E. Reduce effective stormwater runoff from developed areas	• Excessive fine sediment • Excessive turbidity • Embedded substrates • Stream flow – altered magnitude, duration, or rate of change of flows • Water quality impairment	• Timber harvest – impacts to sediment supply, water quality, and runoff processes • Forest roads – impacts to sediment supply, water quality, and runoff processes • Agricultural practices – impacts to sediment supply, water quality, and runoff processes (western portion of basin only) • Development – impacts to water quality and runoff processes	All species	Hillslope runoff and sediment delivery processes have been degraded due to past intensive timber harvest, road building, agriculture, and development. These processes must be addressed for reach-level habitat recovery to be successful.

Priority Locations

1st- Moderately impaired or impaired subwatersheds contributing to Tier 1 reaches (mod. impaired or impaired for sediment *or* flow according to IWA – local rating)
Subwatersheds: 70201, 70202, 70102, 70101

2nd- Moderately impaired or impaired subwatersheds contributing to other reaches
Subwatersheds: 70401, 70402, 70301

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDNR	State Lands HCP, Forest Practices Rules, Habitat Projects	✓	
WDFW	Habitat Program		✓
Washington State Parks	Habitat Projects	✓	
USFS	Northwest Forest Plan, Columbia River Gorge National Scenic Area, Habitat Projects	✓	
Clark Conservation District / NRCS	Landowner technical assistance, conservation planning, habitat projects		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
Underwood Conservation District / NRCS	Landowner technical assistance, conservation planning, habitat projects		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓

Program Sufficiency and Gaps

Forest management programs including the Northwest Forest Plan (federal forest lands), the new Forest Practices Rules (private timber lands), and the WDNR HCP (state timber lands) are expected to afford protections that will passively and actively restore degraded hillslope conditions. Timber harvest rules are expected to passively restore sediment and runoff processes. The road maintenance and abandonment requirements for private timber lands are expected to actively address road-related impairments within a 15 year time-frame. While these strategies are believed to be largely adequate to protect watershed processes, the degree of implementation and the effectiveness of the prescriptions will not be fully known for at least another 15 or 20 years. Of particular concern is the capacity of some forest land owners, especially small forest owners, to conduct the necessary road improvements (or removal) in the required timeframe. Additional financial and technical assistance would enable small forest landowners to conduct the necessary improvements in a timeline parallel to large industrial timber land owners. Ecological restoration of existing developed and agricultural lands occurs relatively infrequently and there are no programs that specifically require restoration in these areas, which are common in the western portion of the basin. Restoring existing developed and farmed lands can involve retrofitting facilities with new materials, replacing existing systems, adopting new management practices, and creating or re-configuring landscaping. Means of increasing restoration activity include increasing landowner participation through education and incentive programs, building support for projects on public lands/facilities, requiring activities through permitting and ordinances, and increasing available funding for entities to conduct restoration projects.

#5 – Restore access to habitat blocked by artificial barriers

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Restore access to isolated habitats blocked by culverts, dams, or other barriers	• Blockages to channel habitats • Blockages to off-channel habitats	• Dams, culverts, in-stream structures	All species	As many as 6 miles of potentially accessible habitat are blocked by culverts or other barriers. There are also passage concerns with culverts under SR 14. Passage restoration projects should focus only on cases where it can be demonstrated that there is good potential benefit and reasonable project costs.

Priority Locations

1st- Lower Gibbons Creek (off-channel habitat), upper Gibbons Creek tributaries (culverts and other barriers), Hardy and Woodward Creeks (culverts under SR 14)
2nd- Other small tributaries with blockages

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDNR	Forest Practices Rules, Family Forest Fish Passage, State Forest Lands HCP		✓
WDFW	Habitat Program		✓
Washington Department of Transportation / WDFW	Fish Passage Program		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
Skamania County	Roads		✓
Clark County	Roads		✓

Program Sufficiency and Gaps

The Forest Practices Rules require forest landowners to restore fish passage at artificial barriers by 2016. Small forest landowners are given the option to enroll in the Family Forest Fish Program in order to receive financial assistance to fix blockages. The Washington State Department of Transportation, in a cooperative program with WDFW, manages a program to inventory and correct blockages associated with state highways. The Salmon Recovery Funding Board, through the Lower Columbia Fish Recovery Board, funds barrier removal projects. Past efforts have corrected major blockages (including passage issues at Duncan Lake) and have identified others in need of repair. Additional funding is needed to correct remaining blockages. Further monitoring and assessment is needed to ensure that all potential blockages have been identified and prioritized.

#6 - Restore riparian conditions throughout the basin

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Restore the natural riparian plant community B. Eradicate invasive plant species from riparian areas	• Reduced stream canopy cover • Altered stream temperature regime • Reduced bank/soil stability • Reduced wood recruitment • Lack of stable instream woody debris • Exotic and/or invasive species	• Timber harvest – riparian harvests • Clearing of vegetation due to agriculture and residential development	All species	Riparian conditions have been degraded due to past timber harvests, development, and agriculture. The increasing abundance of exotic and invasive species is of particular concern. Riparian restoration has a high potential benefit due to the many limiting factors that are addressed. Riparian restoration projects are relatively inexpensive and are often supported by landowners.

Priority Locations

1st- Tier 1 reaches
2nd- Tier 2 reaches
3rd- Tier 3 reaches
4th- Tier 4 reaches

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDNR	State Lands HCP, Forest Practices Rules, Habitat Projects	✓	
WDFW	Habitat Program		✓
Washington State Parks	Habitat Projects		✓
USFS	Northwest Forest Plan, Columbia River Gorge National Scenic Area, Habitat Projects	✓	
Clark Conservation District / NRCS	Landowner technical assistance, conservation planning, habitat projects		✓
Underwood Conservation District / NRCS	Landowner technical assistance, conservation planning, habitat projects		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓
Noxious Weed Control Boards (State and County level)	Noxious Weed Enforcement, Education, Control		✓

Program Sufficiency and Gaps

There are no regulatory mechanisms for actively restoring riparian conditions; however, existing programs will afford protections that will allow for the *passive* restoration of riparian forests. These protections are believed to be adequate for riparian areas on forest lands that are subject to the Northwest Forest Plan (federal lands), Forest Practices Rules (private forest lands) or the State forest lands HCP. Other lands receive variable levels of protection and passive restoration through the Clark and Skamania Counties Comprehensive Plans. Many degraded riparian zones in urban, agricultural, rural residential, or transportation corridor uses will not passively restore with existing regulatory protections and will require active measures. Riparian restoration in these areas may entail tree planting, road relocation, invasive species eradication, and adjusting current land-use in the riparian zone. Means of increasing restoration activity include building partnerships with landowners, increasing landowner participation in conservation programs, allowing restoration projects to serve as mitigation for other activities, and increasing funding for NGOs, government entities, and landowners to conduct restoration projects.

#7 – Create/restore off-channel and side-channel habitat

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Restore historical off-channel and side-channel habitats where they have been eliminated B. Create new channel or off-channel habitats (i.e. spawning channels)	• Loss of off-channel and/or side-channel habitat	• Floodplain filling • Channel straightening • Artificial confinement	chum, coho	There has been significant loss of off-channel and side-channel habitats, especially along the lower portion of streams near their confluence with the Columbia where transportation corridors and other confinement structures have eliminated or blocked access to habitats. This has severely limited chum spawning habitat and coho overwintering habitat. Targeted restoration or creation of habitats would increase available habitat where full floodplain and CMZ restoration is not possible.

Priority Locations

1st- Lower mainstems of most streams (e.g. Gibbons, Hardy, Woodward, Hamilton)
2nd- Other reaches that may have potential for off-channel and side-channel habitat restoration or creation

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDFW	Habitat Program		✓
Washington State Parks	Habitat Projects		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓
USACE	Water Resources Development Act (Sect. 1135 & Sect. 206)		✓

Program Sufficiency and Gaps

There are no regulatory mechanisms for creating or restoring off-channel and side-channel habitat. Construction of chum spawning channels has been conducted on Hamilton and Duncan Creeks and there may be opportunities to expand these efforts. Means of increasing restoration activity include building partnerships with landowners, increasing landowner participation in conservation programs, allowing restoration projects to serve as mitigation for other activities, and increasing funding for NGOs, government entities, and landowners to conduct restoration projects.

#8 – Restore degraded water quality with an emphasis on stream temperature impairments

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Exclude livestock from riparian areas B. Increase riparian shading C. Decrease channel width-to-depth ratios D. Reduce delivery of chemical contaminants to streams E. Address leaking septic systems	• Bacteria • Altered stream temperature regime • Chemical contaminants	• Timber harvest – riparian harvests • Riparian grazing • Leaking septic systems • Clearing of vegetation due to rural development and agriculture • Chemical contaminants from agricultural and developed lands	• All species	Although there are no 303(d) listings for stream temperature, there have been regular exceedances of temperature standards in lower Hamilton, lower Hardy, and lower Duncan Creeks. Temperature impairment is likely related to riparian degradation. Other water quality impairments present human health as well as potential fish health concerns. Gibbons Creek Remnant Channel is listed on the 2002-2004 draft 303(d) list for chromium impairment and is listed as a concern for arsenic. Gibbons Creek was also listed on the 1996 and 1998 lists for fecal coliform impairment. Bacteria impairment in Gibbons Creek is believed to be related to livestock grazing and/or failing septic systems. Chromium and arsenic impairments in the Gibbon Creek Remnant Channel are related to facilities at the Camas/Washougal Industrial Park (Johnson 1998).

Priority Locations

1st- Gibbons Creek (fecal coliform, temperature, chromium, arsenic); Campen Creek (fecal coliform, temperature); Hardy Creek (temperature), Hamilton Creek (temperature), Duncan Creek (temperature)

2nd- Other stream reaches

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
Washington Department of Ecology	Water Quality Program		✓
WDNR	State Lands HCP, Forest Practices Rules	✓	
WDFW	Habitat Program		✓
Clark Conservation District / NRCS	Landowner technical assistance, conservation planning, habitat projects, Centennial Clean Water		✓
Underwood Conservation District / NRCS	Landowner technical assistance, conservation planning, habitat projects, Centennial Clean Water		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓
Clark County Health Department	Septic System Program		✓
Skamania County Health Department	Septic System Program		✓

Program Sufficiency and Gaps

The WDOE Water Quality Program manages the State 303(d) list of impaired water bodies. There was one listing on the draft 2002/2004 303(d) list in Gibbons Creek for chromium and it was also listed as a concern for arsenic. A Water Quality Clean-up Plan (TMDL) will be required by WDOE for chromium; it is expected that this assessment will effectively address the chromium impairment. Gibbons Creek was listed for fecal coliform bacteria impairment on the 1996 and 1998 303(d) lists. A TMDL in response to the fecal coliform bacteria listing was developed by the WDOE (WDOE 1996). The plan was inconclusive in identifying the source of the impairment and recommended additional monitoring. There is little information available as to the current condition of the bacteria impairment on Gibbons Creek. Although there are no 303(d) listings in other stream systems, temperature monitoring has indicated exceedances in several instances. These exceedances need to be evaluated further.

#9 – Provide for adequate instream flows during critical periods

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Protect instream flows through water rights closures and enforcement B. Restore instream flows through acquisition of existing water rights C. Restore instream flows through implementation of water conservation measures	• Stream flow – maintain or improve Summer low-flows	• Water withdrawals	All species	Instream flow management strategies for the Bonneville Tributaries Basin have been identified as part of Watershed Planning for WRIA 28 (LCFRB 2004). Strategies include water rights closures, setting of minimum flows, and drought management policies. This measure applies to instream flows associated with water withdrawals and diversions, generally a concern only during low flow periods. Hillslope processes also affect low flows but these issues are addressed in separate measures.

Priority Locations

Entire Basin

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
Washington Department of Ecology	Water Resources Program		✓

Program Sufficiency and Gaps

The Water Resources Program of the WDOE, in cooperation with the WDFW and other entities, manages water rights and instream flow protections. A collaborative process for setting and managing instream flows was launched in 1998 with the Watershed Planning Act (HB 2514), which called for the establishment of local watershed planning groups who's objective was to recommend instream flow guidelines to WDOE through a collaborative process. The current status of the planning effort is to adopt a watershed plan by December 2004. Instream flow management in the Bonneville Tributaries Basin will be conducted using the recommendations of the WRIA 27/28 Planning Unit, which is coordinated by the LCFRB. Draft products of the WRIA 27/28 watershed planning effort can be found on the LCFRB website: www.lcfrb.gen.wa.us. The recommendations of the planning unit have been developed in close coordination with recovery planning and the instream flow prescriptions developed by this group are anticipated to adequately protect instream flows necessary to support healthy fish populations. The measures specified above are consistent with the planning group's recommended strategies. Ecology should implement the recommendations of the WRIA 27/28 Planning Unit relative to instream flow rule development.

#10 - Restore channel structure and stability

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Place stable woody debris in streams to enhance cover, pool formation, bank stability, and sediment sorting B. Structurally modify channel morphology to create suitable habitat C. Restore natural rates of erosion and mass wasting within river corridors	• Lack of stable instream woody debris • Altered habitat unit composition • Reduced bank/soil stability • Excessive fine sediment • Excessive turbidity • Embedded substrates	• None (symptom-focused restoration strategy)	All species	Channel structure and stability has been impaired by a number of activities including past riparian timber harvest, development, stream crossings, and confinement. Channel stabilization projects and structural enhancements to stream channels may be warranted in some places, especially in lower alluvial reaches that have been simplified through channel son projects could benefit habitat conditions in many areas although watershed processes contributing to wood deficiencies should be considered and addressed prior to placing wood in streams.

Priority Locations

1st- Tier 1 reaches
2nd- Tier 2 reaches
3rd- Tier 3 reaches
4th- Tier 4 reaches

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
NGOs, tribes, agencies, landowners	Habitat Projects		✓
WDFW	Habitat Program		✓
USACE	Water Resources Development Act (Sect. 1135 & Sect. 206)		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
Clark Conservation District / NRCS	Landowner technical assistance, conservation planning, habitat projects		✓
Underwood Conservation District / NRCS	Landowner technical assistance, conservation planning, habitat projects		✓

Program Sufficiency and Gaps

There are no regulatory mechanisms for actively restoring channel stability and structure. Passive restoration is expected to slowly occur as a result of protections afforded to riparian areas and hillslope processes. Past projects have largely been opportunistic and have been completed due to the efforts of local NGOs, landowners, and government agencies; such projects are likely to continue in a piecemeal fashion as opportunities arise and if financing is made available. The lack of LWD in stream channels, and the importance of wood for habitat of listed species, places an emphasis on LWD supplementation projects. Means of increasing restoration activity include building partnerships with landowners, increasing landowner participation in conservation programs, allowing restoration projects to serve as mitigation for other activities, and increasing funding for NGOs, government entities, and landowners to conduct restoration projects.

Table 16. Habitat actions for the Bonneville Tributaries Basin.

Action	Status	Responsible Entity	Measures Addressed	Spatial Coverage of Target Area[1]	Expected Biophysical Response[2]	Certainty of Outcome[3]
Bon-Tribs 1.Conduct floodplain restoration where feasible along the lower reaches of streams before their confluence with the Columbia where they have experienced channel confinement due to development and transportation corridors. Build partnerships with landowners and agencies and provide financial incentives	New program or activity	NRCS, UCD, NGOs, WDFW, LCFRB, USACE	3, 5, 6, 8 & 10	Medium: Lower reaches of several tributaries	High: Restoration of floodplain function, habitat diversity, and habitat availability.	High
Bon-Tribs 2.Prevent floodplain impacts from new development through land use controls and Best Management Practices	New program or activity	Skamania County, WDOE	1	Medium: Applies to privately owned floodprone lands under county jurisdiction	High: Protection of floodplain function, CMZ processes, and off-channel/side-channel habitat. Prevention of reduced habitat diversity and key habitat availability	High
Bon-Tribs 3.Create and/or restore lost side-channel/off-channel habitat for chum spawning and coho overwintering	New program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, UCD, LCFEG	10	Medium: Lower reaches of several streams	High: Increased habitat availability for spawning and rearing	High
Bon-Tribs 4.Expand standards in County Comprehensive Plans to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	Expansion of existing program or activity	Skamania County, WDOE	1 & 2	Medium: Applies to all private lands under county jurisdiction	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
Bon-Tribs 5.Manage future growth and development patterns to ensure the protection of watershed processes. This includes limiting the conversion of agriculture and timber lands to developed uses through zoning regulations and tax incentives	Expansion of existing program or activity	Skamania County	1 & 2	Medium: Applies to all private lands under county jurisdiction	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
Bon-Tribs 6.Increase funding available to purchase easements or property in sensitive areas in order to protect watershed function where existing programs are inadequate	Expansion of existing program or activity	LCFRB, NGOs, WDFW, USFWS, BPA (NPCC)	1 & 2	Low: Residential, agricultural, or forest lands at risk of further degradation	High: Protection of riparian function, floodplain function, water quality, wetland function, and runoff and sediment supply processes	High
Bon-Tribs 7.Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management	Expansion of existing program or activity	Skamania County	1, 4, 6, & 8	Low: Applies to lands under public jurisdiction	Medium: Protection of water quality, greater streambank stability, reduction in road-related fine sediment delivery, restoration and preservation of fish access to habitats	High
Bon-Tribs 8.Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise)	Expansion of existing program or activity	NRCS, UCD, WDNR, WDFW, LCFEG, Skamania County	All measures	Medium: Private lands. Applies to lands in agriculture, rural residential, and forestland uses	High: Increased landowner stewardship of habitat. Potential improvement in all factors	Medium

[1] Relative amount of basin affected by action

[2] Expected response of action implementation

[3] Relative certainty that expected results will occur as a result of full implementation of action

Action	Status	Responsible Entity	Measures Addressed	Spatial Coverage of Target Area[1]	Expected Biophysical Response[2]	Certainty of Outcome[3]
and increasing program marketing and outreach				throughout the basin		
Bon-Tribs 9.Continue to manage federal forest lands according to the Northwest Forest Plan	Activity is currently in place	USFS	1, 2, 4, 5, 6 & 8	Low: National Forest lands	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	High
Bon-Tribs 10.Fully implement and enforce the Forest Practices Rules (FPRs) on private timber lands in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 4, 5, 6 & 8	Medium: Private commercial timber lands	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
Bon-Tribs 11.Implement the prescriptions of the WRIA 27/28 Watershed Planning Unit regarding instream flows	Activity is currently in place	WDOE, WDFW, WRIA 27/28 Planning Unit, Skamania County	9	High: Entire basin	Medium: Adequate instream flows to support life stages of salmonids and other aquatic biota.	Medium
Bon-Tribs 12.Conduct forest practices on state lands in accordance with the Habitat Conservation Plan in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 3, 4, 5 & 7	Medium: State timber lands in the Washougal Basin (approximately 30% of the basin area)	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats. Response is medium because of location and quantity of state lands	Medium
Bon-Tribs 13.Increase the level of implementation of voluntary habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	Expansion of existing program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, UCD, LCFEG	3, 4, 5, 6, 7, 8 & 10	Medium: Priority stream reaches and subwatersheds throughout the basin	Medium: Improved conditions related to water quality, LWD quantities, bank stability, key habitat availability, habitat diversity, riparian function, floodplain function, sediment availability, & channel migration processes	Medium
Bon-Tribs 14.Assess the impact of fish passage barriers throughout the basin and restore access to potentially productive habitats	Expansion of existing program or activity	WDFW, WDNR, Skamania County, WSDOT, LCFEG	5	Medium: As many as 6 miles of stream are potentially blocked by artificial barriers	Medium: Increased spawning and rearing capacity due to access to blocked habitat. Habitat is marginal in most cases	Medium
Bon-Tribs 15.Increase technical support and funding to small forest landowners faced with implementation of Forest and Fish requirements for fixing roads and barriers to ensure full and timely compliance with regulations	Expansion of existing program or activity	WDNR	1, 2, 4, 5, 6 & 8	Low: Small private timberland owners	Medium: Reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
Bon-Tribs 16.Protect and restore native plant communities from the effects of invasive species	Expansion of existing program or activity	Weed Control Boards (local and state); NRCS, UCD, LCFEG	1 & 4	Medium: Greatest risk is in agriculture and residential use areas	Medium: restoration and protection of native plant communities necessary to support watershed and riparian function	Low

Action	Status	Responsible Entity	Measures Addressed	Spatial Coverage of Target Area[1]	Expected Biophysical Response[2]	Certainty of Outcome[3]
Bon-Tribs 17. Assess water quality issues through the development and implementation of water quality clean up plans (TMDLs)	**Expansion of existing program or activity**	**WDOE**	**5**	**Medium: temperature concerns throughout basin and 303(d) listings**	**Medium: Protection and restoration of water quality**	**Low**

5.5 Hatcheries

5.5.1 *Subbasin Hatchery Strategy*

The desired future state of fish production within the Bonneville Tributaries Subbasin includes natural salmon and steelhead populations that are improving on a trajectory to recovery and hatchery programs that either enhance the natural fish recovery trajectory or are operated to not impede progress towards recovery. Hatchery recovery measures in each subbasin are tailored to the specific ecological and biological circumstances for each species in the subbasin. This may involve substantial changes in some hatchery programs from their historical focus on production for mitigation. The recovery strategy includes a mixture of conservation programs and mitigation programs for lost fishing benefits. Mitigation programs involve areas or practices selected for consistentency with natural population conservation and recovery objectives. A summary of the types of natural production enhancement strategies in the Bonneville Tributaries Subbasin are displayed by species in Table 17. There are no fishery enhancement strategies included in the Bonneville tributaries. More detailed descriptions and discussion of the regional hatchery strategy can be found in the Regional Recovery and Subbasin Plan Volume I.

Table 17. Summary of natural production and fishery enhancement strategies to be implemented in the Bonneville Tributaries Subbasin.

		Fall Chinook	Coho	Chum	Winter Steelhead
Natural Production Enhancement	Refuge				
	Supplementation			✓	
	Hatch/Nat Conservation 1/				
	Isolation				
Fishery Enhancement	Hatchery Production				

1/ Hatchery and natural population management strategy coordinated to meet biological recovery objectives. Strategy may include integration and/or isolation strategy over time. Strategy will be unique to biological and ecological circumstances in each watershed.

Conservation-based hatchery programs include strategies and measures which are specifically intended to enhance or protect production of a particular wild fish population within the basin. A unique conservation strategy is developed for each species and watershed depending on the status of the natural population, the biological relationship between the hatchery and natural populations, ecological attributes of the watershed, and logistical opportunities to jointly manage the populations. Four types of hatchery conservation strategies may be employed:

Natural Refuge Watersheds: In this strategy, certain sub-basins are designated as wild-fish-only areas for a particular species. The refuge areas include watersheds where populations have persisted with minimum hatchery influence and areas that may have a history of hatchery production but would not be subjected to future hatchery influence as part of the recovery strategy. More refuge areas may be added over time as wild populations recover. These refugia provide an opportunity to monitor population trends independent of the confounding influence of hatchery fish natural population on fitness and our ability to measure natural population productivity and will be key indicators of natural population status within the ESU.

Hatchery Supplementation: This strategy utilizes hatchery production as a tool to assist in rebuilding depressed natural populations. Supplementation would occur in selected areas that are producing natural fish at levels significantly below current capacity or capacity is expected to increase as a result of immediate benefits of habitat or passage improvements. This is intended to be a temporary measure to jump start critically low populations and to bolster natural fish numbers above critical levels in selected areas until habitat is restored to levels where a population can be self sustaining. This strategy would include Washougal Hatchery chum in the Bonneville Tributaries Subbasin.

Hatchery/Natural Isolation: This strategy is focused on physically separating hatchery adult fish from naturally-produced adult fish to avoid or minimize spawning interactions to allow natural adaptive processes to restore native population diversity and productivity. The strategy may be implemented in the entire watershed or more often in a section of the watershed upstream of a barrier or trap where the hatchery fish can be removed. This strategy is currently aimed at hatchery steelhead in watersheds with trapping capabilities. The strategy may also become part of spring and fall chinook as well as coho strategy in certain watersheds in the future as unique wild runs develop. This strategy would not be included in near-term measures for the Boneville Tributaries Subbasin but could be considered in the future for coho. This definition refers only to programs where fish are physically sorted using a barrier or trap. Some fishery mitigation programs, particularly for steelhead, are managed to isolate hatchery and wild stocks based on run timing and release locations.

Hatchery/Natural Merged Conservation Strategy: This strategy addresses the case where natural and hatchery fish have been homogenized over time such that they are principally all one stock that includes the native genetic material for the basin. Many spring chinook, fall chinook, and coho populations in the lower Columbia currently fall into this category. In many cases, the composite stock productivity is no longer sufficient to support a self-sustaining natural population especially in the face of habitat degradation. The hatchery program will be critical to maintaining any population until habitat can be improved and a strictly natural population can be re-established. This merged strategy is intended to transition these mixed populations to a self-supporting natural population that is not subsidized by hatchery production or subject to deleterious hatchery impacts. Elements include separate management of hatchery and natural subpopulations, regulation of hatchery fish in natural areas, incorporation of natural fish into hatchery broodstock, and annual abundance-driven distribution. Corresponding programs are expected to evolve over time dependent on changes in the populations and in the habitat productivity. This strategy is primarily aimed at chinook salmon in areas where harvest production occurs. There is not a chinook harvest program in the Bonneville Tributaries Subbasin.

Not every lower Columbia River hatchery program will be turned into a conservation program. Fishery mitigation programs will continue to be operated in selected areas. The majority of funding for lower Columbia basin hatchery operations is for producing salmon and steelhead for harvest to mitigate for lost harvest of natural production due to hydro development and habitat degradation. Programs for fishery enhancement will continue during the recovery period, but will be managed to minimize risks and ensure they do not compromise recovery objectives for natural populations. It is expected that the need to produce compensatory fish for harvest through artificial production will reduce in the future as natural populations recover and become harvestable. There are no fishery enhancement programs for in the Bonneville Tributaries Subbasin.

The Washougal Hatchery will be operated to include supplementation strategies for Bonneville Tributaries chum. Fall chinook will not be included as a harvest program in the Bonneville Tributaries Subbasin. This plan adds no new conservation programs at the Washougal Hatchery facility (Table 18).

Table 18. A summary of conservation and harvest strategies to be implemented through Washougal Hatchery programs.

		Stock
Natural Production Enhancement	Supplementation	Washougal River Chum
	Hatch/Nat Conservation 1/	
	Isolation	
	Broodstock development	
Fishery Enhancement	In-basin releases	
	Out of Basin Releases	

1/ May include integrated and/or isolated strategy over time.
√ Denotes new program

5.5.2 *Hatchery Measures and Actions*

Hatchery strategies and measures are focused on evaluating and reducing biological risks consistent with the conservation strategies identified for each natural population. Artificial production programs within the Bonneville tributaries subbasin have been evaluated in detail through the WDFW Benefit-Risk Assessment Procedure (BRAP) relative to risks to natural populations. The BRAP results were utilized to inform the development of these program measures specific to the Bonneville tributaries subbasin (Table 19). The Sub-Basin plan hatchery recovery measures were developed in coordination with WDFW and at the same time as the Hatchery and Genetic Management Plans (HGMP) were developed by WDFW for each hatchery program. As a result, the hatchery measures represented in this document will provide direction for specific actions which will be detailed in the HGMPs submitted by WDFW for public review and for NOAA fisheries approval. It is expected that the HGMPs and these recovery measures will be complimentary and provide a coordinated strategy for the Bonneville Tributaries Basin. Further explanation of specific strategies and measures for hatcheries can be found in the Regional Recovery and Subbasin Plan Volume I.

Table 19. Hatchery program actions to be implemented in the Bonneville Tributaries Basin.

Measure	Description	Comments
H.M 25, 27	Hatchery program utilized for supplementation and enhancement of wild chum and coho populations.	The Washougal Hatchery is currently used for supplementation and risk management of lower Gorge chum populations. This program could be potentially expanded to include more areas and populations. Supplementation programs for Washougal natural coho could be developed with appropriate brood stock in the Washougal Hatchery.
H.M8	Adaptively manage hatchery programs to further protect and enhance natural populations and improve operational efficiencies.	Appropriate research, monitoring, and evaluation programs along with guidance from regional hatchery evaluations will be utilized to improve the survival and contribution of hatchery fish, reduce impacts to natural fish, and increase benefits to natural fish.

** Extension or improvement of existing measures-may require additional funding*
*** New measure-will likely require additional funding*

5.6 Harvest

Fisheries are both an impact that reduces fish numbers and an objective of recovery. The long-term vision is to restore healthy, harvestable natural salmonid populations in many areas of the lower Columbia basin. The near-term strategy involves reducing fishery impacts on natural populations to ameliorate extinction risks until a combination of measures can restore natural population productivity to levels where fishing may resume. The regional strategy for interim reductions in fishery impacts involves: 1) elimination of directed fisheries on natural populations, 2) regulation of mixed stock fisheries for healthy hatchery and natural populations to limit and minimize indirect impacts on natural populations, 3) scaling of allowable indirect impacts for consistency with recovery, 4) annual abundance-based management to provide added protection in years of low abundance, and 5) mass marking of hatchery fish for identification and selective fisheries.

Measures to address harvest impacts are generally focused at a regional level to cover fishery impacts accrued to lower Columbia salmon as they migrate along the Pacific Coast and through the mainstem Columbia River. Fisheries are no longer directed at weak natural populations but incidentally catch these fish while targeting healthy wild and hatchery stocks. Subbasin fisheries affecting natural populations have been largely eliminated. Fishery management has shifted from a focus on maximum sustainable harvest of the strong stocks to ensuring protection of the weak stocks. Weak stock protections generally preclude access to large numbers of potentially harvestable fish in strong stocks.

Fishery impact limits to protect listed weak populations are generally based on risk assessments that identify points where fisheries do not pose jeopardy to the continued persistence of a listed group of fish. In many cases, these assessments identify the point where additional fishery reductions provide little reduction in extinction risks. A population may continue to be at significant risk of extinction but those risks are no longer substantially affected by the specified fishing levels. Often, no level of fishery reduction will be adequate to meet naturally-spawning population escapement goals related to population viability. The elimination of harvest will not in itself lead to the recovery of a population. However, prudent and careful management of harvest can help close the gap in a coordinated effort to achieve recovery.

Fishery actions specific to the subbasins are addressed through the Washington State Fish and Wildlife sport fishing regulatory process. This public process includes an annual review focused on emergency type regulatory changes and a comprehensive review of sport fishing regulations which occurs every two years. This regulatory process includes development of fishing rules through the Washington Administrative Code (WAC) which are focused on protecting weak stock populations while providing appropriate access to harvestable populations. The actions consider the specific circumstances in each area of each subbasin and respond with rules that fit the relative risk to the weak populations in a given time and area of the subbasin. The following table summarizes fishery regulatory and protective actions in Bonneville Tributaries

Table 20. Summary of regulatory and protective fishery actions in Bonneville Tributaries.

Species	General Fishing Actions	Explanation	Other Protective Fishery Actions	Explanations
Fall chinook	Closed to retention	Protects wild fall chinook. No hatchery produced fall chinook in the Lower Gorge tributaries	No fisheries for other salmon	Further protection of wild fall chinook spawners
Chum	Closed to retention	Protects wild chum. Hatchery chum are not released in the Lower Gorge tributaries for harvest	No fisheries for other salmon and trout season in Hamilton Creek closes in late fall	Further protection of wild chum spawners
Coho	Closed to retention	Protects wild coho. Hatchery coho are not released in the Lower Gorge tributaries for harvest.	No fisheries for other salmon and trout season in Hamilton Creek closes in late fall	Further protection of wild coho spawners
Winter steelhead	Winter season closed	Trout season closes in the fall prior to entry of winter steelhead and reopens in the summer after steelhead have spawned	Minimum size restrictions during trout season in Hamilton	Minimum size protects juveniles

Regional measures cover species from multiple watersheds which share the same migration routes and timing, resulting in similar fishery exposure. Regional strategies and measures for harvest are detailed in the the Regional Recovery and Subbasin Plan Volume I. A number of regional strategies for harvest involve implementation of measures within specific subbasins. In-basin fishery management is generally applicable to steelhead and salmon while regional management is more applicable to salmon. Harvest measures with significant application to the Bonneville Tributaries Subbasin populations are summarized in the following table:

Table 21. Regional harvest measures from Volume I, Chapter 7 with significant application to the Bonneville Tributaries Subbasin populations.

Measure	Description	Responsible Parties	Programs	Comments
*F.M14	Continue to improve gear and regulations to minimize incidental impacts to naturally-spawning steelhead.	WDFW, ODFW	Columbia Compact, BPA Fish and Wildlife Program	Regulatory agencies should continue to refine gear, handle and release methods, and seasonal options to minimize mortality of naturally-spawning steelhead in commercial and sport fisheries.
*F.M20	Maintain selective sport fisheries in ocean, Columbia River, and tributaries and monitor naturally-spawning stock impacts.	WDFW, NOAA, ODFW, USFWS	PFMC, Columbia Compact, BPA Fish and Wildlife Program, WDFW Creel	Mass marking of lower Columbia River coho and steelhead has enabled successful ocean and freshwater selective fisheries to be implemented since 1998. Marking programs should be continued and fisheries monitored to provide improved estimates of naturally-spawning salmon and steelhead release mortality.
*F.A10	Columbia River Compact agencies will evaluate effectiveness of the current time and area management strategy for the commercial fishery.	WDFW, ODFW	U.S. vs Oregon (Technical Advisory Committee)	Late fall commercial fisheries target late stock hatchery coho and sturgeon. Chum impacts are limited by gear mesh size restrictions in sturgeon fisheries and by curtailing coho fisheries by November before significant numbers of chum are present. The Compact agencies would evaluate the effectiveness of this management strategy based on information acquired in recent years.
*F.A11	Develop more specific chum management details for pre-season and in-season management of the late fall commercial fishery.	WDFW, ODFW	Columbia Compact	The Compact agencies would develop specific criteria for in-season fishery adjustments (e.g. early closures, gear adjustments, area closures) based on chum encounter rates in the fishery. These criteria would be established as part of the chum management plan.

* Extension or improvement of existing measure
** New measure

5.7 Hydropower

There are no dams or hydropower facilities in the Bonneville Tributaries Basin, hence, no in-basin hydropower actions are identified. However, Columbia River flow levels from Bonneville Dam discharge effect the migration conditions for Bonneville Tributary adult Chum and fall Chinook and effects access to spawning habitats in Hamilton and Hardy creeks. The fall flows from Bonneville Dam also affect the amount of spawning habitat available for chum and fall chinook in the mainstem Columbia near Pierce and Ives islands. The winter and early spring flows at Bonneville Dam are also critical to prevent dewatering and decreased flows through redds during the egg incubation period.

Bonneville tributary anadromous fish populations will benefit from regional hydropower measures recovery measures and actions identified in regional plans to address habitat effects in the mainstem and estuary. The following table summarizes key regional hydropower actions with specific application to the Bonneville Tributary salmon and steelhead populations.

Table 22. Regional hydropower measures from Volume I, Chapter 7 with significant application to the Bonneville Tributaries Subbasin populations.

Measure	Description	Comments
D.M3	Maintain adequate water flows in Bonneville Dam tailrace and downstream habitats throughout salmon migration, incubation and rearing periods	Prevents dewatering and decreased flows in redds during and incubation, as well as increasing the potential spawning sites available for adults. Prevents migration barriers, high temperatures in late summer, lack of resting habitats, and predation losses.
D.M4	Operate the tributary hydro systems to provide appropriate flows for salmon spawning and rearing habitat in the areas downstream of the hydrosystem	The quantity and quality of spawning and rearing habitat for salmon, in particular fall chinook and chum in the North Fork Lewis and Cowlitz, is affected by the water flow discharged at Merwin and Mayfield dams respectively. The operational plans for the Lewis and Cowlitz dams, in conjunction with fish management plans, should include flow regimes, including minimum flow and ramping rate requirements, which enhance the lower river habitat for fall Chinook and chum.

5.8 Mainstem and Estuary Habitat

Bonneviile tributary anadromous fish populations will also benefit from regional recovery strategies and measures identified to address habitat conditions and threats in the Columbia River mainstem and estuary. Strategies involve: 1) avoiding large scale habitat changes where risks are uncertain, 2) mitigating small-scale local habitat impacts to ensure no net loss, 3) protecting functioning habitats while restoring impaired habitats to functional conditions, 4) striving to understand, protect, and restore habitat-forming processes, 5) moving habitat conditions in the direction of the historical template which is presumed to be more consistent with restoring viable populations, and 6) improving understanding of salmonds habitats use and their response to habitat changes. A series of specific measures are detailed in the regional plan for each of these strategies.

5.9 Ecological Interactions

For the purposes of this plan, ecological interactions refer to the relationships of salmon anad steelhead with other elements of the ecosystem. Regional strategies and measures pertaining to non-native species, effects of salmon on system productivity, and native predators of salmon are detailed and discussed at length in the Regional Recovery and Subbasin Plan Volume I and are not reprised at length in each subbasin plan. Strategies include 1) avoiding, eliminating introductions of new exotic species and managing effects of existing exotic species, 2) recognizing the significance of salmon to the productivity of other species and the salmon themselves, and 3) managing predation by selected species while also maintaining a viable balance of predator populations. A series of specific measures are detailed in the regional plan for each of these strategies. Implementation will occur at the regional and subbasin scale.

