SALMONID HABITAT LIMITING FACTORS ANALYSIS

SNOHOMISH RIVER WATERSHED

WATER RESOURCE INVENTORY AREA

7

FINAL REPORT

WASHINGTON STATE
CONSERVATION COMMISSION

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ACRONYMS AND ABBREVIATIONS USED IN THIS REPORT

The following list provides a guide to acronyms and abbreviations used in this report:

BMP	Best Management Practices
BPA	Bonneville Power Administration
CERCLA	Comprehensive Environmental Remediation and Cleanup Liability Act (typically associated with EPA Superfund sites)
cfs	cubic feet per second (a measure of water flow)
CMZ	Channel Migration Zone
CSO	Combined Sewer Overflow
CW	Channel width
CWA	Clean Water Act
dbh	diameter breast height (measurement of tree diameter)
DNRP	King County Department of Natural Resources and Parks
EF	East Fork
ESA	Endangered Species Act
IFIM	Instream Flow Incremental Methodology
LB	Left Bank (looking downstream)
LWD	Large Woody Debris
m	meter
MF	Middle Fork
mgd	million gallons per day
mg/L	milligrams/Liter
mi	mile
mi^2	square miles
NF	North Fork
NRCS	Natural Resource Conservation Service
NWIFC	Northwest Indian Fisheries Commission
ppm	parts per million
RB	Right Bank (looking downstream)
RM	River Mile
SASSI	Salmon and Steelhead Stock Inventory
SEWIP	Snohomish Estuary Wetland Integration Plan
SF	South Fork
SPTH	Site Potential Tree Height
SSHIAP	Salmon and Steelhead Habitat Inventory Assessment Project
SSI	Salmonid Stock Inventory
SWM	Snohomish County Public Works, Surface Water Management Division
TAG	Technical Advisory Group
TFW	Timber, Fish, and Wildlife
TSS	Total Suspended Solids
USFS	U.S. Forest Service
WAC	Washington Administrative Code (rules implementing state statutes)
WADNR	Washington State Department of Natural Resources
WDFW	Washington State Department of Fish and Wildlife
WF	West Fork
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation

WWTIT	Western Washington Treaty Indian Tribes
WWTP	Wastewater Treatment Plant
yd^3	cubic yards
yr	year

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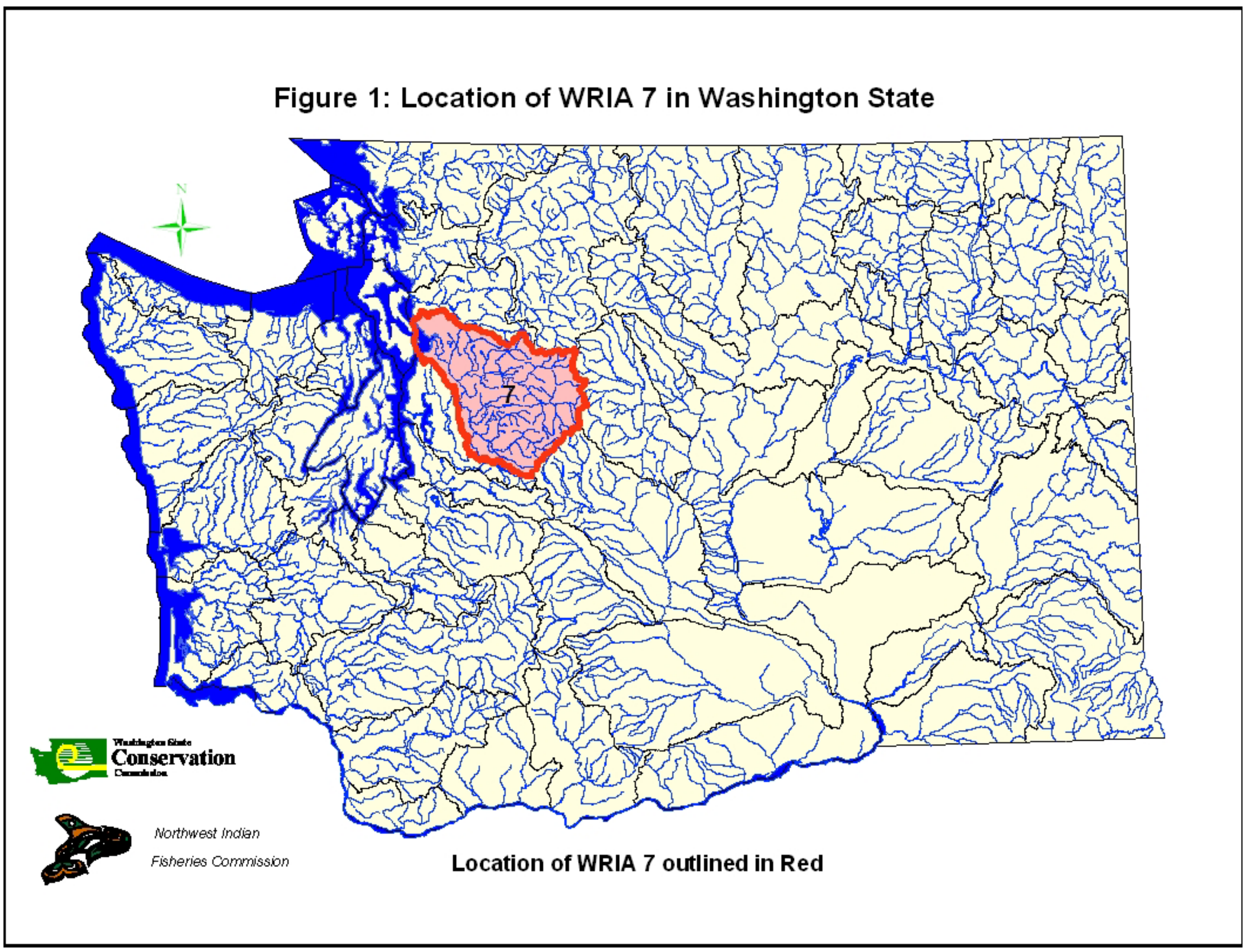
EXECUTIVE SUMMARY

Section 10 of Engrossed Substitute House Bill 2496 (Salmon Recovery Act of 1998), directs the Washington State Conservation Commission, in consultation with local government and treaty tribes to invite private, federal, state, tribal, and local government personnel with appropriate expertise to convene as a Technical Advisory Group (TAG). The purpose of the TAG is to identify limiting factors for salmonids. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." It is important to note that the charge to the Conservation Commission in ESHB 2496 does not constitute a full limiting factors analysis. A full habitat limiting factors analysis would require extensive additional scientific studies for each of the subwatersheds in the Snohomish River watershed (Water Resource Inventory Area (WRIA) 7. Analysis of hatchery, hydro, and harvest impacts would also be inherent components of a comprehensive limiting factors analysis; these elements are not addressed in this report, but will be considered in other forums.

Figure 1: Location of the Snohomish River watershed (WRIA 7) in Washington State



The Snohomish River watershed is the second largest river basin draining to Puget Sound, with a watershed area of 1,980 square miles (Pentec 1999)(Figure 1). Elevations in the watershed range from sea level to 8,000 feet (Gersib et al. 1999). The watershed includes three major rivers, the Skykomish, the Snoqualmie, and the Snohomish, which flow west through broad, glaciated lowland valleys and enter Puget Sound near Everett. These rivers and their tributaries support significant runs of anadromous salmonids, including coho, chinook, chum, and pink salmon, steelhead trout, bull trout/Dolly Varden, and other resident trout species. The Snohomish River watershed, with its multitude of tributary streams, is the second largest watershed in Puget Sound. There are 720 miles of streams in WRIA 7 that are known to support anadromous salmonids and bull trout/Dolly Varden. In addition, WRIA 7 includes ~25 miles of marine shoreline that supports local anadromous salmonid stocks, as well as salmonid stocks from other Puget Sound WRIAs.

The status of identified salmon, steelhead, and bull trout/Dolly Varden stocks in WRIA 7 is shown in Table 1; more detailed information on the stocks can be found in the Distribution and Condition of Salmon, Steelhead, and Bull trout/Dolly Varden chapter. Anadromous salmonids and bull trout/Dolly Varden are known to occupy 720 miles of streams within WRIA 7, with additional areas with presumed presence of these species (Table 2). Known and presumed distribution of anadromous salmonids and bull trout/Dolly Varden are shown on the individual species maps included in the separate Map files included with this report, and supporting data in

Table 1: Snohomish Watershed Salmon, Steelhead, and Bull trout/Dolly Varden Stock Designations and Associated Status

Stock	**Salmonid Stock Inventory Status**	**ESA Listing Status**
Skykomish chinook (includes Snohomish and Pilchuck)	Depressed	Threatened
Snoqualmie chinook	Healthy	Threatened
Skykomish chum	Healthy	Not warranted
Snoqualmie chum	Unknown	Not warranted
Wallace chum	Healthy	Not warranted
Snohomish odd-year pink	Healthy	Not warranted
Snohomish even-year pink	Healthy	Not warranted
Snohomish coho	Healthy	Candidate
Skykomish coho	Healthy	Candidate
SF Skykomish coho	Healthy	Candidate
Snoqualmie coho	Healthy	Candidate
Tolt summer steelhead	Healthy	Not warranted
NF Skykomish summer steelhead	Unknown	Not warranted
SF Skykomish summer steelhead	Healthy	Not warranted
Snohomish/Skykomish winter steelhead	Depressed	Not warranted
Pilchuck winter steelhead	Depressed	Not warranted
Snoqualmie winter steelhead	Depressed	Not warranted
Snohomish bull trout/Dolly Varden	Healthy	Threatened
Snohomish coastal cutthroat	Unknown	

Table 2: WRIA 7 fish distribution extent (miles)			
Species	Known	Presumed	Presumed Floodplain
Chinook	314.1	10.7	253.4
Chum	225.5	38.3	255.8
Pink	248.8	19.1	257.2
Coho	686.6	41.7	183.8
Steelhead	447.4	32	240.4
Bull trout/Dolly Varden	232	500	188.3
All	719.9		

Appendix A. There are additional areas of the watershed with extensive distribution of resident salmonids (e.g., upstream of Snoqualmie Falls, upper Tokul Creek, upper SF Tolt, Sultan River upstream of Culmback Dam, upper Wallace River drainage, upper Woods Creek, etc.), although resident salmonid distribution is not directly considered in this report.

Annual precipitation in WRIA 7 ranges from 35 inches in the lower watershed to 180 inches near the Cascade Mountain crest. A large portion of the Snohomish River watershed drains high-elevation areas of the Cascade Mountains, with spring and early summer snowmelt strongly influencing streamflow patterns in the basin (Pentec 1999). All of the major rivers draining high-elevation lands, including the Skykomish, Snoqualmie, and Snohomish rivers, feature two distinct periods of high monthly flows: high streamflow resulting from winter streamflow occurs in the months of November, December, and January; high monthly flows resulting from high elevation snowmelt occurs during the months of May and June. The mountain snowpack plays a strong role in controlling summer low flow conditions. Annual low flows occur at almost all stream gauges in August, because most of the snowmelt runoff has occurred and very little rainfall typically occurs in July and August. Low-flow basins, such as the Raging River and other small lowland streams, do not benefit from high elevation snowpack. Peak flows in these streams are typically associated with winter storms from October through March, and then decrease to the low point in August (Chamblin).

Data included in this report include formal habitat inventories or studies specifically directed at evaluating fish habitat, other watershed data not specifically associated with fish habitat evaluation, and personal experience and observations of the watershed experts who participated in the TAG. The analysis of habitat conditions in the Snohomish River watershed (WRIA 7) and associated action recommendations are based on these data. Although many of the habitat data/observations in this report may not meet the highest scientific standard of peer reviewed literature, they should nevertheless be considered as valid, as they are based on the collective experience of the watershed experts who are actively working in these drainages. Although there are a significant number of past studies and reports on these watersheds, a large number of salmonid habitat "data gaps" remain, which will require additional specific watershed research or evaluation.

Although some of the historic actions that led to the dramatic decline in salmonid presence in the Snohomish River watershed have ceased or been reduced, and significant restoration efforts have been implemented to address some of these elements, there are numerous habitat-related problems remaining through the watershed that continue to limit salmonid productivity potential. These impacts include:

- Fish Access – Adult and juvenile salmonid access to historic spawning and rearing habitats is significantly impaired in many areas of the watershed by a variety of fish passage barriers (e.g., culverts, dams, dikes/levees, and water quality). Recent inventory efforts have substantially increased the knowledge base of the extent of fish passage barriers in the watershed. Various entities in the watershed have been aggressively working to correct identified fish passage barriers; however, numerous barriers remain. In addition, dikes and levees preclude or inhibit access to floodplain wetland habitats that could provide excellent rearing. Juvenile and adult salmonids are conveyed with floodwaters into areas behind many of the dikes/levees on an infrequent basis (Snohomish dikes/levees are designed to overtop at a 5-year flood +1 foot), but little resulting production may come from these areas due to low dissolved oxygen levels and other water quality problems that may preclude successful outmigration to the river. Some of the effects of lost salmonid production due to access constraints are masked by the establishment of anadromous access (July-December) beginning in 1958 to the entire SF Skykomish upstream of Sunset Falls. Sunset Falls was historically a natural anadromous barrier; anadromous passage has resulted in known/presumed anadromous salmonid/bull trout/Dolly Varden utilization of 72.9 miles (roughly 10% of the Snohomish basin-wide distribution) of historically inaccessible habitat. However, the intent of providing anadromous passage at Sunset Falls was to provide additional salmonid production, rather than to mitigate for losses elsewhere in the watershed. Correction of identified barriers would restore access to available salmonid habitat.

- Floodplain Modifications – Perhaps one of the most profound impacts to salmonid habitat in WRIA 7 has been the loss or impairment of floodplain function. Much of the historic production capacity is thought to have been associated with the vast presence of floodplain and estuarine wetlands. Bortelson et al. (1980) estimate there has been a 74% reduction in presence of floodplain wetlands, and a 32% loss of intertidal wetlands for the Snohomish River. Settlers drained and/or isolated ~3370 hectares of palustrine marsh in the Snohomish River floodplain upstream of Ebey Slough (Haas and Collins 2001). Diking and bank armoring have also contributed to a 2-kilometer decrease in total length of side channels and a 55% reduction in the area of side channel sloughs on the Snohomish River. There has also been a 40% loss of beaver pond area (not including habitat loss in vast floodplain areas). Extensive historical floodplain wetlands at Marshland and lower French Creek have been diked and drained, and no longer provide salmonid habitat. Estimates of lost chinook and coho production capacity associated with the loss of floodplain habitat are 40-61% and 50%, respectively (Haas and Collins 2001). There are concerns with the methodology and accuracy of these estimates, but there does not appear to be any disagreement that the loss of Snohomish floodplain and estuarine function has severely affected salmonid production capacity. Floodplain function has also been severely impaired or lost further upstream on the mainstem rivers and on tributaries by conversion of historical stream associated wetlands to agriculture, and increasing recent conversion of these areas to commercial/residential development. In addition, floodplain function has been severely impaired by ditching and channelization, particularly in agricultural areas and along roads, to improve drainage of naturally wet areas. The cumulative loss of wetlands in these areas has not been estimated, but is likely very significant. Drainages where floodplain wetland connectivity remains relatively intact (e.g., Griffin Creek, Carpenter Creek, Dubuque/Panther Creek, Little Pilchuck Creek) typically produce significantly larger numbers of coho than drainages where floodplain function has been significantly altered.
- Channel Conditions – The loss of channel complexity, cover, bank stability, and presence of pools has adversely affected spawning and rearing habitat. Channel condition and complexity have been dramatically altered through most of the watershed by channelization, loss of large woody debris (LWD) and associated pools, and by loss of bank stability and complexity due to a variety of land use practices. LWD presence is critical to creating habitat diversity, cover, pools, and collecting and retaining sediment

and gravels. Much of the historical LWD was removed from the Snohomish, Snoqualmie, and lower Skykomish Rivers to improve navigation in the late 1800s-early 1900s. LWD recruitment potential is severely impaired in these areas by presence of dikes and levees. LWD is generally absent from most low floodplain areas of mainstem rivers and tributaries, particularly where the streams have been extensively managed through agricultural areas and along roads; LWD recruitment potential in these areas is poor in most locations due to lack of woody riparian vegetation and active removal of any wood that does fall into the creeks. LWD presence is also poor in streams in forested areas, particularly where there has been active forest management, due to stream cleanout and past harvest of riparian trees. Although current LWD condition may be poor in many of these streams, there is potential for future recruitment potential due to recent changes in federal and non-federal forest management.

- Substrate Conditions – Gravel substrate quality is adversely affected by increased presence of fines (<0.85mm) and loss of suitable spawning gravels, affecting spawning success and benthic productivity. Gravel substrates are impaired in many areas of the watershed by significant presence of fine sediments, typically associated with development, agricultural, and forestry land uses. Typical loss of coarse sediment (gravel) transport associated with dams does not appear to be a current limiting factor at Culmback Dam on the Sultan River; the loss of gravel transport downstream of the dam on the SF Tolt has been compensated to some extent by high landslide activity downstream of the dam (Parametrix 2001), but a coarsening of the substrate in the SF Tolt has been observed since 1992 (Nelson).
- Riparian Conditions – Riparian function is integral to the structural stability, diversity, and water quality elements of fish habitat. Impaired riparian function throughout much of the watershed has resulted in increased water temperature, loss of bank stability, loss of instream cover, and loss of LWD recruitment to streams. Riparian function has been severely impaired throughout much of the basin by removal of riparian vegetation; by construction of dikes/levees, roads, etc. that preclude riparian vegetation growth; by channel incision, and channelization that lower the water table in riparian areas; and by altered hydrology that affects the stability and integrity of streambanks. Because of the importance of riparian function to salmonid habitat, it is of critical importance to initiate protection/restoration of riparian function, as some of the key riparian attributes (e.g., LWD recruitment) may not be realized for 80-120 years.
- Water Quality – Salmonids require cool, clean water for effective spawning and rearing. Increased water temperatures in the mainstem and many tributaries affect habitat suitability for spawning and rearing, and also increase suitability for predator species that are known to prey on juvenile salmonids. High water temperatures are identified as a concern in mainstem and tributary areas, typically associated with impaired riparian function. Past limiting factor concerns of low dissolved oxygen levels in the estuary, associated with wood processing mill waste disposal, were corrected in 1975 and are no longer considered as a key problem. However, low dissolved oxygen may be adversely affecting salmonid survival in some estuarine sloughs and tributaries elsewhere in the watershed, particularly upstream of drainage district pump plants (e.g., lower French Creek, Marshland, Swan Trail Slough, etc.) and in areas with high nutrient input (often associated with unrestricted livestock access).
- Water Quantity – Salmonids require suitable instream flows at specific times of the year for effective spawning, incubation, and rearing. The key identified concerns related to water quantity in WRIA 7 are instream water withdrawals, altered hydrology associated with increased impervious surfaces, and altered hydrology from increased rain-on-snow runoff. Several subwatersheds are identified as potentially being at increased

susceptibility to effects from groundwater withdrawals, particularly in areas that are experiencing increased commercial/residential development, although there was insufficient information to determine the extent of impacts. The major water withdrawals in the watershed are the City of Snohomish withdrawal from the Pilchuck River, the City of Everett withdrawals from the upper end of Ebey Slough and the Sultan River, and the Seattle City Light withdrawal from the SF Tolt River. Flow modeling estimates that modification of the seasonal withdrawal pattern associated with the water right transfer would generate negligible physical change in the river flow characteristics of the estuary (Metzgar). The Tulalip Tribes are concerned that the impacts of the withdrawal on Ebey Slough have not been adequately assessed (Nelson), and have appealed the issuance of the water right change (hearing scheduled December 20, 2002 in Thurston County Superior Court). Mitigation associated with the withdrawals on the Sultan and SF Tolt has resulted in reduced peak flows and increased low summer flows downstream of the dams; any outstanding concerns related to instream flows in the Culmback Dam to diversion dam reach on the Sultan River can be considered through the FERC relicensing discussions. The Pilchuck River withdrawal is of concern as it reduces summer low flows downstream of the diversion dam, although effects to salmonid production have not been assessed; there are also fish passage concerns associated with the dam. Natural hydrology has been altered in several of the watersheds within WRIA 7 (e.g., Quilceda and Allen Creek watersheds), the result of increased impervious surfaces from development that result in increased stormwater runoff. The increased frequency and magnitude of peak flows affects streambank and channel habitat integrity. The associated reduction in infiltration of stormwater and loss of wetland function result in a significant reduction in summer base flows, adversely affecting those species that reside in freshwater for an extended period prior to outmigration. Development regulations need to ensure that the natural hydrologic regime is maintained. Adverse impacts have also been identified for several streams (e.g., Beckler River) in the upper forested portions of WRIA 7, where forest harvest has resulted in increased runoff during rain-on-snow events. Most of the hydrologic analyses to date have been unable to detect significant changes associated with timber harvest in the rain-on-snow zone, but there seems to be consensus recognition that adverse effects have occurred. Forest harvest reductions, particularly on Forest Service Lands, should reduce any rain-on-snow associated impacts over time.

- Lakes – There is one large natural lake (Lake Stevens) and hundreds of small lakes in WRIA 7. The primary salmonid habitat concerns associated with lakes in WRIA 7 are the extent of shoreline hardening and number of overwater structures, and lake level management control that affects flows downstream of the lake. Although shoreline hardening and number of overwater structures are identified as concerns in many lakes (e.g., Lake Stevens, Panther/Flowing/Storm lakes), the extent of effects to salmonid production have not been assessed. Similarly, lake level control in some lakes (e.g., Bosworth Lake, instream pond on Purdy Creek) may adversely affect summer baseflows downstream of the lake/pond, but extent of effects to salmonid production have not been assessed.
- Biological Processes –The return of marine-derived nutrients (particularly nitrogen and phosphorous) from salmon carcasses provides an important nutrient source to the oligotrophic waters and riparian areas in the higher elevations of the watershed. WRIA 7 is fortunate to have healthy returns of anadromous salmonid spawners, particularly coho salmon. However the ability to retain marine-derived nutrients in the headwater reaches of the subwatersheds in WRIA 7 may be compromised by the limited presence of LWD and pools in many streams, potentially resulting in carcasses being washed out of the headwater areas. This concern can be addressed by restoring bank and instream habitat

diversity and complexity. Another concern that affects salmonid production, particularly in those subwatersheds that have associated wetland rearing habitat on the Snohomish/Snoqualmie River floodplain, is the presence of invasive fish species in many of these sloughs and wetlands. These invasive species (e.g., bass) are voracious predators, and may be causing significant mortality on rearing juvenile salmonids and outmigrating smolts. No effective control solutions are identified at this time. Even if control/elimination of invasive species were possible in any specific area, the area would likely repopulate as a result of frequent valley-wide floods.

Despite the extensive impacts that have occurred to fresh and marine water habitats in WRIA 7, and the large number of fair, poor, or data gap habitat ratings that exist throughout the area, there are a number of reasons to be optimistic regarding the future of salmonid habitat and productivity in WRIA 7. The Snohomish River watershed (WRIA 7) remains as one of the primary producers of anadromous salmonids and bull trout/ Dolly Varden in the Puget Sound region. However, it is clear that current salmonid habitat conditions, and associated salmonid productivity, could be significantly improved throughout the watershed. Historic salmonid production is estimated to have been substantially greater than that experienced in recent history. The opportunities for habitat protection and restoration in WRIA 7 are greater than in the more developed Puget Sound watersheds to the south. Many of the watersheds are in agricultural or forest management areas, and are not yet locked in place by commercial and residential development. These areas typically offer the greatest habitat protection/restoration potential. However, habitat restoration in other smaller streams should also be actively considered, as they contribute to the overall productivity of WRIA 7, and cumulatively contribute significant overall salmonid production. Several of the more urbanized streams in WRIA 7 have significant salmonid habitat potential, as they are either located in wooded ravines, or have been developed with setbacks that maintain habitat function. Restoration of estuarine and nearshore habitat is also critical, as these habitats are actively utilized by all salmonid species and stocks originating in WRIA 7, as well as stocks originating from other Puget Sound WRIAs. Given the development pressures being experienced in the watershed, the risks to salmonid habitat are great, and it is critical that land use regulations be developed and implemented in a manner that maintains the integrity of salmonid habitat. Increased anadromous salmonid and bull trout/Dolly Varden populations in recent years offer a snapshot of the potential benefits from salmon recovery efforts to date, and should provide incentive to increase habitat protection and restoration efforts throughout the watershed. There is extensive salmonid habitat restoration potential and opportunity remaining. Information in this report can assist in identifying, prioritizing, and implementing salmonid habitat restoration efforts in WRIA 7.

Prioritized habitat action recommendations are provided for each stream in which salmonid presence has been identified, following the discussion of identified salmonid habitat concerns. Those action recommendations at the top of the list are considered to provide greater restoration benefit potential than those towards the bottom of the list, or those on the top of the list may need to be done first to better ensure the effectiveness of those further down the list. The TAG did not prioritize or rank between watersheds on the basis of salmonid productivity potential resulting from habitat restoration. There is general support for the tenets of 1) protect the best remaining habitat, 2) restore those habitat areas that are still functioning, and 3) restore severely impaired non-functioning habitat where feasible. However, strict adherence to these tenets may preclude consideration of high benefit restoration projects in certain watersheds. Habitat restoration projects should be reviewed on their own merits, and the projects prioritized/ranked on the basis of their anticipated benefit to protecting/restoring salmonid production. Habitat protection/ restoration project proposal ranking should consider whether the project addresses the cause of an identified habitat limiting factor, where the project type ranks in the prioritized action recommendations list for that stream, how the project complements other protection/restoration actions, and how the project complements identified habitats needing protection. Project ranking should also consider projects where willing landowners and partnerships can increase the effectiveness/efficiency of the restoration project. Habitat conditions vary between different reaches of a stream; restoration proposals should consider the potential benefits of the proposal in relation to habitat conditions likely to be encountered elsewhere in the watershed.

Protection/restoration of salmonid resources cannot be accomplished by watershed habitat restoration projects alone. It is unlikely that we will be able to resolve the salmon predicament using the same land management approaches that got us into it. We will need to look at the watershed with a clear new vision. Salmonid recovery will require a combination of efforts, including:

- land use regulations alone will not be effective; habitat restoration and resource protection will also require landowner commitment, participation, and stewardship
- revision, implementation, and enforcement of land use ordinances that provide protection for natural ecological processes in the instream, and riparian corridors
- protection of instream and riparian habitat that is currently functioning, particularly key habitat areas, and
- restoration of natural instream and riparian ecological processes where they have been impaired.

This report provides information that can and should be used in the development of salmonid habitat protection and restoration strategies. It should be considered a living document, with additional habitat assessment data and habitat restoration successes incorporated as information becomes available.

THE RELATIVE ROLE OF HABITAT IN HEALTHY POPULATIONS OF NATURAL SPAWNING SALMON

During the last 10,000 years, Washington State salmon populations have evolved in their specific habitats (Miller, 1965). Water chemistry, flow, and the physical stream components unique to each stream have helped shape the characteristics of each salmon population, which has resulted in a wide variety of distinct salmon stocks for each salmon species throughout the State. Within a given species, stocks are units that do not extensively interbreed because returning adults rely on a stream's unique chemical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, thus maintaining the distinctiveness of each stock.

Throughout the salmon's life cycle, the dependence between the stream and a stock continues. Adults spawn in areas near their own origin because survival favors those that do. The timing of juveniles leaving the river and entering the estuary is tied to high natural river flows. It is thought that the faster speed during out-migration reduces predation on the young salmon and perhaps is coincident to favorable feeding conditions in the estuary (Wetherall, 1972). These are a few examples that illustrate how a salmon stock and its environment are intertwined throughout the entire life cycle.

Salmon habitat includes the physical, chemical and biological components of the environment that supports salmon. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, channel physical features, riparian zones, sediment regime, upland conditions, and ecosystem interactions as they pertain to habitat. However, these components closely intertwine. Low stream flows can alter water quality by increasing temperatures and decreasing oxygen levels. The riparian zone interacts with the stream environment, providing nutrients and a food web base, large woody debris for habitat and flow control (stream features), filtering water prior to stream entry (water quality), sediment control and bank stability, and shade to aid in temperature control.

Salmon habitat includes clean, cool, well-oxygenated water flowing at a normal (natural) rate for all stages of freshwater life. In addition, salmon survival depends upon specific habitat needs for the different life history stages, which include egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, ocean rearing, adult migration to spawning areas, and spawning. These specific needs can vary by species and even by stock.

When adult salmon return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to their natal grounds. They need deep pools for resting with vegetative cover and instream structures such as rootwads for shelter from predators. Successful spawning depends on sufficient gravel of the right size for that particular population, in addition to the constant need of adequate flows and water quality, all in unison at the necessary location. Delayed upstream migration can be critical. After entering freshwater, most salmon have a limited time to migrate and spawn, in some cases, as little as two to three weeks. Delays can result in pre-spawning mortality or spawning in a sub-optimum location.

After spawning, the eggs need stable gravel that is not choked with sediment. River channel stability is vital at this life history stage for all species of salmonids. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities that alter stream hydrology. In a natural river system, the upland areas are forested, and the trees and their roots store precipitation, which slows the rate of storm water into the stream, lessening the impact of a potential flood. The natural, healthy river is sinuous and contains numerous large pieces of wood contributed by an intact, mature riparian zone. Both reduce the energy of water moving downstream. Natural systems have floodplains that are connected directly to the river at many points, allowing wetlands to store flood water and later discharge this storage back to the river during lower flows. This not only decreases flood impacts, but also recharges fish habitat later when flows are low. In a healthy river, erosion or sediment input is great enough to provide new gravel for spawning and incubation, but does not overwhelm the system, raising the riverbed and increasing channel instability. Lastly, a natural river system allows floodwaters to freely flow over unaltered banks rather than constraining the energy within the channel, scouring out salmon eggs. A stable egg incubation environment is essential for all salmon, and is a complex function of nearly all habitat components.

Once the young fry leave their gravel nests, certain species such as chum, pink and some chinook salmon quickly migrate downstream to the estuary. Other species, such as coho, steelhead, bulltrout, and chinook, will search for suitable rearing habitat within the side sloughs, side-channels, spring-fed "seep" areas, as well as the outer edges of the stream. These quiet-water side margin and off-channel slough areas are vital for early juvenile habitat. The presence of woody debris and overhead cover aid in food and nutrient inputs as well as provide protection from predators. For most of these species, juveniles use this type of habitat in the spring. Most sockeye salmon populations quickly migrate from their gravel nests to larger lake environments where they have unique habitat requirements. These include water quality sufficient to produce the necessary complex food web to support one to three years of salmon growth in that lake habitat prior to outmigration to the estuary.

As growth continues, the juveniles (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bull trout/Dolly Varden, and certain chinook. For some of these species, this movement is coincident with the summer low flows. Low flows constrain salmon production for stocks that rear within the stream. In non-glacial streams, summer flows are maintained by precipitation, connectivity to wetland discharges, and groundwater inputs. Reductions in these inputs will reduce the amount and quality of habitat; hence the number of salmon from these species.

In the fall, juvenile salmon that remain in freshwater begin to move out of the mainstems, and again, off-channel habitat becomes important. During the winter, coho, steelhead, bull trout/Dolly Varden, and remaining chinook need habitat to sustain their growth and protect them from predators and winter flows. Wetlands, off-channel habitat, undercut banks, rootwads, and pools with overhead cover are important habitat components during this time.

Except for bull trout/Dolly Varden and resident steelhead, juvenile parr convert to smolts as they migrate downstream towards the estuary. Again, flows are critical, and food and shelter are necessary. The natural flow regime in each river is unique, and has shaped the population's characteristics through adaptation over the last 10,000 years. Because of the close inter-relationship between a salmon stock and its stream, survival of the stock depends on natural flow patterns, particularly during migration times.

The estuary provides an ideal area for rapid growth, and some salmon species are heavily dependent on estuaries, particularly chinook, chum, and to a lesser extent, pink salmon. Estuaries contain new food sources to support the rapid growth of salmonid smolts, so adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. Also, the processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as lack of woody debris and sediment transport.

All salmonid species need adequate flow, similar water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a river are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by distance.

Chum and pink salmon use the streams the least amount of time. Washington State adult pink salmon typically begin to enter the rivers in August and spawn in September and October, although Dungeness summer pinks enter and spawn a month earlier (WDFW and WWTIT, 1994). During these times, low flows and associated high temperatures and low dissolved oxygen can be problems. Other disrupted habitat components, such as a shallow and less frequent pools due to elevated sediment inputs and lack of canopy from an altered riparian zone or widened river channel, can worsen these flow and water quality problems because there are fewer refuges for the adults to hold prior to spawning.

The pink salmon fry emerge from their gravel nests in February to April, and migrate downstream to the estuary within a month. After a limited rearing time in the estuary, pink salmon migrate to the ocean for a little over a year, until the next spawning cycle. Most pink salmon stocks in Washington are only in the rivers in odd years. The exception is the Snohomish Basin, which supports two pink salmon stocks. One stock spawns in odd years, and the other stock spawns in even years.

In Washington, adult chum salmon (3-5 years old) have three major run types. Summer chum enter the rivers in August and September, and spawn in September and October. Fall chum adults enter the rivers in late October through November, and spawn in November and December. Winter chum enter from December through January and spawn from January through February. Chum salmon fry emerge from the nests in March and April, and quickly outmigrate to the estuary for rearing. In the estuary, juvenile chum follow prey availability. In Hood Canal, juveniles that arrive in the estuary in February and March migrate rapidly offshore. This migration rate decreases in May and June as levels of zooplankton increase. Later as the food supply dwindles, chum move offshore and switch diets (Simenstad and Salo, 1982). Both chum and pink salmon have similar habitat needs such as unimpeded access to spawning habitat, a stable incubation environment, favorable downstream migration conditions (adequate flows in the spring), and because they rely heavily on the estuary for growth, good estuary habitat is essential.

Chinook salmon have three major run types in Washington State. Spring chinook are in their natal rivers throughout the calendar year. Adults begin river entry as early as February in the Chehalis Basin, but in Puget Sound, entry doesn't begin until April or May. Spring chinook spawn from July through September and typically spawn in the headwater areas where higher gradient habitat exists. Incubation continues throughout the autumn and winter and generally requires more time for the eggs to develop into fry because of the colder water temperatures in the headwater areas. Fry begin to leave the gravel nests in February through early March. After a short rearing period in the shallow side margins and sloughs, all Puget Sound and coastal spring chinook stocks have a component of the juvenile population that begin to leave the rivers to the estuary over the next several months, lasting until August. Within the Puget Sound stocks, it is not uncommon for other juveniles to remain in the river for another year before leaving as yearlings, so that a wide variety of outmigration strategies are used by these stocks. The juveniles of spring chinook stocks in the Columbia Basin exhibit more distinct juvenile life history characteristics. Generally, these stocks remain in the river for a full year. However, some stocks migrate downstream from their natal tributaries in the fall and early winter into larger rivers, including the mainstem Columbia River, where they are believed to over-winter prior to outmigration the next spring as yearling smolts.

Summer chinook begin river entry as early as June in the Columbia, but not until August in Puget Sound. They generally spawn in September or October. Fall chinook stocks range in spawn timing from late September through December. All Washington State summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March, and downstream migration to the estuaries occurs over a broad time period (January through August). A few of these stocks have a component of juveniles that remains in freshwater for a full year after emerging from the gravel nests.

While some emerging chinook salmon fry outmigrate quickly, most inhabit the shallow side margins and side channels for up to two months. Then, some gradually move into the faster areas to rear, and others outmigrate to the estuary. Most summer and fall chinook outmigrate within their first year of life, but a few stocks (Snohomish summer chinook, Snohomish fall chinook, upper Columbia summer chinook) have juveniles that remain in the river for an additional year, similar to many spring chinook (Marshall et al, 1995). However, those in the upper Columbia, have scale patterns that suggest that they rear in a reservoir-like environment (mainstem Columbia River upstream from a dam) rather than in their natal streams and it is unknown whether this is a result of dam influence or whether it is a natural pattern.

The onset of coho salmon spawning is tied to the first significant fall freshet (Chuck Baranski, WDFW, personal communication). Adults typically enter freshwater from September to early December, but have been observed as early as late July and as late as mid-January (WDF et al, 1993). They often mill near the river mouths or in lower river pools until freshets occur. Spawning usually occurs between November and early February, but is sometimes as early as mid-October and can extend into March. Spawning often occurs in tributaries and sedimentation in these tributaries can be a problem, with fine sediments suffocating eggs and excess coarse sediment decreasing channel stability. As chinook salmon fry exit the shallow low-velocity rearing areas, coho fry enter the same areas for the same purpose. As they grow, juveniles move into faster water and disperse into tributaries and areas that adults cannot access (Neave 1949). Pool habitat is important not only for returning adults, but for all stages of juvenile development. Preferred pool habitat includes deep pools with riparian cover and woody debris.

All coho juveniles remain in the river for a full year after leaving the gravel nests, but during their first summer after hatching, low flows can lead to problems such as physical reduction of available habitat, increased stranding, decreased dissolved oxygen, increased water temperature, and increased predation. Juvenile coho are highly territorial and can occupy the same area for a long period of time (Hoar, 1958). Coho abundance can be limited by the number of available suitable territories (Larkin, 1977). Streams with more structure (logs, bushes, etc.) support more coho (Scrivener and Andersen, 1982), not only because they provide more territories, but they also provide more food and cover. There is a positive correlation between their primary diet of insect material in their stomachs and the extent to which the stream was overgrown with vegetation (Chapman, 1965). In addition, the leaf litter in the fall contributes to aquatic insect production (Meehan et al., 1977).

In the autumn as the temperatures decrease, juvenile coho move into deeper pools, and hide under logs, tree roots, and undercut banks (Hartman, 1965). The fall freshets redistribute them (Scarlett and Cederholm, 1984), and over-wintering generally occurs in available side channels, spring-fed ponds, and other off-channel sites to avoid winter floods (Peterson, 1980). The lack of side channels and small tributaries may limit coho survival (Cederholm and Scarlett, 1981). As coho juveniles grow into yearlings, they become more predatory on other salmonids. Coho begin to leave the river a full year after emerging from their gravel nests with the peak outmigration occurring in early May. Coho use estuaries primarily for interim food while they adjust physiologically to saltwater.

Sockeye salmon have a wide variety of life history patterns, including landlocked populations of kokanee that never enter saltwater. Of the populations that migrate to sea, adult freshwater entry varies from spring for the Quinault stock, summer for Ozette and Columbia River stocks, and summer and fall for Puget Sound stocks. Spawning ranges from September through February, depending on the stock.

After fry emerge from the gravel, most migrate to a lake for rearing, although a few types of fry migrate to the sea. Lake rearing ranges from one to three years with most juveniles rearing two years. In the spring after lake rearing is completed, juveniles enter the ocean where more growth occurs prior to adult return for spawning.

Sockeye spawning habitat varies widely. Some populations spawn in rivers (Cedar River) while other populations spawn along the beaches of their natal lake (Ozette), typically in areas of upwelling groundwater. Sockeye also spawn in side channels and spring-fed ponds. The spawning beaches along lakes provide a unique habitat that is often altered by human activities, such as pier and dock construction, dredging, sedimentation, and weed control.

Steelhead have one of the most complex life history patterns of any Pacific salmonid species (Shapovalov and Taft, 1954). In Washington, there are two major run types, winter and summer steelhead. Winter steelhead begin river entry in a mature reproductive state in December and generally spawn from February through May. Summer steelhead enter the river from about May through October with spawning from about February through April. They enter the river in an immature state and require several months to mature (Burgner et al, 1992). Summer steelhead usually spawn farther upstream than winter stocks (Withler, 1966) and dominate inland areas such as the Columbia Basin. Coastal streams support more winter steelhead populations.

Juvenile steelhead can either migrate to sea (anadromy) or remain in freshwater as rainbow trout. In Washington, those that are anadromous usually spend one to three years in freshwater, with the greatest proportion spending two years (Busby et al, 1996). Because of this and their year-round presence in steelhead-bearing streams, steelhead greatly depend on the quality and quantity of freshwater habitat.

Bull trout/Dolly Varden stocks are also very dependent on the freshwater environment, where they reproduce only in clean, cold, relatively pristine streams. Within a given stock, some adults remain in freshwater their entire lives, while others migrate to the estuary where they rear during the spring and summer. They then return upstream to spawn in late summer. Those that remain in freshwater either stay near their spawning areas as residents, or migrate upstream throughout the winter, spring, and early summer, residing in pools. They return to spawning areas in late summer. In some stocks juveniles migrate downstream in spring, overwinter in the lower river, then enter the estuary and Puget Sound the following late winter to early spring (WDFW, 1998). Because these life history types have different habitat characteristics and requirements, bull trout/Dolly Varden are generally recognized as a sensitive species by natural resource agencies. Reductions in their abundance or distribution are inferred to represent strong evidence of habitat degradation.

In addition to the above-described relationships between various salmon species and their habitats, there are also interactions between the species that have evolved over the last 10,000 years such that the survival of one species might be enhanced or impacted by the presence of another. Pink and chum salmon fry are frequently food items of coho smolts, Dolly Varden char, and steelhead (Hunter, 1959). Chum fry have decreased feeding and growth rates when pink salmon juveniles are abundant (Ivankov and Andreyev, 1971), probably the result of occupying the same habitat at the same time and competing for food items. These are just a few examples.

Most streams in Washington are home to several salmonid species, which together, rely upon freshwater and estuary habitat the entire calendar year. As the habitat and salmon review indicated, there are complex interactions between different habitat components, between salmon and their habitat, and between different species of salmon. For just as habitat dictates salmon types and production, salmon production contributes to habitat and to other species.

INTRODUCTION

The quantity and quality of aquatic habitat present in any stream, river, lake or estuary is a reflection of the existing physical habitat characteristics (e.g. depth, structure, gradient, etc) as well as the water quality (e.g. temperature and suspended sediment load). There are a number of processes that create and maintain these features of aquatic habitat. In general, the key processes regulating the condition of aquatic habitats are the delivery and routing of water (and its associated constituents such as nutrients), sediment, and large woody debris (LWD). These processes operate over the terrestrial and aquatic landscape. For example, climatic conditions operating over very large scales can drive many habitat forming processes while the position of a fish in the stream channel can depend upon delivery of wood from forest adjacent to the stream. In addition, ecological processes operate at various spatial and temporal scales and have components that are lateral (e.g., floodplain), longitudinal (e.g., landslides in upstream areas) and vertical (e.g., riparian forest).

The effect of each process on habitat characteristics is a function of variations in local geomorphology, climatic gradients, spatial and temporal scales of natural disturbance, and terrestrial and aquatic vegetation. For example, wood is a more critical component of stream habitat than in lakes, where it is primarily an element of littoral habitats. In stream systems, the routing of water is primarily via the stream channel and subsurface routes whereas in lakes, water is routed by circulation patterns resulting from inflow, outflow and climatic conditions.

Human activities degrade and eliminate aquatic habitats by altering the key natural processes described above. This can occur by disrupting the lateral, longitudinal, and vertical connections of system components as well as altering spatial and temporal variability of the components. In addition, humans have further altered habitats by creating new processes such as the actions of exotic species. The following sections identify and describe the major alterations of aquatic habitat that have occurred and why they have occurred. These alterations are discussed as limiting factors.

Discussion of Habitat Limiting Factor Elements

Fish Passage Barriers

Salmon are limited to certain spawning and rearing locations by natural features of the landscape. These features include channel gradient and the presence of physical features of the landscape (e.g. logjams). Flow can affect the ability of some landscape features to function as barriers. For example, some waterfalls may be impassable at low flows, but then become passable at higher flows. In some cases, flows themselves can present a barrier, such as when extreme low flows occur in some channels; at higher flows fish are not blocked. Flow conditions may also allow accessibility to some anadromous salmonid species, while precluding access to others.

Throughout Washington, barriers have been constructed that have restricted or prevented juvenile and adult fish from gaining access to formerly accessible habitat. The most obvious of these barriers are dams and diversions with no passage facilities that prevent adult salmon from accessing historically used spawning grounds. Culverts are often full or partial fish passage barriers; delayed fish passage during certain flow conditions can be equally as detrimental as a total fish passage barrier. In addition, in recent years it has become increasingly clear that we have also constructed barriers that prevent juveniles from accessing rearing habitat. For example, dikes and levees have blocked off historically accessible side-channel rearing areas, and poorly designed culverts in streams have impacted the ability of juvenile salmonids to move upstream into rearing areas.

Functions of Floodplains

Floodplains are portions of a watershed that are periodically flooded by the lateral overflow of rivers and streams. In general, most floodplain areas are located in lowland areas of river basins and are associated with higher order streams. Floodplains are typically structurally complex, and are characterized by a great deal of lateral, aquatic connectivity by way of distributaries, sloughs, backwaters, side-channels, oxbows, and lakes. Often, floodplain channels can be highly braided (multiple parallel channels).

Properly functioning floodplains provide critical habitat. Aquatic habitats in floodplain areas can be very important for chinook and coho salmon juveniles that often over-winter and seek refuge from high flows in the sloughs and backwaters of floodplains. Floodplains also help dissipate water energy during floods by allowing water to escape the channel and inundate the terrestrial landscape, lessening the impact of floods on incubating salmon eggs. Floodplains also provide coarse beds of alluvial sediments through which subsurface flow passes. This acts as a filter of nutrients and other chemicals to maintain high water quality. Floodplains also provide an area for sediment deposition and storage, particularly for fine sediment, outside of the river channel, reducing the effects of sediment deposition and instability in the river channel.

Impairment of Floodplains by Human Activities

Large portions of the floodplains of many Washington rivers, especially those in the western part of the state, have been converted to urban and agricultural land uses. Many of the urban areas of the state are located in lowland floodplains, while land used for agricultural purposes is often located in floodplains because of the flat topography and rich soils deposited by the flooding rivers.

There are two major types of human impacts to floodplain functions. First, channels are disconnected from their floodplain. This occurs both laterally as a result of the construction of dikes and levees, which often occur simultaneously with the construction of roads, and longitudinally as a result of the construction of road crossings. This has: 1) eliminated off-channel habitats such as sloughs and side channels; 2) increased flow velocity during flood events due to the constriction of the channel; 3) reduced subsurface flows and groundwater contribution to the stream; and 4) simplified channels since LWD is lost and channels are often straightened when levees are constructed. Channels can also become disconnected from their floodplains as a result of down-cutting and incision of the channel from losses of LWD, decreased sediment supplies, and increased high flow events.

The second major type of impact is loss of natural riparian and upland vegetation. The natural riparian and terrestrial vegetation in floodplain areas was historically coniferous forest. Conversion of these forested areas to impervious surfaces, deciduous forests, meadows, grasslands, and farmed fields has occurred as floodplains have been converted to urban and agricultural uses. Riparian forests are typically reduced or eliminated as levees and dikes are constructed. Loss of vegetation on the floodplain reduces shading of water in floodplain channels, eliminates LWD contribution, reduces filtering of sediments, nutrients and toxics, and results in increased water energy during flood flows.

Elimination of off-channel habitats results in the loss of important habitats for juvenile salmonids. Side channels, sloughs and backwaters that are isolated from flooding impacts historically functioned as prime spawning habitat for chum, pink, and coho, and rearing and over-wintering habitat for chinook and coho juveniles. The loss of LWD from channels reduces the amount of rearing habitat available for chinook juveniles. Disconnection of the stream channels from their floodplain due to levee and dike construction increases water velocities, which in turn increases scour of the streambed. Salmon that spawn in these areas may have reduced egg to fry survival due to the scour. Removal of mature native vegetation from riparian zones can increase stream temperatures in channels, which can stress both adult and juvenile salmon. Sufficiently high temperatures can increase mortality.

Streambed Sediment

The sediments present in an ecologically healthy stream channel are naturally dynamic and are a function of a number of processes that input, store, and transport the materials. Processes naturally vary spatially and temporally and depend upon a number of features of the landscape such as stream order, gradient, stream size, basin size, geomorphic context, and hydrological regime. In forested mountain basins, sediment enters stream channels from natural mass wasting events (e.g. landslides and debris flows), channel bank erosion (particularly in glacial deposits), surface erosion, and soil creep. Natural input of sediment to stream channels in these types of basins occurs periodically during extreme climatic events such as floods (increasing erosion) and mass wasting. In lowland, or higher order streams, lateral erosion is the major natural sediment source. Inputs of sediment in these basins tend to be steadier in geologic time.

Once sediment enters a stream channel it can be stored or transported depending upon particle size, stream gradient, hydrological conditions, availability of storage sites, and channel type or morphology. Finer sediments tend to be transported through the system as wash load or suspended load, and have relatively little effect on channel morphology. Coarser sediments (>2 mm diameter) tend to travel as bedload, and can have larger effects on channel morphology as they move downstream, depositing through the channel network.

Some parts of the channel network are more effective at storing sediment, while other parts of the network are more effective at transporting material. There are also strong temporal components to sediment storage and transport, such as seasonal floods, which tend to transport more material. One channel segment may function as a storage site during one time of year and a transport reach at other times. In general, the coarsest sediments are found in upper watersheds while the finest materials are found in the lower reaches of a watershed. Storage sites include various types of channel bars and floodplain areas, and are often associated with LWD.

Effects of Human Actions on Sediment Processes

Changes in the supply, transport, and storage of sediments can occur as the direct result of human activities. Human actions can result in increases or decreases in the supply of sediments to a stream. Increases in sediment deposition in the channel result from increased erosion due to land use practices or isolation of the channel from the floodplain (due to presence of dikes or roads), which eliminate important off-channel storage areas for sediment and increase the sediment load beyond the transport capacity of the stream. In addition, actions that destabilize the landscape in high slope areas such as logging or road construction increase the frequency and severity of mass wasting events. Finally, increases in the frequency and magnitude of flood flows, and/or loss of floodplain vegetation, increase erosion. Increased erosion fills pools and aggrades the channel, resulting in reduced habitat complexity and reduced rearing capacity for some salmonids.

Increased total sediment supply to a channel increases the proportion of fine sediments in the bed, which can reduce the survival of incubating eggs in the gravel and change benthic invertebrate production.

Decreases in sediment supply occur in some streams, primarily as a result of disconnecting the channel from the floodplain. Dams typically block the supply of sediment from upper watershed areas while levees typically isolate the stream from natural upland sources of sediment. In addition, gravels are removed from streambeds to increase flow capacity (dredging) or for mineral extraction purposes. Reduction in sediment supply can alter the streambed composition, which can coarsen the substrate and reduce the amount of gravel substrate suitable for spawning.

In addition to affecting sediment supply, human activities can also affect the storage and movement of sediment in a stream. An understanding of how sediment moves through a system is important for determining where sediment will have the greatest effect on salmonid habitat and for determining which areas will have the greatest likelihood of altering habitats. In general, transport of sediment changes as a result of gradient, hydrology changes (water removal, increased peak flows, or altered timing and magnitude of peak flows), and isolation of the channel from its floodplain. Larger and more frequent flood flows move larger and greater amounts of material more frequently. This can increase bed scour and bank erosion, alter channel morphology, and ultimately degrade the quality of spawning and rearing habitat. Unstable channels become very dynamic and unpredictable compared to the relatively stable channels characteristic of undeveloped areas. Additional reductions in the levels of instream LWD can greatly alter sediment storage and processing patterns, resulting in increased levels of fines in gravels and reduced organic material storage and nutrient cycling.

Riparian Zone Functions

Stream riparian zones include the area of living and dead vegetative material adjacent to a stream. They extend from the edge of the ordinary high water mark of the wetted channel, upland to a point where the zone ceases to have an influence on the stream channel. Riparian forest characteristics in ecologically healthy watersheds are strongly influenced by climate, channel geomorphology, and where the channel is located in the drainage network. Large-scale natural disturbances (fires, severe windstorms, and debris flows) can dramatically alter riparian characteristics. These natural events are typically infrequent, with recovery to healthy riparian conditions for extended periods of time following the disturbance event. The width of the riparian zone and the extent of the riparian zone's influence on the stream are strongly related to stream size and drainage basin morphology. In a basin un-impacted by humans, the riparian zone would exist as a mosaic of tree stands of different acreage, ages (e.g. sizes), and species.

Riparian zone functions include providing hydraulic diversity, adding structural complexity, buffering the energy of runoff events and erosive forces, moderating temperatures, protecting water quality, and providing a source of food and nutrients. They are especially important as the LWD source for streams. LWD directly influences several habitat attributes important to anadromous species. In particular, LWD helps form and maintain the pool structure in streams, and provides a mechanism for sediment and organics sorting and storage upstream and adjacent to LWD formations. Pools provide a refuge from predators and high-flow events for juvenile salmon, especially coho that rear for extended periods in streams.