5.10 Monitoring, Research, & Evaluation

Biological status monitoring quantifies progress toward ESU recovery objectives and also establishes a baseline for evaluating causal relationships between limiting factors and a population response. Status monitoring involves routine and intensive efforts. Routine monitoring of biological data consists of adult spawning escapement estimates, whereas routine monitoring for habitat data consists of a suite of water quality and quantity measurements.

Intensive monitoring supplements routine monitoring for populations and basins requiring additional information. Intensive monitoring for biological data consists of life-cycle population assessments, juvenile and adult abundance estimates and adult run-reconstruction. Intensive monitoring for habitat data includes stream/riparian surveys, and continuous stream flow assessment. The need for additional water quality sampling may be identified. Rather than prescribing one monitoring strategy, three scenarios are proposed ranging in level of effort and cost from high to low (Level 1-3 respectively). Given the fact that routine monitoring is ongoing, only intensive monitoring varies between each level.

An in-depth discussion of the monitoring, research and evaluation (M, R & E) approach for the Lower Columbia Region is presented in the Regional Recovery and Management Plan. It includes site selection rationale, cost considerations and potential funding sources. The following tables summarize the biological and habitat monitoring efforts specific to the Bonneville Tributaries subbasin.

Table 23. Summary of the biological monitoring plan for Bonneville Tributaries populations.

Bonneville Tributaries: Lower Columbia Comprehensive Monitoring Plan				
Monitoring Type	**Fall Chinook**	**Chum**	**Coho**	**Winter Steelhead**
Routine	AA	AA	AA	AA
Intensive				
Level 1		×		
Level 2		×		
Level 3		×		

AA Annual adult abundance estimates
✓ Adult and juvenile intensive biological monitoring occurs periodically on a rotation schedule (every 9 years for 3-year duration)
× Adult and juvenile intensive biological monitoring occurs annually

Table 24. Summary of the habitat monitoring plan for Bonneville Tributaries populations.

Lower Gorge: Lower Columbia Habitat Monitoring Plan				
Monitoring Type	**Watershed**	**Existing stream / riparian habitat**	**Water quantity[3] (level of coverage)**	**Water quality [2] (level of coverage)**
Routine [1] (level of coverage)	Baseline complete	Poor	Stream Gage-Poor IFA-Moderate	WDOE-Moderate USGS-Poor Temperature-Good
Intensive				
Level 1				
Level 2				
Level 3				

IFAComprehensive Instream Flow Assessment (i.e. Instream Flow Incremental Methodology)
[1] Routine surveys for habitat data do not imply ongoing monitoring
[2] Intensive monitoring for water quality to be determined
[3] Water quantity monitoring may include stream gauge installation, IFA or low flow surveys

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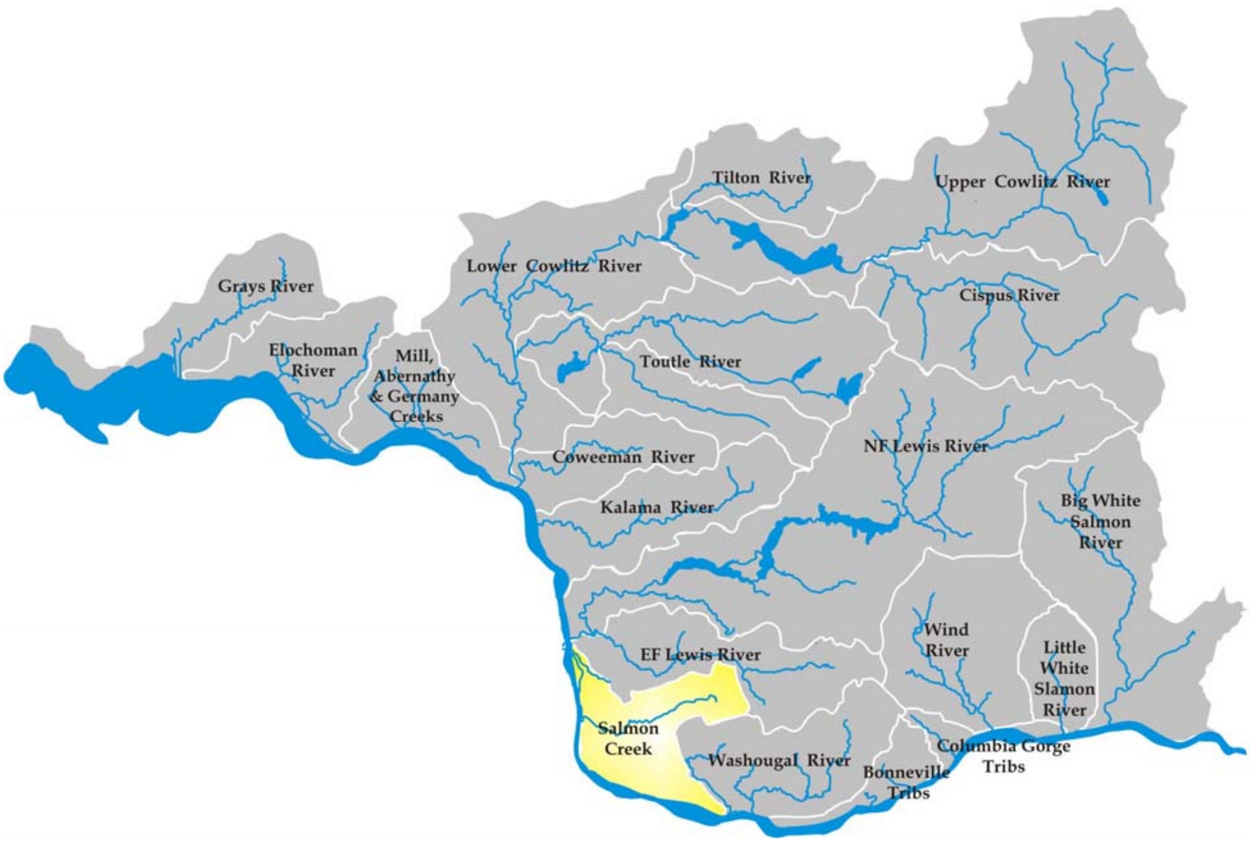


Contents

1.0 Salmon Creek / Lake River – Executive Summary

This plan describes a vision, strategy, and actions for recovery of listed salmon, steelhead, and trout species to healthy and harvestable levels, and mitigation of the effects of the Columbia River hydropower system in Washington lower Columbia River subbasins. Recovery of listed species and hydropower mitigation is accomplished at a regional scale. This plan for the Lake River / Salmon Creek Basin describes implementation of the regional approach within this basin, as well as assessments of local fish populations, limiting factors, and ongoing activities that underlie local recovery or mitigation actions. The plan was developed in a partnership between the Lower Columbia Fish Recovery Board (Board), Northwest Power and Conservation Council (NPPC), federal agencies, state agencies, tribal nations, local governments, and others.

The Lake River / Salmon Creek Basin lies within the Lower Columbia Tributaries Subbasin as defined by the NPPC. Salmon Creek flows into Lake River downstream of Vancouver Lake and the Salmon Creek Basin contains the greatest amount of salmonid habitat in the Salmon Creek / Lake River system. The Salmon Creek Basin historically supported thousands of fall Chinook, winter steelhead, chum, and coho. Today, numbers of naturally spawning salmon and steelhead have plummeted to record lows in the tens or hundreds. Chinook, steelhead and chum have been listed as Threatened under the Endangered Species Act and coho is proposed for listing. The decline has occurred over decades and the reasons are many. Freshwater and estuary habitat quality has been reduced by agricultural practices, forest practices, and urbanization. Key habitats have been isolated or eliminated by dredging and channel modifications and diking, filling, or draining floodplains and wetlands. Altered habitat conditions have increased predation. Competition and interbreeding with domesticated or nonlocal hatchery fish has reduced productivity. Hydropower operation on the mainstem has altered flows, habitat, and migration conditions. Fish are harvested in fresh and saltwater fisheries. In order to meet regional recovery objectives, Salmon Creek salmon and steelhead will need to be managed so as not to drop below their current level of viability.

In recent years, agencies, local governments, and other entities have actively addressed the various threats to salmon and steelhead, but much remains to be done. One thing is clear: no single threat is responsible for the decline in these populations. All threats and limiting factors must be reduced if recovery is to be achieved. An effective recovery plan must also reflect a realistic balance within physical, technical, social, cultural and economic constraints. The decisions that govern how this balance is attained will shape the region’s future in terms of watershed health, economic vitality, and quality of life.

This plan represents the current best estimation of necessary actions for recovery and mitigation based on thorough research and analysis of the various threats and limiting factors that impact Salmon Creek fish populations. Specific strategies, measures, actions and priorities have been developed to address these threats and limiting factors. The specified strategies identify the best long term and short term avenues for achieving fish restoration and mitigation goals. While it is understood that data, models, and theories have their limitations and growing knowledge will certainly spawn new strategies, the Board is confident that by implementation of the recommended actions in this plan, the population goals in the Salmon Creek Basin can be achieved. Success will depend on implementation of these strategies at the program and project level. It remains uncertain what level of effort will need to be invested in each area of impact to ensure the desired result. The answer to the question of precisely how much is enough is currently beyond our understanding of the species and ecosystems and can only be answered through ongoing monitoring and adaptive management against the backdrop of what is socially possible.

1.1 Key Priorities

Many actions, programs, and projects will make necessary contributions to recovery and mitigation in the Salmon Creek Basin. The following list identifies the most immediate priorities.

1. Manage Growth and Development to Protect Watershed Processes and Habitat Conditions

The Salmon Creek / Lake River Basin lies within and adjacent to the expanding Vancouver metropolitan area. The human population in the basin is currently high and is projected to more than double in the next twenty years. Much of the population growth is likely to occur in river valleys and along the major stream corridors. This growth will result in the conversion of forest, rural residential and agricultural land uses to high density residential uses, with potential impacts to habitat conditions and watershed processes. Land-use changes will provide a variety of risks to terrestrial and aquatic habitats. It is imperative that careful land-use planning be used to protect and restore natural fish populations and habitats.

2. Restore Floodplain Function, Riparian Function and Stream Habitat Diversity

Much of the Salmon Creek / Lake River Basin is highly populated and developed. Urban, suburban, and rural residential development affects many of the stream corridors throughout these watersheds. In some areas of the Salmon Creek Basin, agricultural practices have also had an impact on stream corridors. Development and agriculture have modified stream channels, impaired floodplain function, and have degraded riparian forests. Streamside gravel mining has altered channel and floodplain dynamics along the lower mainstem Salmon Creek. Removing or modifying channel control and containment structures to reconnect the stream and its floodplain, where this is feasible and can be done without increasing risks of substantial flood damage, will restore normal habitat-forming processes to reestablish habitat complexity, off-channel habitats, and conditions favorable to fish spawning and rearing. Riparian restoration will enhance streambank stability, channel complexity and water quality. These improvements will be particularly beneficial to chum, fall Chinook, and coho. Partially restoring normal floodplain functions will also help control downstream flooding and provide wetland and riparian habitats critical to other fish, wildlife, and plant species. Existing floodplain function and riparian areas will be protected through local land use ordinances, partnerships with landowners, and the acquisition of land, where appropriate. Restoration will be achieved by working with willing landowners, non-governmental organizations, conservation districts, and state and federal agencies.

3. Manage Forest Lands to Protect and Restore Watershed Processes

The upper Salmon Creek Basin is managed for commercial timber production and has experienced intensive past forest practices activities. Proper forest management is critical to fish recovery. Past forest practices have reduced fish habitat quantity and quality by altering stream flow, increasing fine sediment, and degrading riparian zones. In addition, forest road culverts have blocked fish passage in small tributary streams. Effective implementation of new forest practices through the Department of Natural Resources' Habitat Conservation Plan (state lands) and Forest Practices Rules (private lands) are expected to substantially improve conditions by restoring passage, protecting riparian conditions, reducing fine sediment inputs, lowering water temperatures, improving flows, and restoring habitat diversity. Improvements will benefit all species, particularly winter steelhead and coho.

4. Address Immediate Risks with Short-term Habitat Fixes

Restoration of normal watershed processes that allow a basin to restore itself over time has proven to be the most effective strategy for long term habitat improvements. However, restoration of some critical habitats may take decades to occur. In the near term, it is important to initiate short-term fixes to address current critical low numbers of some species. Examples in the Salmon Creek Basin include building chum salmon spawning channels and constructing coho overwintering habitat such as alcoves, side channels, and log jams. Benefits of structural enhancements are often temporary but will help bridge the period until normal habitat-forming processes are reestablished.

5. Align Hatchery Priorities with Conservation Objectives

Hatcheries throughout the Columbia basin historically focused on producing fish for fisheries as mitigation for hydropower development and widespread habitat degradation. Emphasis of hatchery production without regard for natural populations can pose risks to natural population viability. Hatchery priorities must be aligned to conserve natural populations, enhance natural fish recovery, and avoid impeding progress toward recovery while continuing to provide fishing benefits. There are no hatcheries operating in the Salmon Creek Basin. The Skamania Hatchery will continue to release winter steelhead into Salmon Creek for fishery enhancement.

6. Manage Fishery Impacts so they do not Impede Progress Toward Recovery

This near-term strategy involves limiting fishery impacts on natural populations to ameliorate extinction risks until a combination of measures can restore fishable natural populations. There is no directed Columbia River or tributary harvest of ESA-listed Salmon Creek salmon and steelhead. This practice will continue until the populations are sufficiently recovered to withstand such pressure and remain self-sustaining. Some Salmon Creek salmon and steelhead are incidentally taken in mainstem Columbia River and ocean mixed stock fisheries for strong wild and hatchery runs of fall Chinook and coho. These fisheries will be managed with strict limits to ensure this incidental take does not threaten the recovery of wild populations including those from the Salmon Creek Basin. Steelhead and chum will continue to be protected from significant fishery impacts in the Columbia River and are not subject to ocean fisheries. Selective fisheries for marked hatchery steelhead and coho (and fall Chinook after mass marking occurs) will be a critical tool for limiting wild fish impacts. State and federal legislative bodies will be encouraged to develop funding necessary to implement mass-marking of fall Chinook, thus enabling a selective fishery with lower impacts on wild fish. State and federal fisheries managers will better incorporate Lower Columbia indicator populations into fisheries impact models.

7. Reduce Out-of-Subbasin Impacts so that the Benefits of In-Basin Actions can be Realized

Salmon Creek salmon and steelhead are exposed to a variety of human and natural threats in migrations outside of the subbasin. Human impacts include drastic habitat changes in the Columbia River estuary, effects of Columbia Basin hydropower operation on mainstem, estuary, and nearshore ocean conditions, interactions with introduced animal and plant species, and altered natural predation patterns by northern pikeminnow, birds, seals, and sea lions. A variety of restoration and management actions are needed to reduce these out-of-subbasin effects so that the benefits in-subbasin actions can be realized. To ensure equivalent sharing of the recovery and mitigation burden, impacts in each area of effect (habitat, hydropower, etc.) should be reduced in proportion to their significance to species of interest.

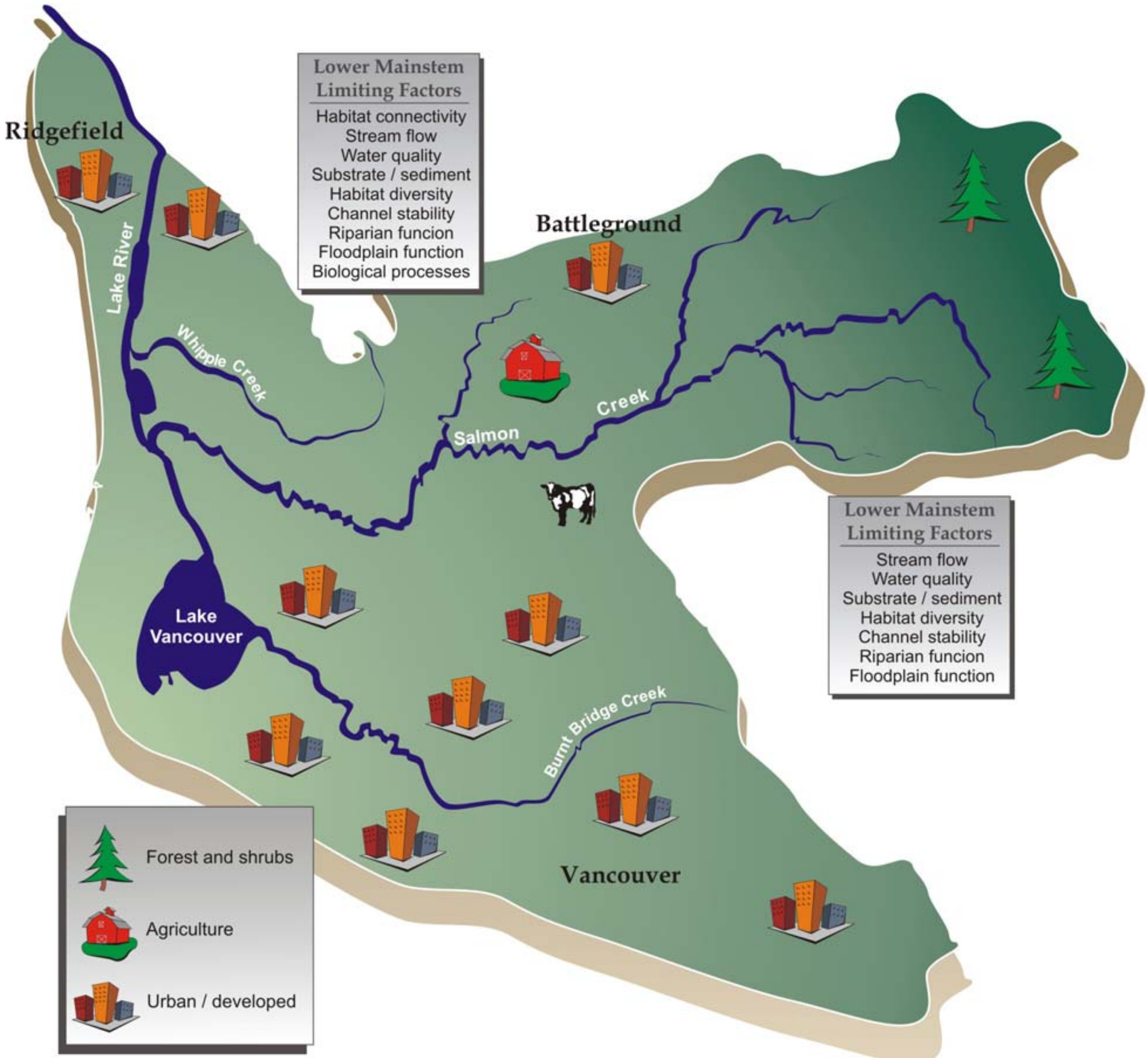


Figure 1. Key features of the Salmon Creek / Lake River Basin including a summary of limiting fish habitat factors in different areas and the status and relative distribution of focal salmonid species.

2.0 Background

This plan describes a vision and framework for rebuilding salmon and steelhead populations in the Salmon Creek/Lake River Basin in Washington's Columbia Lower Tributaries Subbasin. The plan addresses subbasin elements of a regional recovery plan for Chinook salmon, chum salmon, coho salmon, steelhead, and bull trout listed or under consideration for listing as Threatened under the federal Endangered Species Act (ESA). The plan also serves as the subbasin plan for the Northwest Power and Conservation Council (NPCC) Fish and Wildlife Program to address effects of construction and operation of the Federal Columbia River Power System.

Development of this plan was led and coordinated by the Washington Lower Columbia River Fish Recovery Board (LCFRB). The Board was established by state statute (RCW 77.85.200) in 1998 to oversee and coordinate salmon and steelhead recovery efforts in the lower Columbia region of Washington. It is comprised of representatives from the state legislature, city and county governments, the Cowlitz Tribe, private property owners, hydro project operators, the environmental community, and concerned citizens. A variety of partners representing federal agencies, Tribal Governments, Washington State agencies, regional organizations, and local governments participated in the process through involvement on the LCFRB, a Recovery Planning Steering Committee, planning working groups, public outreach, and other coordinated efforts.

The planning process integrated four interrelated initiatives to produce a single Recovery/Subbasin Plan for Washington subbasins of the lower Columbia:

- Endangered Species Act recovery planning for listed salmon and trout.
- Northwest Power and Conservation Council (NPCC) fish and wildlife subbasin planning for eight full and three partial subbasins.
- Watershed planning pursuant to the Washington Watershed Management Act, RCW 90-82.
- Habitat protection and restoration pursuant to the Washington Salmon Recovery Act, RCW 77.85.

This integrated approach ensures consistency and compatibility of goals, objectives, strategies, priorities and actions; eliminates redundancy in the collection and analysis of data; and establishes the framework for a partnership of federal, state, tribal and local governments under which agencies can effectively and efficiently coordinate planning and implement efforts.

The plan includes an assessment of limiting factors and threats to key fish species, an inventory of related projects and programs, and a management plan to guide actions to address specific factors and threats. The assessment includes a description of the subbasin, focal fish species, current conditions, and evaluations of factors affecting focal fish species inside and outside the subbasin. This assessment forms the scientific and technical foundation for developing a subbasin vision, objectives, strategies, and measures. The inventory summarizes current and planned fish and habitat protection, restoration, and artificial production activities and programs. This inventory illustrates current management direction and existing tools for plan implementation. The management plan details biological objectives, strategies, measures, actions, and expected effects consistent with the planning process goals and the corresponding subbasin vision.

3.0 Assessment

3.1 Subbasin Description

3.1.1 *Topography & Geology*

The Salmon Creek / Lake River Basin is part of the Columbia Lower Tributaries Subbasin as defined by the Northwest Power and Conservation Council (NPPC). The basin lies within Clark County and encompasses the highly urbanized Vancouver, Washington metropolitan area; it therefore receives tremendous anthropogenic pressures.

Headwaters of the Salmon Creek Basin begin in the low foothills of the southwestern Washington Cascades in Clark County. Salmon Creek flows into Lake River, which drains north from 2,600-acre Vancouver Lake. Major tributaries entering Lake River are Salmon Creek, Whipple Creek, and Flume Creek. Burnt Bridge Creek flows into Vancouver Lake and its watershed is located in the heart of the city of Vancouver. Salmon Creek is the largest tributary to the Lake River basin, with a drainage area of 91 mi^2. Basin elevation ranges from near sea level at the mouth to 1,998 feet in the headwaters of the Salmon Creek watershed. Most streams in the basin are low gradient, meandering systems located within Clark County's flat alluvial plain. Vancouver Lake and Lake River itself are within the historical Columbia River floodplain and are tidally-influenced. Surface geology in the basin is primarily sedimentary, with volcanic material in headwater areas. Much of the basin is underlain by alluvium from catastrophic flooding of the Columbia River during Pleistocene Ice Ages (Bretz Floods) and from more recent floodplain deposits.

3.1.2 *Climate*

The climate is typified by cool, wet winters and warm, dry summers. Temperatures are moderated by mild, moist air flowing up the Columbia from the Pacific. Precipitation levels are high due to orographic effects. Mean annual precipitation is 40 inches at Vancouver. Average annual minimum temperature at Vancouver is 43°F (6°C) and the average annual maximum is 63°F (17°C). Winter temperatures seldom fall below freezing, with very little snowfall (WRCC 2003).

3.1.3 *Land Use, Ownership, and Cover*

Land use in the Lake River / Salmon Creek Basin is predominately urban and rural development, with nearly the entire Burnt Bridge Creek watershed lying within the Vancouver metropolitan area. Historical wetlands and floodplains have been converted to residential, commercial, industrial, and agricultural uses. The upper reaches of the Salmon Creek basin have been impacted by silvacultural activities and rural residential development. Major urban centers in the basin are Vancouver, Orchards, Salmon Creek, Battle Ground, and Ridgefield. The year 2000 population, estimated at 252,000 persons is expected to increase by 267,500 by year 2020 (LCFRB 2001). The State of Washington owns, and the Washington State Department of Natural Resources (DNR) manages the beds of all navigable waters within the subbasin. Any proposed use of those lands must be approved in advance by the DNR. Maps of land ownership and land cover/land use in the Lake River/Salmon Creek Basin are presented in Figure 2 and Figure 3.

3.1.4 *Development Trends*

Continued population growth is of primary concern in the Lake River basin. Major urban centers in the basin are Vancouver, Orchards, Salmon Creek, Battle Ground, and Ridgefield. The year 2000 population, estimated at 252,000 persons is expected to increase to 519,000 by year

2020 (LCFRB 2001). Continued population growth will increase pressures for conversion of forest, agricultural, and rural residential land uses to high-density suburban and urban uses, with potential impacts to habitat conditions.

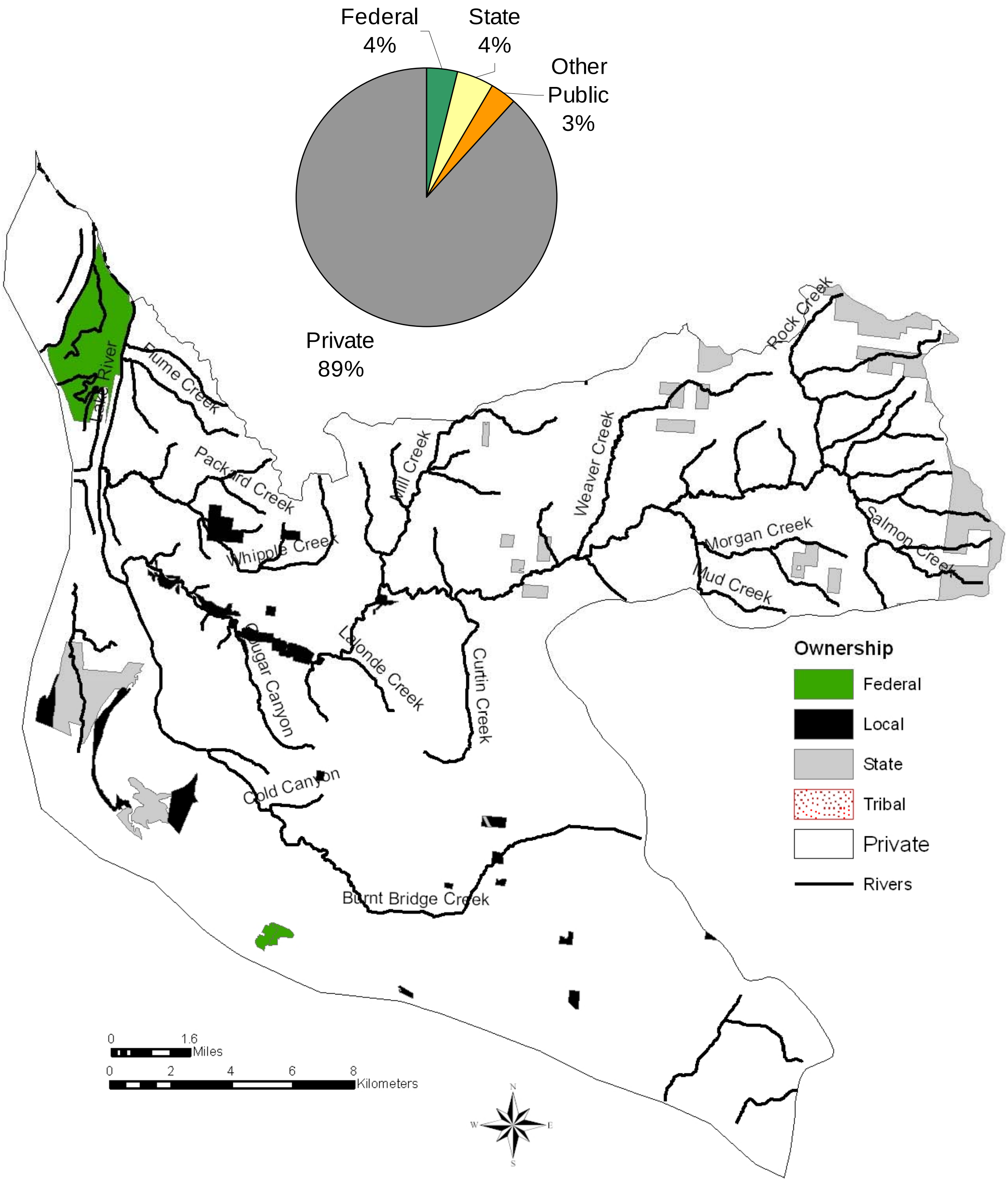


Figure 2. Landownership within the Lake River basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

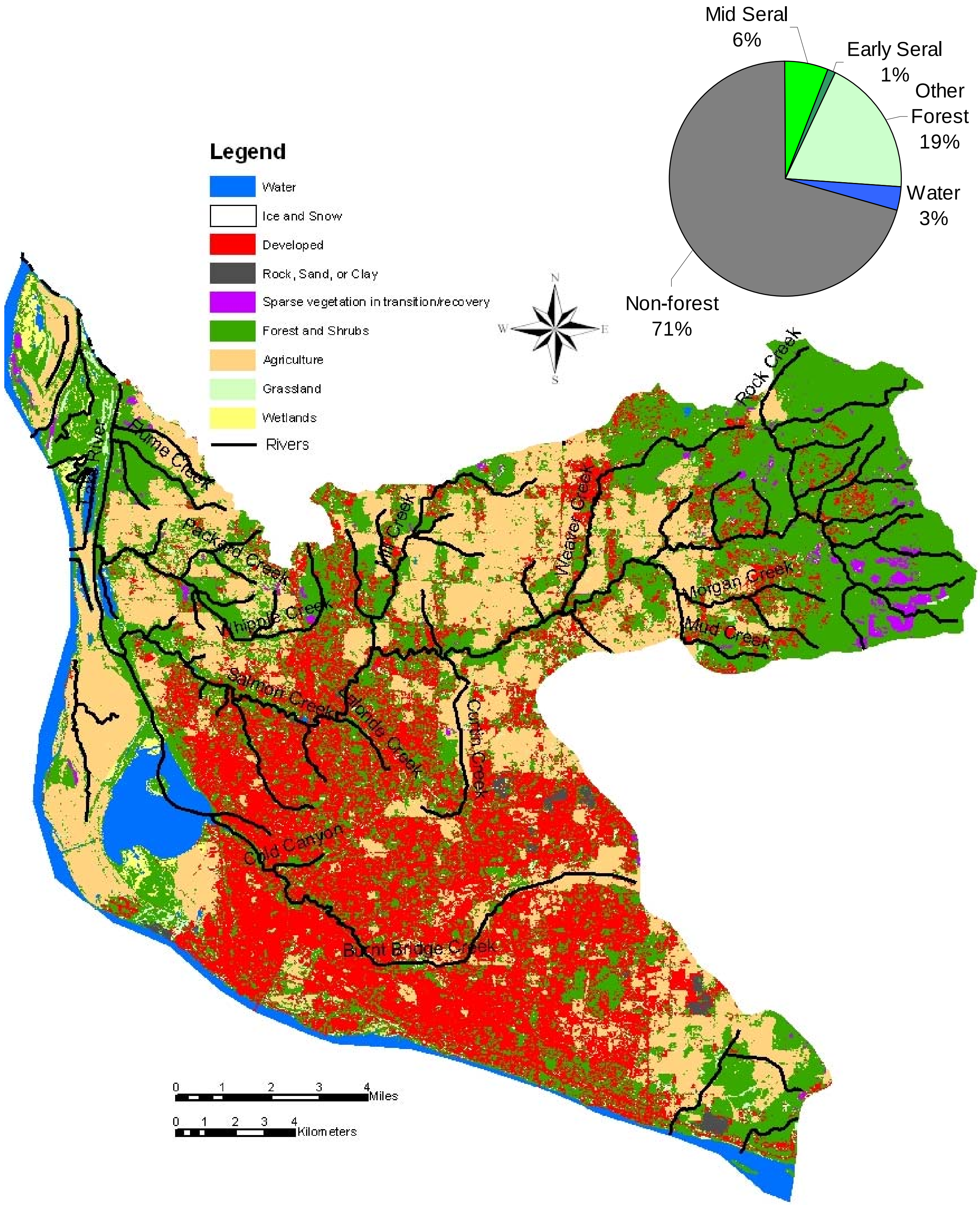


Figure 3. Land cover within the Lake River basin. Vegetation cover (pie chart) derived from Landsat data based on methods in Lunetta et al. (1997). Mapped data was obtained from the USGS National Land Cover Dataset (NLCD).

3.2 Focal and Other Species of Interest

Listed salmon, steelhead, and trout species are focal species of this planning effort for the Lake River / Salmon Creek Basin. Other species of interest were also identified as appropriate. Species were selected because they are listed or under consideration for listing under the U.S. Endangered Species Act or because viability or use is significantly affected by the Federal Columbia Hydropower system. Federal hydropower system effects are not significant within the basin although anadromous species are subject to effects in the Columbia River, estuary, and nearshore ocean. The Lake River / Salmon Creek ecosystem supports and depends on a wide variety of fish and wildlife in addition to designated species. A comprehensive ecosystem-based approach to salmon and steelhead recovery will provide significant benefits to other native species through restoration of landscape-level processes and habitat conditions. Other fish and wildlife species not directly addressed by this plan are subject to a variety of other Federal, State, and local planning or management activities.

Focal salmonid species in Lake River / Salmon Creek watersheds include winter steelhead, chum, fall chinook and coho. Salmon Creek fall Chinook are considered a part of the East Fork Lewis fall chinook population when considering recovery objectives. Bull trout do not occur in the basin. Salmon and steelhead numbers have declined to only a fraction of historical levels (Table 1). Extinction risks are significant for all focal species. Viability of Salmon Creek populations ranges from very low for coho and chum to low for winter steelhead. Returns of Salmon Creek winter steelhead include both natural and hatchery produced fish.

Table 1. Status of focal salmond and steelhead populations in the Lake River / Salmon Creek Basin.

Focal Species	ESA Status	Hatchery Component[1]	Historical numbers[2]	Recent numbers[3]	Current viability[4]	Extinction risk[5]
Chum	Threatened	No	10,000-90,000	<100	Very Low	90%
Coho	Candidate	No	6,000-35,000	Unknown	Very Low	80%
Winter Steelhead	Threatened	Yes	500-8,000	<100	Low	50%
Fall Chinook (a)	Threatened	No	100-400	<100	NA	NA

(a) Considered part of East Fork Lewis population by TRT

[1] *Significant numbers of hatchery fish are released in the basin.*
[2] *Historical population size inferred from presumed habitat conditions using Ecosystem Diagnosis and Treatment Model and NOAA back-of-envelope calculations..*
[3] *Approximate current annual range in number of naturally-produced fish returning to the basin.*
[4] *Propsects for long term persistence based on criteria developed by the NOAA Technical Recovery Team.*
[5] *Probability of extinction within 100 years corresponding to estimated viability*

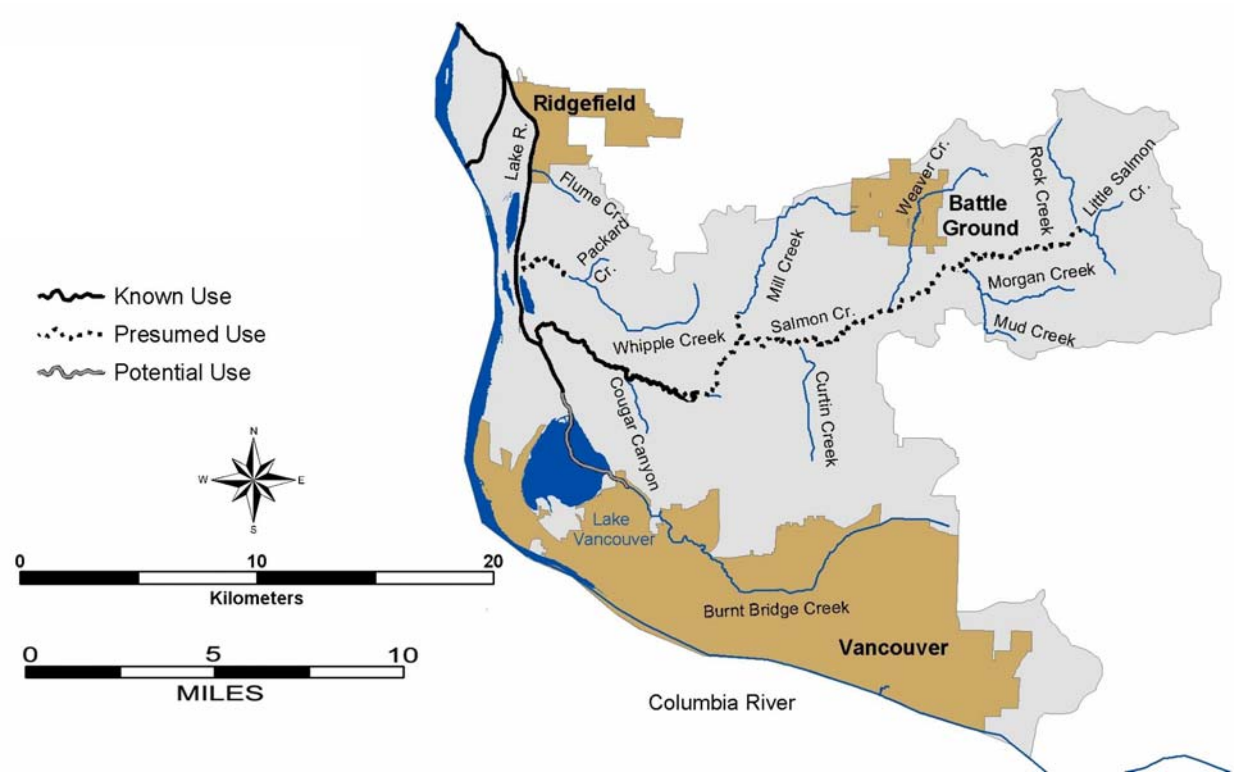
Other species of interest in the Lake River / Salmon Creek Basin include coastal cutthroat trout and Pacific lamprey. These species have been affected by many of the same habitat factors that have reduced numbers of anadromous salmonids.