Effects of Human Activities on Riparian Zones

Riparian zones are impacted by all types of land use practices. Riparian functions are impaired by direct removal of riparian vegetation; by roads and dikes located adjacent to the stream channel; by road crossings, agricultural/livestock crossings, and timber yarding corridors that cross the stream channel; by unrestricted livestock grazing in the riparian zone; and by development encroachment into the riparian corridor. Further, riparian vegetation species composition can be dramatically altered when native trees are replaced by exotic species (e.g., shrubs, reed canarygrass), and where native coniferous riparian areas are converted to deciduous tree species. Deciduous trees are typically of smaller diameter than conifers and decompose faster than conifers, so they do not persist as long in streams and are vulnerable to being washed out by lower magnitude floods. Once impacted, riparian functions can take many decades to recover as forest cover regrows, and coniferous species colonize. It may take as long as 80-120 years to restore functional LWD contribution to the channel.

Changes to riparian zones affect many attributes of stream ecosystems. For example, stream temperatures can increase due to the loss of shade, while streambanks become more prone to erosion due to elimination of the trees and their associated roots. Perhaps the most important impact of riparian alteration is a decline in the frequency, volume, and quantity of LWD due to reduced recruitment from forested areas. Loss of LWD results in a significant reduction in the complexity of stream channels including a decline of pool habitat, which reduces the number of rearing salmonids. Loss of LWD affects the amount of both over-wintering and low flow rearing habitat, as well as providing a variety of other ecological functions in the channel.

Water Quantity

The hydrologic regime of a drainage basin refers to how water is collected, moved and stored. The frequency and magnitude of floods are especially important since floods are the primary source of disturbance in streams and thus play a key role in how channels are structured and function. In ecologically healthy systems, the physical and biotic changes caused by natural disturbances are not usually sustained, and recovery is rapid to pre-disturbance levels. If the magnitude of change is sufficiently large, however, permanent impacts can occur.

Alterations in basin hydrology are caused by changes in soils, decreases in the amount of forest cover, increases in impervious surfaces, elimination of riparian and headwater wetlands, and changes in landscape context. Hydrologic impacts to stream channels occur even at low levels of development (<2% impervious area) and generally increase in severity as more of the landscape is converted to from natural forest cover to more developed land uses.

Salmonid production is profoundly affected by water withdrawals for irrigation, industrial, and domestic use, including water transfers between basins. Removal of water, either directly from the stream channel or from wells that are in hydraulic continuity with stream flows, reduces the amount of instream flow and useable wetted area remaining for support of adult salmonid spawning and juvenile rearing. Reduction of instream flows also typically results in increased water temperature, often to levels that impair salmonid productivity. The relationship between the useable wetted area of a stream and stream flow varies between species and life stages. For example, juvenile coho prefer quiet water in pools for rearing, whereas juvenile steelhead prefer areas of faster water (Hiss and Lichatowich 1990). Streamflow limitations are typically greatest during the dry summer and early fall months when stream flows are lowest. In other instances stream flows may actually increase due to direct or indirect (irrigation ground water return flows) water transfers from other basins. In some instances peak flood flows may be transferred to basins that would otherwise not be affected by flood flows. These situations may increase the stream flow and useable wetted area for fish use, but the increased hydrology may cause channel bedload movement, bank erosion, loss of LWD, and other adverse habitat impacts that would not be experienced under the natural hydrology regime to which the channel is adapted.

Water Quality

Water quality affects productivity and survival of salmonids. There are several water quality parameters that affect salmonids, including water temperature, pH, dissolved oxygen, turbidity, nutrients, and toxic chemicals. Elevated water temperatures are typically associated with loss of mature riparian vegetation along the stream corridor, reduced instream flows during late summer resulting from water withdrawals, or from increased solar exposure to water impounded behind dams. Salmonids generally require a neutral pH; fish may be adversely affected by surface water with pH of 5.6 or less, and can also be adversely affected by high pH values (Spence et al. 1996). Dissolved oxygen levels are directly associated with water temperature, with saturation being higher in colder water. Turbidity refers to the presence of suspended sediment in the water column that may affect survival of eggs or fish. Stormwater runoff (particularly from roads), surface erosion, and increased streambank erosion are the main contributors of turbidity. Natural stream nutrient regimes have been altered. Natural nutrient cycling has been affected by low numbers of salmon carcasses due to reduced numbers of spawners returning to streams; by removal or alteration of riparian vegetation that reduces the entry of litter fall and invertebrates; by the lack of LWD in streams that slows the loss of nutrient sources from the stream; and by stormwater flows that flush available nutrients from the streams. In addition, hatchery salmon carcasses are often not returned to rivers and streams after the salmon are artificially spawned, reducing the cycling of marine-derived nutrients. Increased levels of nutrients result from stormwater runoff with high levels of nitrogen and phosphorus, and from failing septics and sewage treatment plant outfalls. High nutrient levels can lower dissolved oxygen levels in a waterbody. Public health districts regularly monitor for presence of fecal coliform bacteria. Elevated fecal coliform counts that do not meet Washington State water quality standards may result in closure of marine shellfish beds to harvest, but fecal coliform bacteria are not known to affect salmonid health or survival. However, elevated fecal coliform counts may be an indicator of other salmonid habitat problems (e.g., elevated nutrient levels, low dissolved oxygen, unrestricted cattle access to streams) in the watershed. There is far less water quality monitoring for presence of toxic chemicals. Sources of toxics of concern include toxic spills (e.g., oil, paint, pesticides.), runoff from roads/parking lots, exposure of the stream or marine water to treated wood, leaching of pesticides, and leaching of heavy metals.

Estuarine Habitat

Anadromous salmonids are affected by the freshwater habitat conditions described above, but are also affected by habitat conditions in the estuary, as well as in the ocean. Worldwide, few other habitats are so valuable for fish production and yet are so imperiled as estuaries. Estuaries include the area from the uppermost extent of tidal influence within the stream to the upper intertidal line on the delta face. Their abundant food supply, wide salinity gradients, and diverse habitats make these areas particularly valuable to anadromous fish for rearing, feeding, and osmoregulatory acclimation during transition between fresh water and marine habitats (Macdonald et al 1987). The vital role estuaries play in chum salmon ecology is well documented (Walters et al. 1978; Healy 1980A, Levy and Northcote 1982). Other species of salmonids that also inhabit estuaries, sometimes in high densities, include coho (Tschaplinski 1982, Mason 1974, Miller and Simenstad 1997, Nielsen 1994, Hiss 1994), sockeye (Healy 1980A), pinks (Hiss 1994), and chinook (Levy and Northcote 1982, Healy 1980A, Healy 1980B, Congleton et al

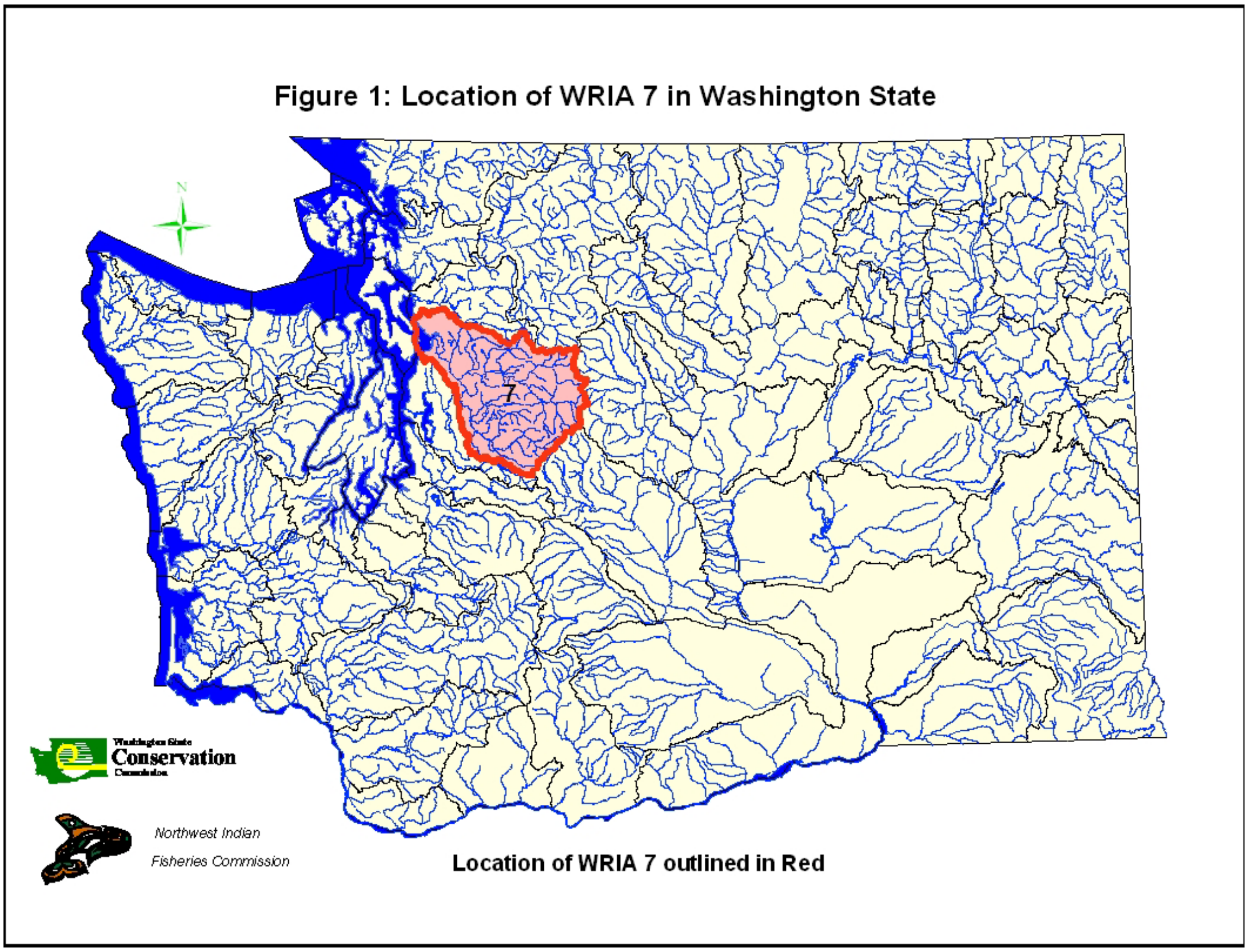
1981, Shreffler et al 1992). According to Levy and Northcote (1982), significant estuary rearing by chum and chinook fry on the Fraser River Delta extends even into tidal channels that are dewatered during normal low tides. In the Skagit River estuary, Beamer and LaRock (1998) found high densities of chinook, chum, and smelt inhabiting a salt marsh tidal channel (Browns Slough) that was not associated with any freshwater stream. Also found in Browns Slough were coho smolts and adult cutthroat trout engorged on smelt. Juvenile chinook have been documented in at least two Puget Sound estuarine salt marshes not associated with chinook spawning streams - Shine Creek on the Olympic Peninsula (Lichatowich 1993) and Seabeck Creek on the Kitsap Peninsula (Hirschi, personal communication). The spawning of Pacific herring, an important forage fish for salmonids, has been documented in Willapa Bay and Grays Harbor estuarine salt marshes, but the presence or importance of Pacific herring has not been assessed in Strait of Juan de Fuca estuaries

WATERSHED DESCRIPTION

Location and Watershed Characteristics

The Snohomish River watershed, draining 1980 mi^2 west of the Cascade Crest, is the second largest river basin draining to Puget Sound (Pentec and NW GIS 1999)(see location of watershed in Figure 2). Elevations in the watershed range from sea level to 8,000 feet (Gersib et al. 1999). The watershed includes three major rivers, the Skykomish, the Snoqualmie, and the Snohomish, which flow west through broad, glaciated lowland valleys and enter Puget Sound near Everett. These rivers and their tributaries support significant runs of anadromous salmonids, including coho, chinook, chum, and pink salmon, and steelhead trout. The Snohomish River watershed is also a major source of municipal water for Everett, southwest Snohomish County, Seattle, Bellevue, and other cities and areas in King County (Pentec and NW GIS 1999).

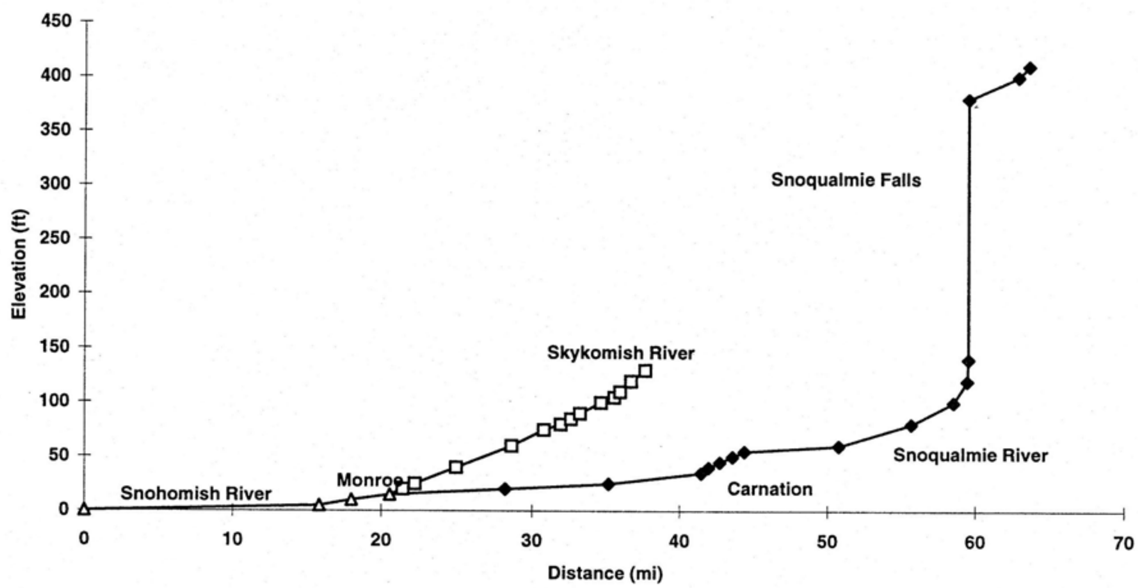
Figure 2: Location of the Snohomish River watershed (WRIA 7) in Washington State



The Snoqualmie and Skykomish rivers originate in tertiary granitic rock to the east, and flow west through glacially-influenced valleys and gently rolling Puget Lowland before draining into Puget Sound (Gersib et al. 1999). Sediment transport and channel behavior along the Snohomish River system are dominated by the effects of the landforms and deposits left by glaciers and the meltwater streams that drained from them (Dunne 1980, as cited in Gersib et al. 1999).

The Skykomish River drains 842 mi^2 and is the largest drainage in the Snohomish River Basin (Gersib et al. 1999). Some tributaries begin high in the Cascade Mountains, such as glacially fed streams draining Mount Hinman and Mount Daniel (Pentec and NW GIS 1999). The upper Skykomish is confined by bedrock. The gradient of the mainstem Skykomish River is considerably greater than that of either the mainstem Snohomish or Snoqualmie rivers (Figure 3). The Skykomish River transports an estimated annual bedload and suspended sediment load of 21,000 yd^3/yr (Collins and Dunne 1991). However, the reach from the confluence of the North and South forks is sediment-limited, consequently eroding terraces along the river. The reach between Startup and Sultan is a response reach, with sediment deposition and wide channel braiding. The reach from Sultan to Monroe acts as a transport reach, with sediment supply and transport in apparent equilibrium; dikes in this section of the river artificially alter the sediment transport regime. Sediment deposition dominates between Monroe and the confluence with the Snoqualmie River. This stretch of the Skykomish is considered to be unstable, as indicated by its frequent channel changes (Collins and Dunne 1987, as cited in Gersib et al. 1987).

Figure 3: Stream profile for mainstem Snohomish, Skykomish, and Snoqualmie rivers (from Pentec and NW GIS 1999)



The relatively steep gradient and high sediment loads in the Skykomish River produce large amounts of excellent spawning habitat for chinook and steelhead (Pentec and NW GIS 1999). In addition, its many side channels and alcoves provide rearing and refuge habitat. Because the river is very powerful, woody debris effectively creates habitat only by forming debris jams. Habitat conditions are strongly influenced by summer flows due to the wide active channel and high sediment load; significantly more habitat is available in side-channels and backwaters during high summer flows.

The Snoqualmie River drains the southern 694 mi^2 portion of the Snohomish River Basin, and flows over a relatively unconfined alluvial floodplain (Gersib et al. 1999). The major tributaries and branches of the Snoqualmie River also begin high in the Cascade Mountains, but none of these streams are fed by glaciers (Pentec and NW GIS 1999). Snoqualmie Falls, a bedrock protrusion, divides the Snoqualmie into two segments. The Snoqualmie River below the falls is a low-gradient, partially confined, meandering river. Above the falls, the Snoqualmie River is also partially confined, but the stream gradient is much greater. Unlike the Skykomish River, the Snoqualmie River transports little gravel (Collins and Dunne 1990, Booth et al. 1991, both as cited in Gersib et al. 1999), due to retention of most of the bedload upstream of Snoqualmie Falls (Booth et al. 1991, as cited in Gersib et al. 1999). The majority of sediment deposition occurs in the SF Snoqualmie and mainstem Snoqualmie downstream of the confluence of the North and Middle Forks.

Salmon spawning habitat in the lower Snoqualmie River (downstream of the falls) is naturally limited because of its low gradient and limited areas of gravel (Pentec and NW GIS 1999). Mainstem spawning occurs in only a few locations: the gravel riffles at the confluences of the Tolt and Raging rivers, and a section of channel below Snoqualmie Falls. Chinook spawning is concentrated in these areas and in the lower Raging and Tolt rivers, but during low-flow years, these tributaries are little utilized. Most coho and steelhead spawning occurs in the tributary rivers and streams.

The Snohomish River drains 332 mi^2 and flows through the lower 21 miles of the river basin (Gersib et al. 1999). The Snohomish River can be divided into two morphologic reaches: 1) the Snohomish River delta, located between the tidally-influenced Ebey Slough and Possession Sound; and 2) the floodplain reach, located between the confluence of the Skykomish and Snoqualmie rivers and Ebey Slough. The Snohomish River is tidally influenced as far upstream as the confluence with the Pilchuck River. Both the delta and floodplain reaches of the Snohomish River have low and relatively consistent gradients. However, sediment originating from the Skykomish River has initiated deposition and increased channel gradient near the confluence of the Skykomish and Snoqualmie rivers. In general, the Snohomish River is an unconfined river with tortuous meanders on the floodplain (Pentec and NW GIS 1999).

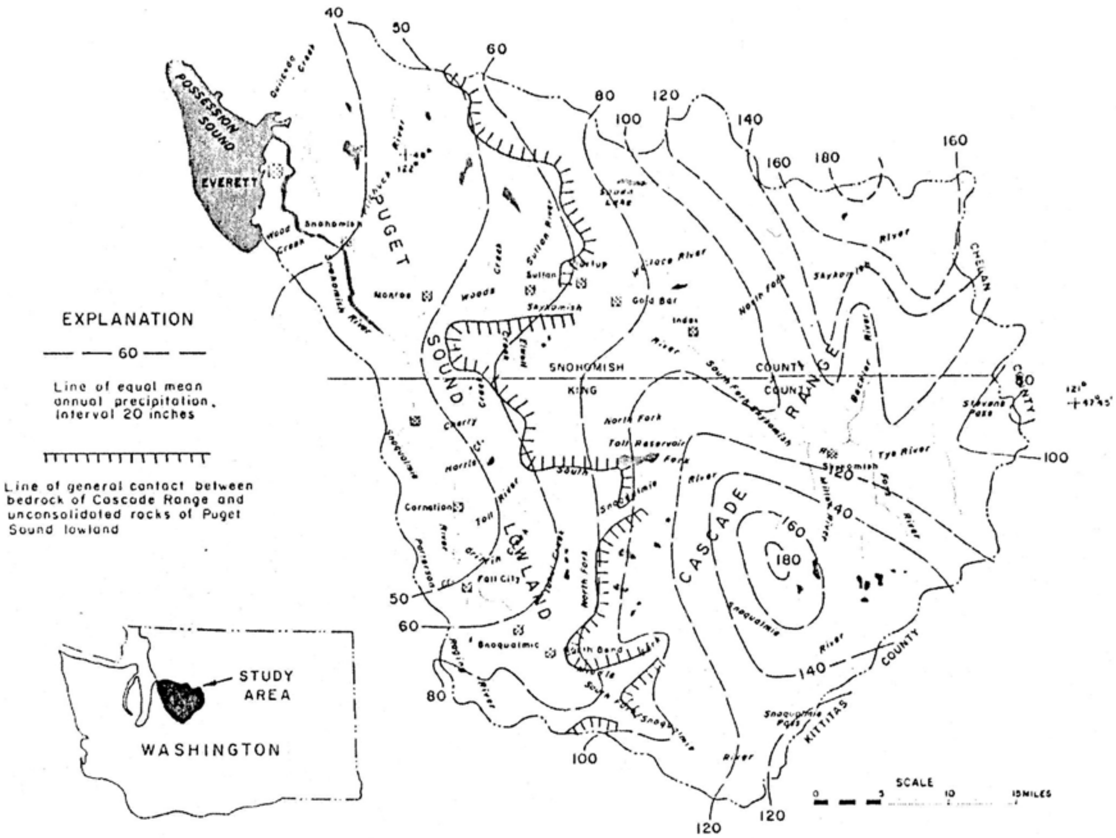
The upper Snohomish River, below the confluence of the Skykomish and Snoqualmie rivers, features gravel bars, gravel riffles, deep pools, side channels, and backwater eddies, all of which provide excellent salmonid habitat (Pentec and NW GIS 1999). Where the gradient decreases just upstream of Snohomish, the river becomes much quieter and develops a channel bottom composed of sands and silts. This section of the channel has been highly impacted by diking and farming, and it currently serves mainly as a transport corridor between the estuary and the rivers above.

Climate/Hydrology

The Snohomish River Basin has a temperate marine climate with cool wet winters and warm dry summers (Gersib et al. 1999). Precipitation is not evenly distributed, primarily due to the Cascade Mountain front; precipitation ranges from 35 to 180 inches/year, with an average of 87 inches. The lowest annual precipitation occurs near Possession Sound and is dominated by rain. The greatest annual precipitation falls as snow near Mount Hinman and Mount Daniel (Nelson 1971, as cited in Gersib et al. 1999)(Figure 4).

A large portion of the Snohomish River watershed drains high-elevation areas of the Cascade Mountains, with spring and early summer snowmelt strongly influencing streamflow patterns in the basin (Pentec and NW GIS 1999). All of the major rivers draining high-elevation lands, including the Skykomish, Snoqualmie, and Snohomish rivers, feature two distinct periods of high monthly flows: high streamflow resulting from winter streamflow occurs in the months of November, December, and January; high monthly flows resulting from high elevation snowmelt

Figure 4: Precipitation isopleths for WRIA 7 (from Pentec and NW GIS 1999, after Nelson 1971)



occurs during the months of May and June. The mountain snowpack plays a strong role in controlling summer low flow conditions. Annual low flow occurs at almost all stream gauges in August, because most of the snowmelt runoff has occurred and very little rainfall typically occurs in July and August. Low-flow basins, such as the Raging River and other small lowland streams, do not benefit from high elevation snowpack. Peak flows in these streams are typically associated only with stormwater runoff from September through January, and then decrease to the low point in August.

Geology (from Gersib et al. 1999)

In general, the Cascade Mountains in the Snohomish River Basin are underlain by granite, granadorite, tonalite, intrusive igneous rocks 5-40 million years old, and small amounts of andesite and basalt volcanic rocks 5-30 million years old. The volcanic rocks cover older (>40 million years old) sedimentary and metamorphic rocks.

Bedrock units in the Snohomish River watershed are covered by thin soils (Nelson 1971, Debose and Klungland 1983), and do not contain significant fracture systems (Turney et al. 1995). These bedrock areas are not an important source of runoff control and groundwater storage because they lack soil mantles and extensive fracture networks that provide opportunity for infiltration of rain and snowmelt (Turney et al. 1995).

Continental and alpine glaciation during the past 2 million years sculpted much of the topography in the Snohomish basin. Alpine glaciers carved the deep U-shaped valleys of the Skykomish, Tolt, and upper Snoqualmie rivers. Continental glaciation left behind thick sequences of glacial deposits and carved a deep, fjord-like trough below the mainstem Snoqualmie River (Turney et al. 1995). This trough is thought to be more than 1,000 feet deep (Newcomb 1952) and is filled with both glacial and interglacial sediments. Only the bedrock outcrop at Snoqualmie Falls interrupts the continuous sediment-filled trough.

The Puget Lobe of the Cordilleran Ice Sheet advanced and retreated several times across the Snohomish River watershed between 1.6 million and 13,500 years ago (Armstrong et al. 1965, Clague et al. 1980, Blunt et al. 1987, Booth 1987). This pattern of glacial advance and retreat is well-recorded in the sediments filling the Snoqualmie River; however, only deposits from the last interglacial period and the last advance of the Puget Lobe are well-documented. The interglacial deposits are referred to as the Olympia gravels. The last glacial advance of the Fraser glaciation, known as the Vashon Stade, deposited the Vashon advance outwash, the Vashon till, and the Vashon recessional outwash. The Olympia gravels and the Vashon advance outwash are frequently separated by the fine-grained sediment laid down in a large proglacial lake that formed ahead of the advancing Puget Lobe.

Land Use

Land uses in the Snohomish River watershed are strongly associated with physical geographic features (Pentec and NW GIS 1999). Private and federal forest lands and federal wilderness areas in the Cascades constitute 74% of the watershed area. Agricultural lands dominate the flat floodplains of the Snoqualmie and Snohomish rivers and account for about 5% of the watershed area. Rural residential development is scattered throughout the floodplains and surrounding plateaus. Urban lands are concentrated in Everett and Marysville (at the mouth of the Snohomish River), and in smaller cities located along the rivers up to the Cascade Mountains.