Brief summaries of the population characteristics and status follow. Additional information on life history, population characteristics, and status assessments may be found in Appendix A (focal species) and B (other species).

3.2.1 *Fall Chinook—Salmon Creek Basin*

ESA: Threatened 1999	**SASSI: Unknown 2002**

The historical Salmon Creek tributary tule fall chinook adult population is estimated from 100-400 fish. The current natural spawning number in the tributaries is less than 100 fish. The Salmon Creek fall chinook population is considered as combined with the East Fork Lewis population for recovery accounting. Natural spawning occurs primarily in the lower 5 miles of Salmon Creek and the lowest reach of Burnt Bridge Creek. Spawning time peaks in October. Juvenile rearing occurs near and downstream of the spawning areas. Juveniles migrate from Salmon Creek in the spring and early summer of their first year.



Distribution

- Historical distribution of fall Chinook in Salmon Creek was documented in 1951 as the lower 5 miles of creek

Life History

- Fall chinook upstream migration in the Columbia River begins in early August or September, depending on early rainfall
- Age ranges from 2 year-old jacks to 6 year-old adults, with dominant adult ages of 3 and 4
- Fry emerge around early April, depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the summer as sub-yearlings

Diversity

- Early spawning components are considered part of the tule population in the lower Columbia River Evolutionary Significant Unit (ESU)

Abundance

- Escapement surveys in 1936 reported 19 fall chinook spawning in Salmon Creek
- In 1951, fall chinook escapement to Salmon Creek was estimated at 100 fish

Productivity & Persistence

- Productivity data is limited for Salmon Creek fall Chinook

Hatchery

- There is no fall chinook hatchery fish released into Salmon Creek

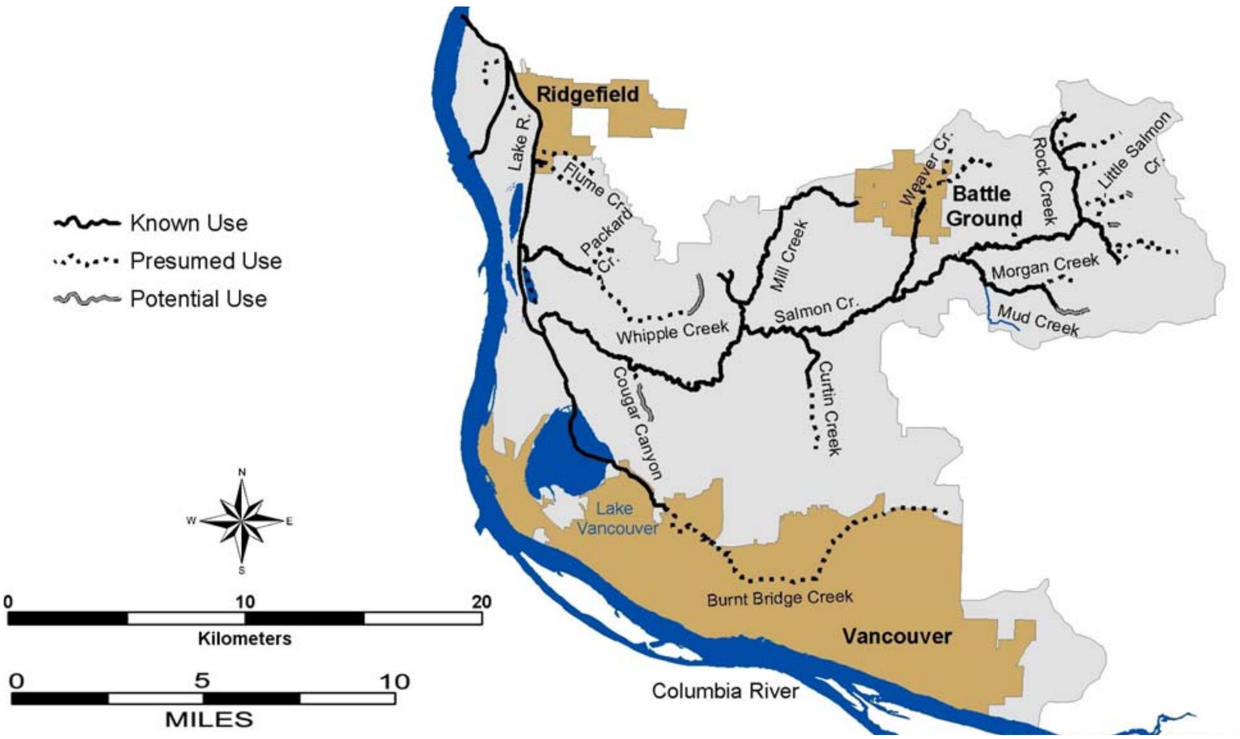
Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska and Columbia River commercial gill net and sport fisheries
- No specific CWT data is available for these populations, however migration patterns and harvest of the bright chinook populations is likely similar to upriver bright (URB) fall chinook and the tule populations similar to lower Columbia hatchery tule chinook
- Columbia River URB chinook harvest is limited to 31.29% based on Endangered Species Act (ESA) limits on Snake River wild fall chinook; however, lower river URB chinook are harvested at a lower rate as they do not pass through the Treaty Indian fishery
- Combined ocean and Columbia River tule fall chinook harvest is currently limited to 49% as a result of ESA limits on Coweeman tule fall chinook
- A popular sport fishery has developed in the mainstem Columbia in late September and early October, targeting the late spawning bright chinook

3.2.2 *Coho—Lower Columbia Subbasin (Salmon Creek)*

ESA: Candidate 1995	**SASSI: Unknown 2002**

The historical Salmon Creek adult population is estimated from 6,000-35,000, with both early and late stock coho produced. Current returns are unknown, but presumed to be very low. Early stock coho spawn in early to mid-November and late stock from late November to March. There is currently no hatchery coho released into Salmon Creek. Natural spawning can occur though out the Salmon Creek basin, but principally in the upper mainstem Salmon Creek, and Morgan, Rock, Mill, and Weaver creeks. Potential for coho spawning also exists in nearby streams, including Burnt Bridge and Whipple creeks. Juveniles rear for a full year in the Salmon Creek basin before migrating as yearlings in the spring.



Distribution

- Managers refer to late stock coho as Type N due to their ocean distribution generally north of the Columbia River
- Managers refer to early stock coho as Type S due to their ocean distribution generally south of the Columbia River
- Salmon Creek flows through Clark County (downstream of the Washougal River and upstream of the Lewis River) and has been largely impacted by urban development, but coho production potential exists in upper Salmon Creek and tributaries: Morgan, Rock, Mill, and Weaver Creeks
- Other creeks near the Salmon Creek watershed with coho production potential include Burnt Bridge and Whipple Creeks

Life History

- Adults enter the Columbia River from mid-September through mid-December
- Peak spawning occurs in December to early January for late stock coho
- Peak spawning occurs in late October to mid November for early stock

- Adults return as 2-year old jacks (age 1.1) or 3-year old adults (age 1.2)
- Fry emerge in the spring, spend one year in fresh water, and emigrate as age-1 smolts the following spring

Diversity
- Both late and early stock (or Type S) coho are believed to be historically produced in Salmon Creek
- Columbia River early and late stock coho produced at Washington hatcheries are genetically similar

Abundance
- WDFW (1951) estimated a coho escapement of 2,050 for Salmon Creek and the small tributaries between the Washougal River and Bonneville Dam combined

Productivity & Persistence
- Natural coho spawning is presumed to be very low
- Salmon Creek habitat enhancement efforts have improved recent year production potential

Hatchery
- There are no hatcheries on any of these streams
- Coho subyearlings have been periodically released into the Salmon Creek Basin
- Co-op and school educational projects in Clark County have included rearing and release of coho juveniles into Salmon Creek

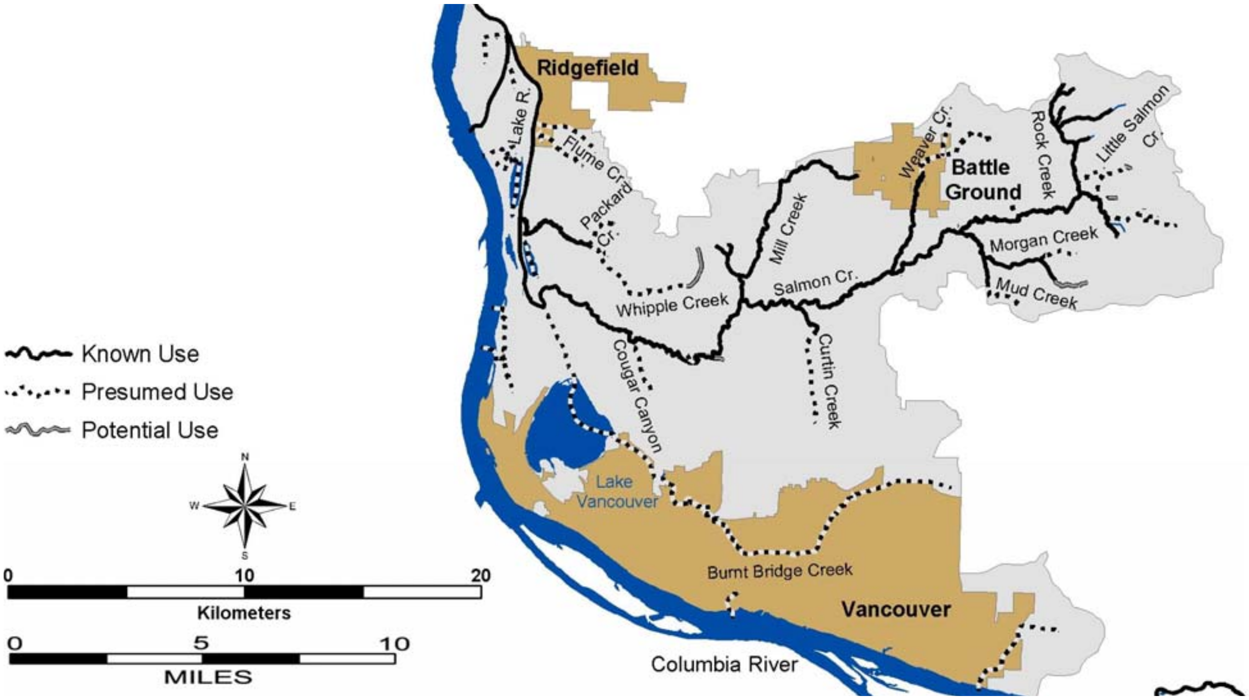
Harvest
- Until recent years, natural produced coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% from 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations
- Columbia River commercial coho fisheries in November were eliminated in the 1990s to reduce harvest of late Clackamas River coho
- Since 1999, Columbia River hatchery coho returns have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Naturally-produced lower Columbia coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon coastal coho and Oregon listed Clackamas and Sandy coho
- During 1999-2002, harvest rates on ESA listed coho were less than 15% each year
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho is constrained in September by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during peak abundance of late hatchery coho
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early hatchery coho, but late hatchery coho harvest can also be substantial
- There is no sport harvest in the Salmon Creek basin

- Harvest of coho produced in these lower Columbia tributaries is assumed to be similar to Oregon's Clackamas and Sandy coho, which were harvested at less then 15% during 1999-2002
- There are no adipose fin-clipped hatchery fish released in these streams

3.2.3 *Winter Steelhead—Lower Columbia Tributaries Subbasin (Salmon Creek)*

ESA: Threatened 1998 **SASSI: Unknown 2002**

The historical Salmon Creek adult population is estimated from 500-8,000 fish. Current natural spawning returns are less than 100 fish. Skamania Hatchery winter steelhead are released into Salmon Creek for harvest opportunity In-breeding between wild and hatchery winter steelhead is possible, but likely low because of differences in spawn timing. Spawning occurs throughout the Salmon Creek basin, the lower reaches of Gee Creek, Whipple Creek, and Burnt Bridge Creek Spawning time is generally from early March to early June. Juvenile rearing occurs both downstream and upstream of the spawning areas. Juveniles rear for a full year or more before migrating from Salmon Creek.



Distribution

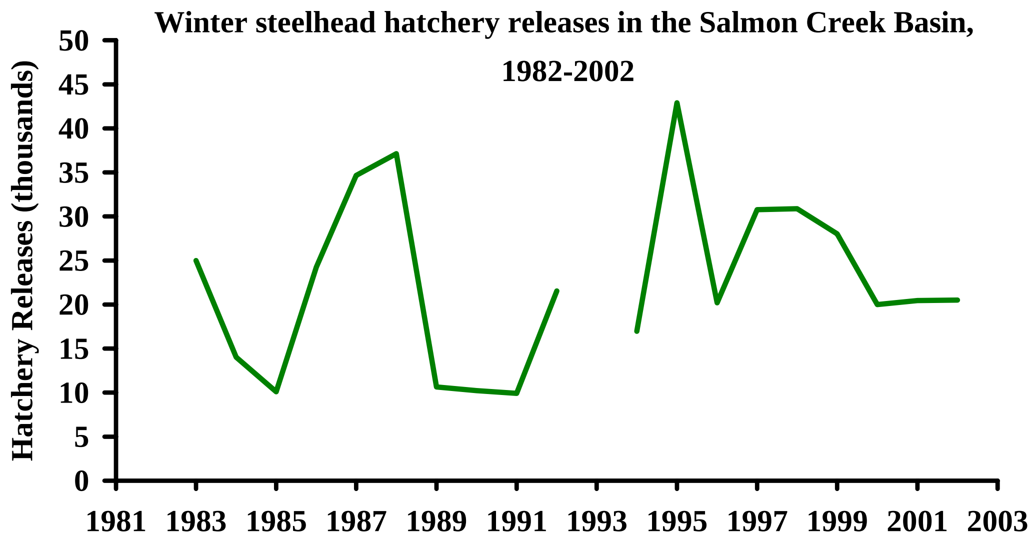
- Winter steelhead are distributed throughout Salmon Creek, the lower reaches of Gee, Whipple, and Burnt Bridge Creek, and portions of the Lake River

Life History

- Adult migration timing for Salmon Creek winter steelhead is from December through April
- Spawning timing on Salmon Creek is generally from early March to early June; limited escapement surveys suggest spawn timing may be early than most lower Columbia winter steelhead
- Age composition data for Salmon Creek winter steelhead are not available
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

Diversity

- Salmon Creek winter steelhead stock is designated based on distinct spawning distribution
- Wild stock interbreeding with Elochoman, Chambers Creek, Cowlitz, and Skamania hatchery brood stock may have occured



Abundance

- In 1936, steelhead were reported in Salmon Creek during escapement surveys
- In 1989, wild winter steelhead spawner surveys on Salmon Creek estimated 80 adult spawners
- Salmon Creek has a winter steelhead escapement goal of 400 wild adults

Productivity & Persistence

- Winter steelhead natural production is expected to be low

Hatchery

- There are no hatcheries on Salmon Creek; hatchery winter steelhead have been planted in the basin since 1957; release data are displayed from 1982-1992, and 1994-2002
- The current hatchery program calls for 20,000 winter steelhead released into lower Salmon Creek
- Hatchery fish contribute little to natural winter steelhead production in the Salmon Creek basin

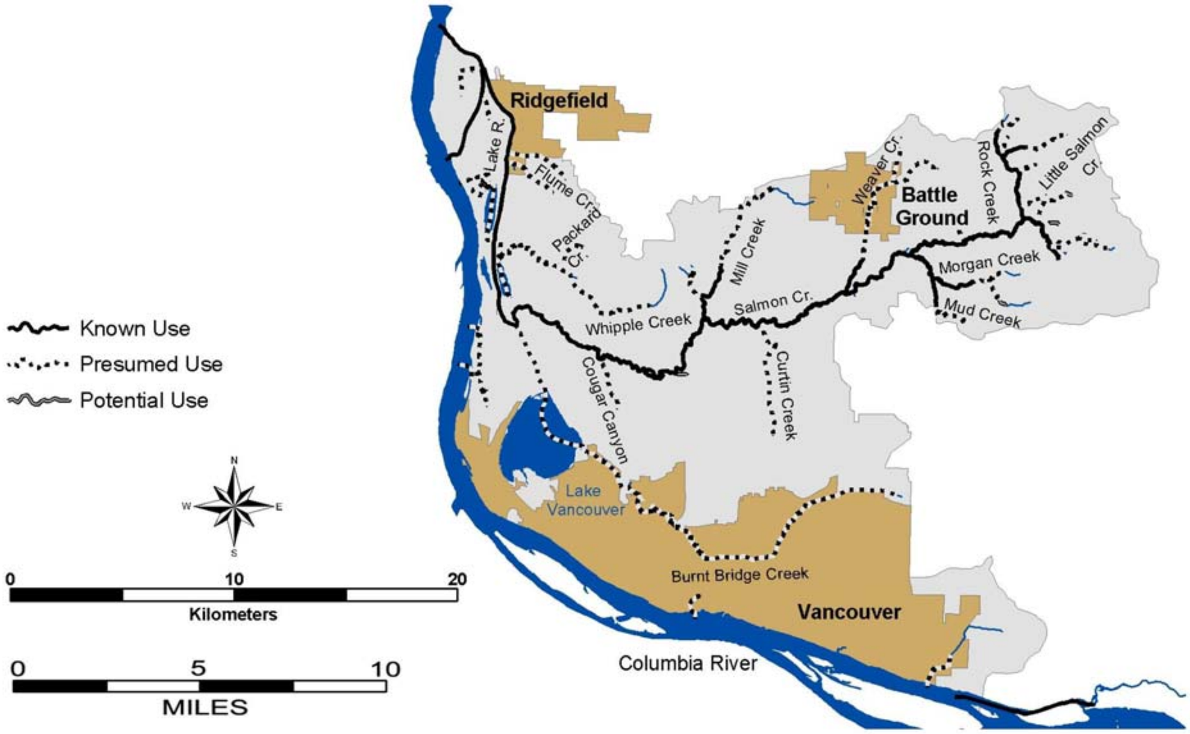
Harvest

- No directed commercial or tribal fisheries target Salmon Creek winter steelhead; incidental harvest currently occurs during the lower Columbia River spring chinook tangle net fisheries
- Treaty Indian harvest does not occur in the Salmon Creek basin
- Winter steelhead sport harvest (hatchery and wild) in Salmon Creek from 1977-1986 averaged 89 fish; since 1992, regulations limit harvest to hatchery fish only
- ESA practice limits fishery impact on wild winter steelhead to 2 % per year

3.2.4 *Cutthroat Trout—Columbia Lower Tributaries Subbasin (Salmon Creek)*

ESA: Not Listed	**SASSI: Unknown**

Coastal cutthroat abundance in Salmon Creek has not been quantified but the population is considered depressed. Both andromous and resident form of cutthroat ar present in the basin. Anadromous cutthroat enter Salmon Creek from July-December and spawn from December through June. Most juveniles rear 2-4 years before migrating from their natal stream.



Distribution

- Anadromous forms have access to the entire subbasin
- Resident forms are documented throughout the system

Life History

- Anadromous and resident forms are present
- Anadromous river entry is from July through December
- Anadromous spawning occurs from December through June
- Resident spawn timing is from February through June

Diversity

- No genetic sampling or analysis has been conducted
- Genetic relationship to other stocks and stock complexes is unknown

Abundance

- Insufficient quantitative data are available to identify wild cutthroat abundance or survival trends

Hatchery

- Hatchery origin anadromous cutthroat were released into Salmon Creek since at least 1952
- Presently 20,000 winter steelhead smolts, and about 145,000 coho fry are released into the subbasin annually
- The hatchery cutthroat release program was discontinued in 1999

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin-clipped hatchery fish occurs in mainstem Columbia summer fisheries downstream of the Salmon Creek
- Wild Salmon Creek cutthroat (unmarked fish) must be released in the mainstem Columbia and Salmon Creek sport fisheries.

3.2.5 *Other Species*

Pacific lamprey – Information on lamprey abundance is limited and does not exist for Columbia lower tributary populations. However, based on declining trends measured at Bonneville Dam and Willamette Falls it is assumed that Pacific lamprey have declined in the Columbia Lower Tributaries Subbasin also. Adult lamprey return from the ocean to spawn in the spring and summer. Juveniles rear in freshwater up to seven years before migrating to the ocean.

3.3 Subbasin Habitat Conditions

This section describes the current condition of aquatic and terrestrial habitats within the subbasin. Descriptions are included for habitat features of particular significance to focal salmonid species including watershed hydrology, passage obstructions, water quality, key habitat availability, substrate and sediment, woody debris, channel stability, riparian function, and floodplain function. These descriptions will form the basis for subsequent assessments of the effects of habitat conditions on focal salmonids and opportunities for improvement.

3.3.1 *Watershed Hydrology*

Streamflows in the subbasin are generally a direct result of rainfall, as no substantial snow accumulations occur in these low elevation systems. The largest stream system, Salmon Creek, has a mean flow in December of nearly 450 cubic feet per second (cfs) and a mean flow in late summer of less than 25 cfs. The hydrologic regime of the Lake River basin has been highly impacted by urban and rural development, especially Burnt Bridge Creek, which exhibits the flashy flow typical of urban basins (Figure 4).

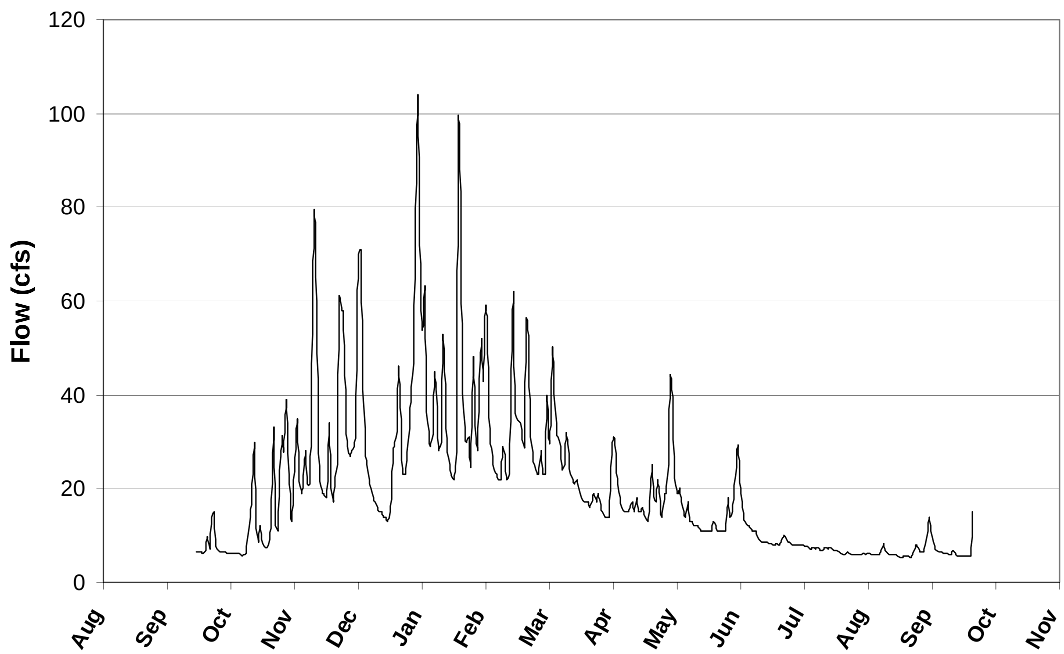


Figure 4. Burnt Bridge Creek for Water Year 2000. Flashy flow typical of urban basins is demonstrated by the preponderance of sharp peaks

Many of the channels in the Lake River basin have been diked, floodplains have been filled or otherwise disconnected, and the amount of impervious land surface has increased dramatically since historical times. The area surrounding Vancouver Lake and to the west was once an extensive network of interconnected sloughs, wetlands, ponds, and tidal channels. Dikes along the Columbia and Lake River now protect developed lowlands from flooding. Vancouver Lake has had a history of water quality problems related to urban development in the basin, including eutrophication and excessive sedimentation. In order to improve water quality and recreational uses, a project in the early 1980s dredged the lake and constructed a flushing channel, which re-connected the lake to the Columbia River. Lake River and Vancouver Lake levels are influenced by tidal fluctuations and by Columbia River levels. Alterations to the flow of the Columbia from mainstem dams, disconnection of historical overflow channels, and the construction of the flushing channel have altered the flow regime of Vancouver Lake and Lake River, with subsequent impacts to water quality, nutrient levels, and sediment dynamics (Wade 2001).

Impaired runoff conditions are a concern in this highly developed basin. The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, indicates that 27 of the 34 subwatersheds (7^{th} field) are "impaired" with respect to runoff conditions and the remaining 7 are "moderately impaired". The widespread hydrologic impairment is related to the high percentage of watershed imperviousness, lack of mature forest vegetation, and alterations to the drainage network due to roads and other development. Over 87% of the Lake River basin is in non-forest or other uses and the road density is a very high 9.7 mi/mi^2. The significant increase in impervious surfaces associated with development has likely decreased infiltration, thereby increasing runoff and peak flows and decreasing base flows. Although stream gaging records on most streams in the area are too sparse or too short-term to detect anthropogenic alterations to flow regimes, there is evidence that on lower Burnt Bridge Creek, peak flows may have increased since the 1970s due to increased urbanization (EnviroData Solutions, Inc, 1998).

Watershed development and water withdrawals have likely reduced streamflows to below historical levels. Mean monthly flows in Salmon Creek fell below 12 cfs in five of the 10 years on record. Observations indicate that Mill Creek was perennial throughout its length prior to 1960; now it typically dries up by mid-July (Wade 2001). Low flow problems exist in the Salmon Creek tributaries Morgan Creek, Mud Creek, and Baker Creek. Instream flow analysis using the toe-width method revealed that, on Salmon Creek tributaries and in Whipple Creek, flows in the fall were considerably below optimum for salmonid spawning and rearing (Caldwell et al. 1999).

As part of the Phase 2 assessments for WRIA 27/28 under the Watershed Management Act, Pacific Groundwater Group completed an HSPF (Hydrologic Simulation Program – Fortran) model analysis of Salmon Creek. The analysis provided information that indicates low base flows during the summer months on Salmon Creek have been impacted by development. A summary of the results are as follows: 1) during summer months surface water diversions of 3-5 cfs may take 15-30% of stream flow when flow is 15-20 cfs, 2) reduced recharge due to impervious surfaces reduces annual base flow by 12%, 3) withdrawal of groundwater from wells (public and private) reduces base flow by an estimated 8%.

In the Salmon Creek basin, current (year 2000) levels of consumptive water use are approximately 5,000 million gallons per year (mgy) and are expected to increase by 5,475 mgy by 2020. Water use in this basin is a significant component of watershed hydrology, making up as much as 75% of late summer stream flow. Assuming full hydraulic continuity between ground and surface waters, the predicted use in 2020 may exceed late summer flows. In the Burnt Bridge Creek basin, current use already exceeds late summer stream flow volumes if one assumes full connection of ground and surface waters. Both Salmon Creek and Burnt Bridge Creek are closed to further surface water rights appropriation (LCFRB 2001).

3.3.2 *Passage Obstructions*

Passage is naturally blocked on Salmon Creek by Salmon Falls at RM 24.1. On the lower river, a 4-foot high falls below the Hwy 99 Bridge might limit passage. The falls is the result of a headcut that followed the avulsion of the stream into gravel pits in 1996. There may be potential passage problems with the flushing channel entering Vancouver Lake due to high flow velocities. Other artificial passage barriers include several culverts, shallow flow where water courses over agricultural land, a stop gate at a private pond, headcuts, an inoperable fish passage structure on Baker Creek, a concrete flume on Burnt Bridge Creek, and railroad/road crossings on some of the Columbia River tributaries (Wade 2002).

3.3.3 *Water Quality*

Vancouver Lake is classified as hyper-eutrophic with very high phosphorous and correspondent algal blooms. The lake was historically 20 feet deep and clear, with sturgeon. Industrial development, two nearby superfund sites, and alterations to basin runoff dynamics have had large impacts. Lake River was listed on the 1998 Washington State 303(d) list of water quality impaired water bodies for fecal coliform, temperature, and sediment bioassay. Burnt Bridge Creek is on the 303(d) list for pH, DO, temperature, and fecal coliform. Salmon Creek is on the 303(d) list for temperature, turbidity, and fecal coliform (WDOE 1998). Salmon Creek and several tributaries regularly exceed state standards for fecal coliform, turbidity, DO, and temperature. Development, septic systems, and agricultural activities contribute to these problems. Low flows and constructed ponds in the upper basin are believed to contribute to elevated temperatures. A more complete description of water quality problems in specific Salmon Creek tributaries can be found in Wade (2001).

3.3.4 *Key Habitat Availability*

Pool habitat is generally lacking in most of the stream systems. Poor conditions are likely associated with a dearth of LWD, alterations to channel morphology, and changes in the flow and sediment regimes as a result of urbanization. Stormwater runoff and a lack of LWD favors glides over pools in Whipple Creek. Channelization, vegetation removal, and dredging have decreased pool habitats in Burnt Bridge Creek. Surveys conducted by the Clark County Conservation District (CCCD) in Salmon Creek revealed that only 10-15% of the stream surface area was pool habitat. Conditions in tributaries were found to be similar, with generally less than 10% of the surface area in pools (Wade 2001).

The abundance and quality of side channels has decreased significantly as a result of the extensive dike network throughout most of the basins. Side channels in the area surrounding Vancouver Lake have been further impacted by placement of dredge spoils during the dredging of the lake. Upper Burnt Bridge Creek, which was once a series of interconnected wetlands, was diked and drained, eliminating most off-channel habitats. Whipple Creek is mostly incised with few side-channels. Diking and channelization eliminated many side channels that were once present in the lower, braided reach of Salmon Creek. Mining activities have eliminated side channel development in Salmon Creek near the I-5 crossing and upper basin side channels have been reduced by various land-use activities. Side channel habitats have also been degraded / eliminated on several Salmon Creek tributaries. Details can be found in Wade (2001).

3.3.5 *Substrate & Sediment*

Stream surveys conducted by the CCCD in the late 1980s determined that sedimentation and compaction of spawning substrate was a major limiting factor in the basin. In Salmon Creek and tributaries, 6 of the 20 surveyed habitat units had over 75% fines.

Fine sediment is readily delivered to streams in this highly developed area due to stormwater runoff, development in riparian zones, stream-adjacent roads and trails, utility corridors, cattle impacts, and recreational activities (Wade 2001). Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. The IWA rates 20 of the 34 subwatersheds as “moderately impaired” with respect to landscape conditions that influence sediment supply. The remaining 14 subwatersheds were rated as “functional”. The presence of functional conditions is related to the flat topography of many subwatersheds, which decreases the potential for sediment delivery to stream channels. However, based on the high natural erodability of soils and the high degree of watershed development, the potential for sediment delivery to stream channels is high. For example, the road density in the basin is a very high 9.7 mi/mi^2 and there are over 44 miles of stream-adjacent roads.

3.3.6 *Woody Debris*

Current levels of LWD are low in the Lake River basin. The disconnection of overflow channels and sloughs has prevented potential recruitment to stream channels. Furthermore, practices including agricultural development, diking, and road building removed riparian vegetation that could provide a source for instream large wood. Currently, only a few scattered areas have levels of natural vegetation capable of supplying wood to streams. The only stream system with any significant LWD levels is Rock Creek in the upper Salmon Creek basin (Wade 2001).

3.3.7 *Channel Stability*

Streambank stabilization has occurred on most of the streams in the Lake River basin in order to protect urban and rural development. Bank hardening has protected most banks from erosion but in some cases has exacerbated erosion in adjacent areas. The avulsion of lower Salmon Creek into stream-adjacent gravel pits initiated an upstream migrating headcut. On Salmon Creek between I-5 and 182nd Avenue there is a high bank, 800-900 feet long, eroding into the creek. In agricultural areas upstream, removal of riparian vegetation has contributed to lateral channel migration. Several bank stability problem areas are located on Salmon River tributaries. These mostly involve livestock access and riparian vegetation removal. Morgan and Mill Creeks contain the most area of bank instability. Additional details can be found in Wade (2001).

3.3.8 *Riparian Function*

Riparian conditions are poor in the Lake River basin. Residential and commercial development, agriculture, transportation corridors, placement of fill, and diking have eliminated most riparian vegetation on Lake River, Whipple Creek, Burnt Bridge Creek, and lower Salmon Creek. Upper basin reaches are impacted by agriculture, rural development, and forest practices (Wade 2001).

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, 25 of the 34 subwatersheds were rated as “impaired” with respect to riparian function, 5 were rated as “moderately impaired”, and 4 were not rated. These results are consistent with an analysis of georeferenced Landsat satellite imagery data that looked at the amount of vegetation cover and stand age to determine that 74% of riparian areas were in poor condition and only 1% were in good (mid- to late-seral stage) condition (Lewis County GIS 2000).

3.3.9 *Floodplain Function*

Extensive urban and rural development has resulted in a substantial loss of floodplain habitats. The Vancouver Lake lowlands and Lake River were once hydraulically connected with the Columbia River and contained a network of overflow channels, sloughs, and wetlands that would have provided important salmonid rearing habitat. This area has been extensively diked, dredged, and drained over the course of human settlement in the area, primarily for agricultural and industrial purposes. Only very high flow events now flood only portions of these lowlands. One particular project that affected floodplain habitats was the dredging of Vancouver Lake in the early 1980s. This project, which was undertaken to improve lake water quality for recreational purposes, involved the placement of fill in wetlands surrounding the lake. Lake River is currently constrained by dikes and a railroad grade, and floodplain areas have been filled, drained, and leveled. Culverts and a railroad dike reduce floodplain connectivity on Whipple Creek. Burnt Bridge Creek has been highly altered through diking, draining, and rerouting into ditches and culverts. Salmon Creek suffers from extensive diking, road crossings, recreational development, bank hardening, and gravel mining operations. The stream is now incised and disconnected from its floodplain in many areas. Many Salmon Creek tributaries have been ditched and relocated as they course through areas of urban and rural development (Wade 2001).

3.4 Stream Habitat Limitations

A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Columbia lower tributary steelhead, chum, fall chinook and coho. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Appendix E.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

3.4.1 *Population Analysis*

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes. Habitat-based assessments were completed in the Salmon Creek basin for fall chinook, chum, coho and winter steelhead.

Model results indicate a decline in adult productivity for all species in the Salmon Creek Basin. Declines in adult productivity (from historical levels) range from 79% for fall chinook to greater than 90% for winter steelhead. Similarly, adult abundance levels have declined for all species (Figure 5). Current estimates of abundance are only 21% of historical levels for fall chinook, 13% of historical levels for winter steelhead, 15% of historical levels for coho, and 0%

of historical levels for chum, as they are functionally extirpated from the basin. Estimated species diversity has also decreased significantly for all species in the Salmon creek basin (Table 2). Species diversity has declined by 57% for both fall chinook and coho, by 61% for winter steelhead, and by 100% for chum.

As with adult productivity, model results indicate that current smolt productivity is sharply reduced compared to historical levels. Current smolt productivity estimates are between 12% and 37% of historical productivity, depending on species (Table 2). Smolt abundance numbers are similarly low, especially for chum and coho (Table 2). Current smolt abundance estimates for chum and coho are at 0% and 14% of historical levels, respectively.

Model results indicate that restoration of PFC conditions would have large benefits in all performance parameters for all species (Table 2). For adult abundance, restoration of PFC conditions would increase current returns by 353% for fall chinook, by 251% for winter steelhead, and by 500% for coho. Adult chum returns would be approximately 1,800 fish. Similarly, smolt abundance numbers would increase for all species (Table 2). Coho would see an increase in smolt abundance of 538%. Chum smolts would increase in number from 0 to 484,000.

Table 2. Salmon Creek - Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template)[1], and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**
Fall Chinook	91	414	444	1.6	6.6	7.7	0.43	1.00	1.00	13,341	53,922	58,100	219	746	869
Chum	0	1,789	4,482	1.0	6.5	9.5	0.00	1.00	1.00	0	483,833	802,195	406	968	1,078
Coho	772	4,621	5,266	2.2	11.0	14.3	0.43	0.99	1.00	17,887	114,139	129,864	51	260	338
Winter Steelhead	64	223	486	2.4	13.9	36.4	0.39	0.98	1.00	1,136	4,038	4,655	43	255	354

[1] Estimate represents historical conditions in the basin and current conditions in the mainstem and estuary.

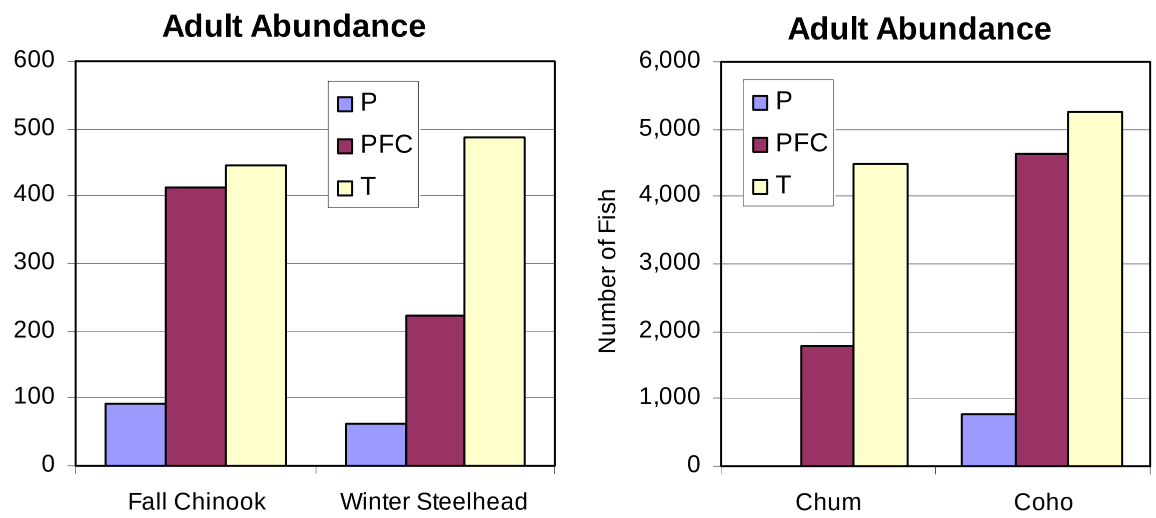


Figure 5. Adult abundance of Salmon Creek fall chinook, coho, winter steelhead and chum based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

3.4.2 *Stream Reach Analysis*

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

Fall chinook primarily use Salmon Creek mainstem reaches. Chum are believed to have historically had a similar distribution as fall chinook. Winter steelhead and coho are distributed throughout the mainstem and tributaries. See Figure 6 for a map of reaches in the Salmon Creek basin.

Important reaches for both fall chinook (Figure 7) and chum (Figure 8) are generally located in the middle mainstem (Salmon 11-13, Salmon 14A-14C and Salmon 16). These reaches, as with the important winter steelhead reaches, all show a strong habitat restoration emphasis. For both species, the reaches of Salmon 14A and Salmon 14B have the highest restoration potential of any reach modeled within the basin.

For coho, the high priority reaches are primarily located in the middle and upper basin (Figure 9). Tributaries such as Suds, Lalonde, Morgan and Rock Creeks also contain high priority reaches for coho. All high priority reaches, except Salmon 31 and Lbtrib 11-1, show a habitat restoration emphasis. Salmon 31 and Lbtrib 11-1 have a combined habitat preservation and restoration emphasis. As with all other modeled species, the reaches of Salmon 14A and Salmon 14B have the highest restoration potential of any reach.

Reaches with a high priority ranking for winter steelhead are located in the middle and upper mainstem Salmon Creek (Figure 10). All high priority reaches, except reach Salmon 31, show a strong habitat restoration emphasis. Salmon 31 shows a combined habitat preservation and restoration emphasis (Figure 10). The reaches of Salmon 14A and 14C have the highest restoration potential of any reach modeled for winter steelhead.

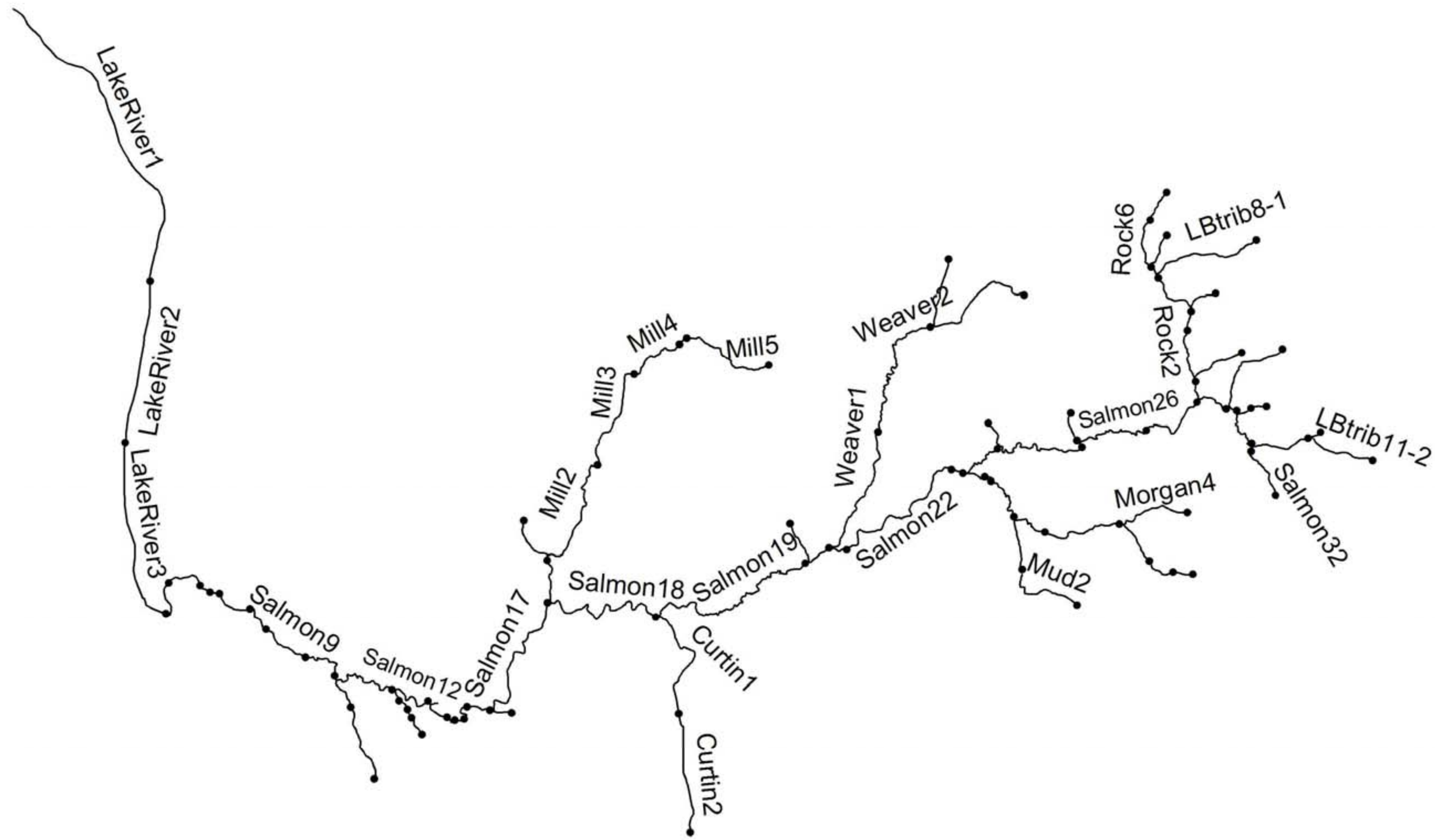


Figure 6. Salmon Creek Basin with EDT reaches identified. For readability, not all reaches are labeled.

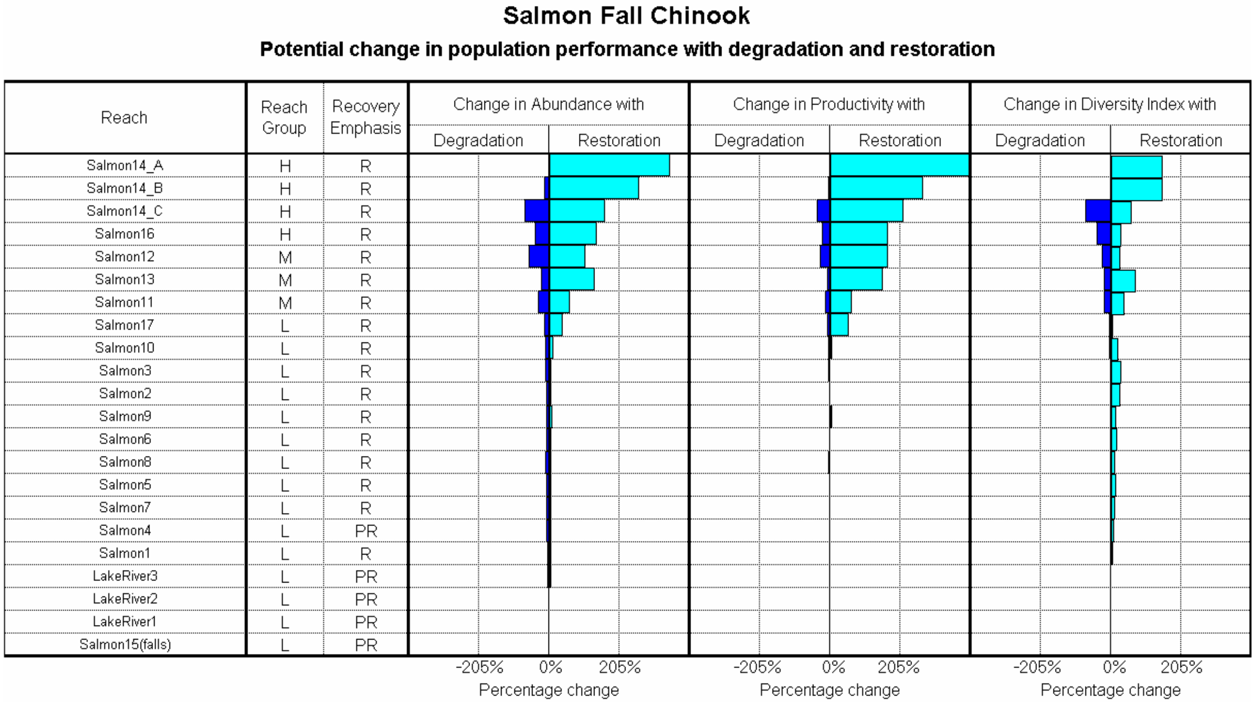


Figure 7. Salmon Creek fall chinook ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. See Appendix E Chapter 6 for more information on EDT ladder diagrams. Percentage change values are expressed as the change per 1000 meters of stream length within the reach.

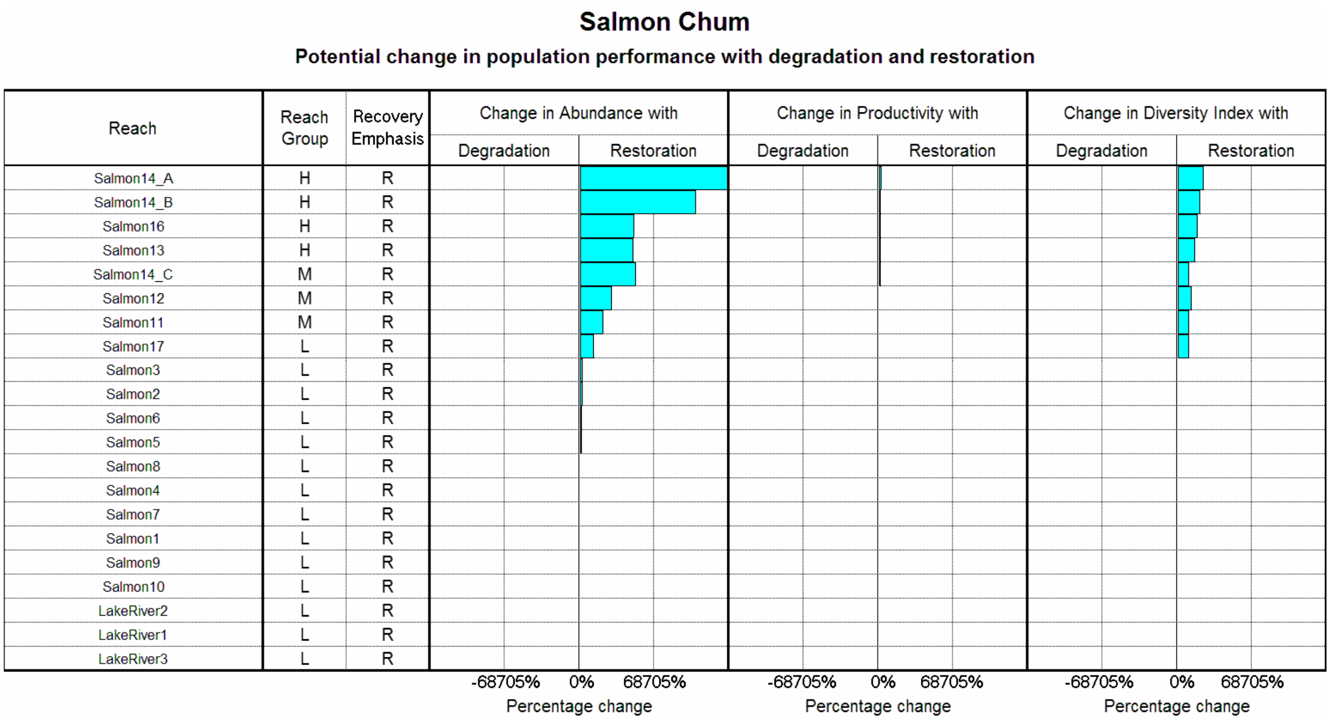


Figure 8. Salmon Creek chum ladder diagram.

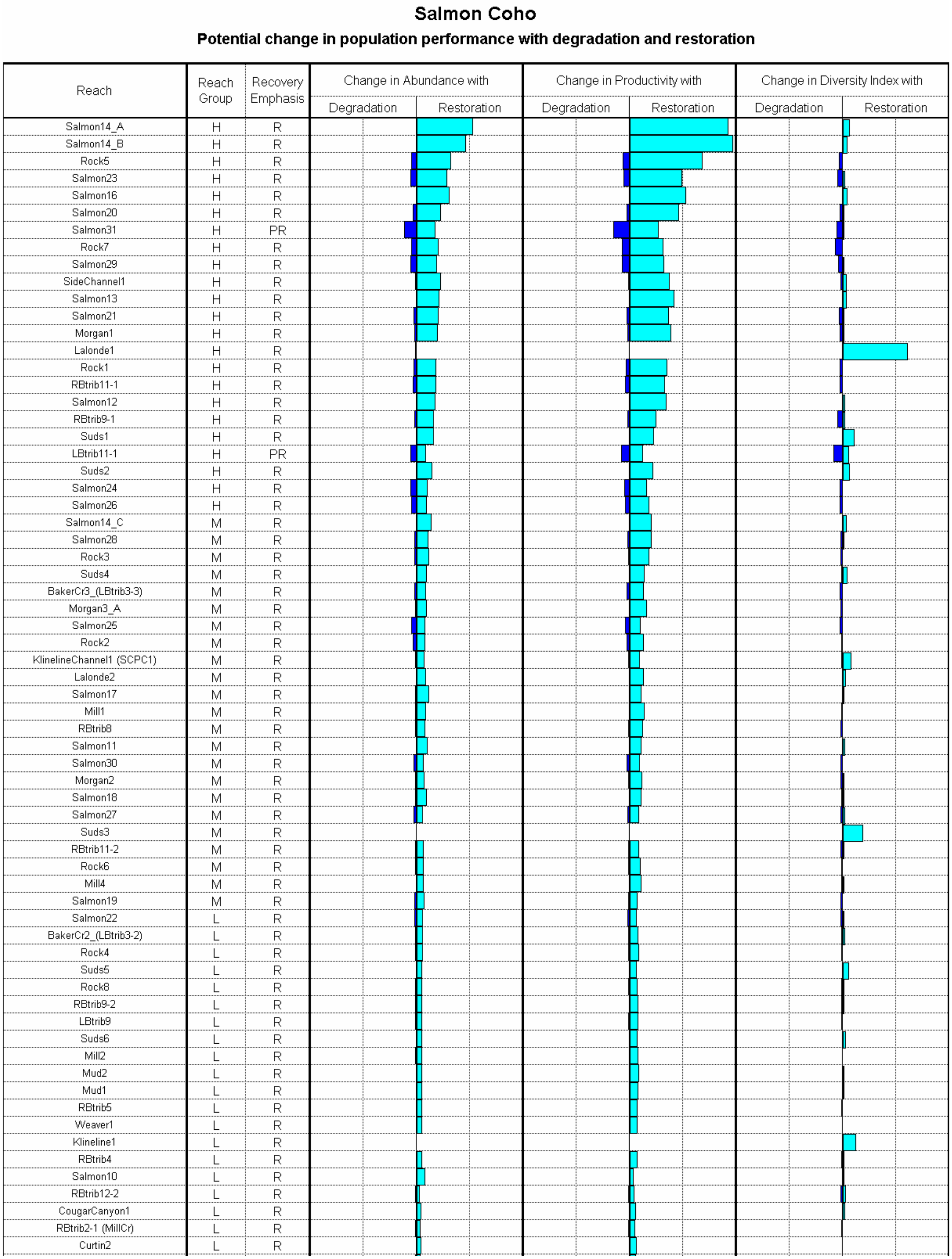


Figure 9. Salmon Creek coho ladder diagram. Some low priority reaches are not included for display purposes.

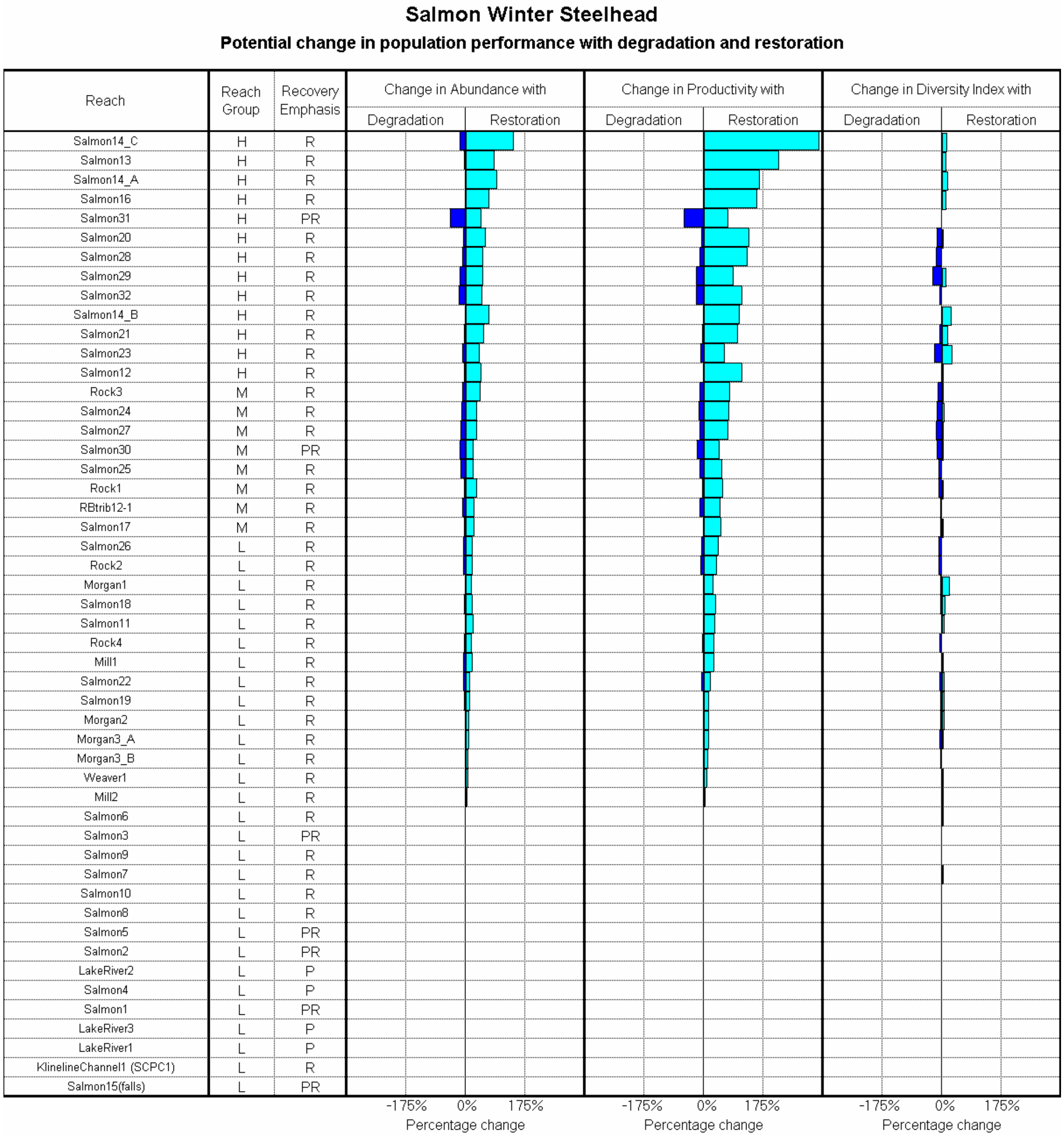


Figure 10. Salmon Creek winter steelhead ladder diagram.

3.4.3 *Habitat Factor Analysis*

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the habitat factor analysis compares current/patient and historical/template habitat conditions. For each reach, EDT generates what is referred to as a "consumer reports diagram", which identifies the degree to which individual habitat factors are acting to suppress population performance. The effect of each habitat factor is identified for each life stage that occurs in the reach and the relative importance of each life stage is indicated. For additional information and examples of this analysis, see Appendix E. Inclusion of the consumer report diagram for each reach is beyond the scope of this document. A summary of the most critical life stages and the habitat factors affecting them are displayed for each species in Table 3.

Table 3. Summary of the primary limiting factors affecting life stages of focal salmonid species. Results are summarized from EDT Analysis.

Species and Lifestage		*Primary factors*	*Secondary factors*	*Tertiary factors*
Salmon Fall Chinook				
most critical	Egg incubation	channel stability, sediment	temperature, harassment	key habitat
second	Spawning	key habitat, habitat diversity		
third	Prespawning holding	habitat diversity	flow, harassment, temperature	
Salmon Chum				
most critical	Prespawning holding	habitat diversity, harassment	key habitat	
second	Egg incubation	channel stability, sediment	key habitat	harassment
third	Spawning	habitat diversity, harassment	key habitat	
Salmon Coho				
most critical	Egg incubation	sediment	channel stability	
second	0-age summer rearing	habitat diversity, temperature	food	channel stability, competition (hatchery), flow, predation, key habitat
third	0-age winter rearing			
Salmon Winter Steelhead				
most critical	Egg incubation	sediment	temperature	
second	Fry colonization	habitat diversity	flow, predation	food
third	0-age summer rearing	habitat diversity, flow	competition (hatchery), pathogens, predation, temperature	

The consumer reports diagrams have also been summarized to show the relative importance of habitat factors by reach. The summary figures are referred to as habitat factor analysis diagrams and are displayed for each species below. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

The greatest impacts to fall Chinook and chum are located in the lower and middle mainstem reaches of Salmon Creek. The primary impacts to key reaches are sediment and habitat diversity (Figure 11 and Figure 12). Other impacts include channel stability, flow, and harassment. These reaches are heavily impacted by the expanding Vancouver metropolitan area. Stream channels have been straightened and confined, riparian areas have been denuded of vegetation, floodplains have been isolated from channels, and uplands have been highly developed.

Important coho reaches in the Salmon Creek basin are generally located in both the middle and upper mainstem, as well as in many of the smaller tributaries. Habitat factors affecting these reaches are varied and include sediment, habitat diversity, channel stability, key habitat and flow (Figure 13). Lesser impacts related to food and temperature are also affecting these reaches. The causes of these impacts are similar to those discussed above.

Key reaches for winter steelhead in the Salmon Creek basin are located primarily in the middle and upper mainstem. These reaches appear to be most impacted from sediment and habitat diversity, with somewhat lesser impacts related to flow, temperature, and predation (Figure 14). This area has been heavily modified since historical times. Rural residential development and agriculture are the primary sources of habitat impairments.

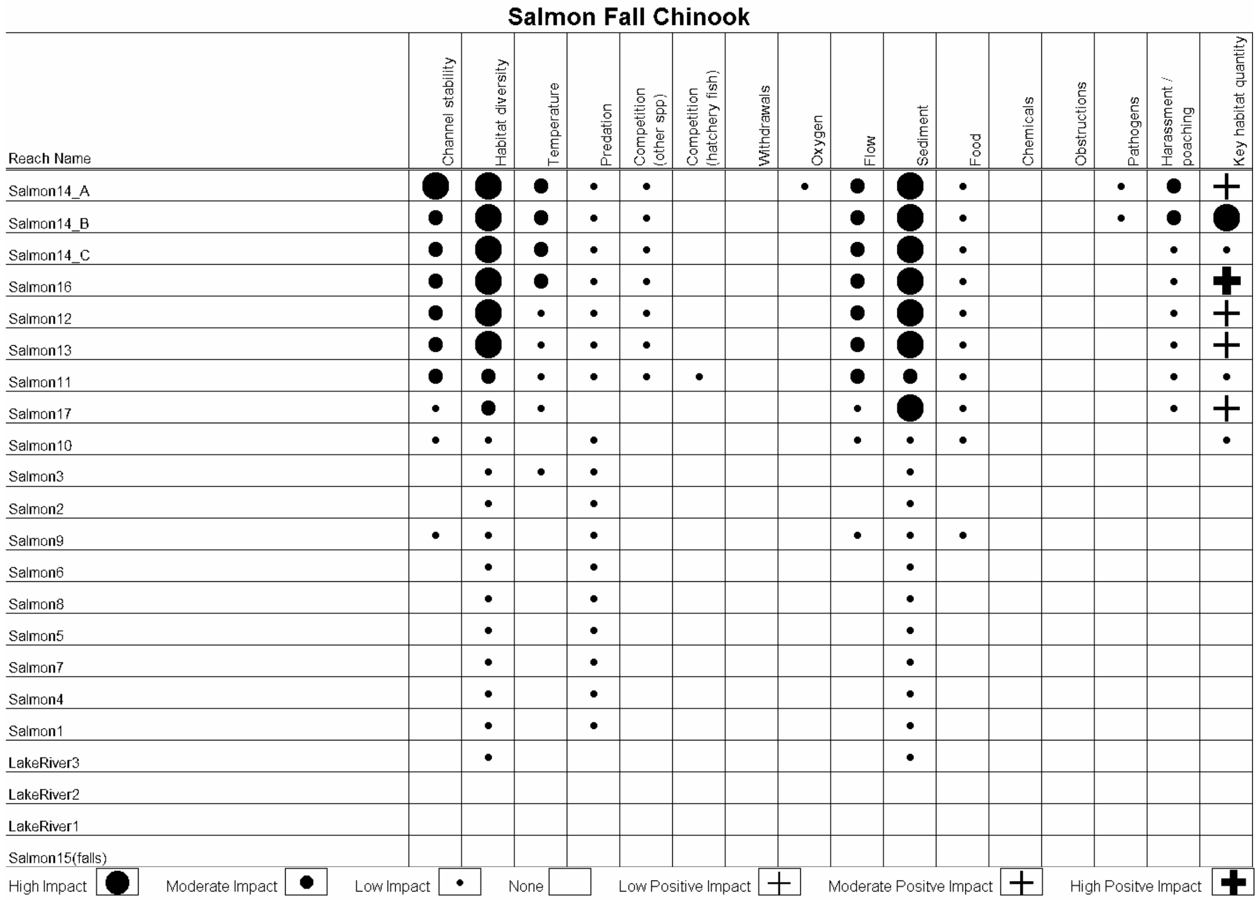


Figure 11. Salmon Creek fall chinook habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Appendix E Chapter 6 for more information on habitat factor analysis diagrams. Some low priority reaches are not included for display purposes.

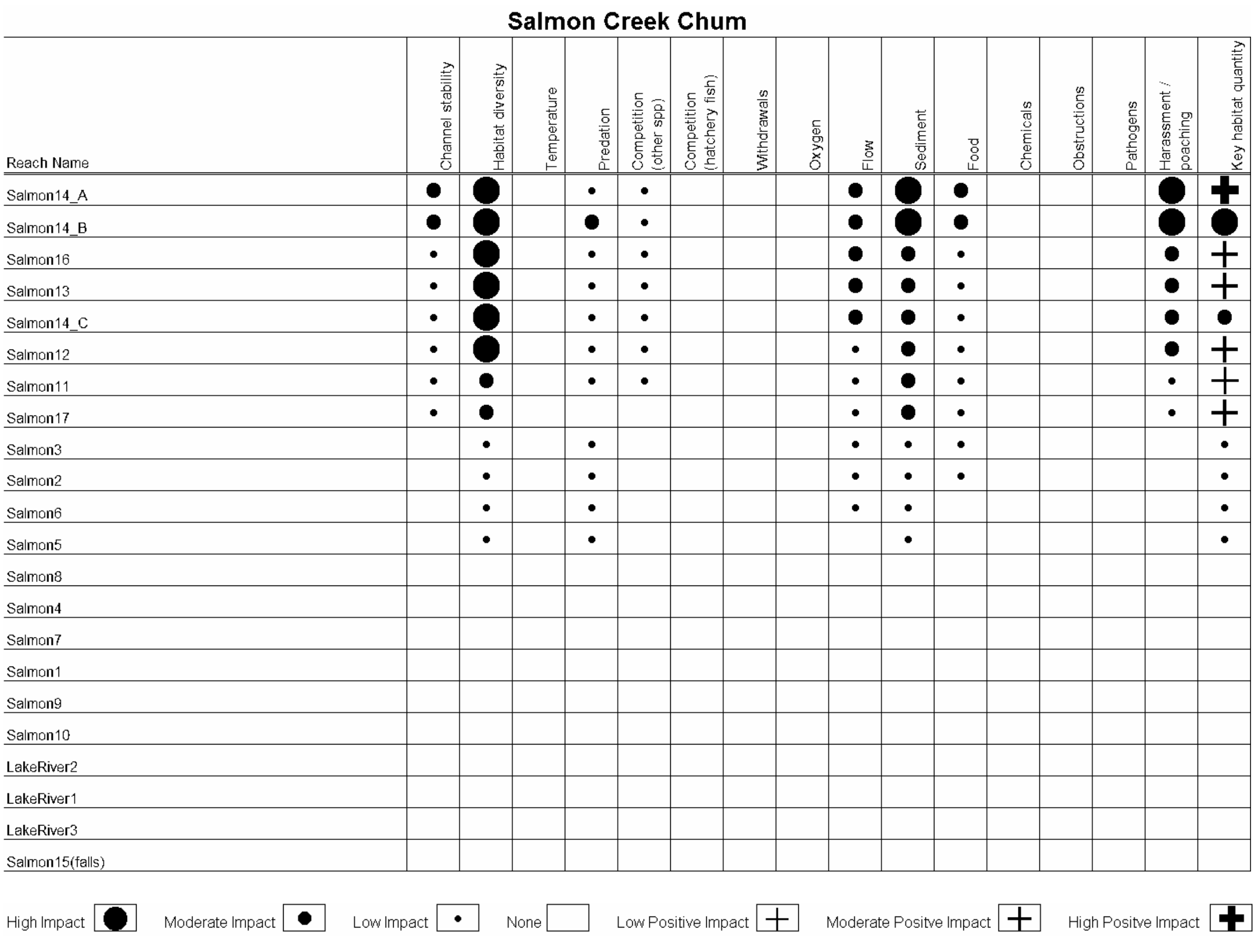


Figure 12. Salmon Creek chum habitat factor analysis diagram.

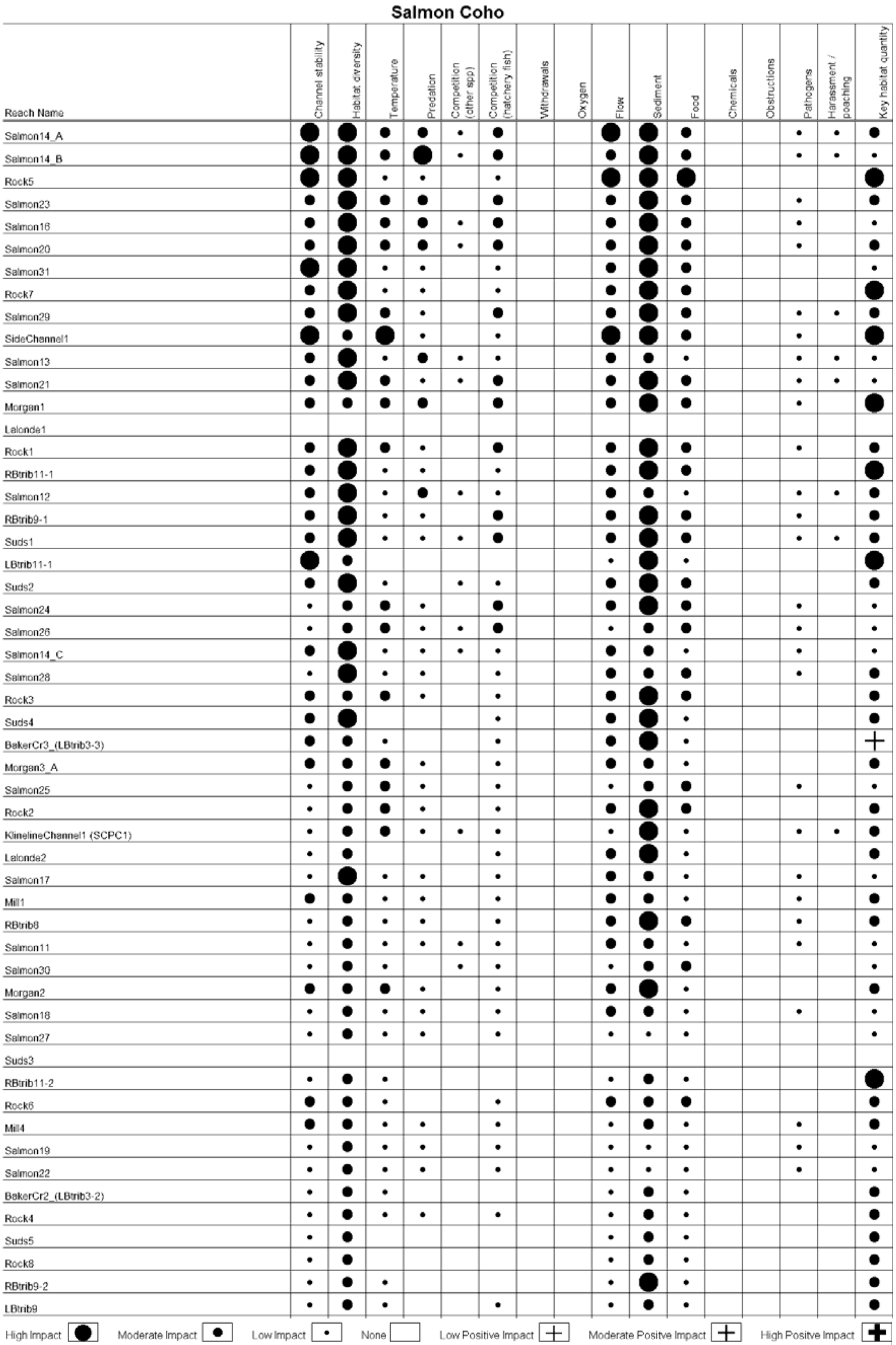


Figure 13. Salmon Creek coho habitat factor analysis diagram. Some low priority reaches are not included for display purposes

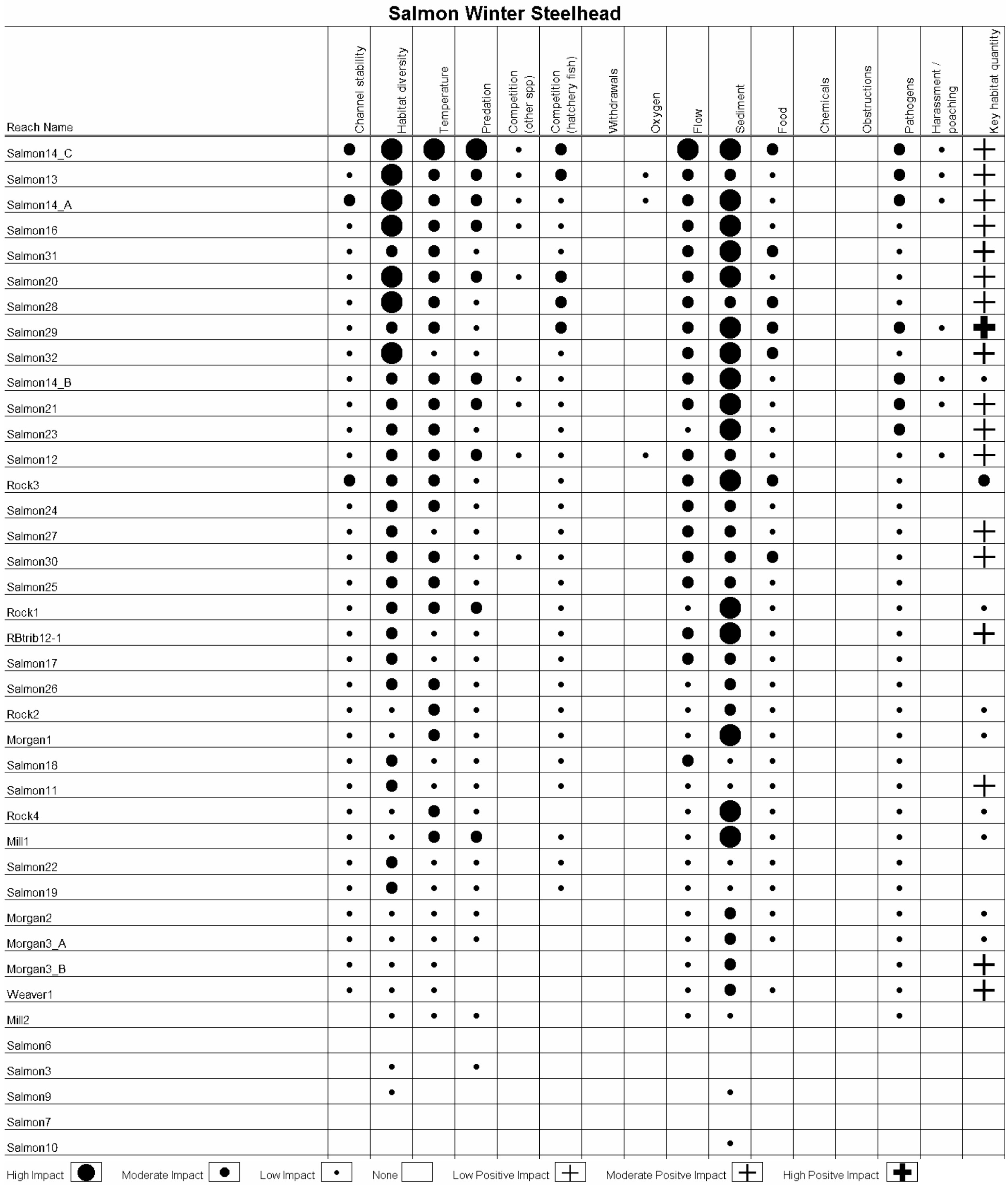


Figure 14. Salmon Creek winter steelhead habitat factor analysis diagram.