DISTRIBUTION AND CONDITION OF SALMON, STEELHEAD, AND BULL TROUT/DOLLY VARDEN STOCKS

General

The mainstem and tributary habitats of WRIA 7 support summer/fall chinook, chum, pink (even- and odd-year), coho, summer and winter steelhead, and bull trout/Dolly Varden, as well as cutthroat (resident and sea-run), rainbow trout, mountain whitefish, and other resident non-salmonids. Specific fish distribution mapping efforts have been conducted for chinook, chum, pink, coho, and steelhead; fish distribution maps for these species are included inthis report. Prior fish distribution mapping for these species included the 1995 Snohomish Salmonid Distribution Mapping Workshop (1:24k map products produced by Libby Halpin-Nelson, Tulalip Tribes), 1998 Conservation Reserve Enhancement Program (CREP) mapping (1:100k map products based primarily on review of Streamnet distribution by Curt Kraemer (WDFW) and Kurt Nelson (Tulalip Tribes)(CREP distribution was available only from the original working maps, the product was not digitized), and Streamnet (1:100k map product maintained by WDFW, based primarily on input only from WDFW staff). Unfortunately, each of these mapping efforts looked at fish distribution from a slightly different perspective, involved input from different sources, and ended up with fish distribution map products that agreed for some species and streams, but disagreed for many species/stream combinations. Distribution differences between these mapping efforts were identified on a composite working map, and additional streams with identified distribution in the WDFW Spawner Survey Database were added. This work product was then reviewed at a workshop on March 22, 2002, and a separate followup meeting with Washington Trout. These meetings attempted to resolve disparities between prior efforts, and add additional observations since those prior efforts. The fish distribution presented in Appendix A and the separate Map files included with this report include input and review from:

Kirk Anderson	King County DNRP
Chuck Baranski	WDFW
Kurt Beardslee	Washington Trout
Hans Berge	King County DNRP
Mike Chamblin	WDFW
Susan Cierebiej	WDFW
Chris Dietrich	WDFW
Jamie Glasgow	Washington Trout
Andy Haas	Snohomish County SWM
Don Hendrick	WDFW
Rich Johnson	WDFW
Curt Kraemer	WDFW
Randy Middaugh	Snohomish County Public Works
Mike Nelson	Snohomish County
Kurt Nelson	Tulalip Tribes
Tony Opperman	WDFW
Anne Savery	Tulalip Tribes
Frank Staller	Washington Trout
Dave Ward	Snohomish County SWM
Mark Wenger	WDFW

Distribution mapping for bull trout/Dolly Varden is more recent, with spawning and rearing distribution based primarily on data compiled by Curt Kraemer (WDFW); presumed rearing distribution extent in WRIA 7 mirrors the expanded coho distribution (known and presumed).

Stream index numbering and River Mile designations are based on *A Catalog of Washington Streams and Salmon Utilization, Volume 1-Puget Sound* (Williams et al. 1975, copy of the WRIA 7 portion of Williams et al. (1975) included for reference in separate Stream Catalog file with this report). There are a number of streams that are shown on the maps in the catalog that were not assigned index numbers, or additional streams that were not even shown on the maps in the catalog, where salmonid species presence has been documented. These streams are designated on the species distribution maps, and are identified in the supporting data in Appendix A with stream index numbers with alpha suffixes (e.g., 07.0940C). Location references are also included in the Comments column for the alpha-suffix streams, using Williams et al. (1975) as the reference base.

Table 3 summarizes the miles of salmonid distribution extent in WRIA 7 as presented on the species distribution maps, by species and cumulatively for all species. Known distribution includes all habitat downstream of the uppermost observation of a species observation (juvenile or adult). Presumed distribution includes suitable habitat upstream of a known observation that has not been surveyed for presence, but where one would expect to find that species. A third category of distribution is "presumed floodplain" presence. Due to the frequency and extent of flooding of the mainstem valley floodplains, particularly in the Snoqualmie and Snohomish river floodplains, there is significant potential for adult (particularly coho, chum, steelhead, and bull trout/Dolly Varden) and juvenile (particularly coho, steelhead, and bull trout/Dolly Varden) salmonids to enter floodplain channels, which would otherwise be inaccessible behind dikes and levees. In addition, the fish distribution maps include very limited extent of Historic/Potential presence. Historic/Potential presence includes areas of known historic presence upstream of anthropogenic caused barriers or channel alterations that preclude current anadromous salmonid utilization. Historic/Potential presence is likely underrepresented due to lack of knowledge of historic channel routing in areas where hydrology has been highly modified (e.g., Marshland). It is also important to recognize that all anadromous salmonid presence upstream of Sunset Falls, on SF Skykomish River, is artificial, the result of a trap and haul operation initiated in 1958 by the Washington Department of Fisheries.

Table 3: WRIA 7 fish distribution extent (miles)

Species	Known	Presumed	Presumed Floodplain
Chinook	314.1	10.7	253.4
Chum	225.5	38.3	255.8
Pink	248.8	19.1	257.2
Coho	686.6	41.7	183.8
Steelhead	447.4	32	240.4
Bull trout/Dolly Varden	232	500	188.3
All	719.9	NA	NA

WRIA 7 known salmon, steelhead and bull trout/Dolly Varden distribution (all species combined) are identified on Map 1 (in the separate Map file included with this report). Supporting data for the fish species distribution represented on Map 1 are included in the fish distribution reference data table included in Appendix A. Individual species distributions for chinook, chum, pink, coho, steelhead, and bull trout/Dolly Varden are represented in Maps 2-7 (in the separate Map files included with this report). Adult and juvenile salmonid distribution is limited by natural and human-caused migration barriers, but may also be significantly influenced by reduced numbers of returning spawning adults (the extent of stream area utilized may decrease as adult or juvenile fish abundance declines), or by impaired habitat conditions that do not provide suitable spawning or rearing conditions. Most current distribution knowledge is based on contemporary stock assessment work (since 1965-1970), and likely represents a more confined distribution than occurred historically, when habitat and fish populations were healthier.

All salmonid species spawn in fresh water upstream from the estuary. Adult salmonids (of different species) may return to fresh water during every month of the year, and spawning times vary by species and stock (Table 4). There is also considerable variation between species and stocks in the juvenile length of residence in freshwater and estuaries (Table 4).

Table 4: Snohomish River salmon stock run timing and juvenile freshwater residence (from Pentec and NW GIS 1999)

Species (Run)	Time of Adult Return	Spawning Season	Time in Freshwater	Estuarine Residence Time
Summer Chinook	June-July	Late Sept-Nov	90-180 days	April-July
Fall Chinook	Aug-Sept	Fall	90-180 days	April-July
Coho	Aug-Nov	Oct-Dec	1 year	March-May
Chum	Sept-March	Sept-March	0-30 days	April-June
Pink	Aug-Sept	Sept-Oct	0-7 days	April-June
Winter Steelhead	Nov-April	Jan-June	2-3 years	March-May
Summer Steelhead	May-Oct	Jan-June	2 years	March-May
Sea-run Cutthroat	Dec-June	Dec-June	1-4 years	Jan-Oct
Bull Trout/Dolly Varden	April-Aug	Sept-Oct	2-3 years	March-May

Chinook

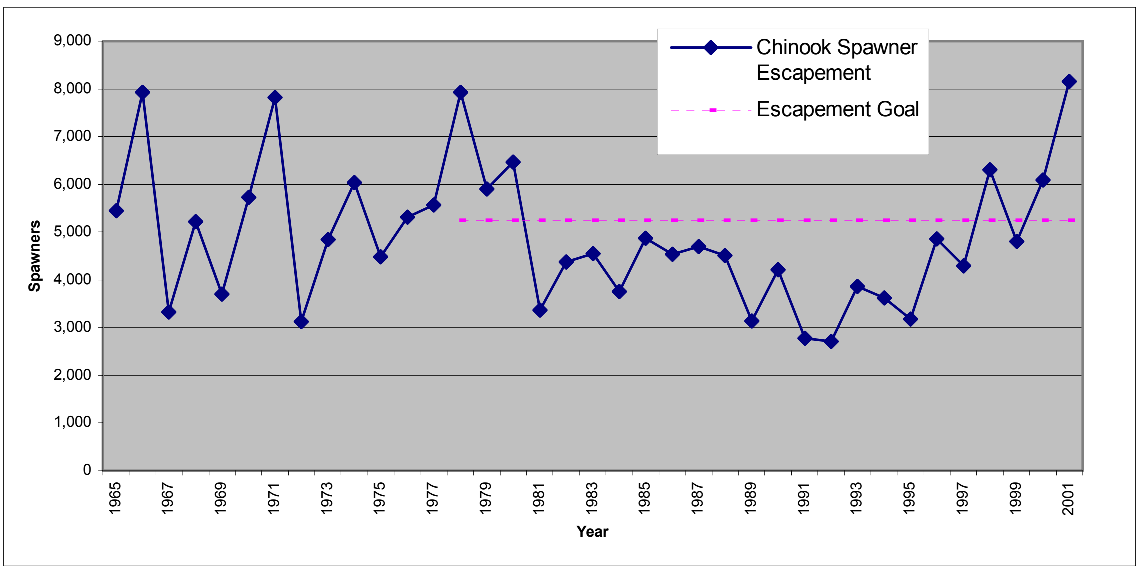
The Salmon and Steelhead Stock Inventory (SASSI)(WDFW and WWTIT 1994) identified four distinct stocks of chinook in WRIA 7: Snohomish River summer chinook, Wallace River summer/fall chinook, Snohomish River fall chinook, and Bridal Veil Creek fall chinook. The four Snohomish basin chinook stocks originally described in SASSI have been reorganized into two stocks--Skykomish and Snoqualmie--following the chinook population delineation used by the Puget Sound Technical Recovery Team (Puget Sound TRT 2001). Chinook salmon distribution is presented in Appendix A and in Map 2 (in the separate Map file included with this report).

The Skykomish chinook stock combines the Snohomish summer, Wallace summer, and Bridal Veil Creek fall chinook stocks and a portion of the Snohomish fall chinook stock. Skykomish chinook were identified as a stock based on their distinct spawning distribution and genetic composition (Puget Sound TRT 2001). Spawning occurs mainly from September through October, and takes place throughout the mainstem Skykomish and Snohomish rivers. Spawning also occurs in the Wallace River, Bridal Veil Creek, Sultan River, Pilchuck River, Woods Creek, Quilceda Creek, Elwell Creek, and in the North and South Fork Skykomish including fish passed above Sunset Falls. Stock status is rated **Depressed** in 2002 because of chronically low escapements.

The Snoqualmie chinook stock is composed of fish from the 1992 SASSI Snohomish fall chinook stock that spawn in the Snoqualmie River and its tributaries. Total spawner escapement estimates are based on total redd counts for the basin conducted on the mainstem Snoqualmie, Tolt, and Raging rivers as well as Tokul Creek. From 1965 to 1976, the period that was used to establish the basin-wide escapement goal of 5,250 spawners, the average escapement for the Snoqualmie population was 733. For the last five years, the average escapement has been 2,037. Based on this average and an increasing abundance trend since 1995, the status of the Snoqualmie stock is rated **Healthy**.

The two individual Snohomish chinook stocks are managed as a single unit, with an escapement goal for natural spawners of 5,250/year. Chinook spawner escapements since 1965 are presented in Figure 5. The composite spawner escapement goal of 5,250 (established in 1978) has been achieved in only 6 of the 24 years since 1978. Spawner escapements dropped below the goal of 5,250 in 1981, dropped as low as 2,708 in 1992, and did not exceed the goal again until 1998. The goal has been exceeded in 3 of the last 4 years, with a spawner escapement of 8,161 in 2001.

Figure 5: Chinook salmon spawner escapements to WRIA 7 (courtesy of WDFW)

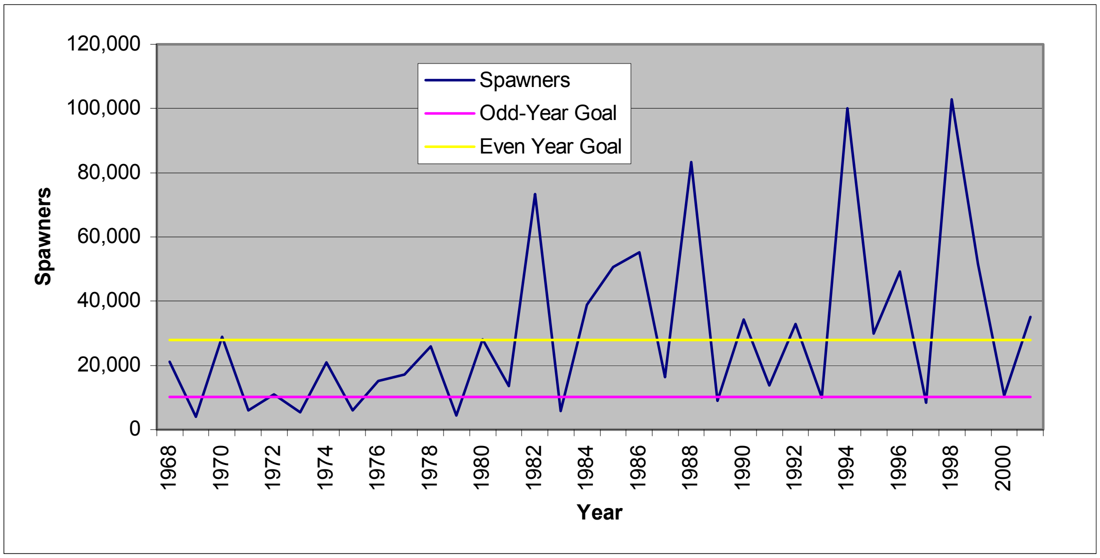


Fall Chum

SASSI (WDFW and WWTIT 1994) tentatively identifies 3 distinct fall chum stocks in WRIA 7. These include the Skykomish, Snoqualmie, and Wallace stocks. Fall chum salmon distribution is presented in Appendix A and in Map 3 (in the separate Map file included with this report). These individual stocks are managed as a single unit, with an escapement goal for natural spawners of 28,000/year for even years and 10,200/year for odd years. Adult entry timing of chum salmon in the Snohomish is probably similar to that in other northern Puget Sound rivers, primarily October through December, with the peak around early to mid-November. Spawning occurs during November through December, with the peak in early to mid-December.

Spawner count data for the Snohomish watershed extends back to 1968, although the quality of escapement data is thought to be better subsequent to a tagging study conducted in 1977. Annual spawner escapement of chum salmon to the Snohomish watershed since 1977 has ranged from 4,400 (1979) to 51,600 (1999) for odd-numbered years, and from 25,900 (1978) to 102,900 for even-numbered years (Figure 6). Since 1977, the spawner escapement goal has been met or exceeded for 9 of the 13 odd-years, and for 10 of 12 even-years. The difference in run size and associated spawner escapement ranges between odd- and even-numbered years may be due to competition with pink salmon, which are present in much greater numbers in odd years than in even years.

Figure 6: Fall chum salmon spawner escapements to WRIA 7 (courtesy of WDFW)



The Skykomish chum stock is separated from other chum stocks geographically (WDFW and WWTIT 1994). Spawn timing in the Skykomish and tributaries is during November and December, with the peak in early to mid-December. The geographic distribution of spawners includes the mainstem Skykomish River from below Monroe (RM 24.0) upstream to at least Proctor Creek (RM 42.0). The heaviest spawning concentrations are in the braided side channels from below Sultan to upstream of Goldbar. Additional spawning occurs in the Wallace and Sultan rivers, Woods Creek, and other tributaries, although the Wallace chum are tentatively considered to be a separate stock. Small numbers of chum are trapped and hauled upstream of Sunset Falls, but the location and success of spawning is unknown. Pilchuck River chum are tentatively included with Skykomish chum, pending further investigation. Skykomish chum are considered to be of native origin, and are genetically similar to Wallace chum. Stock status is designated as **Healthy**, based on trends in spawning escapement levels.

The Snoqualmie chum stock is separated from other chum stocks geographically (WDFW and WWTIT 1994). Chum salmon spawning in the Snoqualmie is poorly documented, but has been observed during December in a side channel near Fall City (RM 36.0) and in the Tolt River, and is likely to occur at other locations. Snoqualmie chum are considered to be of native origin, genetic similarity to other populations has not been determined. Stock status is designated as **Unknown**; numbers of spawners are believed to be small, as incidental reports of chum in the Snoqualmie and tributaries are few.

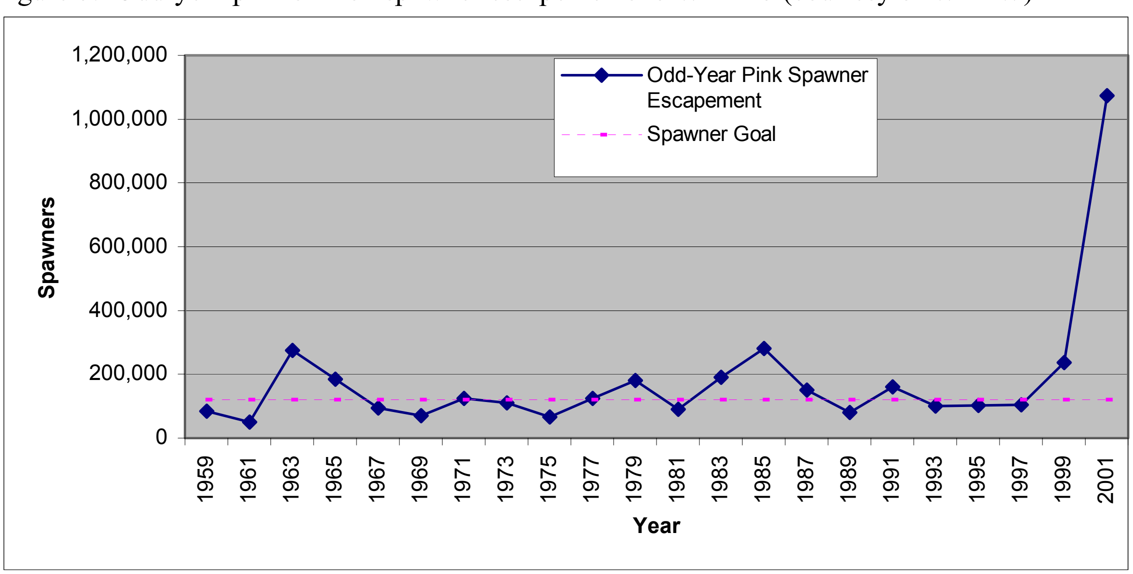
The Wallace chum stock is separated from other chum stocks geographically (WDFW and WWTIT 1994).). Spawn timing in the Wallace River and tributaries is during November and December, with the peak in late-November to earl-December. The geographic distribution of spawners includes the Wallace River to RM 6.7, and in several tributaries. Wallace chum are considered to be of native origin, but may be hybrids resulting from introduction of Grays Harbor chum (1916-1920) and Hood Canal chum (late 1970s) into the Wallace via the Skykomish Hatchery. Genetic analysis has shown that Wallace chum are genetically distinct from other Puget Sound stocks, although Wallace and Skykomish chum are similar. Stock status is designated as **Healthy**, based on trends in spawning escapement.

Pink

Snohomish pink salmon are geographically separated from all other Puget Sound pink stocks (WDFW and WWTIT 1994). Pink salmon distribution is presented in Appendix A and in Map 4 (in the separate Map file included with this report). SASSI identifies two pink salmon stocks: odd- year spawners and even-year spawners. Snohomish pink salmon are managed as a single unit, with an escapement goal for natural spawners of 120,000/year for odd years and 30,000/year for even years. The odd-year stock spawns from mid-September through October throughout the drainage in all accessible mainstem waters and larger tributaries. The even-year stock spawns primarily in September in the mainstem Snohomish and in the lower reaches of the Skykomish. Genetic evidence indicates that the odd-year stock is distinct from, but closely related to other northern Puget Sound pink stocks. The even-year stock is very different from all known Puget Sound pink stocks. The odd-year stock is presumed to be native with only negligible hatchery influence, whereas the even-year stock may be native, or may be a hybrid of native and historically introduced fish. Stock status for the odd-year stock is designated as **Healthy**. Spawner escapements for the even-year stock are low (<6,100), but stock status is designated as **Healthy**, based on trends in spawner escapement.

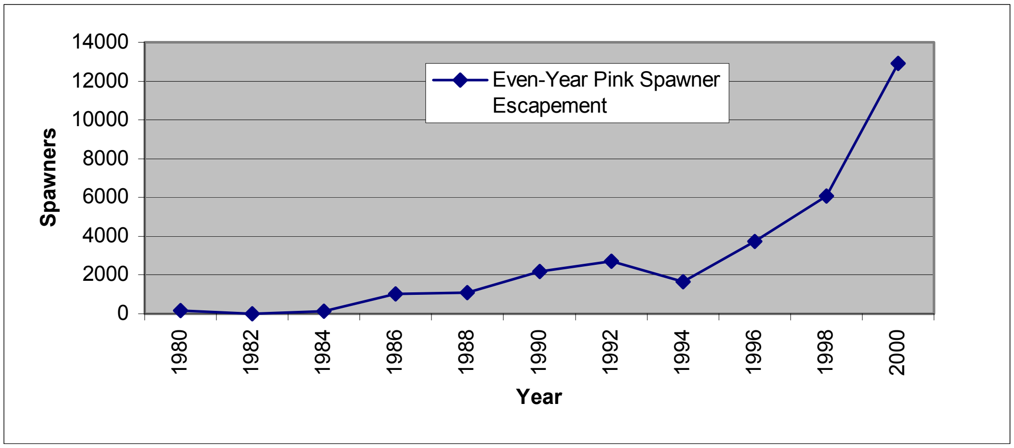
Pink salmon spawner count data for the Snohomish watershed extends back to 1959 for odd-years and to 1980 for even years. The odd-year estimated spawner escapement of pink salmon to the Snohomish watershed has ranged from 50,000 (1961) to 1.1 million (2001)(Figure 7). The odd-

Figure 7: Odd-year pink salmon spawner escapements to WRIA 7 (courtesy of WDFW)



year escapement goal of 120,000 has been met or exceeded in 11 of the 22 odd-years since 1959. The even-year estimated spawner escapement of pink salmon to the Snohomish watershed has ranged from 151 (1980) to 12,900 (2000), and has been steadily increasing since initiation of even-year spawner counts in 1980 (Figure 8).

Figure 8: Even-year pink salmon spawner escapements to WRIA 7 (courtesy of WDFW)



Coho

Coho salmon utilize almost all of the accessible tributaries in the Snohomish watershed. SASSI (WDFW and WWTIT 1994) identifies four coho stocks in WRIA 7: Snohomish coho, Skykomish coho, SF Skykomish coho, and Snoqualmie coho. Coho salmon distribution is presented in Appendix A and in Map 5 (in the separate Map file included with this report). Because there are no genetic data and no significant timing differences or unique biological characteristics among these stocks, their distinction is based primarily on geographic spawning separation. These individual stocks are managed as a single unit, with an escapement goal for natural spawners of 70,000/year. Adult entry timing of coho salmon in the Snohomish is September and October, with spawning occurring from late October through January, with some variation among streams and among years within streams.

The Snohomish coho stock spawns in the large and small tributaries downstream of the confluence of the Skykomish and Snoqualmie rivers, including Quilceda and Allen creeks, the Pilchuck River, French Creek, etc. The Snohomish stock is likely a mixture of native and introduced non-native stocks. Snohomish coho stock status was rated **Depressed** in 1992 SASSI due to a several-year decline in the escapement indicator data. This trend was reversed in the mid-1990s, with escapements that were higher than those observed prior to 1992. Consequently, the stock is rated **Healthy** in 2002.

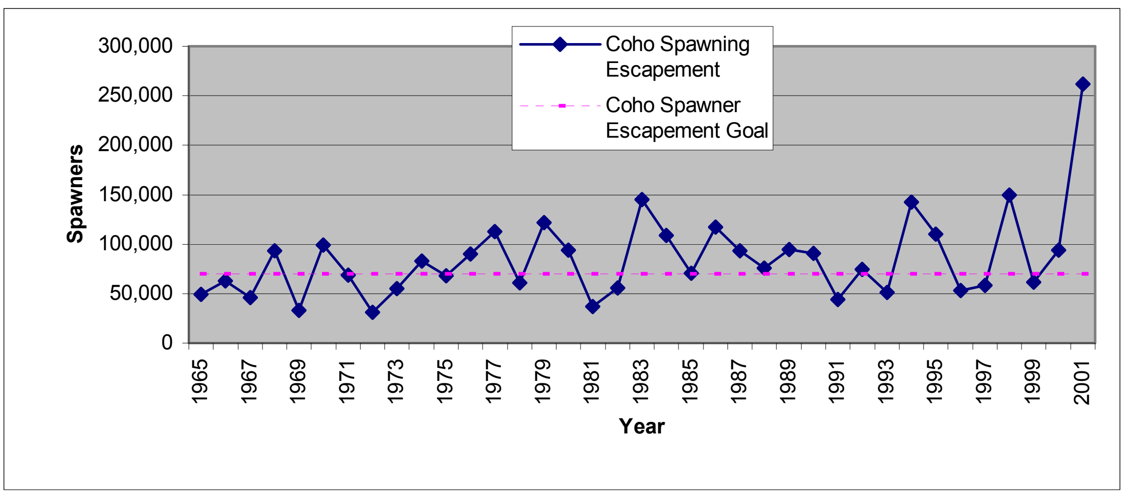
The Skykomish coho stock spawns in the mainstem and tributaries of the Skykomish River (excluding the SF Skykomish upstream of Sunset Falls) and NF Skykomish River. The Skykomish stock is likely a mixture of native and introduced non-native stocks, and the status of the stock is designated as **Healthy**, based on trends in spawning escapement.

The SF Skykomish coho stock spawns in the SF Skykomish watershed upstream of Sunset Falls. There were no naturally spawning coho in this area prior to hatchery stock introductions and construction of the trap and haul facility at Sunset Falls in 1958. The SF Skykomish stock is classified as non-native, the result of plants of Skykomish and Green River stocks in the 1950s. Production is the result of wild spawners. The stock status is designated as **Healthy**, based on trends in spawning escapement.

The Snoqualmie coho stock spawns in the mainstem and tributaries of the Snoqualmie River watershed. There have been substantial off-station releases of various hatchery stocks in this watershed. The stock is likely a mixture of native and introduced non-native stocks, and the status of the stock is designated as **Healthy**, based on trends in spawning escapement.