3.5 Watershed Process Limitations

This section describes watershed process limitations that contribute to stream habitat conditions significant to focal fish species. Reach level stream habitat conditions are influenced by systemic watershed processes. Limiting factors such as temperature, high and low flows, sediment input, and large woody debris recruitment are often affected by upstream conditions and by contributing landscape factors. Accordingly, restoration of degraded channel habitat may require action outside the targeted reach, often extending into riparian and hillslope (upland) areas that are believed to influence the condition of aquatic habitats.

Watershed process impairments that affect stream habitat conditions were evaluated using a watershed process screening tool termed the Integrated Watershed Assessment (IWA). The IWA is a GIS-based assessment that evaluates watershed impairments at the subwatershed scale (3,000 to 12,000 acres). The tool uses landscape conditions (i.e. road density, impervious surfaces, vegetation, soil erodability, and topography) to identify the level of impairment of 1) riparian function, 2) sediment supply conditions, and 3) hydrology (runoff) conditions. For sediment and hydrology, the level of impairment is determined for local conditions (i.e. within subwatersheds, not including upstream drainage area) and at the watershed level (i.e. integrating the entire drainage area upstream of each subwatershed). See Appendix E for additional information on the IWA.

The Salmon Creek/Lake River watershed (Salmon Creek watershed hereafter) includes Salmon Creek, Burnt Bridge Creek, and other minor tributaries to the Lake River. Other drainages entering the Lake River system include Burnt Bridge Creek, Whipple Creek, and Flume Creek. IWA results for the Salmon Creek watershed are shown in Table 4. A reference map showing the location of each subwatershed in the basin is presented in Figure 15. Maps of the distribution of local and watershed level IWA results are displayed in Figure 16.

3.5.1 *Hydrology*

Current Conditions.— The Salmon Creek watershed is primarily a low elevation, rain-dominated system, with the headwaters reaching an elevation of 1,998 ft. Total area of the watershed in the rain-on-snow zone is minimal. Because of the high levels of impervious surface, low levels of hydrologically mature forest cover, and high road densities found in this predominately developed area, local and watershed level hydrologic conditions are generally impaired throughout the majority of the watershed. No subwatershed was considered hydrologically functional at the local or watershed level.

Moderately impaired local and watershed level hydrology conditions are present in Mill Creek (90110), Weaver Creek (90111), and the lower mainstem of Salmon Creek (90104). Two additional subwatersheds along the Salmon Creek mainstem (90107 and 90106) are hydrologically impaired at the local level but only moderately impaired at the watershed scale, suggesting that Weaver and Mill Creeks are buffering downstream conditions to some degree. These mainstem Salmon Creek subwatersheds (90107 and 90106) are rated as moderately impaired because of currently low levels of impervious surface. The upper mainstem and headwaters of Salmon Creek (90108 and 90109) and headwater tributaries Rock Creek (90112) and Morgan Creek (90113) are all rated as hydrologically impaired at both the local and watershed level. These ratings are driven by high current levels of impervious surface, low levels of hydrologically mature forest cover (averaging 10%), and high road densities (exceeding 10 mi/sq mi). Approximately 20% of the Rock Creek and Salmon Creek headwaters subwatersheds are public lands, while an average of 15% of the lower Salmon Creek subwatersheds (90104 and

90106) are in public ownership. Other subwatersheds average less than 5% public ownership. Public lands are comprised primarily of state lands (WDNR) or county parks and open space.

Hydrologic conditions in lower Burnt Bridge Creek (90120 and 90114) are rated as moderately impaired at the local level; the rating is attributable to relatively small subwatershed area, lower impervious surface area, and some park lands. These subwatersheds are rated as impaired at the watershed level because of high levels of impervious surface in contributing upstream subwatersheds, including middle and upper Burnt Bridge Creek (90123, 90124, 90125 and 90128), as well as several contributing storm drainage basins (90126, 90127, 90190 and 90130). The Burnt Bridge Creek drainage lies entirely within the Vancouver city limits and is extensively developed.

In the Lake River mainstem, hydrologic conditions are strongly influenced by tidal fluctuations in the Columbia River. Subwatersheds 90101 and 90131 are rated moderately impaired at the local and watershed level and may be partially buffered by contributing upstream subwatersheds.

Predicted Future Trends.— A portion of the Salmon Creek mainstem subwatersheds (90107, 90106) lie within the urban growth boundary of Battle Ground, and greater than 80% of these subwatersheds are zoned for development but are currently vacant. Given the likelihood for increasing development in these and other nearby subwatersheds (90104, Mill Creek 90110, and Weaver Creek 90111), the predicted trend for hydrologic conditions is to degrade further over the next 20 years.

Given the current level of and likelihood for further development, the predicted trend is for hydrologic conditions in Burnt Bridge Creek to continue to degrade.

Two hydrologically impaired subwatersheds (90134 and 90132) drain the southern portion of the watershed via steep bluffs into the mainstem Columbia River. While these subwatersheds do not support significant numbers of fish, groundwater from this area feeds springs in the mainstem Columbia that are spawning grounds for chum salmon (Wade 2001). Given the potential for development in and around Vancouver, the predicted trend in hydrologic conditions in these subwatersheds is for further degradation.

Table 4. IWA results for the Salmon Creek Watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
90101	M	M	I	M	M	90102, 90103, 90104, 90105, 90106, 90107, 90108, 90109, 90110, 90111, 90112, 90113, 90114, 90115, 90116, 90117, 90118, 90119, 90120, 90121, 90122, 90123, 90124, 90125, 90126, 90127, 90128, 90129, 90130, 90131, 90132, 90133, 90134
90102	I	M	I	I	M	none
90103	I	F	I	M	M	90133
90104	M	M	M	M	M	90106, 90107, 90108, 90109, 90110, 90111, 90112, 90113, 90115, 90116, 90117, 90118
90105	I	F	I	I	F	none
90106	I	M	I	M	M	90107, 90108, 90109, 90110, 90111, 90112, 90113, 90116, 90117, 90118
90107	I	M	I	M	M	90108, 90109, 90111, 90112, 90113, 90118
90108	I	M	I	I	M	90109, 90112, 90113
90109	I	M	M	I	M	none
90110	M	M	I	M	M	none
90111	M	M	I	M	M	none
90112	I	M	M	I	M	none
90113	I	M	I	I	M	none
90114	M	F	I	I	F	90119, 90120, 90121, 90122, 90123, 90124, 90125, 90126, 90127, 90128, 90129, 90130
90115	I	M	I	I	M	none
90116	I	F	I	I	F	none
90117	I	F	M	I	F	none
90118	I	M	I	I	M	none
90119	I	M	I	I	M	none
90120	M	M	I	I	F	90121, 90122, 90123, 90124, 90125, 90126, 90127, 90128, 90129, 90130
90121	I	F	I	I	F	none
90122	I	M	I	I	M	none
90123	I	F	I	I	F	90124, 90125, 90126, 90127, 90128, 90129, 90130
90124	I	F	I	I	F	90125, 90126, 90127, 90128, 90129, 90130
90125	I	F	I	I	F	90126, 90127
90126	I	M	ND	I	F	90127
90127	I	F	ND	I	F	none

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
90128	I	F	I	I	F	none
90129	I	F	ND	I	F	90130
90130	I	F	ND	I	F	none
90131	M	F	I	M	F	90105, 90114, 90119, 90120, 90121, 90122, 90123, 90124, 90125, 90126, 90127, 90128, 90129, 90130
90132	I	M	I	I	M	none
90133	I	M	M	I	M	none
90134	I	M	M	I	M	none

Notes:
[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800030#####.
[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:
F: Functional
M: Moderately impaired
I: Impaired
ND: Not evaluated due to a lack of data
[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.
[d] Subwatersheds upstream from this subwatershed.

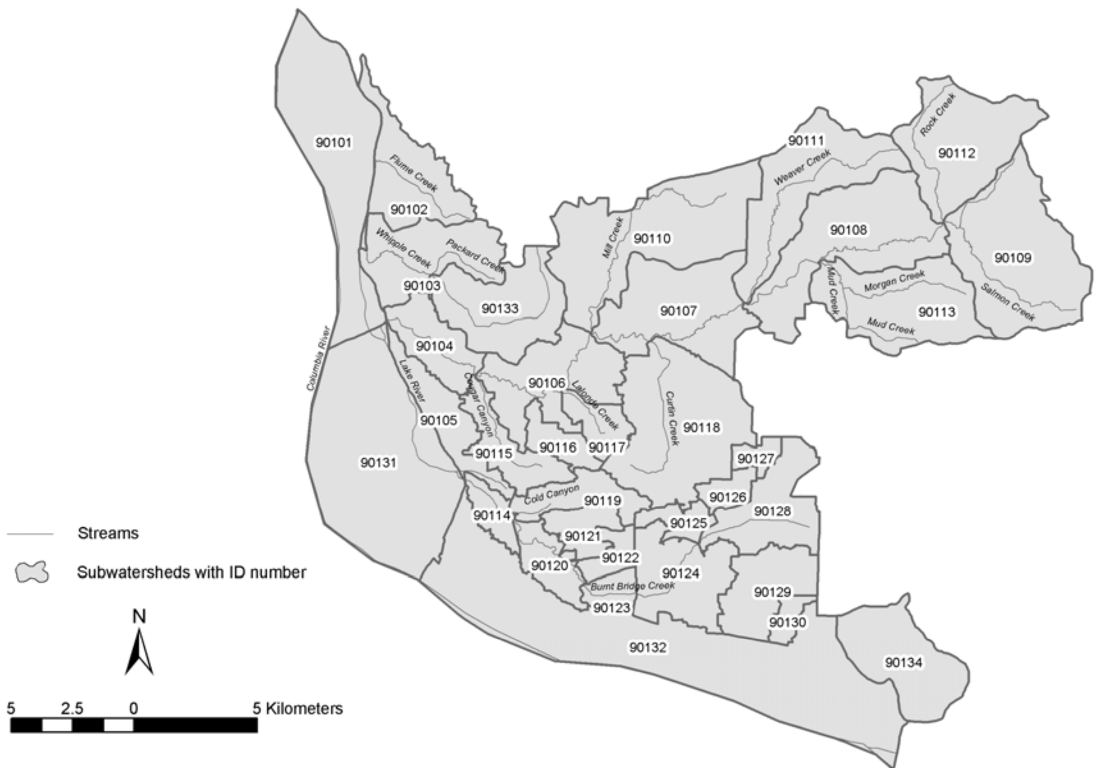


Figure 15. Map of the Salmon Creek basin showing the location of the IWA subwatersheds.

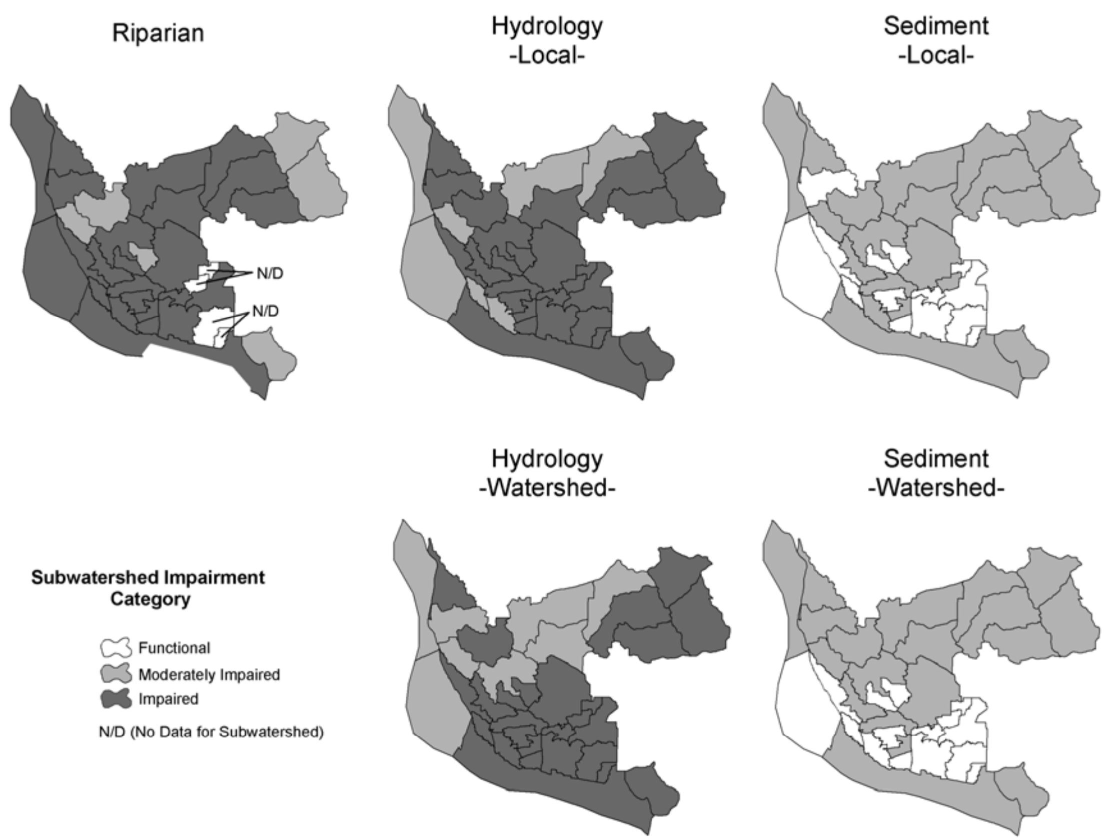


Figure 16. IWA subwatershed impairment ratings by category for the Salmon Creek basin.

3.5.2 *Sediment Supply*

Current Conditions.— Natural erodability rates in the Salmon Creek watershed are quite high relative to the rest of the region, with 12 of 34 exceeding a rating of 50 or greater on a scale of 0-126. One subwatershed (90116) within the Vancouver city limits has the highest natural sediment supply rating in the region (126). Sediment conditions are generally rated as moderately impaired at the local level, with the exception of some of the more heavily developed subwatersheds within the Vancouver city limits, which are rated as functional. None were rated as impaired.

The sediment results must be considered relative to the high natural erodability present. The threshold for impaired sediment conditions is a change in the erodability index under developed or disturbed conditions greater than 3 times the natural erodability index. Reaches within or downstream of subwatersheds with very high natural erodability levels that are rated moderately impaired or even functional may still be subject to considerable sediment loading, particularly in subwatersheds that are hydrologically impaired.

Sediment conditions in the Salmon Creek drainage are rated as moderately impaired throughout the majority of the system. Two small tributaries, Lalonde Creek and one unnamed stream (90117 and 90116), are rated as functional for sediment. However, given the very high natural sediment supply rates in these subwatersheds, 100 and 126, respectively, on a scale of 0-126, and the likelihood of impaired hydrologic conditions, these subwatersheds are likely to be contributing significant sediment loading to the lower mainstem of Salmon Creek.

Factors contributing to moderately impaired sediment ratings throughout the Salmon Creek drainage include high road densities and high levels of natural erodability. Because the majority of roads in the lower elevation areas of the drainage are surfaced and generally maintained, roads are considered to be less of a source of sediment supply than bank erosion from disrupted hydrologic conditions. In addition, the relatively flat topography of the Salmon Creek watershed mitigates impaired sediment conditions somewhat despite the extensive modifications of the landscape. However, the high natural erodability rates, in combination with impaired hydrologic conditions, suggest the potential for high levels of sedimentation from channel incision and bank erosion. This potential is confirmed by observed conditions (Wade 2001). High road densities in sensitive areas in headwaters contribute to moderately impaired ratings. Streamside road densities are particularly high in the Salmon Creek headwaters (90109, >0.8 miles/stream mile) and Rock Creek (90112). Unsurfaced streamside roads that are highly traveled are likely to be significant sources of sediment.

Sediment conditions in most of the Burnt Bridge Creek subwatersheds are rated as functional, despite high natural erodability. The functional ratings result from flat topography and surfaced and well maintained roads. As discussed above for Salmon Creek however, the IWA sediment analysis will underestimate the effects of increased peak flows from high levels of impervious surface on local bank erosion rates in areas with high natural erodability. Therefore, given the conditions observed in the Burnt Bridge Creek system, the functionality of sediment conditions are believed to be overestimated in this system. This is confirmed by observed conditions in the drainage (Wade 2001).

Predicted Future Trends.— Given the potential for expanding development in the Salmon Creek drainage, the predicted trend for sediment conditions is to degrade further, particularly downstream from headwaters areas where steeper slopes are prevalent.

Given the extent of current development and the likelihood of increasing development in currently zoned areas, the predicted trend for sediment conditions in the Burnt Bridge Creek drainage is to degrade further over the next 20 years.

3.5.3 *Riparian Condition*

Current Conditions.— Riparian conditions are rated moderately impaired or impaired in all 30 modeled subwatersheds. The majority of these (24 of 30) are rated as impaired, with moderately impaired ratings in the Salmon Creek headwaters (90109, 90112), Burnt Bridge Creek (90134), Whipple Creek (90133), Lalonde Creek (90117), and the lower mainstem (90104). Poor riparian conditions are related to urban, residential, and agricultural development.

Riparian conditions in Salmon Creek are moderately impaired to impaired across all subwatersheds, with the greatest impairments in the middle of the drainage. The mouth of Salmon Creek (90104), Lalonde Creek (90117), Rock Creek (90112) and Salmon Creek headwaters (90109) are moderately impaired. Lower Salmon Creek (90106) and middle Salmon Creek (90107, 90108) are rated as impaired.

Riparian conditions in the Burnt Bridge Creek drainage are rated as impaired. Riparian conditions in the independent drainages to the Columbia River are moderately impaired to impaired. Extensive development limits the potential for riparian recovery.

Predicted Future Trends.— While development is likely to expand in all subwatersheds in the Salmon Creek drainage, existing riparian vegetation will generally be protected under existing critical areas ordinances. Given this assumption and the extent of existing development, riparian vegetation is predicted to trend stable across all impaired subwatersheds. In the moderately impaired headwaters subwatersheds, some potential for riparian recovery exists on less developed lands and publicly owned lands. However, this potential may be offset by expanding development, even under existing regulations. Given this potential, riparian conditions in the headwaters subwatersheds are predicted to trend stable, with gradual improvement in some areas.

Given the extensive development of the Burnt Bridge Creek drainage and the potential for development within existing management constraints, riparian conditions in this drainage are predicted to trend stable over the next 20 years. Similar to hydrology and sediment, given the potential for expanding development in the independent drainages to the Columbia River, riparian conditions are also predicted to trend stable.

3.6 Other Factors and Limitations

3.6.1 *Hatcheries*

Hatcheries currently release over 50 million salmon and steelhead per year in Washington lower Columbia River subbasins. Many of these fish are released to mitigate for loss of habitat. Hatcheries can provide valuable mitigation and conservation benefits but may also cause significant adverse impacts if not prudently and properly employed. Risks to wild fish include genetic deterioration, reduced fitness and survival, ecological effects such as competition or predation, facility effects on passage and water quality, mixed stock fishery effects, and confounding the accuracy of wild population status estimates. This section describes hatchery programs in the Salmon Creek Basin and discusses their potential effects.

There are no hatcheries operating in the Salmon Creek Basin. Skamania Hatchery winter steelhead are released into lower Salmon Creek to provide harvest opportunity. Skamania Hatchery steelhead are a composite stock and are genetically different from the naturally produced steelhead in Salmon Creek (Table 5). Current release goals are 20,000 winter steelhead smolts that are incubated at the Vancouver Hatchery (because of space limitations at Skamania), transferred to the Skamania Hatchery as fry, and acclimated in net pens in Klineline Pond, adjacent to Salmon Creek (Figure 17). The main threats from hatchery steelhead are potential domestication of the naturally produced steelhead as a result of adult interactions or ecological interactions between natural juvenile salmon and hatchery released juvenile steelhead.

Table 5. Salmon Creek hatchery Production.

Hatchery	Release Location	Winter Steelhead
Skamanaia	Salmon Creek	20,000

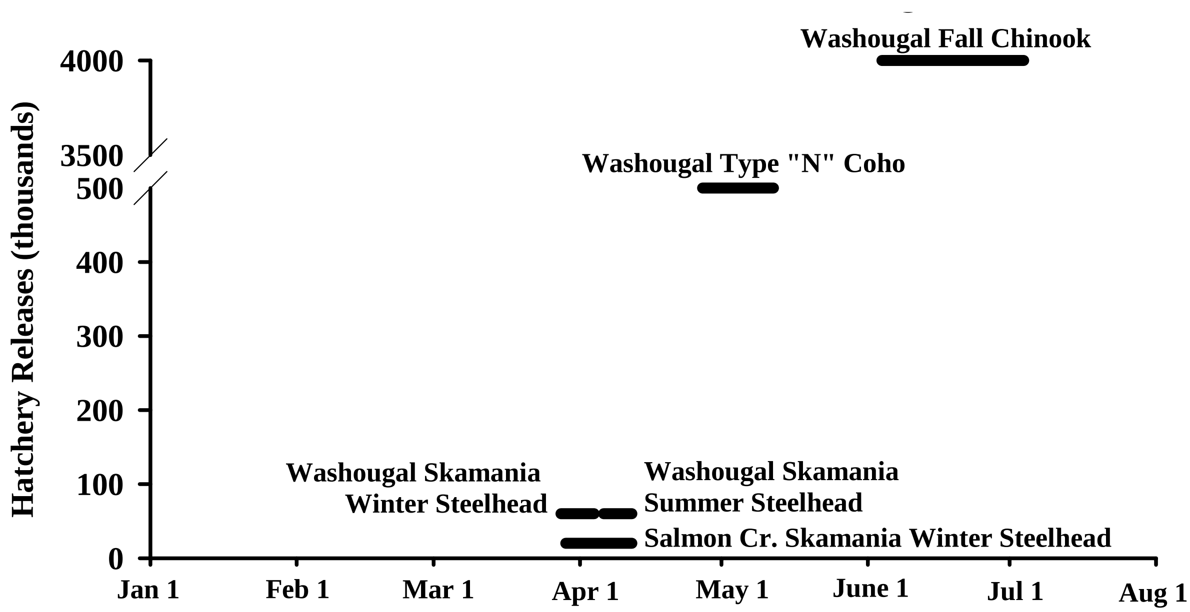


Figure 17. Magnitude and timing of hatchery releases in the Salmon Creek and Washougal River basins by species, based on 2003 brood production goals.

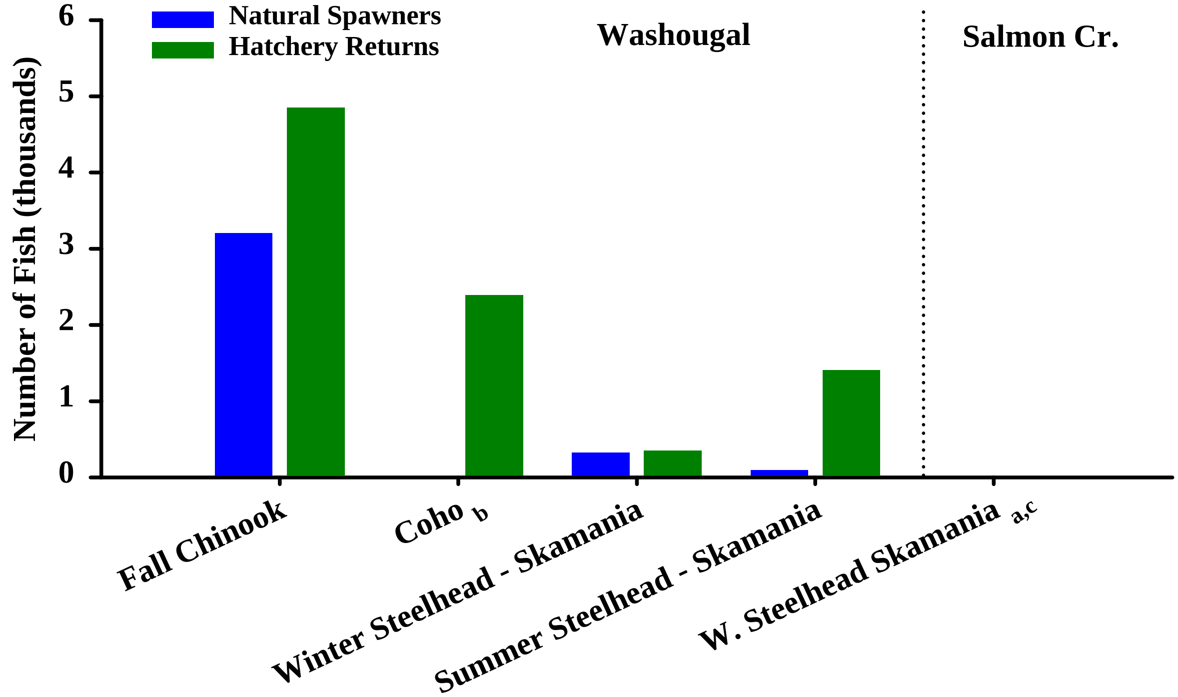


Figure 18. Recent average hatchery returns and estimates of natural spawning escapement in the Salmon Creek and Washgougal River basins by species. The years used to calculate averages varied by species, based on available data. The data used to calculate average hatchery returns and natural escapement for a particular species and basin were derived from the same years in all cases. All data were from 1992 to the present. Calculation of each average utilized a minimum of 5 years of data.

Hatchery Effects

Genetics—Broodstock for the winter steelhead hatchery program at the Skamania Hatchery originated from local Washougal River winter steelhead; current broodstock collection comes from adults returning to the hatchery. Shortfalls in annual broodstock needs have been supplemented from Beaver Creek Hatchery winter steelhead stocks, which originated primarily from Chambers Creek and Cowlitz River stocks. Also, Cowlitz River stocks may have strayed to Salmon Creek after the 1980 eruption of Mt. St. Helens.

Interactions—Hatchery fish account for most adult winter steelhead returning to Salmon Creek; very few wild winter steelhead are present (Figure 18). Also, spawn timing of wild fish and naturally spawning hatchery fish is different, so there is likely minimal interaction between adult wild and hatchery winter steelhead. Winter steelhead natural production is low; returning hatchery adults contribute little to natural production. Hatchery winter steelhead are released as smolts and clear the river quickly, so competition for food resources with natural salmonids is probably minimal. Releases of winter steelhead into Salmon Creek are moderate in number and hatchery fish therefore are not expected to attract excessive amounts of predators toward wild fish.

Water Quality/Disease—Refer to the Washougal River section for information on water quality and disease control issues related to Skamania Hatchery winter steelhead program operations.

Mixed Harvest—The purpose of the winter steelhead hatchery program at the Skamania Hatchery is to provide harvest opportunity to mitigate for winter steelhead lost as a result of hydroelectric development in the lower Columbia River basin. Fisheries that may benefit from this program includes lower Columbia and Salmon Creek sport fisheries. No adults are collected for broodstock needs in Salmon Creek, so all returning adults are available for harvest. Prior to selective fishery regulations, exploitation rates of wild and hatchery winter steelhead likely were similar. Mainstem Columbia River sport fisheries became selective for hatchery steelhead in 1984 and Washington tributaries became selective during 1986–92 (except the Toutle in 1994). Current selective harvest regulations in the lower Columbia and tributary sport fisheries have targeted hatchery steelhead and limited harvest of wild winter steelhead to fewer than 10% (4% in Salmon Creek) This is a successful program supporting a popular fishery.

Passage—There are no hatcheries or facilities for adult hatchery fish collection in Salmon Creek.

Supplementation—Supplementation is not the goal of the Skamania winter steelhead hatchery releases in Salmon Creek; all hatchery winter steelhead are provided for harvest opportunities.

Biological Risk Assessment

The evaluation of hatchery programs and implementation of hatchery reform in the Lower Columbia is occurring through several processes. These include: 1) the LCFRB recovery planning process; 2) Hatchery Genetic Management Plan (HGMP) preparation for ESA permitting; 3) FERC releated plans on the Cowlitz River and Lewis River; and 4) the federally mandated Artificial Production Review and Evaluation (APRE) process. Through each of these processes, WDFW is applying a consistent framework to identify the hatchery program enhancements that will maximize fishing-related economic benefits and promote attainment of regional recovery goals. Developing hatcheries into an integrated, productive, stock recovery tool requires a policy framework for considering the acceptable risks of artificial propagation, and a scientific assessment of the benefits and risks of each proposed hatchery program. WDFW developed the Benefit-Risk Assessment Procedure (BRAP) to provide that framework. The BRAP evaluates hatchery programs in the ecological context of the watershed, with integrated assessment and decisions for hatcheries, harvest, and habitat. The risk assessment procedure consists of five basic steps, grouped into two blocks:

Policy Framework

- Assess population status of wild populations
- Develop risk tolerance profiles for all stock conditions
- Assign risk tolerance profiles to all stocks

Risk Assessment

- Conduct risk assessments for all hatchery programs
- Identify appropriate management actions to reduce risk

Following the identification of risks through the assessment process, a strategy is developed to describe a general approach for addressing those risks. Building upon those strategies, program-specific actions and an adaptive management plan are developed as the final steps in the WDFW framework for hatchery reform.

Table 6 identifies hazard levels associated with risks involved with hatchery programs in the Salmon Creek Basin. Table 7 identifies preliminary strategies proposed to address risks identified in the BRAP for the same populations.

The BRAP risk assessments and strategies to reduce risk have been key in providing the biological context to develop the hatchery recovery measures for lower Columbia River sub-basins.

Table 6. Preliminary BRAP for hatchery programs affecting populations in the Salmon Creek Basin.

Symbol	Description
◯	Risk of hazard consistent with current risk tolerance profile.
?	Magnitude of risk associated with hazard unknown.
●	Risk of hazard exceeds current risk tolerance profile.
░	Hazard not relevant to population

Salmon Creek Population	Hatchery Program: Name	Release (millions)	Genetic: Effective Population Size	Genetic: Domestication	Genetic: Diversity	Ecological: Predation	Ecological: Competition	Ecological: Disease	Demographic: Survival Rate	Demographic: Reproductive Success	Facility: Catastrophic Loss	Facility: Passage	Facility: Screening	Facility: Water Quality
Fall Chinook	EF Lewis S. Steelhead	0.025	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	EF Lewis W. Steelhead	0.080	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Merwin W. Steelhead	0.100	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Lewis Coho Type S	0.880	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Lewis Coho Type N	0.815	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Lewis Coho Type N Eggs	0.860	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Lewis Sp. Chinook 1+	0.900	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Fish First Sp. Chinook 1+	0.150	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	NF Lewis River S. Steelhead	0.050	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Merwin S. Steelhead	0.175	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Speelyai Net Pens S. Steelhead	0.060	░	░	░	?	?	◯	░	░	░	◯	◯	◯
Late Fall Chinook	EF Lewis S. Steelhead	0.025	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	EF Lewis W. Steelhead	0.080	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Merwin W. Steelhead	0.100	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Lewis Coho Type S	0.880	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Lewis Coho Type N	0.815	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Lewis Coho Type N Eggs	0.860	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Lewis Sp. Chinook 1+	0.900	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Fish First Sp. Chinook 1+	0.150	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	NF Lewis River S. Steelhead	0.050	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Merwin S. Steelhead	0.175	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Speelyai Net Pens S. Steelhead	0.060	░	░	░	?	?	◯	░	░	░	◯	◯	◯
Spring Chinook	EF Lewis S. Steelhead	0.025	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	EF Lewis W. Steelhead	0.080	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Merwin W. Steelhead	0.100	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Lewis Coho Type S	0.880	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Lewis Coho Type N	0.815	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Lewis Coho Type N Eggs	0.860	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Lewis Sp. Chinook 1+	0.900	◯	◯	◯	?	?	◯	◯	?	◯	◯	◯	◯
	Fish First Sp. Chinook 1+	0.150	◯	◯	◯	?	?	◯	◯	?	◯	◯	◯	◯
	NF Lewis River S. Steelhead	0.050	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Merwin S. Steelhead	0.175	░	░	░	?	?	◯	░	░	░	◯	◯	◯
	Speelyai Net Pens S. Steelhead	0.060	░	░	░	?	?	◯	░	░	░	◯	◯	◯
Chum	No WDFW Programs													

Table 7. Preliminary strategies proposed to address risks identified in the BRAP for Salmon Creek Basin populations.

	Hatchery Program		Risk Assessment of Hazards														
			Address Genetic Risks					Address Ecological Risks				Address Demographic Risks		Address Facility Risks			
Salmon Population	Name	Release (millions)	Mating Procedure	Integrated Program	Segregated Program	Research/ Monitoring	Broodstock Source	Number Released	Release Procedure	Disease Containment	Research/ Monitoring	Culture Procedure	Research/ Monitoring	Reliability	Improve Passage	Improve Screening	Pollution Abatemer
Fall Chinook	EF Lewis S. Steelhead 1+	0.025						●	●		●						
	EF Lewis W. Steelhead 1+	0.080						●	●		●						
	Merwin W. Steelhead	0.100						●	●		●						
	Lewis Coho Type S	0.880						●	●		●						
	Lewis Coho Type N	0.815						●	●		●						
	Lewis Sp. Chinook 1+	0.900						●	●		●						
	Fish First Sp. Chinook 1+	0.150						●	●		●						
	NF Lewis S. Steelhead 1+	0.050						●	●		●				—	—	
	Merwin S. Steelhead 1+	0.175						●	●		●						
	Speelyai Net Pens S. Steelhead 1+	0.060						●	●		●						
	Klineline (Salmon Ck) W. Steelhead 1+	0.020						●	●		●						
Late Fall Chinook	EF Lewis S. Steelhead 1+	0.025						●	●		●						
	EF Lewis W. Steelhead 1+	0.080						●	●		●						
	Merwin W. Steelhead	0.100						●	●		●						
	Lewis Coho Type S	0.880						●	●		●						
	Lewis Coho Type N	0.815						●	●		●						
	Lewis Sp. Chinook 1+	0.900						●	●		●						
	Fish First Sp. Chinook 1+	0.150						●	●		●						
	NF Lewis S. Steelhead 1+	0.050						●	●		●						
	Merwin S. Steelhead 1+	0.175						●	●		●						
	Speelyai Net Pens S. Steelhead 1+	0.060						●	●		●						
	Klineline (Salmon Ck) W. Steelhead 1+	0.020						●	●		●						
Spring Chinook	EF Lewis S. Steelhead 1+	0.025						●	●		●						
	EF Lewis W. Steelhead 1+	0.080						●	●		●						
	Merwin W. Steelhead	0.100						●	●		●						
	Lewis Coho Type S	0.880						●	●		●						
	Lewis Coho Type N	0.815						●	●		●						
	Lewis Sp. Chinook 1+	0.900		●	●	●		●	●		●		●				
	Fish First Sp. Chinook 1+	0.150		●	●	●		●	●		●		●				
	NF Lewis S. Steelhead 1+	0.050						●	●		●						
	Merwin S. Steelhead 1+	0.175						●	●		●						
	Speelyai Net Pens S. Steelhead 1+	0.060						●	●		●						
	Klineline (Salmon Ck) W. Steelhead 1+	0.020						●	●		●						

Impact Assessment

The potential significance of negative hatchery impacts within the subbasin on natural populations was estimated with a simple index based on: 1) intra-specific effects resulting from depression in wild population productivity that can result from interbreeding with less fit hatchery fish and 2) inter-specific effects resulting from predation of juvenile salmonids of other species. The index reflects only a portion of net hatchery effects but can provide some sense of the magnitude of key hatchery risks relative to other limiting factors. Fitness effects are among the most significant intra-specific hatchery risks and can also be realistically quantified based on hatchery fraction in the natural spawning population and assumed fitness of the hatchery fish relative to the native wild population. Predation is among the most significant inter-specific effects and can be estimated from hatchery release numbers by species. This index assumed that equilibrium conditions have been reached for the hatchery fraction in the wild and for relative fitness of hatchery and wild fish. This simplifying assumption was necessary because more detailed information is lacking on how far the current situation is from equilibrium. The index does not consider the numerical benefits of hatchery spawners to natural population numbers, ecological interactions between hatchery and wild fish other than predation, or out-of-basin interactions, all of which are difficult to quantify. Appendix E contains a detailed description of the method and rationale behind this index.

Because there are no hatcheries in the Columbia Lower Tributaries Subbasin, the indexed potential for negative impacts of hatchery spawners on wild population fitness in Salmon Creek is quite low. The greatest potential fitness impact is for Salmon Creek coho, which have a fitness impact potential of 20%. However, the incidence of coho hatchery spawners suggests that the fitness of natural and hatchery fish is now probably quite similar and natural populations might decline substantially without continued hatchery subsidy under current habitat conditions. Interspecific impacts from predation appear to be 1% or less for all species.

Table 8. Presumed reductions in wild population fitness as a result of natural hatchery spawners and survival as a result of interactions with other hatchery species for Salmon Creek salmon and steelhead populations.

Population	Annual releases[a]	Hatchery fraction[b]	Fitness category[c]	Assumed fitness[d]	Fitness impact[e]	Interacting releases[f]	Interspecies impact[g]
Fall Chinook	0	0.00	0	--	0.00	20,000	0.001
Chum	0[h]	0	--	--	0	20,000	0.001
Coho	0[i]	0.67	2	0.7	0.20	20,000	0.0003
Winter Steelhead	20,000	na	na	na	na	0	0

[a] Annual release goals.
[b] Proportion of natural spawners that are first generation hatchery fish.
[c] Broodstock category: 1 = derived from native local stock, 2 = domesticated stock of native local origin, 3 = originates from same ESU but substantial divergence may have occurred, 4 = out-of-ESU origin or origin uncertain
[d] Productivity of naturally-spawning hatchery fish relative to native wild fish prior to significant hatchery influence. Because population-specific fitness estimates are not available for most lower Columbia River populations, we applied hypothetical rates comparable to those reported in the literature and the nature of local hatchery program practices.
[e] Index based on hatchery fraction and assumed fitness.
[f] Number of other hatchery releases with a potential to prey on the species of interest. Includes steelhead and coho for fall chinook and coho. Includes steelhead for chum.
[g] Predation impact based on interacting releases and assumed species-specific predation rates.
[h] There are no records of hatchery chum releases in the basin.
[i] Hatchery coho salmon are no longer released in the basin; hatchery fish in these basins appear to be strays from other programs..

3.6.2 *Harvest*

Fishing generally affects salmon populations through directed and incidental harvest, catch and release mortality, and size, age, and run timing alterations because of uneven fishing on different run components. From a population biology perspective, this can result in fewer spawners and can alter age, size, run timing, fecundity, and genetic characteristics. Fewer spawners result in fewer eggs for future generations and diminish marine-derived nutrients delivered via dying adults, now known to be significant to the growth and survival of juvenile salmon in aquatic ecosystems. The degree to which harvest-related limiting factors influence productivity varies by species and location.

Most harvest of wild Columbia River salmon and steelhead occurs incidental to the harvest of hatchery fish and healthy wild stocks in the Columbia estuary, mainstem, and ocean. Fish are caught in the Canada/Alaska ocean, U.S. West Coast ocean, lower Columbia River commercial and recreational, tributary recreational, and in-river treaty Indian (including commercial, ceremonial, and subsistence) fisheries. Total exploitation rates have decreased for lower Columbia salmon and steelhead, especially since the 1970s as increasingly stringent protection measures were adopted for declining natural populations.

Current fishing impact rates on lower Columbia River naturally-spawning salmon populations ranges from 2.5% for chum salmon to 45% for tule fall Chinook (Table 9). These rates include estimates of direct harvest mortality as well as estimates of incidental mortality in catch and release fisheries. Fishery impact rates for hatchery produced spring Chinook, coho, and steelhead are higher than for naturally-spawning fish of the same species because of selective fishing regulations. These rates generally reflect recent year (2001-2003) fishery regulations and quotas controlled by weak stock impact limits and annual abundance of healthy targeted fish. Actual harvest rates will vary for each year dependent on annual stock status of multiple west coast salmon populations, however, these rates generally reflect expected impacts of harvest on lower Columbia naturally-spawning and hatchery salmon and steelhead under current harvest management plans.

Table 9. Approximate annual exploitation rates (% harvested) for naturally-spawning lower Columbia salmon and steelhead under current management controls (represents 2001-2003 fishing period).

	AK./Can. Ocean	West Coast Ocean	Col. R. Comm.	Col. R. Sport	Trib. Sport	**Wild Total**	Hatchery Total	Historic Highs
Spring Chinook	13	5	1	1	2	**22**	53	65
Fall Chinook (Tule)	15	15	5	5	5	**45**	45	80
Fall Chinook (Bright)	19	3	6	2	10	**40**	Na	65
Chum	0	0	1.5	0	1	**2.5**	2.5	60
Coho	<1	9	6	2	1	**18**	51	85
Steelhead	0	<1	3	0.5	5	**8.5**	70	75

Columbia River fall Chinook are subject to freshwater and ocean fisheries from Alaska to their rivers of origin in fisheries targeting abundant Chinook stocks originating from Alaska, Canada, Washington, Oregon, and California. Columbia tule fall Chinook harvest is constrained by a Recovery Exploitation Rate (RER) developed by NOAA Fisheries for management of Coweeman naturally-spawning fall Chinook. Some in-basin sport fisheries (like Salmon Creek) are closed to the retention of Chinook to protect naturally spawning populations. Harvest of lower Columbia bright fall Chinook is managed to achieve an escapement goal of 5,700 natural spawners in the North Fork Lewis.

Rates are very low for chum salmon, which are not encountered by ocean fisheries and return to freshwater in late fall when significant Columbia River commercial fisheries no longer occur. Chum are no longer targeted in Columbia commercial seasons and retention of chum is prohibited in Columbia River and Colulmbia lower tributary sport fisheries. Chum are impacted incidental to fisheries directed at coho and winter steelhead.

Harvest of Salmon Creek coho occurs in the ocean commercial and recreational fisheries off the Washington and Oregon coasts and Columbia River as well as recreational fisheries in the Columbia Lower Tributaries Subbasin. Wild coho impacts are limited by fishery management to retain marked hatchery fish and release unmarked wild fish.

Steelhead, like chum, are not encountered by ocean fisheries and non-Indian commercial steelhead fisheries are prohibited in the Columbia River. Incidental mortality of steelhead occurs in freshwater commercial fisheries directed at Chinook and coho and freshwater sport fisheries directed at hatchery steelhead and salmon. All recreational fisheries are managed to selectively harvest fin-marked hatchery steelhead and commercial fisheries cannot retain hatchery or wild steelhead.

Access to harvestable surpluses of strong stocks in the Columbia River and ocean is regulated by impact limits on weak populations mixed with the strong. Weak stock management of Columbia River fisheries became increasingly prevalent in the 1960s and 1970s in response to continuing declines of upriver runs affected by mainstem dam construction. In the 1980s coordinated ocean and freshwater weak stock management commenced. More fishery restrictions followed ESA listings in the 1990s. Each fishery is controlled by a series of regulating factors. Many of the regulating factors that affect harvest impacts on Columbia River stocks are associated with treaties, laws, policies, or guidelines established for the management of other stocks or combined stocks, but indirectly control impacts of Columbia River fish as well. Listed fish generally comprise a small percentage of the total fish caught by any fishery. Every listed fish may correspond to tens, hundreds, or thousands of other stocks in the total catch. As a result of weak stock constraints, surpluses of hatchery and strong naturally-spawning runs often go unharvested. Small reductions in fishing rates on listed populations can translate to large reductions in catch of other stocks and recreational trips to communities which provide access to fishing, with significant economic consequences.

Selective fisheries for adipose fin-clipped hatchery coho (since 1999) and steelhead (since 1984) have substantially reduced fishing mortality rates for naturally-spawning populations and allowed concentration of fisheries on abundant hatchery fish. Selective fisheries occur in the Columbia River and tributaries for steelhead and in the ocean, Columbia River, and tributaries for coho. Columbia River hatchery fall Chinook are not marked for selective fisheries, but likely will be in the future because of recent legislation enacted by Congress.

3.6.3 *Mainstem and Estuary Habitat*

Conditions in the Columbia River mainstem, estuary, and plume affect all anadromous salmonid populations within the Columbia Basin. Juvenile and adult salmon may be found in the mainstem and estuary at all times of the year, as different species, life history strategies and size classes continually rear or move through these waters. A variety of human activities in the mainstem and estuary have decreased both the quantity and quality of habitat used by juvenile salmonids. These include floodplain development; loss of side channel habitat, wetlands and marshes; and alteration of flows due to upstream hydro operations and irrigation withdrawals.

Effects on salmonids of habitat changes in the mainstem and estuary are complex and poorly understood. Effects are similar for Salmon Creek populations to those of most other subbasin salmonid populations. Effects are likely to be greater for chum and fall Chinook which rear for extended periods in the mainstem and estuary than for steelhead and coho which move through more quickly. Estimates of the impacts of human-caused changes in mainstem and estuary habitat conditions are available based on changes in river flow, temperature, and predation as represented by EDT analyses for the NPCC Multispecies Framework Approach (Marcot et al. 2002). These estimates generally translate into a 10-60% reduction in salmonid productivity depending on species (Appendix E). Estuary effects are described more fully in the estuary subbasin volume of this plan (Volume II-A).

3.6.4 *Hydropower Construction and Operation*

There are no hydro-electric dams in the Salmon Creek / Lake River Basin. However, Salmon Creek / Lake River species are affected by changes in Columbia River mainstem and estuary related to Columbia basin hydropower development and operation. The mainstem Columbia River and estuary provide important habitats for anadromous species during juvenile and adult migrations between spawning and rearing streams and the ocean where they grow and mature. These habitats are particularly important for fall chinook and chum which rear extensively in the Columbia mainstem and estuary. Aquatic habitats have been fundamentally altered throughout the Columbia River basin by the construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control.

The hydropower infrastructure and flow regulation affects adult migration, juvenile migration, mainstem spawning success, estuarine rearing, water temperature, water clarity, gas supersaturation, and predation. Dams block or impede passage of anadromous juveniles and adults. Columbia River spring flows are greatly reduced from historical levels as water is stored for power generation and irrigation, while summer and winter flows have increased. These flow changes affect juvenile and adult migration, and have radically altered habitat forming processes. Flow regulation and reservoir construction have increased average water temperature in the Columbia River mainstem and summer temperatures regularly exceed optimums for salmon. Supersaturation of water with atmospheric gases, primarily nitrogen, when water is spilled over high dams causes gas bubble disease. Predation by fish, bird, and marine mammals has been exacerbated by habitat changes. The net effect of these direct and indirect effects is difficult to quantify but is expected to be less significant for populations originating from lower Columbia River subbasins than for upriver salmonid populations. Additional information on hydropower effects can be found in the Regional Recovery and Subbasin Plan Volume I.

3.6.5 *Ecological Interactions*

Ecological interactions focus on how salmon and steelhead, other fish species, and wildlife interact with each other and the subbasin ecosystem. Salmon and steelhead are affected throughout their lifecycle by ecological interactions with non native species, food web components, and predators. Each of these factors can be exacerbated by human activities either by direct actions or indirect effects of habitat alternation. Effects of non-native species on salmon, effects of salmon on system productivity, and effects of native predators on salmon are difficult to quantify. Strong evidence exists in the scientific literature on the potential for significant interactions but effects are often context- or case-specific.

Predation is one interaction where effects can be estimated although interpretation can be complicated. In the lower Columbia River, northern pikeminnow, Caspian tern, and marine mammal predation on salmon has been estimated at approximately 5%, 10-30%, and 3-12%, respectively of total salmon numbers (see Appendix E for additional details). Predation has always been a source of salmon mortality but predation rates by some species have been exacerbated by human activities.

3.6.6 *Ocean Conditions*

Salmonid numbers and survival rates in the ocean vary with ocean conditions and low productivity periods increase extinction risks of populations stressed by human impacts. The ocean is subject to annual and longer-term climate cycles just as the land is subject to periodic droughts and floods. The El Niño weather pattern produces warm ocean temperatures and warm, dry conditions throughout the Pacific Northwest. The La Niña weather pattern is typified by cool ocean temperatures and cool/wet weather patterns on land. Recent history is dominated by a high frequency of warm dry years, along with some of the largest El Niños on record—particularly in 1982-83 and 1997-98. In contrast, the 1960s and early 1970s were dominated by a cool, wet regime. Many climatologists suspect that the conditions observed since 1998 may herald a return to the cool wet regime that prevailed during the 1960s and early 1970s.

Abrupt declines in salmon populations throughout the Pacific Northwest coincided with a regime shift to predominantly warm dry conditions from 1975 to 1998 (Beamish and Bouillon 1993, Hare et al 1999, McKinnell et al. 2001, Pyper et al. 2001). Warm dry regimes result in generally lower survival rates and abundance, and they also increase variability in survival and wide swings in salmon abundance. Some of the largest Columbia River fish runs in recorded history occurred during 1985–1987 and 2001–2002 after strong El Niño conditions in 1982–83 and 1997–98 were followed by several years of cool wet conditions.

The reduced productivity that accompanied an extended series of warm dry conditions after 1975 has, together with numerous anthropogenic impacts, brought many weak Pacific Northwest salmon stocks to the brink of extinction and precipitated widespread ESA listings. Salmon numbers naturally ebb and flow as ocean conditions vary. Healthy salmon populations are productive enough to withstand these natural fluctuations. Weak salmon populations may disappear or lose the genetic diversity needed to withstand the next cycle of low ocean productivity (Lawson 1993).

Recent improvements in ocean survival may portend a regime shift to generally more favorable conditions for salmon. The large spike in recent runs and a cool, wet climate would provide a respite for many salmon populations driven to critical low levels by recent conditions. The National Research Council (1996) concluded: "*Any favorable changes in ocean conditions—which could occur and could increase the productivity of some salmon populations for a time—should be regarded as opportunities for improving management techniques. They should not be regarded as reasons to abandon or reduce rehabilitation efforts, because conditions will change again*". Additional details on the nature and effects of variable ocean conditions on salmonids can be found in the Regional Recovery and Subbasin Plan Volume I.

3.7 Summary of Human Impacts on Salmon and Steelhead

Stream habitat, estuary/mainstem habitat, harvest, hatchery and ecological interactions have all contributed to reductions in productivity, numbers, and population viability. Pie charts in Figure 19 describe the relative magnitude of potentially-manageable human impacts in each category of limiting factor for Salmon Creek salmon and steelhead. Impact values were developed for a base period corresponding to species listing dates. This depiction is useful for identifying which factors are most significant for each species and where improvements might be expected to provide substantial benefits. Larger pie slices indicate greater significance and scope for improvement in an impact for a given species. These numbers also serve as a working hypothesis for factors limiting salmonid numbers and viability.

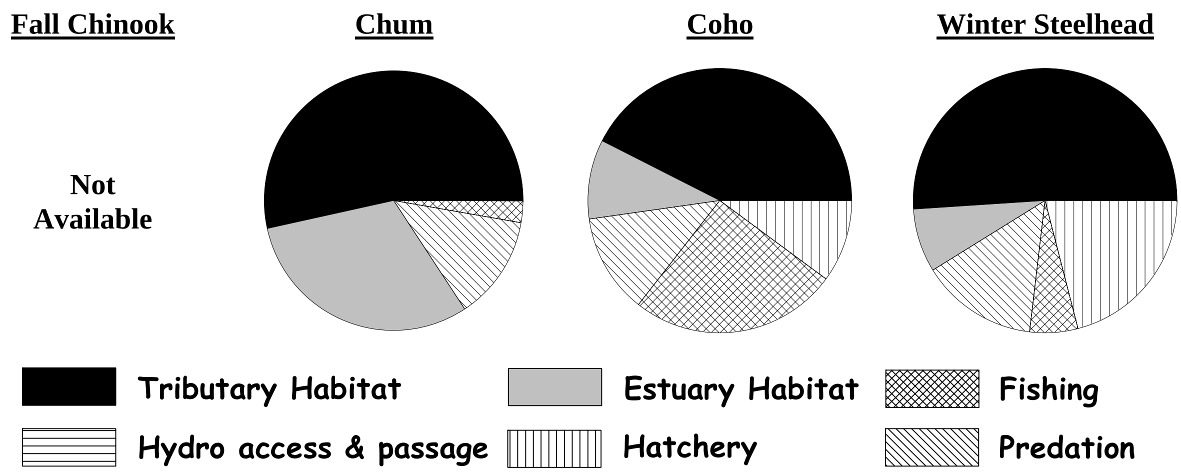


Figure 19. Relative contribution of potentially manageable impacts on Salmon Creek salmonid populations.

This assessment indicates that current salmonid status is the result of large impacts distributed among several factors. No single factor accounts for a majority of effects on all species. Thus, substantial improvements in salmonid numbers and viability will require significant improvements in several factors.

In the Salmon Creek/Lake river Basin, loss of tributary habitat quality and quantity accounts for the largest relative impact on all species. Loss of estuary habitat quality and quantity is also relatively important for all species, but more so for chum. Harvest has a sizeable effect on coho, but is relatively minor for chum and winter steelhead. Coho are the only species moderately impacted by hatcheries in the Salmon Creek subbasin. Predation impacts are relatively important for all species. Hydrosystem access and passage impacts appear to be relatively minor for all species.

Impacts were defined as the proportional reduction in average numbers or productivity associated with each effect. Tributary and estuary habitat impacts are the differences between the pre-development historical baseline and current conditions. Hydro impacts identify the percentage of historical habitat blocked by impassable dams and the mortality associated with juvenile and adult passage of other dams. Fishing impacts are the direct and indirect mortality in ocean and freshwater fisheries. Hatchery impacts include the equilibrium effects of reduced natural population productivity caused by natural spawning of less-fit hatchery fish and also effects of inter-specific predation by larger hatchery smolts on smaller wild juveniles. Hatchery impacts do not include other potentially negative indirect effects or potentially beneficial effects of augmentation of natural production. Predation includes mortality from northern pikeminnow, Caspian terns, and marine mammals in the Columbia River mainstem and estuary. Predation is not a direct human impact but was included because of widespread interest in its relative significance. Methods and data for these analyses are detailed in Appendix E.

Potentially-manageable human impacts were estimated for each factor based on the best available scientific information. Proportions are standardized to a total of 1.0 for plotting purposes. The index is intended to illustrate order-of-magnitude rather than fine-scale differences. Only the subset of factors we can potentially manage were included in this index – natural mortality factors beyond our control (e.g. naturally-occuring ocean mortality) are excluded. Not every factor of interest is included in this index – only readily-quantifiable impacts are included.

4.0 Key Programs and Projects

This section provides brief summaries of current federal, state, local, and non-governmental programs and projects pertinent to recovery, management, and mitigation measures and actions in this basin. These descriptions provide a context for descriptions of specific actions and responsibilities in the management plan portion of this subbasin plan. More detailed descriptions of these programs and projects can be found in the Comprehensive Program Directory (Appendix C).

4.1 Federal Programs

4.1.1 *NOAA Fisheries*

NOAA Fisheries is responsible for conserving, protecting and managing pacific salmon, ground fish, halibut, marine mammals and habitats under the Endangered Species Act, the Marine Mammal Protection Act, the Magnusen-Stevens Act, and enforcement authorities. NOAA administers the ESA under Section 4 (listing requirements), Section 7 (federal actions), and Section 10 (non-federal actions).

4.1.2 *US Army Corps of Engineers*

The U.S. Army Corps of Engineers (USACE) is the Federal government's largest water resources development and management agency. USACE programs applicable to Lower Columbia Fish & Wildlife include: 1) Section 1135 – provides for the modification of the structure or operation of a past USACE project, 2) Section 206 – authorizes the implementation of aquatic ecosystem restoration and protection projects, 3) Hydroelectric Program – applies to the construction and operation of power facilities and their environmental impact, 4) Regulatory Program – administration of Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act.

4.1.3 *Environmental Protection Agency*

The Environmental Protection Agency (EPA) is responsible for the implementation of the Clean Water Act (CWA). The broad goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters so that they can support the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water. The CWA requires that water quality standards (WQS) be set for surface waters. WQS are aimed at translating the broad goals of the CWA into waterbody-specific objectives and apply only to the surface waters (rivers, lakes, estuaries, coastal waters, and wetlands) of the United States.

4.1.4 *Natural Resources Conservation Service*

Formerly the Soil Conservation Service, the USDA Natural Resources Conservation Service (NRCS) works with landowners to conserve natural resources on private lands. The NRCS accomplishes this through various programs including, but not limited to, the Conservation Technical Assistance Program, Soil Survey Program, Conservation Reserve Enhancement Program, and the Wetlands Reserve Program. The NRCS works closely with local Conservation Districts; providing technical assistance and support.

4.1.5 *Northwest Power and Conservation Council*

The Northwest Power and Conservation Council, an interstate compact of Idaho, Montana, Oregon, and Washington, has specific responsibility in the Northwest Power Act of 1980 to mitigate the effects of the hydropower system on fish and wildlife of the Columbia River

Basin. The Council does this through its Columbia River Basin Fish and Wildlife Program, which is funded by the Bonneville Power Administration. Beginning in Fiscal Year 2006, funding is guided by locally developed subbasin plans that are expected to be formally adopted in the Council's Fish and Wildlife Program in December 2004.

4.2 State Programs

4.2.1 *Washington Department of Natural Resources*

The Washington Department of Natural Resources governs forest practices on non-federal lands and is steward to state owned aquatic lands. Management of DNR public forest lands is governed by tenets of their proposed Habitat Conservation Plan (HCP). Management of private industrial forestlands is subject to Forest Practices regulations that include both protective and restorative measures.

4.2.2 *Washington Department of Fish & Wildlife*

WDFW's Habitat Division supports a variety of programs that address salmonids and other wildlife and resident fish species. These programs are organized around habitat conditions (Science Division, Priority Habitats and Species, and the Salmon and Steelhead Habitat Inventory and Assessment Program); habitat restoration (Landowner Incentive Program, Lead Entity Program, and the Conservation and Reinvestment Act Program, as well as technical assistance in the form of publications and technical resources); and habitat protection (Landowner Assistance, GMA, SEPA planning, Hydraulic Project Approval, and Joint Aquatic Resource Permit Applications).

4.2.3 *Washington Department of Ecology*

The Department of Ecology (DOE) oversees: the Water Resources program to manage water resources to meet current and future needs of the natural environment and Washington's communities; the Water Quality program to restore and protect Washington's water supplies by preventing and reducing pollution; and Shoreline and the Environmental Assistance program for implementing the Shorelines Management Act, the State Environmental Protection Act, the Watershed Planning Act, and 401 Certification of ACOE Permits.

4.2.4 *Washington Department of Transportation*

The Washington State Department of Transportation (WSDOT) must ensure compliance with environmental laws and statutes when designing and executing transportation projects. Programs that consider and mitigate for impacts to salmonid habitat include: the Fish Passage Barrier Removal program; the Regional Road Maintenance ESA Section 4d Program, the Integrated Vegetation Management & Roadside Development Program; Environmental Mitigation Program; the Stormwater Retrofit Program; and the Chronic Environmental Deficiency Program.

4.2.5 *Interagency Committee for Outdoor Recreation*

Created through the enactment of the Salmon Recovery Act (Washington State Legislature, 1999), the Salmon Recovery Funding Board provides grant funds to protect or restore salmon habitat and assist related activities with local watershed groups known as lead entities. SRFB has helped finance over 500 salmon recovery projects statewide. The Aquatic Lands Enhancement Account (ALEA) was established in 1984 and is used to provide grant support for the purchase, improvement, or protection of aquatic lands for public purposes, and for providing and improving access to such lands. The Washington Wildlife and Recreation

Program (WWRP), established in 1990 and administered by the Interagency Committee for Outdoor Recreation, provides funding assistance for a broad range of land protection, park development, preservation/conservation, and outdoor recreation facilities.

4.2.6 *Lower Columbia Fish Recovery Board*

The Lower Columbia Fish Recovery Board encompasses five counties in the Lower Columbia River Region. The 15-member board has four main programs, including habitat protection and restoration activities, watershed planning for water quantity, quality, habitat, and instream flows, facilitating the development of an integrated recovery plan for the Washington portion of the lower Columbia Evolutionarily Significant Units, and conducting public outreach activities.

4.3 Local Government Programs

4.3.1 *Clark County*

Clark County is conducting Comprehensive Planning under the State's Growth Management Act. Clark County manages natural resources under various programs including Critical Areas Ordinance, ESA Program, Road Operations, Parks Operations, Stormwater Management, and the Conservation Futures Program.

4.3.2 *City of Vancouver*

The City of Vancouver's Comprehensive Plan was adopted under the Growth Management Act in 2000. The Plan's provisions address natural resource impacts through erosion control, stormwater control, designation of environmental districts, and critical areas protections.

4.3.3 *City of Battle Ground*

The city of Battle Ground's comprehensive planning occurs under the state Growth Management Act. Battle Ground manages natural resource impacts through a Critical Areas Ordinance and a Stormwater Ordinance.

4.3.4 *Clark Conservation District*

Clark Conservation District provides technical assistance, cost-share assistance, and project monitoring in Clark County. Clark CD assists agricultural landowners in the development of farm plans and in the participation in the Conservation Reserve Enhancement Program. Farm plans optimize use, protect sensitive areas, and conserve resources.

4.4 Non-governmental Programs

4.4.1 *Columbia Land Trust*

The Columbia Land Trust is a private, non-profit organization founded in 1990 to work exclusively with willing landowners to find ways to conserve the scenic and natural values of the land and water. Landowners donate the development rights or full ownership of their land to the Land Trust. CLT manages the land under a stewardship plan and, if necessary, will legally defend its conservation values.

4.4.2 *Lower Columbia Fish Enhancement Group*

The Washington State Legislature created the Regional Fisheries Enhancement Group Program in 1990 to involve local communities, citizen volunteers, and landowners in the state's salmon recovery efforts. RFEGs help lead their communities in successful restoration, education and monitoring projects. Every group is a separate, nonprofit organization led by their own board of directors and operational funding from a portion of commercial and recreational fishing license fees administered by the WDFW, and other sources. The mission of the Lower Columbia RFEG (LCFEG) is to restore salmon runs in the lower Columbia River region through habitat restoration, education and outreach, and developing regional and local partnerships.

4.5 NPCC Fish & Wildlife Program Projects

There are no NPCC Fish & Wildlife Program Projects in the Salmon Creek / Lake River Basin.

4.6 Washington Salmon Recovery Funding Board Projects

Type	Project Name	Subbasin
Restoration	Burnt Bridge Creek Riparian Enhancement	Salmon

5.0 Management Plan

5.1 Vision

Washington lower Columbia salmon, steelhead, and bull trout are recovered to healthy, harvestable levels that will sustain productive sport, commercial, and tribal fisheries through the restoration and protection of the ecosystems upon which they depend and the implementation of supportive hatchery and harvest practices.

The health of other native fish and wildlife species in the lower Columbia will be enhanced and sustained through the protection of the ecosystems upon which they depend, the control of non-native species, and the restoration of balanced predator/prey relationships.

The Salmon Creek Basin will play a key role in the regional recovery of salmon and steelhead. Natural populations of fall Chinook, winter steelhead, chum, and coho will be restored to higher levels of viability by significant reductions in human impacts throughout the lifecycle. Salmonid recovery efforts will provide broad ecosystem benefits to a variety of subbasin fish and wildlife species. Recovery will be accomplished through a combination of improvements in subbasin, Columbia River mainstem, and estuary habitat conditions as well as careful management of hatcheries, fisheries, and ecological interactions among species.

Habitat protection or restoration will involve a wide range of Federal, State, Local, and non-governmental programs and projects. Success will depend on effective programs as well as a dedicated commitment to salmon recovery across a broad section of society.

Some hatchery programs will be realigned to focus on protection, conservation, and recovery of native fish. The need for hatchery measures will decrease as productive natural habitats are restored. Where consistent with recovery, other hatchery programs will continue to provide fish for fishery benefits for mitigation purposes in the interim until habitat conditions are restored to levels adequate to sustain healthy, harvestable natural populations.

Directed fishing on sensitive wild populations will be eliminated and incidental impacts of mixed stock fisheries in the Columbia River and ocean will be regulated and limited consistent with wild fish recovery needs. Until recovery is achieved, fishery opportunities will be focused on hatchery fish and harvestable surpluses of healthy wild stocks.

Columbia basin hydropower effects on Salmon Creek Basin salmonids will be addressed by mainstem Columbia and estuary habitat restoration measures. Hatchery facilities in the Salmon Creek Basin will also be called upon to produce fish to help mitigate for hydropower impacts on upriver stocks where compatible with wild fish recovery.

This plan uses a planning period or horizon of 25 years. The goal is to achieve recovery of the listed salmon species and the biological objectives for other fish and wildlife species of interest within this time period. It is recognized, however, that sufficient restoration of habitat conditions and watershed processes for all species of interest will likely take 75 years or more.

5.2 Biological Objectives

Biological objectives for Salmon Creek salmonid populations are based on recovery criteria developed by scientists on the Willamette/Lower Columbia Technical Recovery Team convened by NOAA Fisheries. Criteria involve a hierarchy of ESU, Strata (i.e. ecosystem areas within the ESU – Coast, Cascade, Gorge), and Population standards. A recovery scenario describing population-scale biological objectives for all species in all three strata in the lower Columbia ESUs was developed through a collaborative process with stakeholders based on biological significance, expected progress as a result of existing programs, the absence of apparent impediments, and the existence of other management opportunities. Under the preferred alternative, individual populations will variously contribute to recovery according to habitat quality and the population's perceived capacity to rebuild. Criteria, objectives, and the regional recovery scenario are described in greater detail in the Regional Recovery and Subbasin Plan Volume I.

Focal populations in the Salmon Creek Basin are targeted to stabilize and not further reduce their viability. The recovery scenario differentiates the role of populations by designating primary, contributin, and stabilizing categories. *Primary populations* are those that would be restored to high or better probabilities of persistence. *Contributing populations* are those where low to medium improvements will be needed to achieve stratum-wide average of moderate persistence probability. *Stabilizing populations* are those maintained at current levels.

The objective in the Salmon Creek Basin is to stabilize the populations to no less than the current viability level (Table 10). The low viability level for winter steelhead provides for a 40-74% probability of persistence over 100 years, and the very low viability level for chum and coho provides for a 0-40% probability of persistence over 100 years. Fall chinook status in Salmon Creek would also be stabilized, but fall chinook recovery objectives focus on improvement in the East Fork Lewis River population when considering the combined EF Lewis/Salmon Creek fall chinook population.

Cutthroat will benefit from improvements in stream habitat conditions for anadromous species. Lamprey are also expected to benefit from habitat improvements in the estuary, Columbia River mainstem, and Salmon Creek although specific spawning and rearing habitat requirements are not well known. Bull trout do not occur in the basin.

Table 10. Current viability status of Salmon populations and the biological objective status that is necessary to meet the recovery criteria for the Cascade strata and the lower Columbia ESU.

Species	ESA Status	Hatchery Component	Current		Objective	
			Viability	Numbers	Viability	Numbers
Winter Steelhead	Threatened	Yes	Low	<100	Low[S]	100
Chum	Threatened	No	Very low	<100	Very low[S]	100
Coho	Candidate	No	Very low	unknown	Very low[S]	unknown
Fall Chinook(a)	Threatened	No	NA	<100	NA	NA

(a) The East Fork Lewis fall chinook population is the focus for rimprovement for the combined EF Lewis/Salmon Creek population
P = primary population in recovery scenario
C = contributin population in recovery scenario
S = stabilizing population in recovery scenario

5.3 Integrated Strategy

An Integrated Regional Strategy for recovery emphasizes that: 1) it is feasible to recover Washington lower Columbia natural salmon and steelhead to healthy and harvestable levels; 2) substantial improvements in salmon and steelhead numbers, productivity, distribution, and diversity will be required; 3) recovery cannot be achieved based solely on improvements in any one factor; 4) existing programs are insufficient to reach recovery goals, 5) all manageable effects on fish and habitat conditions must contribute to recovery, 6) actions needed for salmon recovery will have broader ecosystem benefits for all fish and wildlife species of interest, and 7) strategies and measures likely to contribute to recovery can be identified but estimates of the incremental improvements resulting from each specific action are highly uncertain. The strategy is described in greater detail in the Regional Recovery and Subbasin Plan Volume I.

The Integrated Strategy recognizes the importance of implementing measures and actions that address each limiting factor and risk category, prescribing improvements in each factor/threat category in proportion to its magnitude of contribution to salmon declines, identifying an appropriate balance of strategies and measures that address regional, upstream, and downstream threats, and focusing near term actions on species at-risk of extinction while also ensuring a long term balance with other species and the ecosystem.

Population productivity improvement increments identify proportional improvements in productivity needed to recover populations from current status to medium, high, and very high levels of population viability consistent with the role of the populationin the recovery scenario. Productivity is defined as the inherent population replacement rate and is typically expressed by models as a median rate of population increase (PCC model) or a recruit per spawner rate (EDT model). Corresponding improvements in spawner numbers, juvenile outmigrants, population spatial struction, genetic and life history diversity, and habitat are implicit in productivity improvements.

Improvement targets were developed for each impact factor based on desired population productivity improvements and estimates of potentially manageable impacts (see Section 3.7). Impacts are estimates of the proportional reduction in population productivity associated with human-caused and other potentially manageable impacts from stream habitats, estuary/mainstem habitats, hydropower, harvest, hatcheries, and selected predators. Reduction targets were driven by the regional strategy of equitably allocating recovery responsibilities among the six manageable impact factors. Given the ultimate uncertainty in the effects of recovery actions and the need to implement an adaptive recovery program, this approximation should be adequate for developing order-of-magnitude estimates to which recovery actions can be scaled consistent with the current best available science and data. Objectives and targets will need to be confirmed or refined during plan implementation based on new information and refinements in methodology.

The following table identifies population and factor-specific improvements consistent with the biological objectives for this subbasin. Per factor increments are less than the population net because factor affects are compounded at different life stages and density dependence is largely limited to freshwater tributary habitat. The biological objectives for all Salmon Creek populations are to stabilize them at current viability levels, meaning that extinction risks are not increased beyond current risk levels. This means that impact factors relative to Salmon Creek populations must be addressed to the degree they do not increase their effect on salmonid productivity. Salmon Creek fall Chinook are considered part of the East Fork Lewis fall Chinook population and improvement is focused on the East Fork Lewis segment of the population.

Table 5-2. Productivity improvements consistent with biological objectives for the Salmon Creek subbasin.