Spawner count data for the Snohomish watershed extends back to 1965 (Figure 9). Spawner count data for the SF Skykomish coho stock are based on actual counts of fish transported upstream of Sunset Falls. Numerical counts are also available for coho returning to the Skykomish Hatchery. Escapement estimates for the other stocks of natural spawning coho are based on comparison of index area counts with those in 1977, when a large scale tagging study was conducted in the Snohomish River watershed. The total estimated return or spawners of coho salmon to the Snohomish watershed has ranged from 31,000 (1972) to 261,600 (2001); the coho spawner escapement goal of 70,000 has been exceeded in 20 of the 37 years in the database, and 6 of the last 10 years.

Figure 9: Coho salmon spawner escapements to WRIA 7 (courtesy of WDFW)



Steelhead

In the Snohomish River watershed, three summer steelhead stocks and three winter steelhead stocks have been identified (WDFW and WWTIT 1994). Combined summer and winter steelhead distribution is presented in Appendix A and in Map 6 (in the separate Map file included with this report). Wild summer stocks occur in the forks of the Tolt River, the upper NF Skykomish River, and the upper SF Skykomish River. The summer steelhead stocks in the Tolt and NF Skykomish rivers are native, and the SF Skykomish summer steelhead stock was developed by colonization of non-native steelhead, and is maintained by trap and haul of adults over Sunset Falls. Wild winter steelhead include the Snohomish/Skykomish, Snoqualmie, and Pilchuck river stocks. Wild winter steelhead in each stock are native. There is little or no information available to indicate whether these stocks are genetically distinct; the stocks are designated based on geographic isolation of spawning populations, and in some cases, biological characteristics. The number of stocks may expand or contract once comprehensive genetic analysis has been conducted.

Adult return timing of summer steelhead stocks is generally May though October, which is distinct from the return timing of winter steelhead stocks from November through April. Spawn timing for summer steelhead stocks may be similar to other steelhead stocks in the Puget Sound area, typically February though April. Spawn timing for winter steelhead stocks is generally from early March to early-mid June. Native summer steelhead populations were historically small, limited by their habitats. Summer steelhead developed in areas isolated from the native winter stocks. In the Snohomish River watershed, this separation occurs upstream of waterfalls that were probable migration barriers except during the low flows of summer and early fall.

The Tolt summer steelhead stock spawns in the forks of the Tolt River (WDFW and WWTIT 1994). Presence of native, wild summer steelhead in the Tolt is supported by historic accounts, which preceded any stocking of hatchery-origin summer steelhead. However, almost nothing is known or published about their historic abundance, entry and spawn timing, or size distribution (Pfeifer 1990, as cited in WFDW and WWTIT 1994). As far as is known, the only habitat in the Snoqualmie watershed that was historically selected by summer steelhead is that located in the forks of the Tolt River (WDFW and WWTIT 1994). Summer steelhead that aggregate in the upper Snoqualmie River may ultimately spawn in the Tolt, or possibly some other river in the Snoqualmie watershed. While there is little doubt that a native run of summer steelhead historically returned to the Tolt River, uncertainty about the level of contribution by hatchery fish spawning in the wild results in a stock origin designation of Unknown. Stock status in 1992 SASSI is designated as **Depressed**. In 2002, the stock status is rated **Healthy** due to a consistent increase in escapements and escapement estimates, which have exceeded the escapement goal of 121 adults in every year since 1992.

Summer steelhead in the NF Skykomish River and tributaries are a distinct stock based on the geographical isolation upstream of Bear Creek Falls, which are considered to be an anadromous fish passage barrier except during low flows (WDFW and WWTIT 1994). The NF Skykomish stock is primarily a native stock with some small level of interaction with hatchery summer steelhead. Adult return timing is generally from July through October. Stock status is designated as **Unknown**.

The SF Skykomish summer steelhead stock spawns throughout the SF Skykomish and tributaries upstream of Sunset Falls (WFDW and WWTIT 1994).   Summer steelhead were able to colonize the habitat upstream of Sunset Falls following implementation of the trap and haul operation in the late 1950s. Stock origin is identified as Non-Native, the result of hatchery plants of fry and smolts, as well as stray hatchery and wild adults. The primary hatchery donor stock was Skamania Hatchery summer steelhead. Stock status is designated as **Healthy**.

Summer steelhead spawner count data are only available for the Tolt (Figure 10) and SF Skykomish (Figure 11) rivers. Spawner count data for the SF Skykomish summer steelhead stock are based on actual counts of fish transported upstream of Sunset Falls. Spawner data for the Tolt and NF Skykomish summer steelhead are limited, as summer and winter steelhead cannot be separately identified during spawning.

Figure 10: Summer steelhead spawner escapements in the Tolt River (courtesy of WDFW)

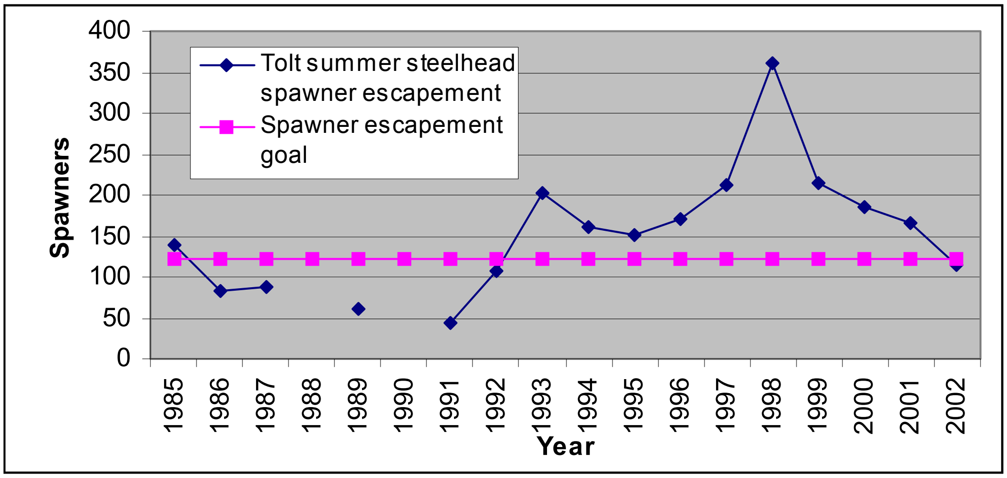
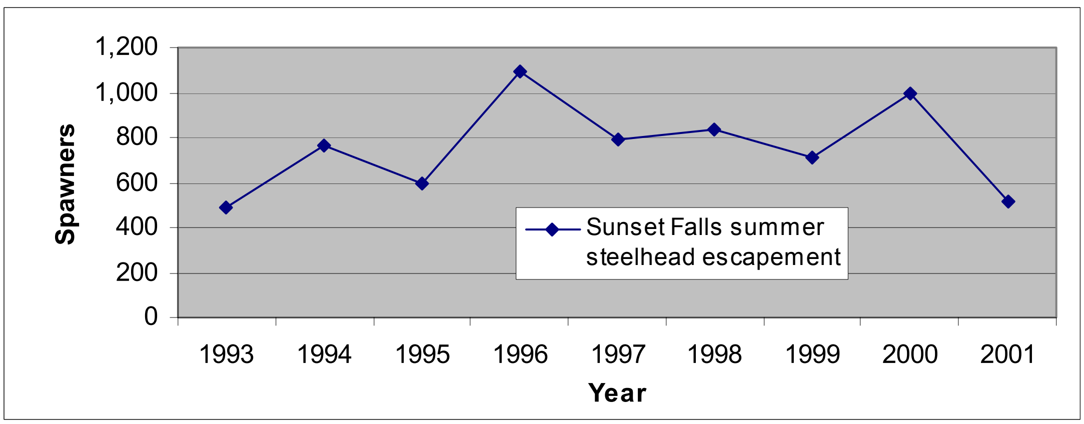


Figure 11: Summer steelhead spawner escapements for the SF Skykomish River (actual counts of steelhead transported over Sunset Falls)(courtesy of WDFW)



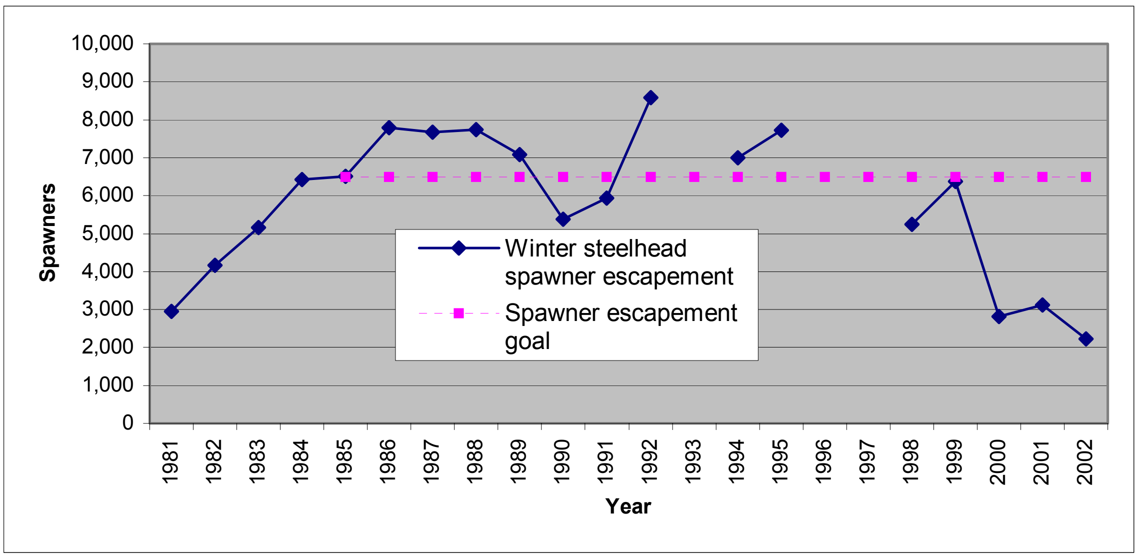
The Snohomish/Skykomish winter steelhead stock spawns in the mainstems of the Snohomish, Skykomish, Sultan and Wallace rivers and associated tributaries, and are designated as a distinct stock based on geographical isolation of the spawning population (WDFW and WWTIT 1994). Stock origin is identified as Native, and stock status in 1992 SASSI is designated as **Healthy**. However, the stock status is rated **Depressed** in 2002 due to a severe short-term decline in total escapements since 1999.

The Pilchuck winter steelhead stock spawns in the Pilchuck River and tributaries, and is designated as a distinct stock based on the geographical isolation of the spawning population and its slightly older age structure than other steelhead in the Snohomish River watershed (WDFW and WWTIT 1994). The percentage of three-salt adults (fish that spend three years in saltwater) returning to the Pilchuck River appears to be higher than elsewhere in the basin. The stock origin is identified as Native, and has little interaction with hatchery stocks. Stock status in 1992 SASSI is designated as **Healthy**. However, the stock status is rated **Depressed** in 2002 because of a short-term severe decline in total escapement since 1999.

The Snoqualmie winter steelhead stock spawns in the mainstems of the Snoqualmie, Tolt, and Raging rivers, and associated tributaries, and is designated as a distinct stock based on the geographical isolation of the spawning population (WDFW and WWTIT 1994). Winter steelhead are native to the basin. While hatchery-origin (Chambers Creek) winter runs have been stocked into the system as fry or smolts for many years, there is little contribution to the wild stock from naturally spawning hatchery fish. The stock origin is identified as Native. Stock status in 1992 SASSI is designated as **Healthy**. However, the stock status is rated **Depressed** in 2002 because of a short-term severe decline in total escapement since 1999.

Winter steelhead (composite of all 3 winter steelhead stocks) spawner escapement data for the Snohomish watershed extends back to 1981 (Figure 12). The total estimated spawner return to the Snohomish watershed of winter steelhead has ranged from 2,234 (2002) to 8,588 (1992). Beginning in the 1984-85 season, an escapement goal of 6,500 winter steelhead was set for the Snohomish River watershed, and fisheries were managed to achieve the goal, which is to be achieved by wild-origin adults and does not include hatchery-origin adults spawning in the wild. The spawner escapement goal of 6,500 was met or exceeded in 8 of the years from 1985-1995, but has experienced a precipitous decline since 1995 (no spawner data available for 1996 and 1997).

Figure 12: Winter steelhead spawner escapements to WRIA 7 (courtesy of WDFW)



Sockeye

No persistent anadromous sockeye salmon stocks are identified in SASSI as present in WRIA 7, although periodic presence of low numbers of riverine spawning sockeye has been noted in several streams. Observed sockeye are likely stray adults originating from other river systems (e.g., Baker River or Cedar River), or potentially the result of limited survival of riverine adult spawning sockeye.

Kokanee (non-anadromous sockeye) do exist in Lake Roesiger (in the Woods Creek watershed) and in Lake Stevens (in the Stevens Creek watershed). These stocks naturally reproduce in tributary streams to these lakes. Lake Roesiger was treated with rotenone in the 1950s to reduce populations of warmwater species. Kokanee were replanted into the lake, likely from Lake Whatcom stock. Observations by Andy Loch of morphological characteristics of kokanee in

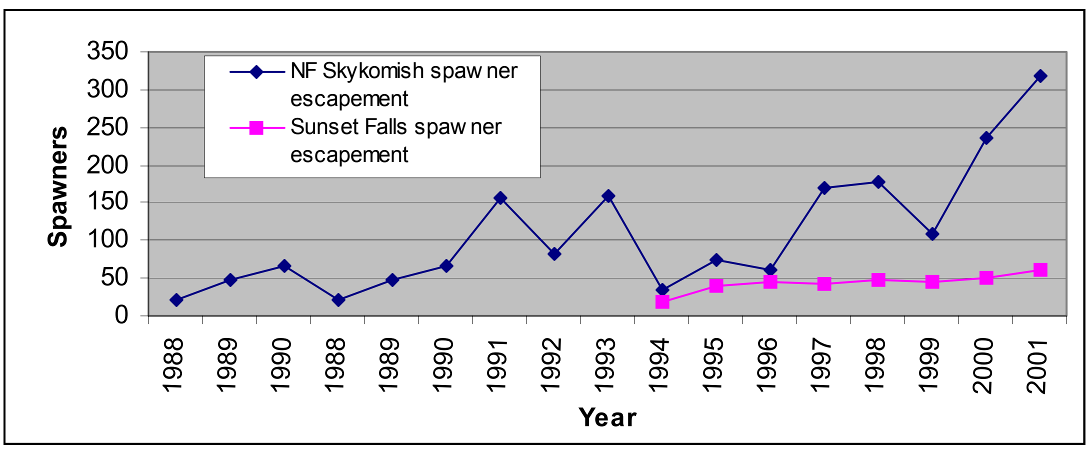
Lake Roesiger suggest there may be two distinct populations of kokanee (Ward), indicating there may have been some survival of the prior kokanee population.

Char (Bull Trout/DollyVarden)

WDFW (1998) identifies a single bull trout/Dolly Varden stock in the Snohomish River watershed, with primary spawning areas identified in the upper NF Skykomish and tributaries between Bear Creek Falls and Deer Creek Falls, and in the EF Foss River, upstream of Sunset Falls on SF Skykomish. Bull trout/Dolly Varden distribution is presented in Appendix A and in Map 7 (in the separate Map file included with this report). Anadromous, fluvial, and resident life history forms are all found in the Skykomish River watershed, at times spawning at the same time and place (Kraemer 1994, as cited in WDFW 1998). Only resident bull trout/Dolly Varden are found in upper tributary reaches that lie upstream of falls that are adult fish passage barriers (e.g., Troublesome Creek). Spawning occurs from late August to early-mid November, but is more typically seen between the first week in October and the first week of November. Spawning commences as water temperature drops to ~8°C, and decreases when the water temperature increases above 8°C. Skykomish bull trout/Dolly Varden are native and are maintained by wild production, although bull trout/Dolly Varden found in the SF Skykomish have only recently invaded that subbasin with the construction of the Sunset Falls trap and haul fishway in the late 1950s. Stock status is designated as **Healthy**.

Sunset Falls trap counts and estimated NF Skykomish spawner escapements are presented in Figure 13. Sport fishery restrictions in recent years may have facilitated bull trout/Dolly Varden recovery in recent years. Brook trout have been introduced into many lakes in the Skykomish River watershed. Emigration of brook trout fry from some of these lakes and subsequent hybridization with native bull trout/Dolly Varden is a possibility, but has not been documented in the Skykomish watershed. However, field surveys of the appropriate intensity have not yet been conducted.

Figure 13: Bull trout/Dolly Varden spawner escapements to the Skykomish River watershed (courtesy of WDFW)



In the fall of 2000, electrofishing and snorkel surveys were performed on NF Snoqualmie, MF Snoqualmie, and SF Snoqualmie rivers upstream of Snoqualmie Falls to search for bull trout/Dolly Varden (Solomon and Boles 2002). Rainbow trout, cutthroat trout, rainbow/cutthroat hybrids, sculpin, and brook trout were found, but neither bull trout nor Dolly Varden were detected (Berge and Mavros 2001, as cited in Solomon and Boles 2002). Nighttime snorkeling was also conducted in 2001 in the SF Snoqualmie River and Denny Creek; no native char were detected in these surveys. Lack of detection does not mean that bull trout/Dolly Varden are absent from the watershed upstream of Snoqualmie Falls,, but does indicate that if they are present, their potential density in the upper watershed is low. Although native char are found in adjacent watersheds (e.g., the Skykomish watershed and downstream of Snoqualmie Falls) it appears that a remnant population does not exist upstream of Snoqualmie Falls (Berge and Mavros 2001, as cited in Solomon and Boles 2002).

Coastal Cutthroat Trout

The Snohomish coastal cutthroat stock has been identified as distinct based on the geographic distribution of its spawning grounds (Blakely et al. 2000). Coastal cutthroat are found throughout the various reaches of the Snohomish basin, including the mainstem Snohomish, Snoqualmie, and Skykomish rivers, and nearly all of their tributaries. Stock status is designated as **Unknown**. Coastal cutthroat distribution was not mapped as part of this effort, but is considered to be ubiquitous throughout the watershed, including upstream of natural and anthropogenic-caused anadromous fish passage barriers (e.g., Snoqualmie Falls, upper Woods Creek, Culmback Dam, etc.).

All life history forms (anadromous, fluvial, adfluvial, and resident) are present tin the Snohomish basin (Blakely et al. 2000). The anadromous life-history form is found in most perennial streams and in some intermittent streams throughout the anadromous reaches of the system. In the Snohomish, the major anadromous cutthroat producers are Quilceda Creek and the Pilchuck River watershed up to and including Worthy Creek. Nearly all of the anadromous cutthroat in the Skykomish watershed are found downstream from the town of Goldbar. Major Skykomish cutthroat producers are Woods Creek and the Wallace River. Anadromous cutthroat are found in nearly all the tributaries of the Snoqualmie River to Snoqualmie Falls. Major Snoqualmie producers include Cherry Creek, Stossel Creek, and the Raging River.

The fluvial life history is found in the larger rivers upstream of the anadromous reaches (Blakely et al. 2000). There are limited numbers of fluvial cutthroat in the Snohomish and Skykomish portions of the basin, but large numbers in the Snoqualmie portion. There are nearly 100 miles of stream supporting fluvial cutthroat in the forks of the Snoqualmie River and the upper forks of the Tolt River.

The adfluvial life history form is found in a number of lakes within the Snohomish basin (Blakely et al. 2000). They are found in two reservoirs, the SF Tolt Water Supply Reservoir, and Spada Lake on the Sultan River. They are also found in a number of lowland lakes including Bridges, Boyle, Flowing, Storm, Panther, and Stevens lakes, and in a number of small ponds and sloughs, as well as in some alpine or near-alpine lakes.

The small-sized resident life history forms are found throughout the basin, generally occupying the smaller streams often found in conjunction with one or more of the other three larger life history forms (Blakely et al. 2000). Many of the resident populations are native although some may reflect the stocking history of the fluvial or adfluvial fish where they co-mingle with those life history forms. Because many of the beaver ponds are small, it is believed that cutthroat inhabiting these areas are most likely resident fish, although the presence of adfluvial, fluvial, or anadromous fish is also possible.

Other Species

Resident trout species, other than cutthroat, are not specifically considered or referenced in this report. These species are present throughout these same watersheds and should also be considered whenever habitat or fish production modifications are considered.

HABITAT LIMITING FACTORS BY SUB-WATERSHED

General

This chapter complements several key salmonid habitat assessment reports that have been completed for the Snohomish River watershed (WRIA 7), that compile available information on the condition of salmonid habitat in the watershed, including:

- Snohomish River Watershed Conditions and Issues Report – Revised Final Report (1999)
- Initial Snohomish River Watershed Chinook Salmon Conservation/Recovery Technical Work Plan (SBSRTC 1999)
- Snohomish River Watershed Chinook Salmon Habitat Evaluation Matrix (SBSRTC 2000)
- Snohomish River Watershed Chinook Salmon Near Term Action Agenda (SBSRF 2001)
- Salmon Overlay to the Snohomish Estuary Wetland Integration Plan (City of Everett and Pentec Environmental 2001)
- Snohomish River Watershed Salmonid Habitat Conditions Review (SBSRTC 2002)[Note that the subwatershed boundaries are substantially different between the Habitat Conditions Review report and those in this report. At the request of the TAG, a comparison of subwatershed boundaries in the two reports is included in this report as Appendix C.]
- A Historical Analysis of Habitat Alterations in the Snohomish River Valley, Washington, Since the Mid-19th Century (Haas and Collins 2001), and
- Mapping Historical Conditions in the Snoqualmie River Valley (RM 0–RM 40)(Collins and Sheikh 2002)
- Snoqualmie Watershed Aquatic Habitat Conditions report: Summary of 1999-2001 Data (Solomon and Boles 2002)

Conditions of the streams and rivers of the Snohomish River watershed range from pristine to heavily impacted (Pentec Environmental and NW GIS 1999). The range of conditions reflects the variety of land uses found in the watershed, including wilderness, commercial forestry, agriculture, commercial and residential development, and urbanization. Most of the waterbodies greatly affected by human activities drain the suburban foothills or lie in the floodplains of the major rivers. Principal impacts have been caused by construction of dikes, channelization of floodplain tributaries, elimination of wetlands and estuarine habitat, riparian forest removal, non-point water quality pollution, industrial discharges, fish passage barriers, log raft storage, and removal of large wood from channels.

Anthropogenic impacts in the Snohomish River watershed are not new, with many of the habitat impacts dating back over 100 years (Pentec Environmental and NW GIS 1999). Navigation and fishing records from the late 1800s show that woody debris was being removed from the river to improve navigation. Maps from 1921 of the western portion of the watershed already show the cities and towns located in the Snoqualmie and Snohomish valleys, as well as agricultural development across the floodplains. Aerial photographs of the estuary in the 1950s reveal far more widespread intertidal log raft storage and processing than occur today, and also show more river-adjacent industries in operation. The watershed is recovering from some past land use actions; many other impacts of past land use actions remain in the watershed. Rapid urbanization is the greatest new threat to salmonid habitat in the Snohomish watershed.

Habitat management alone cannot restore salmon populations, but it is a necessary component of recovery (SBSRTC 1999). Current conditions in the freshwater, estuarine, and marine environments (and the policies and practices influencing them) must be modified in order to reestablish the natural conditions and processes that shaped salmon evolution. The following habitat management concepts and principles were identified for chinook restoration by the Snohomish Watershed Salmon Recovery Technical Committee, but are also applicable to restoration of other salmonid species:

- Emphasize protection and reconnection of habitat;
- Use historical information to guide decisions;
- Preserve and restore natural ecosystem processes;
- Use monitoring and assessment to guide adaptive management; and
- Preserve options for the future.

These restoration elements are discussed in further detail in SBSRTC (1999).

Habitat Elements Included in this Analysis of Salmonid Habitat Limiting Factors by the Washington State Conservation Commission:

The habitat elements considered in the Water Resource Inventory Area (WRIA) 7 (Snohomish River watershed) salmonid habitat limiting factors report include:

Loss of Access to Spawning and Rearing Habitat

This habitat element includes human-placed structures that restrict access to spawning habitat for adult salmonids or rearing habitat for juveniles, including culverts, tide gates, levees, dams, water diversion screening, etc. Additional factors considered are low stream flow or temperature conditions that function as barriers during certain times of the year. This chapter includes inventory data from the WDFW Fish Passage Database (summarized to location and barrier status only), and identifies additional barriers where known. Barrier status of "Yes" indicates that the culvert is either a partial or total barrier to anadromous salmonid passage. Attribute data for each of the sites identified in the WDFW Fish Passage Database, Metadata, and a Data Dictionary can be accessed at the WDFW website: http://www.wa.gov/wdfw/hab/envrest/sshrdata2.htm

Washington Trout recently completed an extensive inventory of culverts located within the anadromous accessible waters from the confluence of the Skykomish and Snoqualmie rivers upstream to Snoqualmie Falls on the Snoqualmie River, and to Sunset Falls on the SF Skykomish, including the NF Skykomish. Unfortunately, it could not be determined for any specific stream/subwatershed (except the Cherry Creek watershed) whether the available inventory represented a comprehensive inventory of fish passage barriers. Inventoried sites included identified road crossings on the best maps they could find, with other casual upstream and downstream observations as they were inventorying those mapped road crossings. In addition, the inventory does not include culverts on private land where they were denied permission to access the site; a list of sites where access was denied is not available. Consequently, the culvert inventory status for most subwatersheds where Washington Trout conducted inventories is reflected in this report as: "The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone."

Floodplain Conditions

Floodplains are relatively flat areas adjacent to larger streams and rivers that are periodically inundated during high flows. In a natural state, they allow for the lateral movement of the main channel and provide storage for floodwaters, sediment, and large woody debris. Floodplains generally contain numerous sloughs, side channels, and other features that provide important spawning habitat, rearing habitat, and refugia during high flows. This habitat element includes direct loss of aquatic habitat from human activities in floodplains (such as filling) and disconnection of main channels from floodplains with dikes, levees, and revetments. Disconnection can also result from channel incision caused by changes in hydrology or sediment inputs.

Channel Conditions

This habitat element addresses instream habitat characteristics such as bank stability, pools, and large woody debris that are not adequately captured by other designated habitat elements. Changes in these characteristics are often symptoms of other habitat effects elsewhere in the watershed, which should also be identified in the appropriate habitat element discussion (sediment condition, riparian condition, etc.).