Species	Net increase	Per factor	Baseline impacts					
			Trib.	Estuary	Hydro.	Pred.	Harvest	Hatch.
Fall Chinook (a)	230%	39%	0.53	0.32	0.00	0.24	0.65	0.01
Chum	0%	0%	1.00	0.58	0.00	0.24	0.05	0.00
Coho	na	na	na	na	na	na	na	na
Winter Steelhead	10%	1%	0.87	0.13	0.00	0.24	0.10	0.36

(a) Reflects improvement and impacts associated with the East Fork Lewis fall chinook population

5.4 Tributary Habitat

Habitat assessment results were synthesized in order to develop specific prioritized measures and actions that are believed to offer the greatest opportunity for species recovery in the subbasin. As a first step toward measure and action development, habitat assessment results were integrated to develop a multi-species view of 1) priority areas, 2) factors limiting recovery, and 3) contributing land-use threats. For the purpose of this assessment, limiting factors are defined as the biological and physical conditions serving to suppress salmonid population performance, whereas threats are the land-use activities contributing to those factors. Limiting Factors refer to local (reach-scale) conditions believed to be directly impacting fish. Threats, on the other hand, may be local or non-local. Non-local threats may impact instream limiting factors in a number of ways, including: 1) through their effects on habitat-forming processes – such as the case of forest road impacts on reach-scale fine sediment loads, 2) due to an impact in a contributing stream reach – such as riparian degradation reducing wood recruitment to a downstream reach, or 3) by blocking fish passage to an upstream reach.

Priority areas and limiting factors were determined through the technical assessment, including primarily EDT analysis and the Integrated Watershed Assessment (IWA). As described later in this section, priority areas are also determined by the relative importance of subbasin focal fish populations to regional recovery objectives. This information allows for scaling of subbasin recovery effort in order to best accomplish recovery at the regional scale. Land-use threats were determined from a variety of sources including Washington Conservation Commission Limiting Factors Analyses, the IWA, the State 303(d) list, air photo analysis, the Barrier Assessment, personal knowledge of investigators, or known cause-effect relationships between stream conditions and land-uses.

Priority areas, limiting factors and threats were used to develop a prioritized suite of habitat measures. Measures are based solely on biological and physical conditions. For each measure, the key programs that address the measure are identified and the sufficiency of existing programs to satisfy the measure is discussed. The measures, in conjunction with the program sufficiency considerations, were then used to identify specific actions necessary to fill gaps in measure implementation. Actions differ from measures in that they address program deficiencies as well as biophysical habitat conditions. The process for developing measures and actions is illustrated in Figure 20 and each component is presented in detail in the sections that follow.

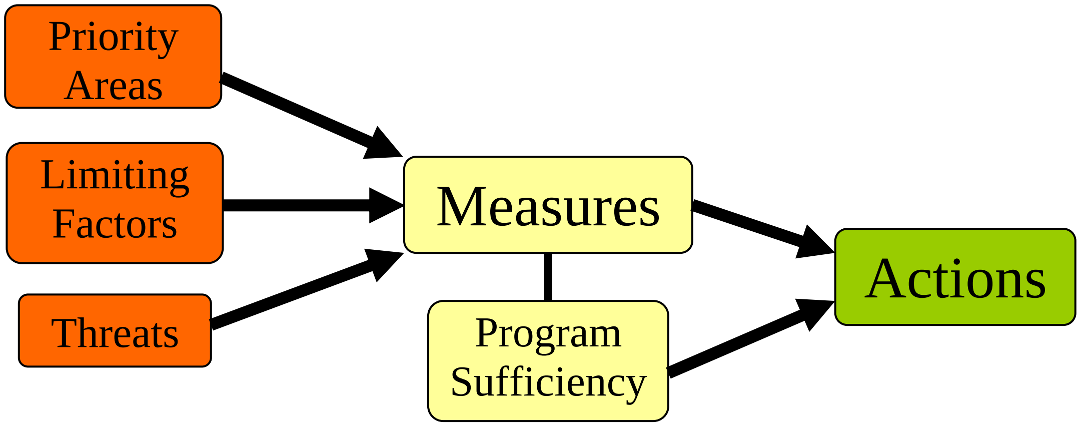


Figure 20. Flow chart illustrating the development of subbasin measures and actions.

5.4.1 *Priority Areas, Limiting Factors and Threats*

Priority habitat areas and factors in the subbasin are discussed below in two sections. The first section contains a generalized (coarse-scale) summary of conditions throughout the basin. The second section is a more detailed summary that presents specific reach and subwatershed priorities.

Summary

Decades of human activity in the Salmon Creek Basin have significantly altered watershed processes and reduced both the quality and quantity of habitat needed to sustain viable populations of salmon and steelhead. Moreover, with the exception of fall Chinook, stream habitat conditions within the Salmon Creek Basin have a high impact on the health and viability of salmon and steelhead relative to other limiting factors. The following bullets provide a brief overview of each of the priority areas in the basin. These descriptions are a summary of the reach-scale priorities that are presented in the next section. These descriptions summarize the species most affected, the primary limiting factors, the contributing land-use threats, and the general type of measures that will be necessary for recovery. A tabular summary of the key limiting factors and land-use threats can be found in Table 11.

The Salmon Creek basin contains no Tier 1 or 2 reaches, which reflects that Salmon Creek salmonid populations are not expected to be recovered to a high level of viability for recovery planning purposes. It is important for recovery planning, however, that these populations do not decline further, which will be a challenging objective considering the expected continued intensive development of the basin. The areas with the greatest current or potential contribution to focal salmonid population health and productivity are listed below.

- **Lower mainstem Salmon & tributaries** *(reaches Salmon 12-16; Suds 1-2)* – The lower mainstem Salmon Creek reaches with the greatest potential production are located in the vicinity of Salmon Creek County Park, near the I-5 crossing. These reaches historically provided productive habitats for fall Chinook, chum, coho, and winter steelhead. This area is heavily impacted by urban and rural development in the expanding Vancouver metropolitan area. Effective recovery measures will involve land-use planning that adequately protects habitat-forming processes in sensitive areas (wetlands, floodplains, riparian corridors). Restoration of riparian areas along these and upstream reaches will also yield important benefits.

- **Upper mainstem Salmon & tributaries** *(reaches Salmon 20-32; Morgan 1; Rock 1, 5, 7)* – A few potentially productive reaches for coho and winter steelhead are located on the mainstem between the Hwy 503 crossing and Salmon Falls. Rock Creek and other, smaller, tributaries (e.g., Morgan Creek) also contain potentially productive habitats for coho. These reaches are heavily impacted by agricultural uses and rural residential development. As with the lower basin, the upper basin is expected to continue to develop rapidly. In light of the continued growth, there needs to be emphasis on land-use planning that provides adequate protections to sensitive areas. In addition, riparian and floodplain restoration that targets impacts related to grazing and rural development will yield important benefits to salmonid habitat.

Table 11. Salmonid habitat limiting factors and threats in priority areas. Priority areas include the lower Salmon mainstem (LM) and upper mainstem Salmon & tributaries (UM). Linkages between each threat and limiting factor are not displayed – each threat directly and indirectly affects a variety of habitat factors.

Limiting Factors			**Threats**		
	LM	**UM**		**LM**	**UM**
Habitat connectivity			***Agriculture/grazing***		
Blockages to off-channel habitats	✓		Clearing of vegetation	✓	✓
Habitat diversity			Riparian grazing	✓	✓
Lack of stable instream woody debris	✓	✓	Floodplain filling	✓	✓
Altered habitat unit composition	✓	✓	***Urban/suburban/rural development***		
Loss of off-channel and/or side-channel habitats	✓		Clearing of vegetation	✓	✓
Channel stability			Floodplain filling	✓	✓
Bed and bank erosion	✓	✓	Increased impervious surfaces	✓	✓
Channel down-cutting (incision)	✓	✓	Increased drainage network	✓	✓
Riparian function			Roads – riparian/floodplain impacts	✓	✓
Reduced stream canopy cover	✓	✓	Leaking septic systems	✓	✓
Reduced bank/soil stability	✓	✓	***Channel manipulations***		
Exotic and/or noxious species	✓	✓	Bank hardening	✓	✓
Reduced wood recruitment	✓	✓	Channel straightening	✓	✓
Floodplain function			Artificial confinement	✓	✓
Altered nutrient exchange processes	✓	✓	Dredge and fill activities	✓	
Reduced flood flow dampening	✓	✓	***Mining***		
Restricted channel migration	✓	✓	Clearing of vegetation	✓	
Disrupted hyporheic processes	✓	✓	Channel and/or floodplain substrate removal	✓	
Stream flow			Floodplain filling	✓	
Altered magnitude, duration, or rate of change	✓	✓	Increased water surface area	✓	
Water quality			***Recreation***		
Altered stream temperature regime	✓	✓	River recreation (harassment)	✓	
Excessive turbidity	✓	✓			
Bacteria	✓	✓			
Reduced dissolved oxygen concentrations	✓				
Substrate and sediment					
Lack of adequate spawning substrate	✓				
Excessive fine sediment	✓	✓			
Embedded substrates	✓	✓			
Biological processes					
Harassment	✓				

Specific Reach and Subwatershed Priorities

Specific reaches and subwatersheds have been prioritized based on the plan's biological objectives, fish distribution, critical life history stages, current habitat conditions, and potential fish population performance. Reaches have been placed into Tiers (1-4), with Tier 1 reaches representing the areas where recovery measures would yield the greatest benefits towards accomplishing the biological objectives. The reach tiering factors in each fish population's importance relative to regional recovery objectives, as well as the relative importance of reaches within the populations themselves. Reach tiers are most useful for identifying habitat recovery measures in channels, floodplains, and riparian areas. Reach-scale priorities were initially identified within individual populations (species) through the EDT Restoration and Preservation Analysis. This resulted in reaches grouped into categories of high, medium, and low priority for each population (see Stream Habitat Limitations section). Within a subbasin, reach rankings for all of the modeled populations were combined, using population designations as a weighting factor. Population designations for this subbasin are described in the Biological Objectives section. The population designations are 'primary', 'contributing', and 'stabilizing'; reflecting the level of emphasis that needs to be placed on population recovery in order to meet ESA recovery criteria.

Spatial priorities were also identified at the subwatershed scale. Subwatershed-scale priorities were directly determined by reach-scale priorities, such that a Group A subwatershed contains one or more Tier 1 reaches. Scaling up from reaches to the subwatershed level was done in recognition that actions to protect and restore critical reaches might need to occur in adjacent and/or upstream upland areas. For example, high sediment loads in a Tier 1 reach may originate in an upstream contributing subwatershed where sediment supply conditions are impaired because of current land use practices. Subwatershed-scale priorities can be used in conjunction with the IWA to identify watershed process restoration and preservation opportunities. The specific rules for designating reach tiers and subwatershed groups are presented in Table 12. Reach tier designations for this basin are included in Table 13. Reach tiers and subwatershed groups are displayed on a map in Figure 21. A summary of reach- and-subwatershed-scale limiting factors is included in Table 14.

Table 12. Rules for designating reach tier and subwatershed group priorities. See Biological Objectives section for information on population designations.

Designation	Rule
Reaches	
Tier 1:	All high priority reaches (based on EDT) for one or more primary populations.
Tier 2:	All reaches not included in Tier 1 and which are medium priority reaches for one or more primary species and/or all high priority reaches for one or more contributing populations.
Tier 3:	All reaches not included in Tiers 1 and 2 and which are medium priority reaches for contributing populations and/or high priority reaches for stabilizing populations.
Tier 4:	Reaches not included in Tiers 1, 2, and 3 and which are medium priority reaches for stabilizing populations and/or low priority reaches for all populations.
Subwatersheds	
Group A:	Includes one or more Tier 1 reaches.
Group B:	Includes one or more Tier 2 reaches, but no Tier 1 reaches.
Group C:	Includes one or more Tier 3 reaches, but no Tier 1 or 2 reaches.

Group D:	Includes only Tier 4 reaches.

Table 13. Reach Tiers in the Salmon Creek Basin

Tier 3	Tier 4		
Lalonde1	BakerCr1_(LBtrib3-1)	Morgan2	Salmon17
LBtrib11-1	BakerCr2_(LBtrib3-2)	Morgan3_A	Salmon18
Morgan1	BakerCr3_(LBtrib3-3)	Morgan3_B	Salmon19
RBtrib11-1	CougarCanyon1	Morgan4	Salmon2
RBtrib9-1	CougarCanyon2	Mud1	Salmon22
Rock1	Curtin1	Mud2	Salmon25
Rock5	Curtin2	NW119thCulv	Salmon27
Rock7	CurtinCulv	RBtrib11-2	Salmon3
Salmon12	Dam1	RBtrib11Culv1	Salmon30
Salmon13	Fishway1	RBtrib12-1	Salmon4
Salmon14_A	Klineline1	RBtrib12-2	Salmon5
Salmon14_B	KlinelineChannel1 (SCPC1)	RBtrib2-1 (MillCr)	Salmon6
Salmon14_C	LakeRiver1	RBtrib4	Salmon7
Salmon16	LakeRiver2	RBtrib5	Salmon8
Salmon20	LakeRiver3	RBtrib8	Salmon9
Salmon21	Lalonde2	RBtrib9-2	Suds3
Salmon23	LalondeCulv1	RBtrib9Dam	Suds4
Salmon24	LBtrib11-2	Reservoir1	Suds5
Salmon26	LBtrib5	Rock2	Suds6
Salmon28	LBtrib7-1	Rock3	SudsCulv1
Salmon29	LBtrib8-1	Rock4	SudsCulv2
Salmon31	LBtrib9	Rock6	SudsCulv3
Salmon32	LittleSalmon1	Rock8	SudsCulv4
SideChannel1	Mill1	RockCulv1	SudsCulv5
Suds1	Mill2	Salmon1	TenneyCr(LBtrib1)
Suds2	Mill3	Salmon10	Weaver1
	Mill4	Salmon11	Weaver2
	Mill5	Salmon15(falls)	Weaver3
			WeaverCulv1

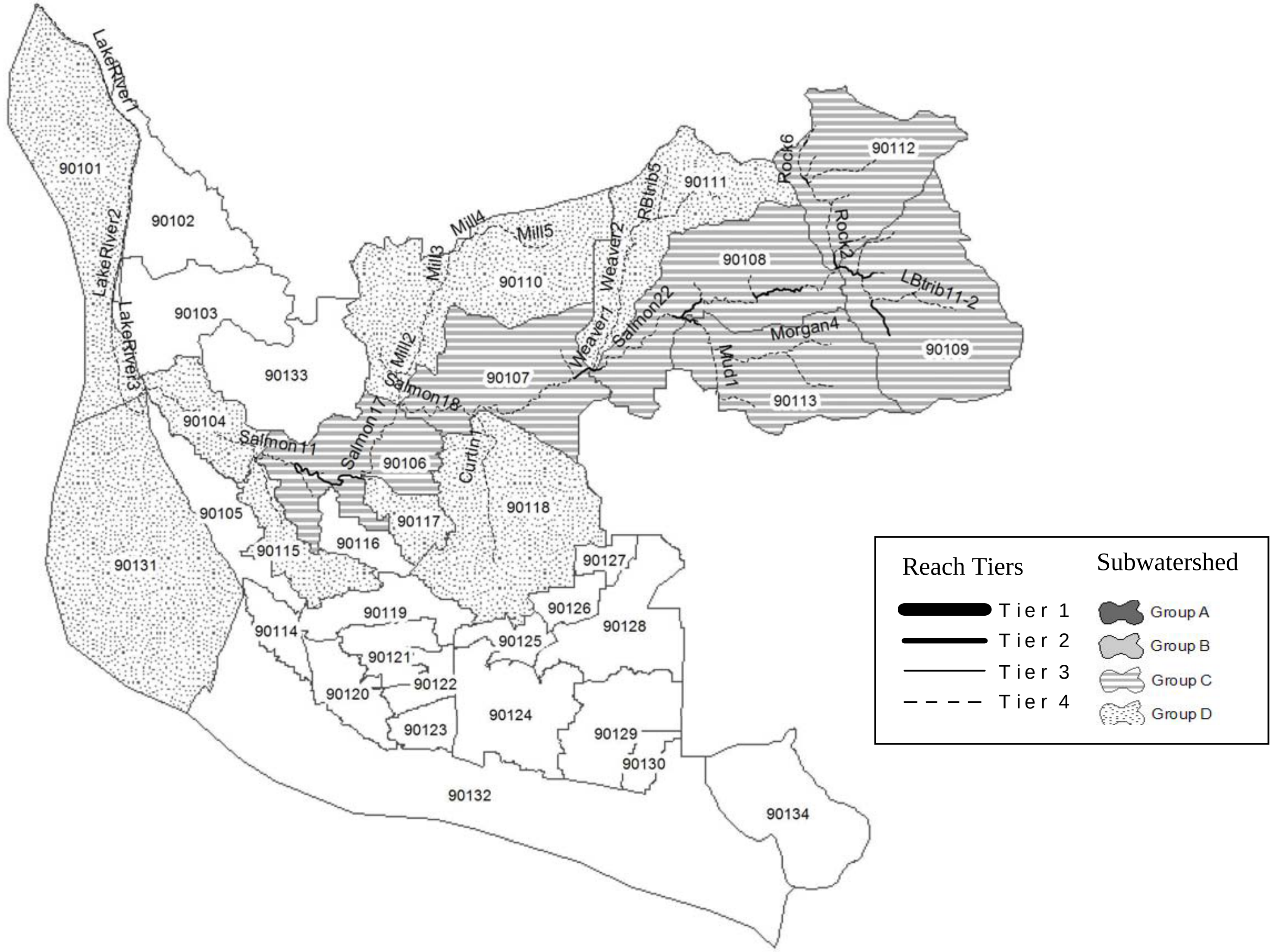


Figure 21. Reach tiers and subwatershed groups in the Salmon Creek Basin. Tier 1 reaches and Group A subwatersheds represent the areas where recovery actions would yield the greatest benefits with respect to species recovery objectives. The subwatershed groups are based on Reach Tiers. Priorities at the reach scale are useful for identifying stream corridor recovery measures. Priorities at the subwatershed scale are useful for identifying watershed process recovery measures. Watershed process recovery measures for stream reaches will need to occur within the surrounding (local) subwatershed as well as in upstream contributing subwatersheds.

Table 14. Summary Table of reach- and subwatershed-scale limiting factors in priority areas. The table is organized by subwatershed groups, beginning with the highest priority group. Species-specific reach priorities, critical life stages, high impact habitat factors, and recovery emphasis (P=preservation, R=restoration, PR=restoration and preservation) are included. Watershed process impairments: F=functional, M=moderately impaired, I=impaired. Species abbreviations: ChS=spring Chinook, ChF=fall Chinook, StS=summer steelhead, StW=winter steelhead.

Sub-watershed Group	Sub-watershed	Reaches within subwatershed	Species Present	High priority reaches by species	Critical life stages by species	High impact habitat factors	Preservation or restoration emphasis	Watershed processes (local) Hydrology	Watershed processes (local) Sediment	Watershed processes (local) Riparian	Watershed processes (watershed) Hydrology	Watershed processes (watershed) Sediment
C	90113	BakerCr1_(LBtrib3-1) BakerCr2_(LBtrib3-2) BakerCr3_(LBtrib3-3) Fishway1 Morgan1 Morgan2 Morgan3_A Morgan3_B Morgan4 Mud1 Mud2 SideChannel1	StW	none				I	M	I	I	M
			Coho	Morgan1 SideChannel1	egg incubation summer rearing winter rearing adult holding	channel stability temperature flow sediment key habitat quantity	R					
	90112	LBtrib5 LBtrib7-1 LBtrib8-1 LBtrib9 Rock1 Rock2 Rock3 Rock4 Rock5 Rock6 Rock7 Rock8 RockCulv1	StW	none				I	M	M	I	M
			Coho	Rock1 Rock5 Rock7	egg incubation fry colonization summer rearing winter rearing	channel stability habitat diversity flow sediment food key habitat quantity	R					
	90109	LBtrib11-1 LBtrib11-2 LittleSalmon1 RBtrib11-1 RBtrib11-2 RBtrib11Culv1 RBtrib12-1 RBtrib12-2 Salmon28 Salmon29 Salmon30 Salmon31 Salmon32	StW	Salmon28 Salmon29 Salmon31 Salmon32	egg incubation fry colonization summer rearing winter rearing	habitat diversity sediment	PR	I	M	M	I	M
			Coho	LBtrib11-1 RBtrib11-1 Salmon29 Salmon31	spawning egg incubation fry colonization summer rearing winter rearing juvenile migrant (age-0)	channel stability habitat diversity sediment key habitat quantity	PR					
	90108	Salmon21 Salmon23 Salmon24 Salmon26 RBtrib9-1 Salmon25 Salmon27 RBtrib8 Salmon22 RBtrib9-2 RBtrib9Dam	StW	Salmon21 Salmon23	egg incubation fry colonization summer rearing	sediment	R	I	M	I	I	M
			Coho	Salmon21 Salmon23 Salmon24 Salmon26 RBtrib9-1	egg incubation fry colonization summer rearing winter rearing	habitat diversity sediment	R					
	90107	Salmon20 Salmon18 Salmon19 RBtrib4	StW	Salmon20	egg incubation summer rearing winter rearing	habitat diversity sediment	R	I	M	I	M	M
			Coho	Salmon20	egg incubation summer rearing winter rearing	habitat diversity sediment	R					
	90106	Klineline1 KlinelineChannel1 (SCPC1) Lalonde1 LalondeCulv1 Salmon11 Salmon12 Salmon13 Salmon14_A Salmon14_B Salmon14_C Salmon15(falls) Salmon16 Salmon17 Suds1 Suds2 Suds3 Suds4 Suds5 Suds6 SudsCulv1 SudsCulv2 SudsCulv3 SudsCulv4 SudsCulv5 TenneyCr(LBtrib1)	ChF	Salmon14_A Salmon14_B Salmon14_C Salmon16	spawning egg incubation fry colonization adult holding	channel stability habitat diversity sediment key habitat quantity	R	I	M	I	M	M
			Chum	Salmon13 Salmon14_A Salmon14_B Salmon16	spawning egg incubation fry colonization adult migrant adult holding	habitat diversity sediment harassment key habitat quantity	R					
			StW	Salmon13 Salmon14_A Salmon14_B Salmon14_C Salmon16	egg incubation fry colonization summer rearing	habitat diversity temperature predation flow sediment	R					
			Coho	Lalonde1 Salmon12 Salmon13 Salmon14_A Salmon14_B Salmon16 Suds1 Suds2	spawning egg incubation fry colonization summer rearing winter rearing juvenile migrant (age-0) juvenile migrant (age-1)	channel stability habitat diversity predation flow sediment	R					

Sub-watershed Group	Sub-watershed	Reaches within subwatershed	Species Present	High priority reaches by species	Critical life stages by species	High impact habitat factors	Preservation or restoration emphasis	Watershed processes (local)			Watershed processes (watershed)	
								Hydrology	Sediment	Riparian	Hydrology	Sediment
D	90131	Salmon1	All	none				M	F	I	M	F
	90118	Curtin1 Curtin2 CurtinCulv	Coho	none				I	M	I	I	M
	90117	Lalonde2	Coho	none				I	F	M	I	F
	90115	CougarCanyon1 CougarCanyon2 NW119thCulv	Coho	none				I	M	I	I	M
	90111	RBtrib5	StW	none				M	M	I	M	M
		Weaver1 Weaver2 Weaver3 WeaverCulv1	Coho	none								
	90110	Dam1	StW	none				M	M	I	M	M
		Mill1 Mill2 Mill3 Mill4 Mill5 RBtrib2-1 (MillCr) Reservoir1	Coho	none								
	90104	Salmon2 Salmon3 Salmon4 Salmon5 Salmon6 Salmon7 Salmon8 Salmon9 Salmon10	All	none				M	M	M	M	M
	90101	LakeRiver1	All	none				M	M	I	M	M
		LakeRiver2	Chum	none								
		LakeRiver3	StW	none								

5.4.2 *Habitat Measures*

Measures are means to achieve the regional strategies that are applicable to the Salmon Creek Basin and are necessary to accomplish the biological objectives for focal fish species. Measures are based on the technical assessments for this subbasin (Section 3.0) as well as on the synthesis of priority areas, limiting factors, and threats presented earlier in this section. The measures applicable to the Salmon Creek Basin are presented in priority order in Table 15. Each measure has a set of submeasures that define the measure in greater detail and add specificity to the particular circumstances occurring within the subbasin. The table for each measure and associated submeasures indicates the limiting factors that are addressed, the contributing threats that are addressed, the species that would be most affected, and a short discussion. Priority locations are given for some measures. Priority locations typically refer to either stream reaches or subwatersheds, depending on the measure. Addressing measures in the highest priority areas first will provide the greatest opportunity for effectively accomplishing the biological objectives.

Following the list of priority locations is a list of the programs that are the most relevant to the measure. Each program is qualitatively evaluated as to whether it is sufficient or needs expansion with respect to the measure. This exercise provides an indication of how effectively the measure is already covered by existing programs, policy, or projects; and therefore indicates where there is a gap in measure implementation. This information is summarized in a discussion of Program Sufficiency and Gaps.

The measures themselves are prioritized based on the results of the technical assessment and in consideration of principles of ecosystem restoration (e.g. NRC 1992, Roni et al. 2002). These principles include the hypothesis that the most efficient way to achieve ecosystem recovery in the face of uncertainty is to focus on the following prioritized approaches: 1) protect existing functional habitats and the processes that sustain them, 2) allow no further degradation of habitat or supporting processes. 3) re-connect isolated habitat, 4) restore watershed processes (ecosystem function), 5) restore habitat structure, and 6) create new habitat where it is not recoverable. These priorities have been adjusted for the specific circumstances occurring in the Salmon Creek Basin. These priorities are adjusted depending on the results of the technical assessment and on the specific circumstances occurring in the basin. For example, re-connecting isolated habitat could be adjusted to a lower priority if there is little impact to the population created from passage barriers.

5.4.3 *Habitat Actions*

The prioritized measures and associated gaps are used to develop specific Actions for the subbasin. These are presented in Table 16. Actions are different than the measures in a number of ways: 1) actions have a greater degree of specificity than measures, 2) actions consider existing programs and are therefore not based strictly on biophysical conditions, 3) actions refer to the agency or entity that would be responsible for carrying out the action, and 4) actions are related to an expected outcome with respect to the biological objectives. Actions are not presented in priority order but instead represent the suite of activities that are all necessary for recovery of listed species. The priority for implementation of these actions will consider the priority of the measures they relate to, the “size” of the gap they are intended to fill, and feasibility considerations.

Table 15. Prioritized measures for the Salmon Creek Basin.

#1 – Protect stream corridor structure and function

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Protect floodplain function and channel migration processes B. Protect riparian function C. Protect access to habitats D. Protect instream flows through management of water withdrawals E. Protect channel structure and stability F. Protect water quality G. Protect the natural stream flow regime	Potentially addresses many limiting factors	Potentially addresses many limiting factors	All Species	Stream corridors throughout the Salmon Creek / Lake River Basin have been impacted by a host of land-use activities including urbanization, rural residential development, agricultural practices, transportation corridors, and timber harvests. Many riparian areas are denuded of vegetation and the stream is heavily channelized in many areas. Preventing further degradation of stream channel structure, riparian function, and floodplain function will be an important component of recovery.

Priority Locations

1st- Tier 3 reaches (Salmon Creek Basin and Lake River)
2nd- Tier 4 reaches (Salmon Creek Basin and Lake River)
3rd- Other Lake River tributaries (i.e. Burnt Bridge Creek, Whipple Creek)

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
NOAA Fisheries	ESA Section 7 and Section 10	✓	
US Army Corps of Engineers (USACE)	Dredge & fill permitting (Clean Water Act sect. 404); Navigable waterways protection (Rivers & Harbors Act Sect, 10)	✓	
WA Department of Natural Resources (WDNR)	State Lands HCP, Forest Practices Rules, Riparian Easement Program	✓	
WA Department of Fish and Wildlife (WDFW)	Hydraulics Projects Approval	✓	
Clark County	Comprehensive Planning		✓
City of Vancouver	Comprehensive Planning		✓
City of Battle Ground	Comprehensive Planning		✓
Clark Conservation District / Natural Resources Conservation Service (NRCS)	Agricultural land habitat protection		✓
Noxious Weed Control Boards (State and County level)	Noxious Weed Education, Enforcement, Control		✓
Non-Governmental Organizations (NGOs) (e.g. Columbia Land Trust) and public agencies	Land acquisition and easements		✓

Program Sufficiency and Gaps

Alterations to stream corridor structure that may impact aquatic habitats are regulated through the WDFW Hydraulics Project Approval (HPA) permitting program. Other regulatory protections are provided through USACE permitting, ESA consultations, HCPs, and County regulations. Riparian areas within private timberlands are protected through the Forest Practices Rules (FPR) administered by WDNR. The FPRs came out of an extensive review process and are believed to adequately protect riparian areas with respect to stream shading, bank stability, and LWD recruitment. The program is new, however, and careful monitoring of the effect of the regulations is necessary, particularly with respect the effect on watershed hydrology and sediment supply. The basin is heavily developed and land-use conversion and development are increasing throughout the basin and local government ordinances must ensure that new development occurs in a manner that protects key habitats. Conversion of land-use from forest or agriculture to residential use has the potential to increase impairment of aquatic habitat, particularly when residential development is paired with flood control measures. Local governments can limit potentially harmful land-use conversions by thoughtfully directing growth through comprehensive planning and tax incentives, by providing consistent protection of critical areas across jurisdictions, and by preventing development in floodplains. In cases where existing programs are unable to protect critical habitats due to inherent limitations of regulatory mechanisms, conservation easements and land acquisition may be necessary.

#2 – Protect hillslope processes

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Manage forest practices to minimize impacts to sediment supply processes, runoff regime, and water quality B. Manage agricultural practices to minimize impacts to sediment supply processes, runoff regime, and water quality C. Manage growth and development to minimize impacts to sediment supply processes, runoff regime, and water quality	• Excessive fine sediment • Excessive turbidity • Embedded substrates • Stream flow – altered magnitude, duration, or rate of change of flows • Water quality impairment	• Timber harvest – impacts to sediment supply, water quality, and runoff processes • Forest roads – impacts to sediment supply, water quality, and runoff processes • Agricultural practices – impacts to sediment supply, water quality, and runoff processes • Development – impacts to sediment supply, water quality, and runoff processes	All species	Hillslope runoff and sediment delivery processes have been degraded due to past intensive timber harvest, road building, development, and agriculture. Limiting additional degradation will be necessary to prevent further habitat impairment.

Priority Locations

1st- Functional subwatersheds contributing to Tier 3 reaches (functional for sediment *or* flow according to the IWA – local rating)
Subwatersheds: 90116, 90117 (functional for sediment – see IWA section for qualification of sediment ratings in this basin)
2nd- All other functional subwatersheds plus Moderately Impaired subwatersheds contributing to Tier 3 reaches
Subwatersheds: 90103, 90105, 90131, 90114, 90121, 90123, 90124, 90125, 90129, 90130, 90128, 90127 (functional for sediment – see IWA section for qualification of sediment ratings in this basin); 90106, 90118, 90107, 90110, 90111, 90108, 90113, 90112, 90109
3rd- All remaining subwatersheds

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDNR	Forest Practices Rules, State Lands HCP	✓	
Clark County	Comprehensive Planning		✓
City of Vancouver	Comprehensive Planning		✓
City of Battle Ground	Comprehensive Planning		✓
Clark Conservation District / NRCS	Agricultural land habitat protection		✓

Program Sufficiency and Gaps

Hillslope processes on private forest lands are protected through Forest Practices Rules administered by the WDNR. These rules, developed as part of the Forests & Fish Agreement, are believed to be adequate for protecting watershed sediment supply, runoff processes, and water quality on private forest lands. Small private landowners may be unable to meet some of the requirements on a timeline commensurate with large industrial landowners. Financial assistance to small owners would enable greater and quicker compliance. On non-forest lands (agriculture and developed), local government comprehensive planning is the primary nexus for protection of hillslope processes. Local governments can control impacts through zoning that protects existing uses, through stormwater management ordinances, and through tax incentives to prevent agricultural and forest lands from becoming developed. These protections are especially important in the Salmon Creek / Lake River Basin due to expanding growth. There are few to no regulatory protections of hillslope processes that relate to agricultural practices; such deficiencies need to be addressed through local or state authorities. Protecting hillslope processes on agricultural lands would also benefit from the expansion of technical assistance and landowner incentive programs (NRCS, Conservation Districts).

#3 – Provide for adequate instream flows during critical periods

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Protect instream flows through water rights closures and enforcement B. Restore instream flows through acquisition of existing water rights C. Restore instream flows through implementation of water conservation measures	• Stream flow – maintain or improve Summer low-flows	• Water withdrawals	All species	Demand for flows is high and rapidly increasing in this highly developed basin. Instream flow management strategies have been identified as part of Watershed Planning for WRIA 28 (LCFRB 2004). Strategies include water rights closures, setting of minimum flows, and drought management policies. This measure applies to instream flows associated with water withdrawals and diversions, generally a concern only during low flow periods. Hillslope processes also affect low flows but these issues are addressed in separate measures.

Priority Locations

Entire Basin

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
Washington Department of Ecology	Water Resources Program		✓
WRIA 27/28 Watershed Planning Unit	Watershed Planning	✓	
City of Vancouver	Water Supply Program		✓
Clark Public Utilities	Water Supply Program		✓

Program Sufficiency and Gaps

The Water Resources Program of the WDOE, in cooperation with the WDFW and other entities, manages water rights and instream flow protections. A collaborative process for setting and managing instream flows was launched in 1998 with the Watershed Planning Act (HB 2514), which called for the establishment of local watershed planning groups who's objective was to recommend instream flow guidelines to WDOE through a collaborative process. The current status of the planning effort is to adopt a watershed management plan by December 2004. Instream flow management in the Salmon Creek / Lake River Basin will be conducted using the recommendations of the WRIA 27/28 Planning Unit, which is coordinated by the LCFRB. Draft products of the WRIA 27/28 watershed planning effort can be found on the LCFRB website: www.lcfrb.gen.wa.us. The recommendations of the planning unit have been developed in close coordination with recovery planning and the instream flow prescriptions developed by this group are anticipated to adequately protect instream flows necessary to support healthy fish populations. The measures specified above are consistent with the planning group's recommended strategies. Ecology should implement the recommendations of the WRIA 27/28 Planning Unit relative to instream flow rule development

#4 - Restore riparian conditions throughout the basin

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Restore the natural riparian plant community B. Exclude livestock from riparian areas C. Eradicate invasive plant species from riparian areas	• Reduced stream canopy cover • Altered stream temperature regime • Reduced bank/soil stability • Reduced wood recruitment • Lack of stable instream woody debris • Exotic and/or invasive species • Bacteria	• Timber harvest – riparian harvests • Riparian grazing • Clearing of vegetation due to agriculture and residential development	All species	Riparian areas have been heavily impacted throughout the basin by timber harvest, development, residential landscaping, agriculture, transportation corridors, and urbanization. The increasing abundance of exotic and invasive species is of particular concern. Riparian reforestation has a high potential benefit due to the many limiting factors that are addressed. Riparian restoration projects are relatively inexpensive and are often supported by landowners.

Priority Locations

1st- Tier 3 reaches (Salmon Creek Basin and Lake River)
2nd- Tier 4 reaches (Salmon Creek Basin and Lake River)
3rd- Other Lake River tributaries (i.e. Burnt Bridge Creek, Whipple Creek)

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDNR	State Lands HCP, Forest Practices Rules	✓	
WDFW	Habitat Program		✓
Clark Conservation District / NRCS	Agricultural land habitat restoration		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
NGOs, tribes, agencies, landowners	Habitat Projects		✓
Noxious Weed Control Boards (State and County level)	Noxious weed control		✓

Program Sufficiency and Gaps

There are no regulatory mechanisms for actively restoring riparian conditions; however, existing programs will afford protections that will allow for the *passive* restoration of riparian forests. These protections are believed to be adequate for riparian areas on forest lands that are subject to Forest Practices Rules or the State forest lands HCP. Other lands receive variable levels of protection and passive restoration through the Clark County and the City of Vancouver's Comprehensive Plans. Many degraded riparian zones in urban, agricultural, rural residential, or transportation corridor uses will not passively restore with existing regulatory protections and will require active measures that are not called for in any existing policy. Riparian restoration in these areas may entail livestock exclusion, tree planting, road relocation, invasive species eradication, and adjusting current land-use in the riparian zone. Means of increasing restoration activity include building partnerships with landowners, increasing landowner participation in conservation programs, allowing restoration projects to serve as mitigation for other activities, and increasing funding for NGOs, government entities, and landowners to conduct restoration projects.

#5 - Restore floodplain function and channel migration processes

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Set back, breach, or remove artificial confinement structures	• Bed and bank erosion • Altered habitat unit composition • Restricted channel migration • Disrupted hyporheic processes • Reduced flood flow dampening • Altered nutrient exchange processes • Channel incision • Loss of off-channel and/or side-channel habitat • Blockages to off-channel habitats	• Floodplain filling • Channel straightening • Artificial confinement	chum, fall chinook, coho	There has been significant degradation of floodplain connectivity and constriction of channel migration zones along all of the stream segments in the basin. Adjusting stream crossings and selective breaching, setting back, or removing confining structures would help to restore floodplain and CMZ function as well as facilitate the creation of off-channel and side channel habitats. There are challenges with implementation due to private lands, existing infrastructure already in place, potential flood risk to property, and large expense.