Streambed Sediment Conditions

Changes in the input of fine and coarse sediment to stream channels can have a broad range of effects on salmonid habitat. Increases in coarse sediment can create channel instability, increased bank erosion, and reduce the frequency and volume of pools. Decreases in coarse sediment transport (e.g., downstream of a dam) can limit the availability of spawning gravel and result in channel incision. Increases in fine sediment can fill in pools, decrease the survival rate of eggs deposited in the gravel, and lower the production of benthic invertebrates. This habitat element addresses these and other sediment-related habitat effects caused by human activities throughout a watershed. These human activities include or result in increases in sediment input from landslides, roads, agricultural practices, construction activities, and bank erosion; decreases in gravel availability caused by dams and floodplain constrictions; and changes in sediment transport brought about by altered hydrology and reduction of large woody debris.

Riparian Conditions

Riparian areas are the land areas adjacent to streams, rivers, and nearshore environments that interact with the aquatic environment. This habitat element addresses factors that limit the ability of native riparian vegetation to provide shade, nutrients, bank stability, and a source for large woody debris. Adverse effects to riparian condition result from timber harvest, clearing for agriculture or development, construction of roads, dikes, or other structures, and direct access of livestock to creek channels.

Water Quality

Water quality factors addressed by this habitat element include temperature, dissolved oxygen, and toxics that directly affect salmonid production. Turbidity is also included, although the sources of sediment problems may also be discussed in the substrate condition habitat element. In some cases, fecal coliform bacteria problems are identified because they may serve as indicators of other effects in a watershed, such as direct animal access to streams.

Water Quantity

Changes in flow conditions can have a variety of effects on salmonid habitat. Decreased low flows can reduce the availability of summer rearing habitat and contribute to temperature and access problems, while increased peak flows can scour or bury spawning nests. Other alterations to seasonal hydrology can strand fish or limit the availability of habitat at various life stages. Stormwater runoff from impervious surfaces, or increased exposure to rain-on-snow events, increase the frequency and magnitude of peak flow events, affecting the stability of the creek and associated habitat. All types of hydrologic changes can alter channel and floodplain complexity. This habitat element considers changes in flow conditions brought about by water withdrawals, the presence of roads and impervious surfaces, the operation of dams and diversions, alteration of floodplains and wetlands, stormwater runoff from impervious surfaces, and a variety of land use practices.

Estuarine and Nearshore Habitat

This habitat element considers habitat effects that are unique to estuarine and nearshore environments. Estuarine habitat includes areas in and around the mouths of streams extending throughout the area of tidal influence. These areas provide especially important rearing habitat for chinook, chum, and other salmonid species, and provide for critical adult and juvenile salmonid osmoregulatory adjustment between freshwater and saltwater. Effects to estuarine/nearshore habitat have resulted from loss of habitat complexity due to filling, diking, log raft storage, and channelization; and loss of tidal connectivity to small stream mouths or off-channel wetlands caused by tidegates. Nearshore habitat includes intertidal and shallow subtidal saltwater areas adjacent to land that provide migration and rearing habitat for adult and juvenile fish. Important features of these areas include eelgrass and kelp beds, cover, large woody debris, spawning habitat for forage fish, and the availability of prey species for juvenile salmonids. Impacts include bulkheads, overwater structures, filling, dredging, contamination with industrial chemicals, and alteration of longshore sediment processes.

Lake Habitat

Lakes can provide important spawning and rearing habitat for salmonids. This habitat element considers effects typical to lake environments, such as the construction of docks and piers, increases in aquatic vegetation, and the application of herbicides to control plant growth.

Biological Processes

This habitat element considers impacts to fish brought about by the introduction of exotic plants and animals, and also from the loss of ocean-derived nutrients caused by a reduction in the amount of available salmon carcasses. The intent is to restore ocean-derived nutrients to freshwater streams through the restoration of healthy viable natural spawning populations of anadromous salmonids. Freshwater streams may be currently deficient in marine derived nutrients due to low spawning returns or habitat problems that limit fish utilization or productivity. There are few specific locations where there is information sufficient to characterize the extent to which lack of marine derived nutrients may be a limiting factor for salmonid production.

Watershed Discussions

Watershed discussions are presented for those streams in WRIA 7 that support anadromous salmonids, including bull trout/Dolly Varden, and generally follow the WRIA 7 stream index numbering sequence presented in Williams et al. (1975). The entire WRIA 7 portion of the report is included for reference in an accompanying stream catalog file. Streams without index numbers in Williams et al. (1975) are either assigned uncommitted numbers or are assigned an alpha extension, generally ascending from downstream to upstream. Location clarification for streams with assigned alpha extensions are noted in the Comments field in the fish distribution summary table in Appendix A or in the text.

Where information is available, the habitat description is contrasted to historical conditions known to have supported greater natural salmonid production. A list of prioritized/ranked salmonid habitat action recommendations is included at the end of each watershed section; these action recommendations reflect collaborative input from the TAG as to which habitat protection/restoration actions are likely to benefit salmonid production to the greatest extent within the watershed. The action recommendations are based on collective scientific opinion of salmonid production benefit and do not necessarily consider feasibility, landowner interest, or cost, and do not include any prioritization between watersheds. These additional elements should be considered in the development and implementation of the salmonid restoration strategy for the Snohomish watershed.

Tulalip Creek 07.0001

General

Tulalip Creek is an independent tributary entering the northern end of Tulalip Bay (Williams et al. 1975). The Tulalip watershed drains an estimated 10,234 acres (Nelson). Forested conditions still exist on 54% of the watershed. Impacts from rural and suburban residential land use pose the biggest impacts and future threat to the watershed. Rural and suburban residential land use covers 25% of the watershed.

Fish Access

The WDFW SSHEAR Dam Database (February 2002) identifies a dam on Tulalip Creek at the outlet to Shoecraft Lake (RM 5.0) that is a total barrier to fish passage. There is also a dam at the mouth of Tulalip Creek that is associated with the Tulalip Tribe's hatchery operation. The dam, constructed in the early 1920s (SBSRTC 1999), is a total barrier to fish passage (Nelson). A comprehensive inventory of culverts or other blockages has not been conducted.

Floodplain Modifications

Most of channels within both watersheds are confined to moderately confined (Nelson). Floodplain width varies between 6m to 23.8m. Floodplain connectivity remains in good condition.

Channel Conditions

Channel complexity is still in good condition (Nelson). LWD counts within Tulalip and Battle creeks range between 132 pieces/km to 362 pieces/km. However, past logging has reduced LWD recruitment in the near term. As decay of LWD in streams progresses, in-stream habitat conditions may deteriorate until trees within the riparian zone reach the desired size and begin to replenish LWD levels (Haas et al. 1998).

Width-to-depth ratios range from 2 to 35.2 (Haas et al. 1998).

Substrate Condition

Stream surveys in 1997 reported embeddedness levels that ranged from 15% to 80%. Of the fifteen reaches surveyed in 1997, six of those reaches were reported to have some obvious signs of erosion (Haas et al. 1998).

Riparian Condition

Riparian areas are in relatively good condition (Nelson). Most streams have a wide and intact-riparian zone and an extensive wetland system still occurs within the watershed. However, both zones have been extensively altered. Wetland and lake surface area in Tulalip Creek accounts for 21.5% of the sub-watershed. Riparian forests consist of deciduous and mixed vegetation. Most reaches have riparian buffer widths of greater than 30m (Haas et al. 1998) but less than one site potential tree height.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Tulalip watershed (includes both Tulalip and Battle creeks (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Tulalip	0	32	36	15	4	10	2	1

Water Quantity

USGS previously maintained a stream gauge on Tulalip Creek from 1974 to 1977 (Nelson). The Tulalip Tribes in cooperation with USGS reactivated a gauge on Tulalip Creek in 2001.

Overall, there is no evidence of reduced baseflows or changes in high flows within Tulalip Creek (Nelson). Extensive wetland systems in both watersheds provide baseflow support (Haas et al. 1998). Changes in flows would principally occur through changes in vegetative cover and the loss or conversion of wetlands, which is a future concern. Total impervious area for Tulalip Creek is 5% (Haas et al. 1998). Wetland and lake surface area in Tulalip Creeks account for 21.5% of the sub-watershed.

The Tulalip Hatchery withdraws water from both the east and west forks of Tulalip Creek (Nelson). The intake on EF Tulalip Creek is ~0.3 miles upstream of the confluence of the forks. The intake on WF Tulalip Creek is ~0.75 miles upstream of the confluence. The flow that is taken out of Tulalip Creek is mixed with well water before use in the hatchery. Immediately below the intakes the streams go intermittent, however both intake locations are within a 0.2 miles of Tony's Marsh, where a substantial amount of groundwater enters the system. There is no apparent influence of the hatchery withdrawal at the downstream end of Tony's Marsh (1.5 miles downstream). Use of Tulalip Creek by the hatchery varies over the course of the year, with instream flow effects typically only apparent during August and September.

Water Quality

Generally, water quality is relatively good in the Tulalip Creek watershed (Nelson). No waterbody segments within this watershed have been placed on the 303(d) list. Water quality monitoring has shown non-point parameters (e.g. fecal coliform bacteria, temperature) to be within state water quality standards. However, trend analysis has shown increases in fecal coliform bacteria occurring at several sites, which may pose a future problem (Paul and Nelson 1996).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Tulalip Creek watershed:

- Restore riparian function, where impaired
- Protect integrity of wetlands and forest cover within the watershed

Battle (Mission) Creek 07.0005

General

Battle (Mission Creek) is an independent tributary entering the southeastern end of Tulalip Bay (Williams et al. 1975). The Battle Creek watershed drains an estimated 5,247 acres (Nelson).

Forested conditions still exist on 76% of the watershed (Nelson). Impacts from rural and suburban residential land use pose the biggest impacts and future threat to the watershed. Rural and suburban residential land use covers 11% of the watershed.

Fish Access

Anadromous salmonid access to Battle Creek has been blocked by a dam at the mouth since the early 1970s (Nelson). The dam and impoundment are associated with the Tulalip Tribe's hatchery operation. An inventory of culverts or other blockages has not been conducted.

Floodplain Modifications

Most of channels within the watershed are confined to moderately confined (Nelson). Floodplain width varies between 6m to 23.8m. Floodplain connectivity is still in good condition.

Channel Conditions

Channel complexity is still in good condition (Knudsen). Pieces of LWD within Tulalip and Battle Creek range between 132 pieces/km to 362 pieces/km. However, past logging has reduced LWD recruitment in the near term. As decay of LWD in streams progresses, in-stream habitat conditions may deteriorate until trees within the riparian zone reach the desired size and begin to replenish LWD levels (Haas et al. 1998). Width-to-depth ratios range from 2 to 35.2 (Haas et al. 1998).

Substrate Condition

Stream surveys in 1997 reported embeddedness levels that ranged from 15% to 80%. Of the fifteen reaches surveyed in 1997, six of those reaches were reported to have some obvious signs of erosion (Haas et al. 1998).

Riparian Condition

Riparian conditions are in relatively good condition (Nelson). Most streams have a wide and intact riparian zone, and an extensive wetland system still occurs within the watershed. Most reaches have riparian buffer widths of greater than 30m (Haas et al. 1998), but less than one site potential tree height. However, riparian conditions consist of deciduous and mixed vegetation.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Tulalip watershed (includes both Tulalip and Battle creeks (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Tulalip	0	32	36	15	4	10	2	1

Water Quantity

USGS previously maintained a stream gauge on Battle Creek from 1974 to 1977 (Nelson). The Tulalip Tribes in cooperation with USGS reactivated a gauge on Battle Creek in 2001.

Overall, there is no evidence of reduced baseflows or changes in high flows within Battle Creek (Nelson). Extensive wetland systems in both watersheds provide baseflow support (Haas et al. 1998). Wetland and lake surface area in Battle Creek accounts for 12.6% of the sub-watershed. Changes in flows would principally occur through changes in vegetative cover and the loss or conversion of wetlands, which is a future concern. Total impervious area for Battle Creek is 2.3% (Haas et al. 1998).

Water Quality

Generally, water quality is relatively good in the Battle Creek watershed. No waterbody segments within this watershed have been placed on the 303(d) list. Water quality monitoring has shown non-point parameters (e.g. fecal coliform bacteria, temperature) to be within state water quality standards. However, trend analysis has shown increases in fecal coliform bacteria occurring at several sites, which may pose a future problem (Paul and Nelson 1996, as referred by Nelson).

From 1991 to 1995, mean dry season water temperature in Battle Creek ranged from 10.69 to 12.76^{o}C, and mean dry season dissolved levels at six sites ranged from 9.6 to 11.03 mg/l (Paul and Nelson 1996).

Action Recommendations

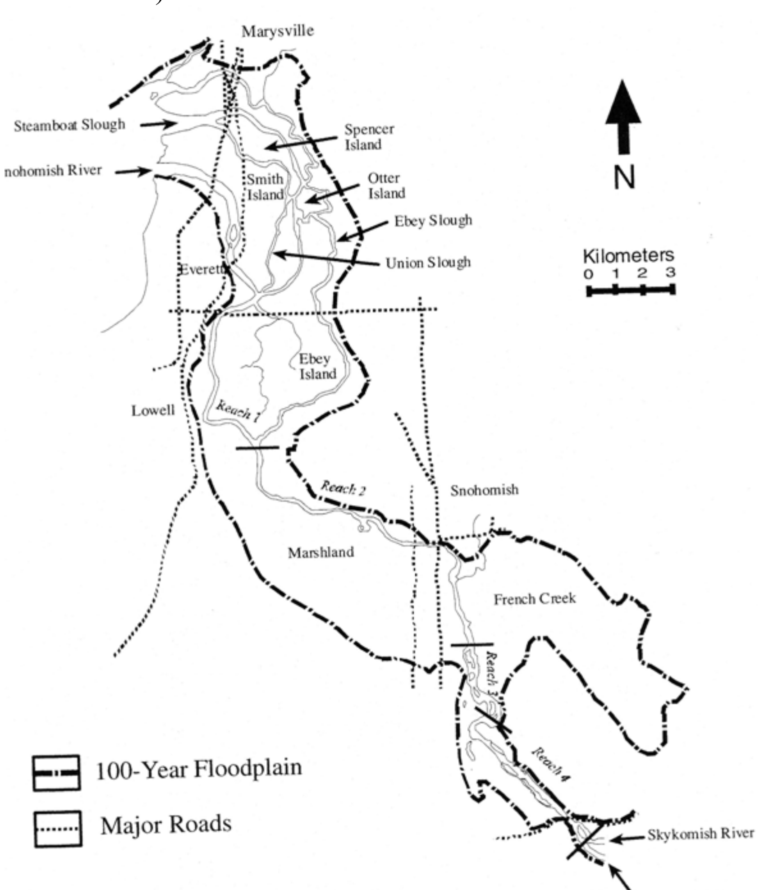
The following ranked salmonid habitat restoration actions are recommended for the Battle (Mission) Creek watershed:

- Restore riparian function, where impaired
- Protect integrity of wetlands and forest cover within the watershed

Snohomish River 07.0012

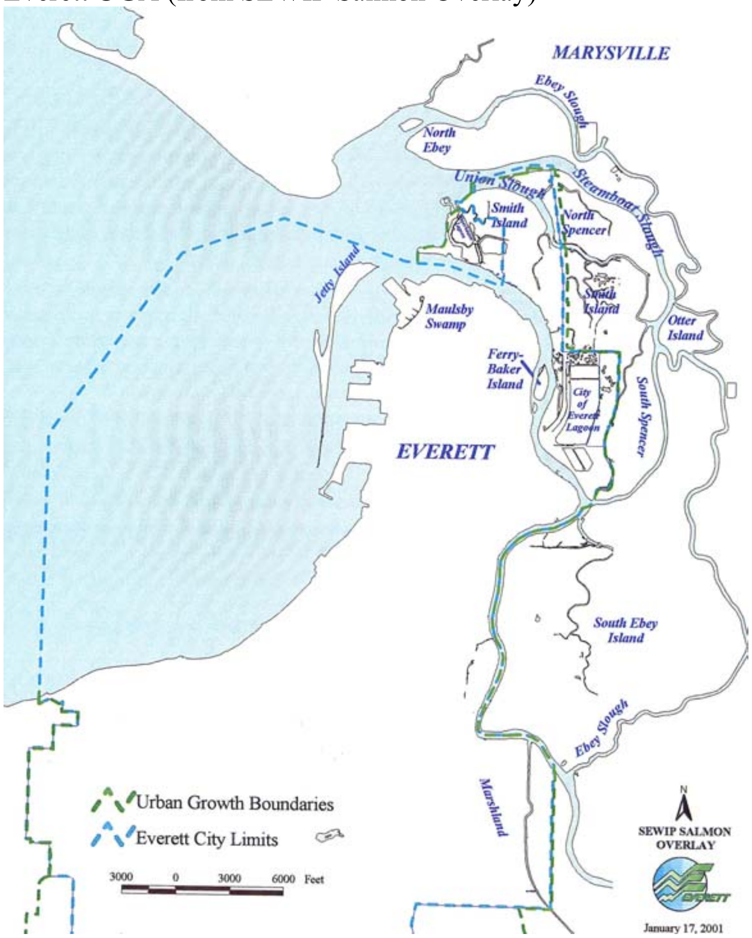
General

Figure 14: Snohomish River reach designations (from Haas and Collins 2001)



The Snohomish River drains an area of 1,880 mi^2 (Snohomish watershed 342 mi^2, Snoqualmie watershed 703 mi^2, Skykomish watershed 835 mi^2)(Pentec Environmental and NW GIS 1999). The Snohomish River, including the Snohomish estuary, extends from the mouth upstream to the confluence of the Snoqualmie and Skykomish rivers at RM 20.5. Haas and Collins (2001) divided the Snohomish River into 4 reaches, delineated based on valley confinement, slope, and relative degree of hydromodification (Figure 14). Reach 1, from Port Gardner to the head of Ebey Slough (RM 8.1) is the lower estuary component, which includes the mainstem and three major distributary sloughs. A significant portion of the lower western half of Reach 1 (mouth to the upstream end of Spencer Island) is within the City of Everett urban growth boundary (City of Everett and Pentec Environmental 2001)(Figure 15). Reach 2, From RM 8.1 to RM 15.3, is heavily diked and tidally influenced. Reach 3, from RM15.3 to Thomas' Eddy at RM 17.5, contains several forested islands and shallow riffles, with Thomas' Eddy being the upper extent of tidal influence. Reach 4, from Thomas' Eddy upstream to the confluence (RM 21) of the Skykomish and Snoqualmie rivers is a pool-riffle channel with several side channels.

Figure 15: Extent of Snohomish River estuary within City of Everett UGA (from SEWIP Salmon Overlay)



The Snohomish estuary provides essential ecological functions for anadromous salmonids, including feeding (rearing), migration, predator avoidance, and saltwater/freshwater osmoregulatory adaptation (City of Everett and Pentec Environmental 2001).

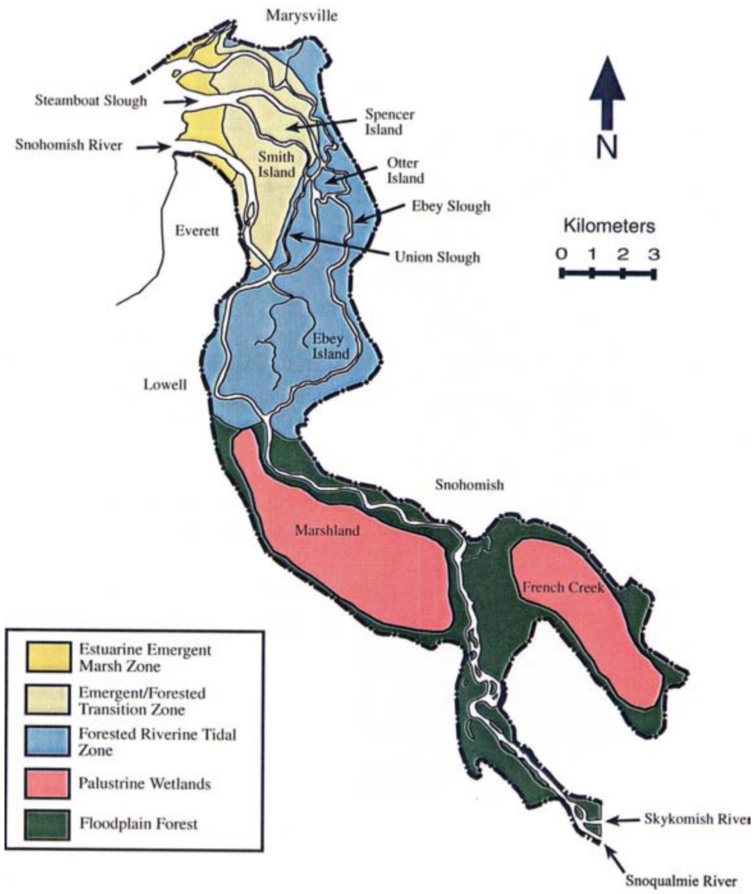
Fish Access

Adult and juvenile salmonids are able to freely immigrate and emigrate through the Snohomish River and estuarine sloughs between the marine waters of Possession Sound and the upper watershed. In prior years, water quality conditions in the lower portion of the estuary caused salmonid mortalities and may have impaired/precluded salmonid access through the estuary under certain conditions; these water quality problems have been corrected, and are no longer considered to significantly impact salmonid immigration or emigration (see Estuarine/Marine Nearshore section below). However, salmonid access has been precluded to historic estuarine and floodplain wetlands adjacent to the Snohomish River and associated estuarine sloughs by an extensive network of dikes and levees from near the mouth to upstream of French Creek. Access to remnant estuarine slough complexes is specifically precluded/impaired into Marshland, Deadwater Slough, and French Creek by presence of drainage pumping stations; access to numerous smaller independent tributaries to the Snohomish River and estuarine sloughs is impaired/precluded by presence of tidegates/ floodgates in the dikes/levees. These access limitations are more specifically addressed in the section discussions for each of the tributary watersheds. Estimated salmonid benefits associated with restoration of estuarine connectivity to the historic Snohomish River estuarine/floodplain wetlands are identified in the Salmon Overlay to the Snohomish Estuary Wetland Integration Plan (City of Everett and Pentec Environmental 2001).

Floodplain Modifications

Natural floodplain width in Reach 1 includes the mainstem and distributary sloughs (Haas and Collins 2001). In Reach 2, floodplain width ranges from 2.5 to 5 kilometers wide, but much of the channel is diked or armored. The floodplain in Reach 3 is ~1.5 kilometers wide, with much of the channel diked or armored. The floodplain in Reach 4 is ~1 kilometer wide downstream of the SR 522 bridge, and 0.5 kilometers wide upstream of the bridge to the confluence.

Figure 16: Approximate location of wetlands within the 100-year floodplain of the Snohomish River in the mid-19th century (from Haas and Collins 2001)



Beginning in the mid-19th century, settlers cleared, drained, ditched, and diked the Snohomish River valley. Prior to human induced changes, the Snohomish River watershed included ~3950 hectares of tidal marsh (not including mudflats) upstream to the upper end of Ebey Slough (Figure 16). The historic marsh was composed of 5% within the estuarine emergent marsh (EEM) zone, 29% within the emergent/ forested transition (EFT) zone, and 66% within the forested riverine/tidal (FRT) zone (Haas and Collins 2001). Only one-sixth of the historic marsh area remains. Sixty-one blind tidal channel networks >6 meters wide at the mouth have been lost, and only 25% of the blind tidal slough area remains intact and connected to the channel network. Distributary slough and main-stem channel area and position have changed little, but near continuous diking, riparian clearing, and LWD removal have significantly modified habitat conditions in the channel margins. One of the few remaining undiked areas is Otter Island, which appears to have remained very stable over time (Houghton).

Diking and draining activities in the estuary and Snohomish River floodplain have very significantly altered this historically wet, river-influenced landscape (Snohomish County Public Works 1991). Settlers drained and/or isolated ~3370 hectares of palustrine marsh in the floodplain upstream of Ebey Slough (Haas and Collins 2001). Location, acreage, and length of levees for the Diking and Flood Control Districts in the Snohomish River floodplain are shown in Figure 17and Table 6. Flow control devices (tidegates, floodgates, pumps) isolate or restrict access from the river to tens of kilometers of channels. Diking and bank armoring have also contributed to a 2-kilometer decrease in total length of side channels and a 55% reduction in the area of side channel sloughs. There has also been a 40% loss of beaver pond area (not including habitat loss in vast floodplain areas). Evaluation of aerial photographs indicates that 37.62 miles (35.19%) of the 106.9 miles of bank along the Snohomish River are diked (Pentec Environmental and NW GIS 1999). Dikes along the Snohomish River are generally built to contain the 5-year flood +1 foot of freeboard, although portions of certain dikes are designed to overtop at the 5-year flood; additional protection is provided at other locations in the cities of Everett, Marysville, and Snohomish to protect sewage treatment lagoons and areas zoned for commercial and industrial uses (Snohomish County Public Works 1991). Past flood flows have caused significant damages

Figure 17: Diking and Flood Control Districts (from Snohomish County Public Works 1991)

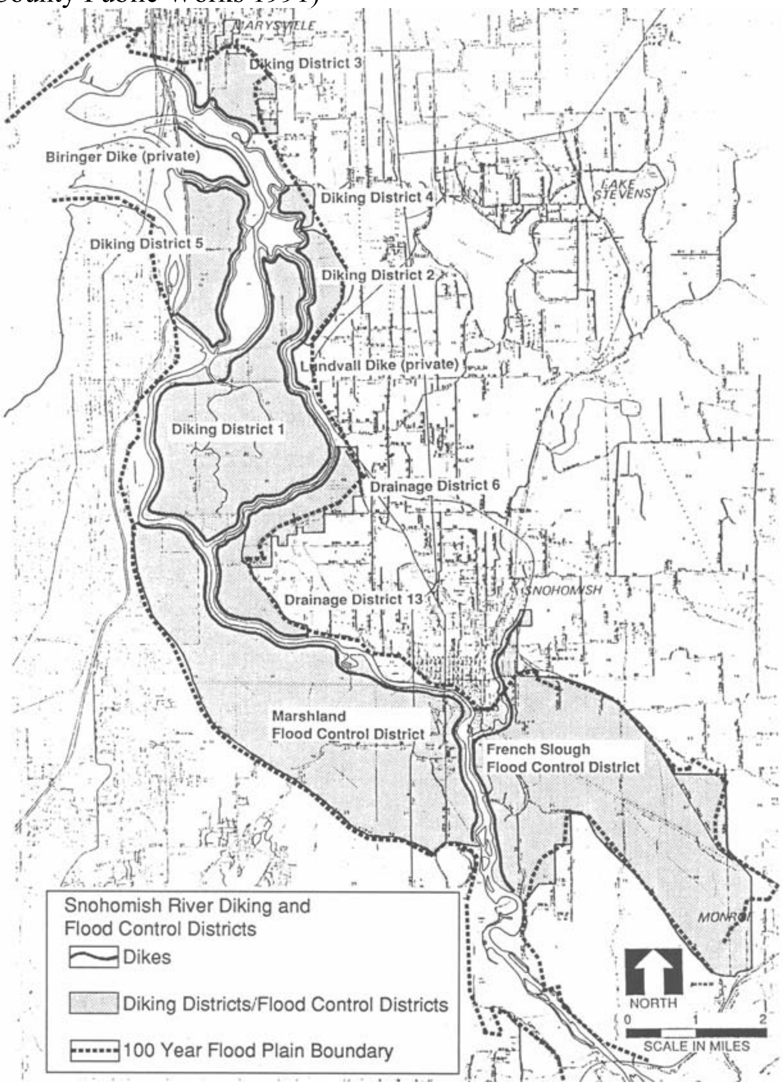


Table 5:Historical flood damages in the lower Snohomish valley (from Snohomish County Public Works 1991)

Date of Flood	Estimated Discharge\1 (cfs)	Total Damages (1989 Prices)
February 1932	NA	$ 8,460,000
December 1933	NA	9,900,000
December 1943	64,600	1,660,000
October 1947	58,700	144,000
February 1951	136,000	16,600,000
November 1959	113,300	9,900,000
December 1964	66,000	4,200,000
December 1975	115,000\2	42,400,000
November 1986	91,200\2	2,000,000
November 1990	186,000\2	(pending)

\1 Discharge estimates based on Snohomish Gage in operation since 1942. Since 1964, stage only has been recorded at the Snohomish Gage.