Priority Locations

1st- Tier 3 reaches with hydro-modifications (obtained from EDT ratings)
Reaches: All Tier 3 reaches except Morgan 1; Salmon 31-32; LB trib11-1; & Side Channel 1 (on Morgan Creek)
2nd- Tier 4 reaches with hydro-modifications
Reaches: All Tier 4 reaches except Mill 1; RB trib 2-1 (Mill Cr); RB trib 9-2; Rock 2-3; LB trib 5 (Rock Cr); RB trib 11-2; RB trib 12-2; LB trib 11-2
3rd- Other reaches with hydro-modifications
Reaches: Most of Whipple and Burnt Bridge Creeks

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDFW	Habitat Program		✓
USACE	Water Resources Development Act (Sect. 1135 & Sect. 206)		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓

Program Sufficiency and Gaps

There currently are no programs or policy in place that set forth strategies for restoring floodplain function and channel migration processes in the Salmon Creek / Lake River Basin. Without programmatic changes, projects are likely to occur only seldom as opportunities arise and only if financing is made available. The level of floodplain and CMZ impairment in the Basin and the importance of these processes to listed fish species put an increased emphasis on restoration. Means of increasing restoration activity include building partnerships with landowners, increasing landowner participation in conservation programs, allowing restoration projects to serve as mitigation for other activities, and increasing funding for NGOs and government entities to conduct projects. Floodplain restoration projects are often expensive, large-scale efforts that require partnerships among many agencies, NGOs, and landowners. Building partnerships is a necessary first step toward floodplain and CMZ restoration.

#6 – Restore degraded water quality with emphasis on temperature impairments

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Exclude livestock from riparian areas B. Increase riparian shading C. Decrease channel width-to-depth ratios D. Reduce delivery of chemical contaminants to streams E. Address leaking septic systems	• Altered stream temperature regime • Bacteria • Chemical contaminants	• Timber harvest – riparian harvests • Riparian grazing • Clearing of vegetation due to rural development and agriculture • Leaking septic systems • Chemical contaminants from agricultural and developed lands	All species	There are several stream segments listed on the Washington State 303(d) list for temperature impairments. There are several other water quality impairments throughout the basin, with fecal coliform bacteria as the most common. Bacteria is more of a human health concern than a fish health concern. Development, agricultural activities, riparian degradation, and septic systems contribute to water quality problems.

Priority Locations

1st- Tier 3 or 4 reaches with 303(d) listings (1996 list, 1998 list, or 2002-2004 draft list)
Reaches: Lake River 1 (temperature, bacteria, sediment bioassay); Salmon 8 (temperature, bacteria, turbidity); Salmon 11-12, 18-22, 29-30 (bacteria); CougarCanyon2 (bacteria); Mill1 (bacteria); Weaver 1-2 (bacteria, ammonia, dissolved oxygen, pH); RBtrib4, 5, 11-1 (bacteria)
2nd- Other reaches with 303(d) listings
Reaches: Whipple Creek (bacteria); Burnt Bridge Creek (dissolved oxygen, bacteria, temperature); Curtin Creek (bacteria)
3rd- All remaining reaches

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
Washington Department of Ecology	Water Quality Program		✓
WDNR	State Lands HCP, Forest Practices Rules	✓	
WDFW	Habitat Program		✓
City of Vancouver	Comprehensive Planning		✓
Clark County	Comprehensive Planning		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
Clark Conservation District / NRCS	Agricultural land habitat restoration		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓
Clark County Health Department	Septic System Program		✓

Program Sufficiency and Gaps

The WDOE Water Quality Program manages the State 303(d) list of impaired water bodies. There are several listings in the Salmon Creek / Lake River Basin and several additional areas of concern (1996, 1998, and 2002/2004 303(d) lists) (WDOE). There is currently a Water Quality Clean-up Plan (TMDL) – Submittal Report for fecal coliform bacteria and turbidity for the Salmon Creek Basin (WDOE 2001). Other TMDLs are required by the WDOE to address the other parameters and it is anticipated that the TMDLs will adequately set forth strategies to address the water quality impairments. It will be important that the strategies specified in the TMDLs are implementable and adequately funded. The 303(d) listings are believed to address the primary water quality concerns; however, other impairments may exist that the current monitoring effort is unable to detect. Additional monitoring is needed to fully understand the degree of water quality impairment in the basin, especially regarding polluted urban runoff and agricultural pollutants.

#7- Restore degraded hillslope processes on forest, agricultural, and developed lands

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Upgrade or remove problem forest roads B. Reforest heavily cut areas not recovering naturally C. Employ agricultural Best Management Practices with respect to contaminant use, erosion, and runoff D. Reduce watershed imperviousness E. Reduce effective stormwater runoff from developed areas	• Excessive fine sediment • Excessive turbidity • Embedded substrates • Stream flow – altered magnitude, duration, or rate of change of flows • Water quality impairment	• Timber harvest – impacts to sediment supply, water quality, and runoff processes • Forest roads – impacts to sediment supply, water quality, and runoff processes • Agricultural practices – impacts to sediment supply, water quality, and runoff processes • Development – impacts to water quality and runoff processes	All species	Hillslope runoff and sediment delivery processes have been degraded due to past intensive timber harvest, road building, agriculture, and development. These processes must be addressed for reach-level habitat recovery to be successful.

Priority Locations

1st- Moderately impaired or impaired subwatersheds contributing to Tier 3 reaches (mod. impaired or impaired for sediment *or* flow according to IWA – local rating)
Subwatersheds: 90106, 90118, 90107, 90110, 90111, 90108, 90113, 90112, 90109

2nd- Moderately impaired or impaired subwatersheds contributing to other reaches
Subwatersheds: All remaining subwatersheds

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDNR	State Lands HCP, Forest Practices Rules	✓	
WDFW	Habitat Program		✓
Clark Conservation District / NRCS	Agricultural land habitat restoration		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓
Clark County	Stormwater Management		✓
City of Vancouver	Stormwater Management		✓
City of Battle Ground	Stormwater Management		✓

Program Sufficiency and Gaps

Restoration of hillslope (upland) processes on existing developed and agricultural lands occurs relatively infrequently and there are no programs that specifically require restoration in these areas. Restoring existing developed and farmed lands can involve retrofitting facilities with new materials, replacing existing systems, adopting new management practices, and creating or re-configuring landscaping. Means of increasing restoration activity include increasing landowner participation through education and incentive programs, building support for projects on public lands/facilities, requiring activities through permitting and ordinances, and increasing available funding for entities to conduct projects. Forest management programs including the new Forest Practices Rules (private timber lands) and the WDNR HCP (state timber lands) are expected to afford protections that will passively and actively restore degraded hillslope conditions. Timber harvest rules are expected to passively restore sediment and runoff processes. The road maintenance and abandonment requirements for private timber lands are expected to actively address road-related impairments within a 15 year time-frame. While these strategies are believed to be largely adequate to protect watershed processes, the degree of implementation and the effectiveness of the prescriptions will not be fully known for at least another 15 or 20 years. Of particular concern is the capacity of some forest land owners, especially small forest owners, to conduct the necessary road improvements (or removal) in the required timeframe. Additional financial and technical assistance would enable small forest landowners to conduct the necessary improvements in a timeline parallel to large industrial timber land owners.

#8 - Restore channel structure and stability

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Place stable woody debris in streams to enhance cover, pool formation, bank stability, and sediment sorting B. Structurally modify channel morphology to create suitable habitat C. Restore natural rates of erosion and mass wasting within river corridors	• Lack of stable instream woody debris • Altered habitat unit composition • Reduced bank/soil stability • Excessive fine sediment • Excessive turbidity • Embedded substrates	• None (symptom-focused restoration strategy)	All species	Channel structure and stability have been altered by various stream corridor projects and adjacent land-uses over the years. The land-uses with the greatest impacts in the upper basin include riparian timber harvests and agriculture. In the lower portion of the basin, development, urbanization, channelization, mining, and transportation corridors have dramatically impacted stream channels. A particular area of concern is between I-5 and Highway 99, where the mainstem avulsed into streamside gravel mining ponds in 1996. An upstream migrating headcut has resulted from this avulsion. This and other areas could benefit from bank stabilization and structural enhancements. Large wood installation projects have occurred in several reaches and may be warranted in additional areas although watershed processes contributing to wood deficiencies should be considered and addressed prior to placing wood in streams.

Priority Locations

1st- Salmon Creek 13-14 (gravel pit avulsions); Salmon 24 & 26, Morgan 1, & Rock 5 (road and livestock grazing impacts)
2nd- Remaining Tier 3 reaches
3rd- Tier 4 reaches

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
NGOs, tribes, agencies, landowners	Habitat Projects		✓
WDFW	Habitat Program		✓
USACE	Water Resources Development Act (Sect. 1135 & Sect. 206)		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
Clark Conservation District / NRCS	Agricultural land habitat restoration		✓

Program Sufficiency and Gaps

There are no regulatory mechanisms for actively restoring channel stability and structure. Passive restoration is expected to slowly occur as a result of protections afforded to riparian areas and hillslope processes. Past projects have largely been opportunistic and have been completed due to the efforts of local NGOs, landowners, and government agencies; such projects are likely to continue in a spotty fashion as opportunities arise and only if financing is made available. The lack of LWD in stream channels, and the importance of wood for habitat of listed species, places an emphasis on LWD supplementation projects. Means of increasing restoration activity include building partnerships with landowners, increasing landowner participation in conservation programs, allowing restoration projects to serve as mitigation for other activities, and increasing funding for NGOs, government entities, and landowners to conduct restoration projects.

#9 – Limit intensive recreational use during critical periods

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Limit intensive recreational use of stream channels during adult holding and spawning periods	• Harassment	• Harassment	chum, fall chinook	Much of the Salmon Creek / Lake River Basin is readily accessible to people for recreational activities due to the proximity to a populated area. As a result, harassment potential was identified as a concern through the EDT analysis. The primary life stages affected are pre-spawning (adult) holding and egg incubation. Human activity in and around the stream in the vicinity of Salmon Creek County Park is of particular concern during spawning, egg incubation, and early rearing of chum and fall chinook.

Priority Locations

1st- Salmon Creek 12-16 (Salmon Creek County Park)
2nd- Remaining Tier 3 reaches
3rd- Remaining Tier 4 reaches

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDFW	Enforcement		✓
Clark County	Parks and Recreation		✓
City of Vancouver	Parks and Recreation		✓

Program Sufficiency and Gaps

There currently is little policy in place directly aimed at limiting recreational use of the river for harassment reduction during critical periods.

#10 – Restore access to habitat blocked by artificial barriers

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Restore access to isolated habitats blocked by culverts, dams, or other barriers	• Blockages to channel habitats • Blockages to off-channel habitats	• Dams, culverts, in-stream structures	All species	Only about 3 miles of potentially accessible habitat are believed to be blocked by culverts or other barriers. The blocked habitat is thought to be marginal in the majority of cases and no individual barriers in themselves account for a significant portion of blocked miles. Passage restoration projects should focus only on cases where it can be demonstrated that there is good potential benefit and reasonable project costs.

Priority Locations

1st- Small tributaries with blockages

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDNR	Forest Practices Rules, Family Forest Fish Passage, State Forest Lands HCP		✓
WDFW	Habitat Program		✓
Washington Department of Transportation / WDFW	Fish Passage Program		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
City of Vancouver	Roads		✓
Clark County	Roads		✓

Program Sufficiency and Gaps

The Forest Practices Rules require forest landowners to restore fish passage at artificial barriers by 2016. Small forest landowners are given the option to enroll in the Family Forest Fish Program in order to receive financial assistance to fix blockages. The Washington State Department of Transportation, in a cooperative program with WDFW, manages a program to inventory and correct blockages associated with state highways. The Salmon Recovery Funding Board, through the Lower Columbia Fish Recovery Board, funds barrier removal projects. Past efforts have corrected major blockages and have identified others in need of repair. Additional funding is needed to correct remaining blockages. Further monitoring and assessment is needed to ensure that all potential blockages have been identified and prioritized.

#11 – Create/restore off-channel and side-channel habitat

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Restore historical off-channel and side-channel habitats where they have been eliminated B. Create new channel or off-channel habitats (i.e. spawning channels)	• Loss of off-channel and/or side-channel habitat	• Floodplain filling • Channel straightening • Artificial confinement	chum coho	There has been significant loss of off-channel and side-channel habitats, especially along Lake River and the lower mainstem of Salmon Creek that has been extensively channelized. This has severely limited chum spawning habitat and coho overwintering habitat. Targeted restoration or creation of habitats would increase available habitat where full floodplain and CMZ restoration is not possible.

Priority Locations

1st- Lake River and lower mainstem Salmon Creek
2nd- Other reaches that may have potential for off-channel and side-channel habitat restoration or creation

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDFW	Habitat Program		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓
USACE	Water Resources Development Act (Sect. 1135 & Sect. 206)		✓

Program Sufficiency and Gaps

There are no regulatory mechanisms for creating or restoring off-channel and side-channel habitat. Means of increasing restoration activity include building partnerships with landowners, increasing landowner participation in conservation programs, allowing restoration projects to serve as mitigation for other activities, and increasing funding for NGOs, government entities, and landowners to conduct restoration projects.

Table 16. Habitat actions for the Salmon Creek Basin.

Action	Status	Responsible Entity	Measures Addressed	Spatial Coverage of Target Area[1]	Expected Biophysical Response[2]	Certainty of Outcome[3]
Salm 1. Expand standards in County and City Comprehensive Plans to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	**Expansion of existing program or activity**	**Clark County, City of Vancouver, WDOE**	**1 & 2**	**High: Applies to nearly all of the basin**	**High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes**	**High**
Salm 2. Manage future growth and development patterns to ensure the protection of watershed processes. This includes limiting the conversion of agriculture and timber lands to developed uses through zoning regulations and tax incentives (in consideration of urban growth boundaries). Use availability of water to help guide growth.	**Expansion of existing program or activity**	**Clark County, City of Vancouver, City of Battleground**	**1 & 2**	**High: Applies to nearly all of the basin**	**High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes**	**High**
Salm 3. Prevent floodplain impacts from new development through land use controls and Best Management Practices	**New program or activity**	**Clark County, City of Vancouver, WDOE**	**1**	**Medium: Applies to privately owned floodprone lands under county jurisdiction**	**High: Protection of floodplain function, CMZ processes, and off-channel/side-channel habitat. Prevention of reduced habitat diversity and key habitat availability**	**High**
Salm 4. Increase funding available to purchase easements or property in sensitive areas in order to protect watershed function where existing programs are inadequate	**Expansion of existing program or activity**	**LCFRB, NGOs, WDFW, USFWS, BPA (NPCC)**	**1 & 2**	**Medium: Residential, agricultural, or forest lands at risk of further degradation**	**High: Protection of riparian function, floodplain function, water quality, wetland function, and runoff and sediment supply processes**	**High**
Salm 5. Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management	**Expansion of existing program or activity**	**Clark County, Vancouver, Battleground**	**1, 4, 6, & 7**	**Low: Applies to lands under public jurisdiction**	**Medium: Protection of water quality, greater streambank stability, reduction in road-related fine sediment delivery, restoration and preservation of fish access to habitats**	**High**
Salm 6. Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach	**Expansion of existing program or activity**	**NRCS, Clark CD, WDNR, WDFW, LCFEG, Clark County, Vancouver**	**All measures**	**High: Applies to agriculture, forest, and developed lands throughout the basin**	**High: Increased landowner stewardship of habitat. Potential improvement in all factors**	**Medium**
Salm 7. Implement the prescriptions of the WRIA 27/28 Watershed Planning Unit regarding instream flows. Develop a regional water source in the Vancouver Lake Lowlands within 10 years	**Activity is currently in place**	**WDOE, WDFW, WRIA 27/28 Planning Unit, Vancouver, Clark Public Utilities**	**3**	**High: Entire basin**	**High: Adequate instream flows to support life stages of salmonids and other aquatic biota.**	**Medium**
Salm 8. Conduct floodplain restoration where feasible along the mainstem Salmon Creek and in major tributaries that have experienced channel	**New program or activity**	**NRCS, CCD, NGOs, WDFW, LCFRB, USACE, LCFEG**	**4, 5, 6, 8 & 10**	**Medium: Mainstem Salmon Creek and lower portion of major**	**Medium: Restoration of floodplain function, habitat diversity, and habitat availability.**	**Medium**

[1] Relative amount of basin affected by action
[2] Expected response of action implementation
[3] Relative certainty that expected results will occur as a result of full implementation of action

Action	Status	Responsible Entity	Measures Addressed	Spatial Coverage of Target Area[1]	Expected Biophysical Response[2]	Certainty of Outcome[3]
confinement. Build partnerships with landowners and agencies and provide financial incentives				**tributaries**		
Salm 9. Protect and restore native plant communities from the effects of invasive species	**Expansion of existing program or activity**	**Weed Control Boards (local and state); NRCS, Clark CD, LCFEG**	**1 & 5**	**High: Greatest risk is in agriculture and residential use areas**	**Medium: restoration and protection of native plant communities necessary to support watershed and riparian function**	**Low**
Salm 10. Address water quality impairments through the development and implementation of water quality clean up plans (TMDLs)	**Expansion of existing program or activity**	**WDOE**	**6**	**High: Private agricultural and rural residential lands**	**Medium: Protection and restoration of water quality**	**Low**
Salm 11. Fully implement and enforce the Forest Practices Rules (FPRs) on private timber lands in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	**Activity is currently in place**	**WDNR**	**1, 2, 4, 6, 7 & 10**	**Low: Private commercial timber lands**	**Medium: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats**	**Medium**
Salm 12. Increase the level of implementation of voluntary habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	**Expansion of existing program or activity**	**LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, Clark CD, LCFEG**	**4, 5, 6, 7, 8, 10 & 11**	**Low: Priority stream reaches and subwatersheds throughout the basin**	**Medium: Improved conditions related to water quality, LWD quantities, bank stability, key habitat availability, habitat diversity, riparian function, floodplain function, sediment availability, & channel migration processes**	**Medium**
Salm 13. Increase technical support and funding to small forest landowners faced with implementation of Forest and Fish requirements for fixing roads and barriers to ensure full and timely compliance with regulations	**Expansion of existing program or activity**	**WDNR**	**1, 2, 4, 6, 7 & 10**	**Low: Small private timberland owners**	**Medium: Reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats**	**Medium**
Salm 14. Assess the impact of fish passage barriers throughout the basin and restore access to potentially productive habitats	**Expansion of existing program or activity**	**WDFW, WDNR, Clark County WSDOT, LCFEG**	**10**	**Low: Only approximately 3 miles of potential habitat is blocked by artificial barriers**	**Medium: Increased spawning and rearing capacity due to access to blocked habitat. Habitat is marginal in most cases**	**Medium**
Salm 15. Conduct forest practices on state lands in accordance with the Habitat Conservation Plan in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	**Activity is currently in place**	**WDNR**	**1, 2, 4, 6, 7 & 10**	**Low: State timber lands in the Salmon Creek Basin (approximately 4% of the basin area)**	**Medium: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats. Response is medium because of location and quantity of state lands**	**Medium**
Salm 16. Create and/or restore lost side-channel/off-channel habitat for chum spawning and coho overwintering	**New program or activity**	**LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, Clark CD, LCFEG**	**11**	**Low: Lake River and lower mainstem Salmon Creek**	**High: Increased habitat availability for spawning and rearing**	**Low**
Salm 17. Limit intensive recreational use of priority reaches in Salmon Creek during critical periods	**Expansion of existing program or activity**	**Clark County, City of Vancouver, WDFW**	**9**	**Low: Key reaches in Salmon Creek**	**Medium: Increased survival of salmonids**	**Low**

5.5 Hatcheries

5.5.1 *Subbasin Hatchery Strategy*

The desired future state of fish production within the Salmon Creek Subbasin includes natural salmon and steelhead populations that are improving on a trajectory to recovery and hatchery programs that either enhance the natural fish recovery trajectory or are operated to not impede progress towards recovery. Hatchery recovery measures in each subbasin are tailored to the specific ecological and biological circumstances for each species in the subbasin. This often involves substantial changes in many hatchery programs from their historical focus on production for mitigation. The recovery strategy includes a mixture of conservation programs and mitigation programs for lost fishing benefits. Mitigation programs involve areas or practices selected for consistency with natural population conservation and recovery objectives. A summary of the types of natural production enhancement strategies and fishery enhancement strategies to be implemented in the Salmon Creek Subbasin are displayed by species in Table 17. More detailed descriptions and discussion of the regional hatchery strategy can be found in the Regional Recovery and Subbasin Plan Volume I.

Table 17. Summary of natural production and fishery enhancement strategies to be implemented in the Salmon Creek Basin.

		Species				
		Fall Chinook	**Spring Chinook**	**Coho**	**Chum**	**Winter Steelhead**
Natural Production Enhancement	**Refuge**	✓				
	Hatch/Nat Conservation 1/					
	Isolation					
	Supplementation			✓		
Fishery Enhancement	**Hatchery Production**					✓

1/ Hatchery and natural population management strategy coordinated to meet biological recovery objectives. Strategy may include integration and/or isolation strategy over time. Strategy will be unique to biological and ecological circumstances in each watershed.

Conservation-based hatchery programs include strategies and measures which are specifically intended to enhance or protect production of a particular wild fish population within the basin. A unique conservation strategy is developed for each species and watershed depending on the status of the natural population, the biological relationship between the hatchery and natural populations, ecological attributes of the watershed, and logistical opportunities to jointly manage the populations. Four types of hatchery conservation strategies may be employed:

Natural Refuge Watersheds: In this strategy, certain sub-basins are designated as wild-fish-only areas for a particular species. The refuge areas include watersheds where populations have persisted with minimum hatchery influence and areas that may have a history of hatchery production but would not be subjected to future hatchery influence as part of the recovery strategy. More refuge areas may be added over time as wild populations recover. These regugia provide an opportunity to monitor population trends independent of the confounding influence of hatchery fish natural population on fitness and our ability to measure natural population productivity and will be key indicators of natural population status within the ESU. The Salmon Creek Subbasin would be a refuge area for natural fall Chinook

Hatchery Supplementation: This strategy utilizes hatchery production as a tool to assist in rebuilding depressed natural populations. Supplementation would occur in selected areas that are producing natural fish at levels significantly below current capacity or capacity is expected to increase as a result of immediate benefits of habitat or passage improvements. This is intended to be a temporary measure to jump start critically low populations and to bolster natural fish numbers above critical levels in selected areas until habitat is restored to levels where a population can be self sustaining. This strategy would include coho in the Salmon Creek Subbasin.

Hatchery/Natural Isolation: This strategy is focused on physically separating hatchery adult fish from naturally-produced adult fish to avoid or minimize spawning interactions to allow natural adaptive processes to restore native population diversity and productivity. The strategy may be implemented in the entire watershed or more often in a section of the watershed upstream of a barrier or trap where the hatchery fish can be removed. This strategy is currently aimed at hatchery steelhead in watersheds with trapping capabilities. The strategy may also become part of the fall chinook and coho strategies in certain watersheds in the future as unique wild runs develop. This strategy would not be included in near-term measures for the Salmon Creek Subbasin but could be considered in the future for coho. This definition refers only to programs where fish are physically sorted using a barrier or trap. Some fishery mitigation programs, particularly for steelhead, are managed to isolate hatchery and wild stocks based on run timing and release locations.

Hatchery/Natural Merged Conservation Strategy: This strategy addresses the case where natural and hatchery fish have been homogenized over time such that they are principally all one stock that includes the native genetic material for the basin. Many spring chinook, fall chinook, and coho populations in the lower Columbia currently fall into this category. In many cases, the composite stock productivity is no longer sufficient to support a self-sustaining natural population especially in the face of habitat degradation. The hatchery program will be critical to maintaining any population until habitat can be improved and a strictly natural population can be re-established. This merged strategy is intended to transition these mixed populations to a self-supporting natural population that is not subsidized by hatchery production or subject to deleterious hatchery impacts. Elements include separate management of hatchery and natural subpopulations, regulation of hatchery fish in natural areas, incorporation of natural fish into hatchery broodstock, and annual abundance-driven distribution. Corresponding programs are expected to evolve over time dependent on changes in the populations and in the habitat productivity. This strategy is primarily aimed at Chinook salmon in areas where harvest production occurs. There is not a chinook harvest program in the Salmon Creek Subbasin.

Not every lower Columbia River hatchery program will be turned into a conservation program. The majority of funding for lower Columbia basin hatchery operations is for producing salmon and steelhead for harvest to mitigate for lost harvest of natural production due to hydro development and habitat degradation. Programs for fishery enhancement will continue during the recovery period, but will be managed to minimize risks and ensure they do not compromise recovery objectives for natural populations. It is expected that the need to produce compensatory fish for harvest through artificial production will reduce in the future as natural populations recover and become harvestable. There are fishery enhancement programs for winter steelhead in the Salmon Creek Subbasin.

The Skamania Hatchery will continue to support winter steelhead fisheries with hatchery releases in the Salmon Creek Basin. Fall chinook will not be included as a harvest program in the Salmon Creek Basin. This plan adds one new conservation program from the Lewis River Hatchery coho production (Table18).

Table 18. A summary of conservation and harvest strategies to be implemented in the Salmon Creek Basin through hatchery programs.

		Stock
Natural Production Enhancement	Supplementation Hatch/Nat Conservation 1/ Isolation Broodstock development	Lewis River coho√
Fishery Enhancement	In-basin releases (final rearing at Salmon Creek) Out of Basin Releases (final rearing at Salmon Creek)	Skamania Winter Steelhead

1/ May include integrated and/or isolated strategy over time.
√ Denotes new program

5.5.2 *Hatchery Measures and Actions*

Hatchery strategies and measures are focused on evaluating and reducing biological risks consistent with the conservation strategies identified for each natural population. Artificial production programs within the Salmon Creek Subbasin have been evaluated in detail through the WDFW Benefit-Risk Assessment Procedure (BRAP) relative to risks to natural populations. The BRAP results were utilized to inform the development of these program actions specific to the Lake River / Salmon Creek Basin (Table 19). The Sub-Basin plan hatchery recovery actions were developed in coordination with WDFW and at the same time as the Hatchery and Genetic Management Plans (HGMP) were developed by WDFW for each hatchery program. As a result, the hatchery actions represented in this document will provide direction for specific actions which will be detailed in the HGMPs submitted by WDFW for public review and for NOAA fisheries approval. It is expected that the HGMPs and these recovery actions will be complimentary and provide a coordinated strategy for the Salmon Creek Subbasin hatchery programs. Further explanation of specific strategies and measures for hatcheries can be found in the Regional Recovery and Subbasin Plan Volume I.

Table 19. Hatchery program actions to be implemented in the Salmon Creek Basin.

Action	Description	Comments
H.A 25, 27**	Hatchery program utilized for supplementation and enhancement of coho populations.	Supplementation programs for Salmon Creek natural coho could be developed with appropriate broodstock from the Lewis River Hatchery. Co-op and school educational programs could be supportive of and participate in the supplementation effort
H.M8	Adaptively manage hatchery programs to further protect and enhance natural populations and improve operational efficiencies.	Appropriate research, monitoring, and evaluation programs along with guidance from regional hatchery evaluations will be utilized to improve the survival and contribution of hatchery fish, reduce impacts to natural fish, and increase benefits to natural fish.

** Extension or improvement of existing actions-may require additional funding*
*** New action-will likely require additional funding*

5.6 Harvest

Fisheries are both an impact that reduces fish numbers and an objective of recovery. The long-term vision is to restore healthy, harvestable natural salmonid populations in many areas of the lower Columbia basin. The near-term strategy involves reducing fishery impacts on natural populations to ameliorate extinction risks until a combination of actions can restore natural population productivity to levels where increased fishing may resume. The regional strategy for interim reductions in fishery impacts involves: 1) elimination of directed fisheries on natural populations, 2) regulation of mixed stock fisheries for healthy hatchery and natural populations to limit and minimize indirect impacts on natural populations, 3) scaling of allowable indirect impacts for consistency with recovery, 4) annual abundance-based management to provide added protection in years of low abundance, while allowing greater fishing opportunity consistent with recovery in years with much higher abundance, and 5) mass marking of hatchery fish for identification and selective fisheries.

Actions to address harvest impacts are generally focused at a regional level to cover fishery impacts accrued to lower Columbia salmon as they migrate along the Pacific Coast and through the mainstem Columbia River. Fisheries are no longer directed at weak natural populations but incidentally catch these fish while targeting healthy wild and hatchery stocks. Subbasin fisheries affecting natural populations have been largely eliminated. Fishery management has shifted from a focus on maximum sustainable harvest of the strong stocks to ensuring protection of the weak stocks. Weak stock protections often preclude access to large numbers of otherwise harvestable fish in strong stocks.

Fishery impact limits to protect ESA-listed weak populations are generally based on risk assessments that identify points where fisheries do not pose jeopardy to the continued persistence of a listed group of fish. In many cases, these assessments identify the point where additional fishery reductions provide little reduction in extinction risks. A population may continue to be at significant risk of extinction but those risks are no longer substantially affected by the specified fishing levels. Often, no level of fishery reduction will be adequate to meet naturally-spawning population escapement goals related to population viability. The elimination of harvest will not in itself lead to the recovery of a population. However, prudent and careful management of harvest can help close the gap in a coordinated effort to achieve recovery.

Fishery actions specific to the subbasins are addressed through the Washington State Fish and Wildlife sport fishing regulatory process. This public process includes an annual review focused on emergency type regulatory changes and a comprehensive review of sport fishing regulations which occurs every two years. This regulatory process includes development of fishing rules through the Washington Administrative Code (WAC) which are focused on protecting weak stock populations while providing appropriate access to harvestable populations. The actions consider the specific circumstances in each area of each subbasin and respond with rules that fit the relative risk to the weak populations in a given time and area of the subbasin. A summary of regulatory and protective fishery actions in Salmon Creek are summarized in Table 20.

Table 20. Summary of regulatory and protective fishery actions in Salmon Creek.

Species	General Fishing Actions	Explanation	Other Protective Fishing Actions	Explanation
Fall chinook	Closed to retention	Protects wild fall chinook. No harchery fall chinook produced for harvest in Salmon Creek	No season for other salmon. Steelhead fishing in winter season only	Prevents incidental handle of wild fall chinook adults
chum	Closed to retention	Protects wild chum. No hatchery chum produced for harvest in Salmon Creek	No season for other salmon	Reduces incidental handle of wild f chum
coho	Closed to retention	Protects wild coho. No hatchery coho produced for harvest in Salmon Creek	Trout season has a minimum size restriction	Prevents incidental handle of wild coho juveniles
Winter steelhead	Open for adipose fin clipped steelhead in Winter	Retain only hatchery produced steelhead. Non marked wild fish must be released	Trout and steelhead fishing closed in spring and minimum size rules	Spring Closure Protects adult wild steelhead during spawning and minimum size protects juvenile steelhead

Regional actions cover species from multiple watersheds which share the same migration routes and timing, resulting in similar fishery exposure. Regional strategies and actions for harvest are detailed in the the Regional Recovery and Subbasin Plan Volume I. A number of regional strategies for harvest involve implementation of actions within specific subbasins. In-basin fishery management is generally applicable to steelhead and salmon while regional management is more applicable to salmon. Harvest actions with significant application to the Salmon Creek Subbasin populations are summarized in Table 21.

Table 21. Regional harvest actions from Volume I, Chapter 7 with significant application to Salmon Creek populations.

Action	Description	Responsible Parties	Programs	Comments
**F.A12	Monitor chum handle rate in tributary winter steelhead.	WDFW	Columbia Compact	State agencies would include chum incidental handle assessments as part of their annual tributary sport fishery sampling plan.
*F.A13	Monitor and evaluate commercial and sport impacts to naturally-spawning steelhead in salmon and hatchery steelhead target fisheries.	WDFW, ODFW	Columbia Compact, BPA Fish and Wildlife Program	Includes monitoring of naturally-spawning steelhead encounter rates in fisheries and refinement of long-term catch and release handling mortality estimates. Would include assessment of the current monitoring programs and determine their adequacy in formulating naturally-spawning steelhead incidental mortality estimates.
*F.A14	Continue to improve gear and regulations to minimize incidental impacts to naturally-spawning steelhead.	WDFW, ODFW	Columbia Compact, BPA Fish and Wildlife Program	Regulatory agencies should continue to refine gear, handle and release methods, and seasonal options to minimize mortality of naturally-spawning steelhead in commercial and sport fisheries.
*F.A20	Maintain selective sport fisheries in Ocean, Columbia River, and tributaries and monitor naturally-spawning stock impacts.	WDFW, NOAA, ODFW, USFWS	PFMC, Columbia Compact, BPA Fish and Wildlife Program, WDFW Creel	Mass marking of lower Columbia River coho and steelhead has enabled successful ocean and freshwater selective fisheries to be implemented since 1998. Marking programs should be continued and fisheries monitored to provide improved estimates of naturally-spawning salmon and steelhead release mortality.

* Extension or improvement of existing action
** New action

5.7 Hydropower

No dams hydropower facilities exist in the Salmon Creek subbasin, hence, no in-basin hydropower actions are identified. Salmon Creek anadromous fish populations will benefit from regional hydropower measures recovery measures and actions identified in regional plans to address habitat effects in the mainstem and estuary.

5.8 Mainstem and Estuary Habitat

Salmon Creek anadromous fish populations will also benefit from regional recovery strategies and measures identified to address habitat conditions and threats in the Columbia River mainstem and estuary. Regional recovery plan strategies involve: 1) avoiding large scale habitat changes where risks are known or uncertain, 2) mitigating small-scale local habitat impacts to ensure no net loss, 3) protecting functioning habitats while restoring impaired habitats to functional conditions, 4) striving to understand, protect, and restore habitat-forming processes, 5) moving habitat conditions in the direction of the historical template which is presumed to be more consistent with restoring viable populations, and 6) improving understanding of salmonds habitats use in the Columbia River mainstem and estuary and their response to habitat changes. A series of specific measures are detailed in the regional plan for each of these strategies.

5.9 Ecological Interactions

For the purposes of this plan, ecological interactions refer to the relationships of salmon and steelhead with other elements of the ecosystem. Regional strategies and measures pertaining to exotic or non-native species, effects of salmon on system productivity, and native predators of salmon are detailed and discussed at length in the Regional Recovery and Subbasin Plan Volume I and are not reprised at length in each subbasin plan. Strategies include 1) avoiding, eliminating introductions of new exotic species and managing effects of existing exotic species, 2) recognizing the significance of salmon to the productivity of other species and the salmon themselves, and 3) managing predation by selected species while also maintaining a viable balance of predator populations. A series of specific measures are detailed in the regional plan for each of these strategies. Implementation will occur at the regional and subbasin scale.

5.10 Monitoring, Research, & Evaluation

Biological status monitoring quantifies progress toward ESU recovery objectives and also establishes a baseline for evaluating causal relationships between limiting factors and a population response. Status monitoring involves routine and intensive efforts. Routine monitoring of biological data consists of adult spawning escapement estimates, whereas routine monitoring for habitat data consists of a suite of water quality and quantity measurements.

Intensive monitoring supplements routine monitoring for populations and basins requiring additional information. Intensive monitoring for biological data consists of life-cycle population assessments, juvenile and adult abundance estimates and adult run-reconstruction. Intensive monitoring for habitat data includes stream/riparian surveys, and continuous stream flow assessment. The need for additional water quality sampling may be identified. Rather than prescribing one monitoring strategy, three scenarios are proposed ranging in level of effort and cost from high to low (Level 1-3 respectively). Given the fact that routine monitoring is ongoing, only intensive monitoring varies between each level.

An in-depth discussion of the monitoring, research and evaluation (M, R & E) approach for the Lower Columbia Region is presented in the Regional Recovery and Management Plan. It includes site selection rationale, cost considerations and potential funding sources. The following tables summarize the biological and habitat monitoring efforts specific to Salmon Creek.

Table 22. Summary of the biological monitoring plan for Salmon Creek populations.

Salmon Creek: Lower Columbia Biological Monitoring Plan			
Monitoring Type	**Chum**	**Coho**	**Winter Steelhead**
Routine	AA	AA	AA
Intensive			
Level 1			
Level 2			
Level 3			

AA Annual adult abundance estimates
✓ Adult and juvenile intensive biological monitoring occurs periodically on a rotation schedule (every 9 years for 3-year duration)
× Adult and juvenile intensive biological monitoring occurs annually

Table 23. Summary of the habitat monitoring plan for Salmon Creek populations.

Salmon Creek: Lower Columbia Habitat Monitoring Plan				
Monitoring Type	**Watershe d**	**Existing stream / riparian habitat**	**Water quantity[3] (level of coverage)**	**Water quality [2] (level of coverage)**
Routine [1] (level of coverage)	Baseline complete	Poor	Stream Gage-Good IFA-Moderate	WDOE-Moderate USGS-Moderate Temperature-Good
Intensive				
Level 1			✓	
Level 2				
Level 3				

IFAComprehensive Instream Flow Assessment (i.e. Instream Flow Incremental Methodology)
[1] Routine surveys for habitat data do not imply ongoing monitoring
[2] Intensive monitoring for water quality to be determined
[3] Water quantity monitoring may include stream gauge installation, IFA or low flow surveys

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