\2 Estimate at the Monroe Gage

Source: PNRBC (1980), costs updated to 1989 prices.

in the lower Snohomish valley (Table 5), necessitating substantial expenditures of public and private funds to repair dike breaches that have occurred, in addition to the associated salmonid and habitat losses.

The historical analysis conducted by Haas and Collins (2001) attempts to quantify the loss/ alteration of habitat relevant to rearing juvenile chinook and coho salmon. This information is then expanded with salmon production data measured in areas of the Skagit River. They estimated that loss of estuarine habitat quantity downstream of the head of Ebey Slough has resulted in reduced production capacity for chinook salmon from historic levels of 2.6 million smolts to current levels between 1.0 and 1.6 million smolts, a decrease of 40-61%. Disconnection and destruction of off-channel habitat (primarily as a result of the draining and diking of the extensive Marshland and French Creek marshes) has eliminated ~95% of chinook salmon rearing capacity and coho salmon smolt production capacity in the floodplain. Potential pre-smolt chinook rearing capacity in the floodplain decreased from a mean estimate of ~1.2 million in the mid-19th century to 36,000 in 1998. Haas and Collins (2001) suggest that the Snohomish River estuary is commonly a bottleneck to chinook

Table 6: Snohomish River valley levee systems (from Snohomish County Public Works 1991)

Flood Control Organization \1	Area Protected (acres)	Length of Levee (miles)
Diking Improvement District 1 (Ebey Island)	3800	13.1
Diking District 2 (Rt. Bank Ebey Slough - mi. 8 to 10)	475	2.5
Diking District 3 (Rt. Bank Ebey Sl. - near Marysville)	400	2.1
Diking District 4 (Rt. Bank Ebey Slough - mi. 6 to 8)	140	1.2
Diking District 5 (Smith Island)	1250	4.1
Drainage District 6 (Rt. Bank Ebey Slough - mi. 10 to 12)	480	2.2
Drainage Improvement District 13 (Rt. Bank Sno. River and Ebey Slough)	562	2.9
French Slough Flood Control District (Rt. Bank Sno. River - mi. 14 to 16.5)	5676	3.2\a
Marshland Flood Control District (Lt. Bank Sno. River - mi. 7 to 15.5)	6000	8.5
Private Dikes:		
Biringer (No. Spencer Island)	348	2.6
Lundvall (Rt. Bank Ebey Sl. mi. 8 to 9)	130	1.8
Totals	19,261	44.2

\1 Location in miles indicate river mile distance from mouth of river.

\a French Slough Levees along the Snohomish R. and the Pilchuck River up to the BNRR tracks.

production, with chinook experiencing density-dependent production constraints 45-78% of the time during the period 1968-1999.

Assumptions made by Haas and Collins (2001) regarding the importance and use of these habitat areas, the application of productivity values from another watershed, and the resulting conclusion of density dependence and a 'bottleneck' effect, are questioned by some researchers when the complexities in related to other parameters of production (e.g., habitat quality and life history diversity) are not incorporated. Haas and Collins (2001) also qualify the validity of their assumptions of habitat use to some degree. Preliminary research results suggest that juvenile salmonid utilization of blind tidal channels is possibly less extensive in the Snohomish River than in the Skagit River, with juveniles passing quickly through the distributary sloughs into nearshore marine habitats (Houghton, Rowse). The effects of this behavior on subsequent survival are not yet known. However, there is general agreement that estuarine habitat is critically important, that it has been extensively altered since historic times, and that preservation and restoration of estuarine habitats will be important factors for rebuilding salmonid populations.

Haas and Collins (2001) estimate a similar reduction of production potential for coho salmon due to diking and loss of blind tidal channels. They estimate that over 50% of coho smolt production capacity has been lost in the Snohomish River from pre-development times. Summer coho smolt production potential decreased from a mean estimate of 3.4 million smolts in the mid-19th century to 155,000 smolts currently; winter coho smolt production potential dropped from ~7.4 million to 376,000 (Haas and Collins 2001). Several model scenarios were explored regarding historic utilization of the marsh areas. When loss of rootwads due to attrition and lack of new recruitment of wood were considered, historic production estimates for summer coho salmon parr, and winter pre-smolt coho salmon in the mainstem Snohomish are 161% and 52% greater than current estimates, respectively. As a result of the shift in quantity and quality of critical habitats available to juvenile salmonids, it is assumed that there may have been a loss of life history diversity in the populations as well (Houghton, Chamblin).

Channel Conditions

Mainstem channel position and area have changed little from 1884 through 1998, presumably because of diking and bank armoring (Haas and Collins 2001). Although diking and bank armoring have clearly contributed to the stability of river channels over time, several TAG participants theorize that most historic channel changes in the estuary were likely highly influenced by formation of logjams. Over the past two centuries, there have been intensive efforts to remove logjams and other LWD from the Snohomish River, reducing the potential for LWD-influenced channel changes. Historically, large accumulations of wood in the form of snags and logjams provided important habitat for juvenile and adult salmonids in the Snohomish River (Toth and Houck 2001). Collins and Sheikh (2002) estimate that 10,345 snags were removed from the Snohomish River (includes Snoqualmie and Skykomish rivers) from 1881 to 1910. This removal was less than noted for the Skagit River, but greater than for either the Nooksack or Stillaguamish rivers. In addition, between 1861 and 1906, the Army Corps of Engineers removed an average of 58 overhanging trees/year from the Snohomish River banks, primarily to reduce boating hazards and protect structures such as bridges. Remaining LWD in the Snohomish River largely consists of individual pieces of old, relict cedar on the bed of the river, and secondarily, smaller diameter, younger pieces on the banks (Haas and Collins 2001). LWD averages 18 pieces per channel width, 0.42 meters in diameter, and 8 meters in length, with 22% of the logs having rootwads. In contrast, a largely undisturbed reach of the Nisqually River contains 140 pieces per channel width (Collins et al. 2002, submitted, as cited in Haas and Collins 2001). Presence and retention of LWD also appears to be adversely affected by bank modification, with LWD as a percentage of channel habitat in the slack-water channel margin along hydromodified banks being <50% of wood abundance in the slack-water channel margin of natural banks. In some areas of the distributary channels below the divergence of Ebey Slough, old pilings, historically used for vessel or log raft moorage, function in some ways as LWD, providing cover and velocity refuge, and serve to trap additional LWD pieces (Houghton).

Lack of riparian vegetation and alteration of vegetation species diversity (see Riparian Condition section below), in conjunction with extensive diking, results in limited recruitment of LWD that is large enough to function as cover or influence channel morphology. In addition to production losses experienced to date, future production potential for chinook, summer coho parr, and winter pre-smolt coho in the mainstem could decrease by 39%, 54%, and 35%, respectively, if existing LWD continues to decay and is not replenished through new recruitment (Haas and Collins 2001).

In general, depths of the water in the mainstem and distributary channels are sufficient to provide consistent holding water for adult salmon (Houghton). Pools within the mainstem (upstream of RM 15.2) are large and spaced on average every three channel-widths (Haas and Collins 2001).

Substrate Condition

From the Snoqualmie/Skykomish confluence downstream to Snohomish, the habitat of the Snohomish River is composed of gravel bars, gravel riffles, deep pools, side channels, and backwater eddies, providing excellent salmonid habitat (Pentec Environmental and NW GIS 1999). As the gradient decreases downstream of Snohomish, the substrate is composed mostly of sands and silts. Sands that are dredged from the upper settling watershed of the federal navigation channel are high quality; sands dredged from the lower settling watershed and maintenance dredging of Port of Everett facilities typically meet Puget Sound Dredged Disposal Analysis (PSDDA) disposal criteria. In recent years, these dredged sands have been in demand for a number of beneficial use projects such as the Jetty Island berm project and capping the Eagle Harbor and Tulalip Landfill Superfund sites (Houghton).

Sediment in the vicinity of the Tulalip landfill and in some areas of the East Waterway may be contaminated, requiring special considerations for disposal (Houghton).

The Puget Sound Ambient Monitoring Program (PSAMP) has monitored sediments in Everett Harbor and other areas of Puget Sound since 1989. Based on sampling of six sites within Everett Harbor that reportedly represent 1,500 acres, PSAMP (1998, as cited in Golder Associates 2001) estimated ~75% of the area was not contaminated (below state sediment quality standards), 5% was moderately contaminated, and 20% was contaminated and exceeded state cleanup screening levels. In 1999, additional sediment sampling was done in Everett Harbor, Port Gardner, and Possession Sound. Based on toxicity and chemistry analysis, some sampling stations in the harbor and Port Gardner "displayed infaunal community characteristics that suggest strong evidence of pollution-induced degradation (Long et al. 1999, as cited in Golder Associates 2001). However, most areas within the industrial and commercial areas adjacent to Everett contain minimally-impacted sediments.

Port Gardner and inner Everett Harbor are included on the 1998 303(d) list of impaired waterbodies, based on sediment samples in the northeast waterway and southeast waterway that document a wide variety of chemical contaminants and for sediment bioassay. Possession Sound is also included on the 1998 303(d) list of impaired waterbodies, based on sediment samples that document a wide variety of chemical contaminants and for sediment bioassay (most samples taken from deep waters (Houghton)). Possession Sound is also included on the 303(d) list for excursions from the water temperature at sampling site PSS019.

Riparian Condition

Prior to timber harvest and clearing in the late 19th century, 20% of the floodplain riparian forest was coniferous, containing trees up to 4 meters in diameter (Haas and Collins 2001). Currently, 70% of the Snohomish River has riparian forest less than or equal to one site-potential tree height (56m) in width. The current floodplain riparian forest, which is almost entirely comprised of cottonwood (*Populus trichocarpa*), red alder (*Alnus rubra*), and willows (*Salix* spp.), contains only 2% coniferous trees; very few trees exceed 1 meter in diameter.

Pentec Environmental and NW GIS (1999) evaluated riparian condition on the banks of the Snohomish River (Table 7). Riparian conditions 4, 5, and 7, and possibly 10 would typically be considered to reflect functional riparian conditions for a large mainstem river. Cumulatively, these riparian condition categories include only 22% of the total riparian area evaluated for the Snohomish River, indicating lack of current riparian function, as well as limited potential for LWD recruitment.

Table 7: Riparian conditions on the Snohomish River (right and left banks combined)(from Pentec Environmental and NW GIS 1999)

Riparian Condition	Total Miles	% of Total
1. Grass or brush	43.56	41
2. Single line of trees	21.53	20
3. 20-200 foot forested	5.07	5

4. 200-400 foot forested	4.96	5
5. >400 foot forested	4.37	4
6. Residences or farms, little forest	3.50	3
7. Residences or farms, significant forest	0	0
8. Roads or railroads	3.73	3
9. Industrial	6.44	6
10. Unforested wetland	13.74	13
Total	106.9	100

Dikes isolate the river from riparian areas along 44 miles of estuarine shoreline (Pentec and NW GIS 1999, as cited in SBSRTC 2002)). One of the only undisturbed reference areas indicative of historic riparian condition is on both banks of Ebey Slough around and downstream of Otter Island (Houghton). There is also some good spruce riparian forest on upper Ebey Slough, but it is located on the back side of the dike, minimizing riparian function (Chamblin). There are excellent opportunities to restore riparian function along the Snohomish River, through revision of the Army Corps of Engineers vegetation standards for dikes, by setbacks of functioning dikes, and through restoring riparian function on dikes that have been breached (Chamblin). However, riparian restoration opportunities are compromised by invasive non-indigenous noxious weeds (blackberry, reed canary grass, Japanese knotweed)(Houghton, Bails).

Water Quantity

Gauged streamflow information is available for Snohomish River at Snohomish (gauge 12155500) for the period 1941-1966, and at Monroe (gauge 12150800) for the period 1963-1994 (Pentec Environmental and NW GIS 1999).

The average annual runoff for the Snohomish watershed (Skykomish, Snoqualmie, and Snohomish rivers) is 7.09 million acre-feet, with an average annual flow of 9951 cfs measured at Monroe in 1985 (Pacific Northwest River Basin Commission 1980, Williams et al. 1975, both as referenced in Pentec Environmental 2001). The maximum discharge for the Snohomish River (near Monroe) was measured at 150,000 cfs on November 25, 1990 (USGS Website).

A watershed assessment conducted in 1995 (PGG 1995, as cited in Pentec Environmental and NW GIS 1999) reported that analysis of total annual streamflow at seven gauges within WRIA 7 showed declining streamflow (normalized to precipitation) on the Snohomish, Snoqualmie, and Tolt rivers. Normalized streamflow trends could reflect changes due to land-use activities or water withdrawals. The apparent streamflow declines are too large to be explained by allocated withdrawals alone, and may be partly related to limitations inherent in the analysis. However, data show considerable scatter, and the findings indicate that conclusions should be drawn with caution. Gersib et al. (1999 Draft) evaluated baseflows at three stations in the Snohomish/ Snoqualmie/Skykomish watershed for the period 1963-1997. They found that baseflows appear to have declined at all three gauges, with an indicated 15-20% decline on mean baseflow at the Snohomish gauge for the period. The magnitude of declines in the Skykomish and Snoqualmie rivers add to about the same magnitude as the decline in the Snohomish River. The baseflow reductions did not appear to be readily explained by analysis of effects of weather, upstream water withdrawals, dams/reservoirs/water exports, or changes in snowpack or melt timing.

Ecology has approved a transfer of prior Weyerhaeuser Surface Water Right S1-10617C to the Snohomish Regional Water Authority (Metzgar). The certificated water right authorizes the instantaneous withdrawal of 36 million gallons per day (mgd)(56 cfs), and maximum annual quantity of 28.7 mgd (32.149 acre-feet/yr)(City of Everett et al. 1998). The point of withdrawal would remain on Ebey Slough, ~1,500 feet downstream of the bifurcation from the Snohomish River. Of the total instantaneous withdrawal of 36 mgd, 15 mgd is reserved by agreement for future municipal use by the City of Everett, with 21 mgd being available for municipal use by the Woodinville Water and Northshore utility districts (Metzgar). Flow modeling estimates that modification of the seasonal withdrawal pattern associated with the water right transfer would generate negligible physical change in the river flow characteristics of the estuary. The Tulalip Tribes are concerned that the impacts of the withdrawal on Ebey Slough have not been adequately assessed (Nelson), and have appealed the issuance of the water right change (hearing scheduled December 20, 2002 in Thurston County Superior Court).

Water Quality

Habitat loss in the Snohomish estuary was probably at its worst in the 1940s-1970s (Houghton). The timber and pulp and paper mill industry, which began operating in the lower Snohomish River during the 1800s, had a major impact on the estuarine habitat and water quality (Golder Associates 2001). Numerous log rafts covered significant intertidal areas of the waterways and adjacent mudflats. The pulp mills discharged significant quantities of toxic effluent and organic solids into offshore and nearshore waters. This resulted in very poor water quality conditions (low dissolved oxygen, contaminants) at the mouth of the Snohomish River that created a barrier to the normal migration of salmon through the lower estuary of the Snohomish River (Orlob et al. 1951). Under certain conditions of tide, river flow, and waste discharge, up to 5 miles of river channel was deficient in the dissolved oxygen considered necessary to sustain fish life. Of 53 water quality samples collected in the lower Snohomish River on September 29, 1949, none revealed a dissolved oxygen content greater than 5 ppm, and sulfite waste liquor concentrations were recorded as high as 650 ppm. About one-third of all samples contained less than 1 ppm dissolved oxygen, and the average was 2.04 ppm. During the period of the 1949 survey, numerous kills of herring, candlefish, and even adult salmon were noted. During 1966-1971, ~2.5 million pounds/day of solid waste was discharged into deep waters and ~400,000 pounds/day were discharged into inshore waters (Ecology 1976, as cited in Golder Associates 2001). In late 1975, discharges of solids to deep and inshore waters decreased by 80% and 50%, respectively (Golder Associates 2001). Also, discharges of sulfite waste liquor were reduced. Field studies in the early 1970s demonstrated that deep waters (36-73m) were considerably more toxic (larval oyster bioassays) than shallow waters (0-18m). Juvenile salmon held in shallow water live boxes were killed by high concentrations of dissolved hydrogen sulfide. Water quality improved rapidly after reduction of effluent discharges in 1975 and it is likely that sediment from the river buried some contaminated sediments, although some localized areas still remain contaminated (Fricke 1995, as cited in Golder Associates 2001). A recent study by NMFS did not find elevated concentrations of PCBs or aromatic hydrocarbons in the stomach contents or tissues of juvenile salmon collected in the Snohomish estuary (Varanasi et al. 1993, as cited in Golder Associates 2001).

The Snohomish River has high stream temperatures, turbidity, bacteria, organics and metals (Thornburgh and Williams, 2000). The Snohomish River is included on the 1998 303(d) list of impaired waterbodies for water temperature (just upstream of mouth, 2 miles downstream of SR 2 bridge, RM 12.7, and RM 13.0), fecal coliform bacteria (at site PSS 015, and RM 12.7, 13.0, and 16.5), dissolved oxygen (RM 16.5), and copper (RM 12.7). Excursions from the criterion for pH at RM 13.0 and 16.5, and for mercury and copper at sampling site 07A111 are thought to be reflective of natural conditions. Sediment quality standards were exceeded for a variety of chemical contaminants at the Mill E/Koppers site.

Water quality sampling in August 1993 found dissolved oxygen concentrations at sampling sites in Port Gardner, lower Snohomish River, Steamboat Slough, and Ebey Slough to be less than saturation, and inversely related to salinity (Cusimano 1995). Oxygen levels in lower Ebey Slough by Marysville were found to be as low as 6.6 mg/l. Ebey and Steamboat sloughs had relatively high chlorophyll *a* concentrations (up to 7.4 ug/l in lower Ebey Slough). Ammonia was found in measurable amounts in Port Gardner, lower Snohomish River and the sloughs, but not in upper Snohomish River or Possession Sound. Fecal coliform bacteria concentrations were found to be below the state water quality criterion for all sampling sites in the lower part of the river and sloughs.

Water quality and quantity modeling conducted pursuant to the TMDL study for the Snohomish estuary identified that under critical conditions (certain flow and tide conditions during the normal low flow period of July-October) natural dissolved oxygen concentrations would be below the Marine Class A criteria when salinity exceeds 1‰ (Cusimano 1997). Waste load allocations were recommended for the City of Everett WWTP (two discharges), the City of Marysville WWTP, the Lake Stevens Sewer District WWTP, and the City of Snohomish WWTP to meet the allowable anthropogenically-caused dissolved oxygen deficit of 0.2 mg/l. The cities of Monroe and Sultan WWTPs were identified as having only a small effect on dissolved oxygen in the Skykomish River. Treated effluent from the City of Everett and City of Snohomish sewage treatment plants is passed through diffusers into the Snohomish River (Metzgar). The diffusers are located above the level of the river bottom to minimize maintenance.

Ebey Slough is included on the 1998 303(d) list of impaired waterbodies for water column bioassay, dissolved oxygen, pH, and fecal coliform bacteria. Additional concerns of arsenic and ammonia-N are being addressed through CERCLA remediation. Water quality temperature standards exceedances have also been observed, but were determined to be reflective of natural conditions (1998 303(d) Decision Matrices).

Hundreds of cattle access the Snohomish River between French Creek and the City of Snohomish and along Ebey Slough, causing bank erosion and degrading water quality; these problems could be addressed through fencing and enhanced riparian revegetation (Haas 2001).

Predictive modeling of groundwater leachate near the Tulalip Landfill Superfund site along Steamboat Slough indicated that arsenic and ammonia-N levels are likely at levels that do not meet surface water quality standards (1998 303(d) Decision Matrices); these concerns were addressed through a CERCLA Cleanup Action Plan. EPA has recently removed the Superfund designation at this site.

A pond was constructed within the historic estuary just north and west of the I-5 bridge over the mainstem Snohomish for storage/treatment of wood-waste liquors from the old Weyerhaeuser mill (Metzgar, Houghton). This pond is isolated from the river, even at flood flows, and has not been actively used since the closure of the mill. However, water and sediment quality in the ponded area is poor.

Lakes

Lake habitat concerns in the Snohomish River watershed are included in the discussion for the watershed in which they are located. Most "lakes" directly associated with the Snohomish River mainstem are old isolated sloughs and distributary channels.

Estuarine/Marine Nearshore

Since the mid-1800s, the lower Snohomish River and estuary have undergone major alterations. Bortleson et al. (1980, as cited in Golder Associates 2001) estimated a 74% loss of subaerial wetlands, and a 32% loss of intertidal wetlands. Most of the subaerial wetlands were impacted by diking for agricultural uses. Intertidal areas were impacted by dredging and removal of LWD to enhance navigation, and by diking and filling of side channels. Because much of this area was simply diked for agricultural use, the soils and topography behind the dikes are largely intact over large areas (City of Everett and Pentec Environmental 2001). Other reductions in habitat function have resulted from human-induced stressors such as log raft storage and sediment contamination, which can be reversed. Because of the nature of the losses in habitat area and function that have resulted from urban, industrial, and agricultural development over the last century, the Snohomish River estuary has substantial potential for restoration of salmonid habitat function.

The estuarine areas at the mouth of Quilceda Creek and Ebey and Steamboat sloughs have limited diking and are close to the natural historical condition (City of Everett and Pentec Environmental 2001). Log raft storage has been and continues to be the major industrial use in this area; however, recent declines in timber harvest have substantially reduced the intensity of log raft storage over the estuarine delta in this area.

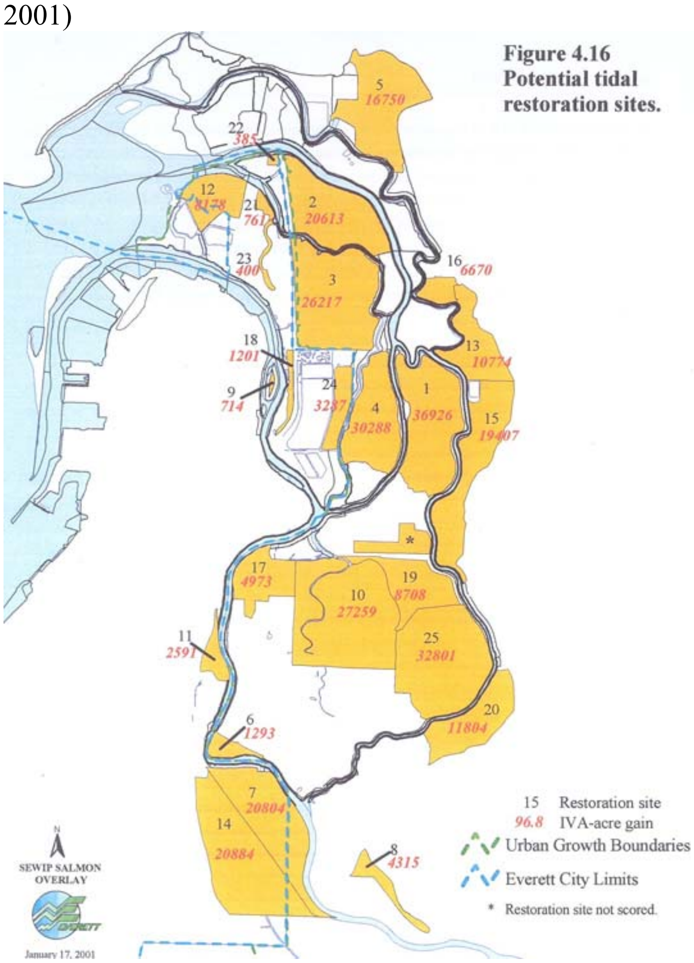
The creation of Jetty Island and associated deflection of ~50% of the Snohomish River flow and sediment down the lower Snohomish channel have altered the character of estuarine/nearshore habitat at the mouth of the Snohomish River (City of Everett and Pentec Environmental 2001). Prior to the construction of Jetty Island, the lower Snohomish River resembled the extensive mud and sandflats that persist outside of Jetty Island. Other emergent marshes similar to Maulsby Swamp likely were present along the base of the bluff south toward the naval base. The lower Snohomish along the Everett waterfront has been extensively dredged and filled, primarily for timber-related industries, since the inception of the City of Everett. The Army Corps of Engineers dredges in the mainstem federal navigation channel every ~2-3 years, alternating between the upper and lower settling basins; the sediment from these settling basins is high quality sand that is used for a variety of projects within and outside the watershed (Houghton). Ongoing dredging alters the natural depth contours in the main thalweg of the mainstem Snohomish River, but the channel fringe has remained fairly stable except where altered by Port of Everett or other industrial berth maintenance dredging. Most material that is dredged passes PSDDA open water disposal criteria. Ebey and Steamboat sloughs are not dredged, and Union Slough was last dredged in ~1910. The cumulative effects and long-term consequences associated with ongoing dredging have not been quantified (Chamblin). Shoreline fill has occurred just south of Preston Point, at the 10th Street boat launch, the north and south marinas, and at the naval base, reducing the area of historical intertidal mudflats by ~50% (Pentec Environmental 1992, as cited in City of Everett and Pentec Environmental 2001). Shoreline fill has also been placed at many other locations throughout the estuary (e.g., Simpson Lee Mill site, Tulalip landfill, I-5 right-of-way, etc.)(Haas). Extensive mudflats persist waterward of Maulsby Swamp and along the east side of Jetty Island, but they have been extensively used for log raft storage (City of Everett and Pentec Environmental 2001), thus decreasing eelgrass presence in the area (Haas). Log raft storage has been precluded by the Port of Everett on the southwestern side of Jetty Island, resulting in natural levels of eelgrass presence in the area.

The City of Everett and Pentec Environmental (2001) applied a model to assess existing estuarine/marine nearshore habitat conditions and associated habitat functions. The largest concentration of remaining high-quality habitats was found to be along the eastern distributary channels (Ebey-Steamboat sloughs), with the highest scoring estuarine sites including Otter

Island, Ferry Baker Island (lower Snohomish River), and Quilceda Creek mouth. In addition, the nearshore along the southern side of the Tulalip Indian Reservation and the extensive tideflats were also identified as having high habitat value. The lowest habitat values (typically representative of the most degraded sites) were generally along the diked/leveed portion of the lower Snohomish River, and along the highly developed and altered shorelines of the lower river and in the East Waterway.

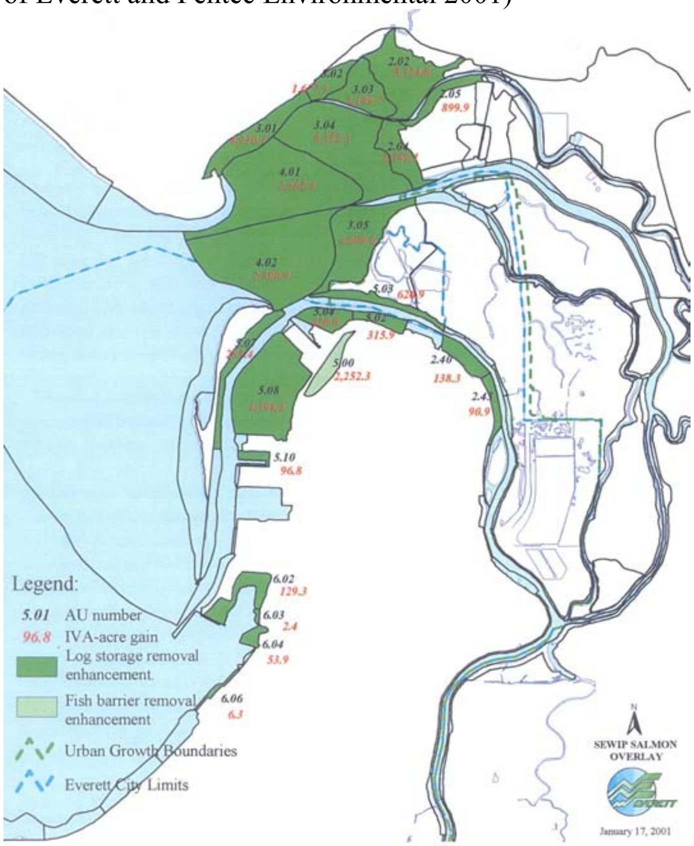
The greatest potential for further estuarine habitat degradation or loss is within the City of Everett Urban Growth Area (UGA), except for areas such as Ferry Baker Island and Maulsby Swamp, which are protected from development under the City's revised Shoreline Master Program. In the Salmon Overlay, a hypothetical scenario of future buildout within the UGA is projected to result in a loss of 226 acres of intertidal habitats and 306 acres of isolated palustrine wetlands, in part through filling for development and in part through restoration of tidal habitat function as mitigation for that development. Although the palustrine wetlands historically functioned as salmon habitat, they have no direct present function as habitat for salmonids. A significant part of this loss of isolated palustrine wetlands would occur in the Marshlands area (~50% wetland loss). The mitigation policies within the Salmon Overlay (which is part of the City of Everett's updated Shoreline Master Program) would require that these losses be compensated for with 568 acres of tidal habitats, which would result in a net increase of 342 acres of tidal habitat accessible to anadromous fish.

Figure 18: Potential tidal restoration sites in Snohomish estuary (from City of Everett and Pentec Environmental 2001)



The Salmon Overlay to the SEWIP identifies a variety of potential tidal habitat restoration/ mitigation sites and opportunities (City of Everett and Pentec Environmental 2001). Identified opportunities include restoration of tidal/river connectivity (Figure 18), improving existing habitat through removal of stressors (e.g., log rafting)(Figure 19), and riparian buffer enhancement. The tidal habitat model that was used presents a numerical estimate of the relative habitat gain that could be obtained at each site if restored (City of Everett and Pentec Environmental 2001). Within the UGA, the areas with greatest potential habitat gain from restoration of river/tidal connectivity are Marshlands 1, Marshlands 2, Smith Island Delta front, upper Union Slough, and Simpson Lee. An additional 15 estuarine tidal/river connectivity restoration sites located outside the UGA are identified that would significantly benefit salmonid habitat. The Salmon Overlay prioritizes the river/tidal connectivity restoration sites using consideration of salmonid

Figure 19: Potential stressor removal (log rafting and fish access) opportunities in the Snohomish estuary (from City of Everett and Pentec Environmental 2001)



habitat benefits, existing functions foregone, landscape, and technical difficulties anticipated. Ability to implement restoration at these sites may be impaired by lack of ownership or interest in altering existing land use for salmonid habitat restoration.

The tidal habitat model used in the Salmon Overlay to the SEWIP indicates there would be substantial habitat benefit by eliminating/reducing log raft storage in the intertidal/nearshore area (Figure 19). Log rafting has occurred extensively across the lower intertidal estuary, although closure of mills on the Everett shoreline and reduced timber harvest in the watershed have resulted in a significant reduction in active log rafting in recent years (Houghton). However, significant log rafting still occurs in Union, Steamboat, and Ebey sloughs, and in the lower Snohomish River. Log rafting has been found to reduce benthic infauna through sediment compaction, bark accumulations on the substrate, and shading (Smith 1977); low dissolved oxygen levels and high concentrations of wood leachates have also been observed in areas of intensive log rafting in semi-enclosed bays (Pease 1973, as cited in Haas 2001). Significant bark accumulations have only been observed in isolated locations in the Snohomish estuary (e.g., East Waterway). Log raft storage has also been associated with increased seal/sea lion presence at some locations, as the log rafts provide good haulout habitat.

Historic dredging and filling within Port Gardner have eliminated large areas of natural shallow nearshore habitat. The placement of dredged sediments on Jetty Island to create shallow nearshore habitat moved the natural shallow nearshore habitat farther out into Possession Sound (Haas). However, the creation of Jetty Island created shoreline and shallow-water areas that are highly productive, supporting many species of fish and baitfish, invertebrates, and shorebirds (Pentec Environmental 1996a and 1996b, as cited in City of Everett and Pentec Environmental 2001). In addition, the reduction of flow and sediment deposition across the tideflats has likely allowed expansion of eelgrass beds west of the southern half of the island. Eelgrass is present on >25% of the Snohomish delta outside of Jetty Island, and along a portion of the southern shore of Port Gardner (City of Everett and Pentec Environmental 2001). Patches of eelgrass are present elsewhere in the marine nearshore, including along the southeastern shore of Jetty Island. These areas rank high for habitat quality, and warrant protection. Eelgrass presence on the northern portion of the delta, swept by the outflow from Steamboat and Ebey sloughs, is more dynamic than in the protected areas behind Jetty Island.

Nearshore habitat conditions from Preston Point to Mukilteo have been severely altered (Chamblin, Houghton, Rowse, Metzgar). Dredge and fill operations have occurred adjacent to the lower Snohomish channel and around the East Waterway, including placement of extensive amounts of fill between 10th Street and 13th Street, at the Navy Homeport facility (formerly Norton Terminal), and at the Port of Everett's marine terminals. In addition, the railroad is located immediately adjacent to the entire shoreline from the Port of Everett's South Terminal to Mukilteo, encroaching at numerous locations into historic intertidal habitat, and isolating the nearshore from natural sediment recruitment and riparian processes. The only areas with continuing sediment recruitment are where tributaries along the south Everett shoreline have continued to transport sediment through culverts under the railroad fill into the nearshore. To the north of the estuary, much of the marine shoreline is bulkheaded from west of Priest Point to and through Tulalip Bay. From Tulalip Bay north to Kayak Point, shoreline conditions are more natural, although there are substantial shoreline modifications at several of the shoreline communities (Haas). The loss of natural nearshore processes has adversely affected forage fish spawning habitat conditions; effects to salmonid utilization have not been determined.

Action Recommendations

The following ranked habitat restoration actions are recommended for the Snohomish River, Snohomish estuary, and nearshore:

- Reduce/eliminate log raft storage in the estuary/nearshore
- Restore hydraulic connectivity and fish access to tidal sloughs, and historic marshes and floodplain wetlands
- Restore riparian function, particularly in conjunction with tidal habitat restoration
- Minimize nearshore bulkheading and explore opportunities to restore natural nearshore functions

Deadwater Slough 07.0024, EF Deadwater Slough 07.0028, and tributaries

General

Deadwater Slough is a historic large blind tidal slough complex entering the RB of the lower Snohomish River at RM 4.0 (Williams et al. 1975). Deadwater Slough is historically the largest of the natural blind tidal slough complexes in the Snohomish River estuary (Haas and Collins 2001). A portion of the slough originates in a forested wetland on State owned land at the southeastern end of Ebey Island.

Fish Access

Salmonid presence occurs upstream to a pump station located at ~RM 0.3 (Chamblin). The pump station precludes upstream adult and juvenile salmonid access. However, salmonids may access upstream of the pumping plant during flood events that overtop the dikes (~5-year flood plus one foot); it is unknown whether salmonids that enter during flood events would be able to survive water quality conditions and safely exit out of the slough.

Floodplain Modifications

The entirety of Deadwater Slough and tributaries has been extensively ditched and channelized to serve as an agricultural drainage network, although the historic tidal slough configuration remains generally intact. Restoration of tidal connectivity to Deadwater Slough is rated as one of the higher benefit restoration opportunities in the Snohomish estuary (City of Everett and Pentec Environmental 2001). No information was available on whether there has been similar soil level subsidence through the Deadwater Slough agricultural areas, as has been observed in agricultural lands in Marshland and French Creek.

Channel Conditions/Substrate Condition/Riparian Condition

Substrate is fine-grained, characteristic of estuarine sloughs. A portion of the slough originates in a forested wetland on State owned land at the southeastern end of Ebey Island (Nelson). There is little riparian vegetation or LWD through the agricultural drainage network.

Water Quantity/Water Quality

Poor water quality is known to occur upstream of the pumping stations at Marshland and French Creek, and is also likely on lower Deadwater Slough. Natural tidal flushing has been eliminated by presence of the pumping plant at the mouth of the slough and water quality may be impaired by unrestricted livestock access to the channels at several locations (Haas). The slough downstream of the pump plant has a very strong odor of manure, and the upper slough has abundant algae presence (Rowse).

Water quality sampling in August 1993 indicates that Marshland, Deadwater Slough, and Swan Trail Slough have the poorest water quality in the Snohomish River drainage (Cusimano 1995). The data suggest that diel changes in dissolved oxygen may be high due to productivity (between sampling days, dissolved oxygen was 8.9 and 15.0 mg/l for Deadwater Slough). Levels of chlorophyll *a* indicate the waters are hypereutrophic (e.g, chlorophyll *a* concentrations in Deadwater Slough exceed 100 ug/l). High levels of nutrients, turbidity, and fecal coliform bacteria were also found. Pumps at the outlet of Deadwater Slough were not operating during the survey.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Deadwater Slough watershed:

- Assess water quality conditions upstream and downstream of the pumping plant prior to implementing fish passage upstream of the pumping plant
- Restore tidal flushing into Deadwater Slough
- Eliminate unrestricted livestock access to channels, and restore riparian function throughout the drainage

Bigelow Creek/Wetlands 07.0035?

General

Bigelow Creek/Wetland enters the left bank of the Snohomish River at RM 6.0, at the old Simpson Lee Mill site (Haas 2001). Bigelow Creek supports known coho rearing, and may provide rearing for other salmonids. The City of Everett owns the entire old Simpson Lee Mill site, providing excellent opportunities for restoration of one of the few key left-bank estuarine wetlands in the lower Snohomish River.

Fish Access/ Floodplain Modifications

Bigelow Creek/Wetland flows through a partially filled wetland complex prior to entering the Snohomish River. A tidegate through the dike at the mouth of Bigelow Creek previously impaired access into the wetlands, but has been removed, providing unrestricted access and tidal influence into the wetland (Crane). Juvenile salmonid use has been documented by the Tulalip Tribes (Haas 2001), and also observed by Chamblin.

The creek/wetland flows through the old Simpson Lee mill site, which was heavily altered from natural conditions. Extensive fill was placed in historic wetlands, and the creek was ditched, channelized, and culverted through the mill site and along the railroad (Chamblin, Metzgar). Wetland channel characteristics have been restored where the creek flows along the railroad tracks, including open wetlands in the denser vegetated areas (Crane). Removal of fill material from the historic wetlands would also enhance habitat quality.

Channel Conditions

No quantitative channel condition information is available. Some habitat restoration work, including placement of large wood and riparian revegetation has been done where the creek flows along the railroad.

Substrate Condition

Substrate is composed primarily of fine-grained material, characteristic of lower river floodplain wetlands, providing juvenile salmonid rearing opportunity.

Riparian Condition

Review of the 2001 aerial photos provided by Snohomish County SWM indicates variable riparian condition in the watershed. The lower ~0.25 mile flows through floodplain wetland with relatively young vegetation. Upstream, habitat conditions have been restored along the railroad, including riparian plantings. Overall, riparian condition would likely rate as poor/fair in the anadromous zone of the watershed, but with the potential to improve as riparian vegetation matures.

Water Quantity

Bigelow creek/wetland receives stormwater from the railroad and from the developed hillside at the upstream end. Effects of stormwater runoff have not been evaluated in this drainage.

Water Quality

No water quality monitoring data are available.

Action Recommendations

The following ranked habitat restoration actions are recommended for Bigelow Creek:

- Removal fill material from the old Simpson Lee Mill site to restore historic floodplain wetland habitat function
- Assess effects of stormwater runoff to wetland and channel habitat function, address identified problems

Quilceda Creek 07.0044, Unnamed 07.0045, Sturgeon Creek 07.0046, Unnamed 07.0048, WF Quilceda 07.0049, MF Quilceda 07.0058, and tributaries

General

Quilceda Creek is an independent RB tributary to the north end of the Snohomish estuary, entering Ebey Slough at the western end (Williams et al. 1975). The Quilceda Creek watershed drains ~38mi^2 (Carroll 1999), including the eastern edge of the Tulalip Indian Reservation and much of the I-5/urban corridor north of Marysville.

Quilceda Creek and its tributaries provide good spawning and rearing habitat for salmonids, as well as supplying resident fish habitat (Carroll and Thornburgh 1995). The Quilceda Creek watershed was a good producer of coho (Brock, Chamblin). There has been a significant reduction in coho production in the Quilceda watershed, with low returns even in 2001, when there were large coho returns elsewhere in the Snohomish watershed (Chamblin).

Fish Access

The WDFW Fish Passage Database (February 2002) includes inventory of five culverts in the Quilceda watershed. The following culverts are included in the inventory:

Stream	Road Crossing	River Mile	Barrier Status
WF Quilceda	I-5	NA	No
MF Quilceda	SR 9	NA	No
Unnamed 07.0060	SR 531	NA	No fish use indicated
Unnamed 07.0061	SR 531	NA	No
Unnamed 07.0061	SR 531	NA	No

Nelson (1995, as cited in SBSRTC 2002) indicates that fish passage in MF Quilceda is obstructed upstream of RM 3.8; this may be the barrier culvert that was corrected by Snohomish County SWM in 1999 (Carroll). No other major blockages are known in the Quilceda watershed, except for the culvert at the SR 9 crossing (Carroll). Adopt-A-Stream has recently completed a comprehensive culvert inventory for the Quilceda watershed; the data are currently being reviewed for incorporation into the WDFW Fish Passage Database, and were not available for inclusion in this report (Brian Benson, WDFW, personal communication).

Floodplain Modifications

Tidal influence extends to upstream of I-5 (~RM 2.0). There has been extensive ditching/ channelization of much of the Quilceda Creek watershed, particularly in the WF and MF Quilceda drainages. Streams have been rerouted to drain current and previous agriculture areas, with many channels routed in ditches along roads.

There is ongoing discussion of restoring floodplain function in Edgecomb Creek (07.0060) by relocating and reconfiguring more natural floodplain characteristics through currently open agricultural land, prior to the land being develop and locked in place in its current severely channelized configuration (Brock). This same consideration is also applicable to several other tributaries in the watershed that have been channelized through agricultural lands. Restoration of floodplain function would certainly be beneficial to salmonids, but care should be taken to ensure that the restored floodplain is of sufficient width to allow natural channel migration as the low gradient channels through the floodplain get filled with sediment or dammed by beaver activity (Carroll).

Based on extent of hydric soils, ~75-85% of the wetlands in the Quilceda/Allen Creek watersheds have been lost (Snohomish County 1986, as cited in Carroll 1999). Many of the remaining wetland acres have been altered to some degree by urbanization and agricultural activities. There are extensive wetland complexes in the headwaters of both MF Quilceda and Quilceda creeks that warrant special consideration for protection, as they are at substantial risk due to expanding development (Carroll 1999, Brock). There are also beaver pond marshes along Sturgeon Creek and the lower portion of Quilceda Creek running through the Boeing test site that provide excellent rearing habitat for coho and cutthroat.

Channel Conditions/Substrate Condition

Available quantitative data on channel conditions indicate low presence of LWD and relatively low pool frequency through most of the channel types (Table 8). The designation of pool habitat by Purser (Table 8) appears to conflict with that in Nelson (1994), who identified pools as the dominant habitat in mainstem Quilceda Creek. There is also high presence of fine sediment in the channel types sampled (Table 8). High fine sediment levels in Quilceda are a cause for concern (Nelson 1994, as cited in Carroll 1999). The highest fine sediment deposition areas were found in lower and upper Quilceda Creek. The highest sediment loads in the watershed were found at the water quality monitoring site that drains both the upper Quilceda and MF Quilceda (Thornburgh 1994). The 1993 Snohomish County SWM surveys (as cited in Thornburgh 1994) noted agricultural impacts in upper Quilceda Creek. The source of sediment in MF Quilceda included streambank erosion associated with a culvert in Edgecomb Creek, a gravel mining operation, and agricultural activities (Thornburgh 1994). Little recent development has occurred in WF Quilceda, where total suspended solids levels were low. Primary sediment sources in WF

Table 8: Channel conditions for Quilceda Creek (courtesy of Michael Purser)

	Rosgen Class	Reach Length(m)	Ave BFW(m)	Ave LWD/CW	Pool Freq/CW	% Pools	% Fines
Quilceda	A	100	2.40	0.07	0.00	0.00	
Quilceda	C	4660	4.61	0.05	0.05	25.13	97.56
Quilceda	E	2372	11.55	0.14	0.02	6.54	100.00
Quilceda	F	2652	4.78	0.17	0.09	28.21	73.79
Quilceda	G	769	3.33	0.09	0.03	3.44	13.75
Quilceda	X	3892	3.52	0.00	0.01	38.24	

Quilceda are agricultural activities and ditching (Thornburgh 1994), although sedimentation from adjacent dirt bike trails (Carroll and Thornburgh 1995) was also noted as a concern. Dirt bike activities were stopped in 2000 and fine sediment levels reduced substantially as a result (Carroll).

Riparian Condition

Review of the 2001 aerial photos provided by Snohomish County SWM indicates variable riparian condition in the watershed. There are some fair/good riparian buffers where the creeks flow through ravines and in the headwaters of Quilceda and MF Quilceda creeks; riparian condition is poor through most agricultural lands, with limited potential for restoration as agricultural lands are converted to residential (Brock). Approximately 20% of the reaches surveyed in 1993 had riparian buffer widths of >100 feet (Nelson 1995, as cited in SBSRTC 2002). Carroll and Thornburgh (1995) report a wide riparian buffer and adjacent wetland system, about 200-500 feet in width, along most of the length of Quilceda Creek, except where it passes through agricultural land, with the largest buffer downstream of the confluence of WF Quilceda. A 75-100 foot riparian buffer has been maintained along MF Quilceda through portions of residential development, but is absent where the creek passes through farm fields (Carroll 1999).

Overhead canopy is dense in the lower 0.5 mile of Edgecomb Creek (Carroll and Thornburgh 1995). There is some riparian vegetation between 172nd Street NE and the north bank of the creek; a large forested tract borders the south bank. Vegetation is absent through farm fields and sparse through the residential area. The headwaters of Olaf Strad Creek are well protected with forested vegetation, but there is little overstory vegetation where the stream enters farmland. The entirety of Sturgeon Creek is bordered by forestland or a forested buffer.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Quilceda Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Quilceda Cr	0	17	22	39	6	15	0	0

Water Quantity

Gauged streamflow information is available for Quilceda Creek near Marysville for the period 1946-77 (mainstem Quilceda near 108th) and for the period 1984-86 (mainstem Quilceda upstream of the WF Quilceda confluence, and at ~RM 1.3 of WF Quilceda)(Carroll and Thornburgh 1995).

Groundwater is a key contributor to streamflow in Quilceda Creek, accounting for 46 to 60% of streamflow during periods without precipitation (Larson and Marti 1996). Groundwater contribution to streamflow in the mainstem ranged from 8 to 33%; groundwater comprised 67-83% of streamflow in MF Quilceda. The depth to groundwater in the Quilceda watershed is shallow, ranging from as little as one foot below the ground surface in the northern part of the study area, to 29 feet below the ground in the southern part. Any development that decreases groundwater recharge or storage capacity of the aquifer will decrease the flow in Quilceda Creek, especially during periods of not rainfall and lowest flows. This shallow water table supports the few remaining wetlands and is the reason for the many ditches constructed to drain agricultural areas. The shallow groundwater will make it difficult to construct stormwater retention ponds associated with increasing development in the watershed.

Although groundwater interacts with Quilceda Creek throughout its length, infiltration of precipitation and aquifer recharge is greater than aquifer discharge to the stream in the northern portion of the watershed, and discharge to the stream is greater than aquifer recharge in the southern portion of the watershed (Larson and Marti 1996). Rainfall is stored in the northern portion, moves via groundwater to the south, and discharges to the stream where it is incised in narrow canyons. Development activities in the northern portion of the watershed, such as ditching and paving (without adequate stormwater storage), will decrease aquifer recharge, increase winter streamflow, and decrease summer flows.

HSPF flow modeling was conducted as part of the Quilceda Watershed Plan, comparing flows for four future, one current, and one past scenario (Beyerlein and Brascher 1995). Current peak streamflows in the Quilceda/Allen watershed have increased by an average of 40% from pre-development streamflows. Even with implementation of stormwater controls, new development could increase peak streamflows by an additional 35% in lower Quilceda Creek, and could cause greater increase in peak flows in upper Quilceda Creek. The natural characteristics of the basin (outwash soils, flat-gradient floodplains, wetlands, and trees) play the largest role in attenuating current and future flood flows. Preservation of these natural resources combined with stormwater facilities, particularly in the moderate to steep sloped areas, will help to reduce the impacts of future development. Despite the critical importance of peak flows to habitat integrity, there has been limited consideration or implementation of the stormwater runoff control management recommendations in the Quilceda/Allen Watershed Management Plan to date (Brock).

Water Quality

Water temperature monitoring from May 1993 to April 1994 documented dry season mean water temperatures in Quilceda Creek ranging from 12.0 to 13.7^{o}C; all water temperatures were under 16^{o}C (Thornburgh 1994).

Quilceda Creek is included on the 1998 303(d) list of impaired waterbodies for dissolved oxygen (5 reaches, including in WF Quilceda and MF Quilceda) and fecal coliform bacteria (6 reaches). Water quality sampling conducted in 1993-1994 found that seasonal means met the dissolved oxygen water quality standard of 8 mg/l, although several samples at the WF Quilceda and Smokey Point sampling sites failed to meet the standard (Thornburgh 1994). The Tulalip Tribes found widespread fecal coliform bacteria violations and high nitrate levels during monitoring of eight sites on Quilceda and Allen creeks from 1987-1990 (Thornburgh et al. 1991, as cited in Snohomish County Public Works 2000). Snohomish County SWM sampling in the watershed from 1992-1995 showed that most of the bacteria and nutrient loading was contributed from EF Quilceda Creek, where farming and septic systems predominated (Thornburgh 1996, as cited in Snohomish County Public Works 2000). Excursions from the criterion for pH have been observed in WF Quilceda, but are thought to be reflective of natural conditions (1998 303(d) Decision Matrices). There is a history of poor livestock practices on WF Quilceda Creek, but these problems are being reduced as WF Quilceda converts from agricultural to residential land use (Brock). However, recent (2000 and 2001) water quality monitoring at several sites in the Quilceda watershed indicated that WF Quilceda has the highest fecal coliform bacteria counts in the watershed (Thornburgh 1994). The Tulalip Tribes completed a fencing project on WF Quilceda in the 1990s to eliminate livestock access to a few severely eroded sections of the creek (Nelson). Snohomish Conservation District proposed bridges to eliminate impacts at cattle crossings.

Agricultural lands have been suspected as a major contributor to water quality problems in the Quilceda/Allen watersheds, along with residential and industrial lands (Bachert 1994). Non-point pollution associated with agriculture include mismanagement of livestock wastes, poor pasture conditions, and direct access of livestock to streams and wetlands. Since the majority of agriculture in these watersheds is animal based, pollution problems tend to be livestock management oriented. A survey of livestock-based farms in was conducted in 1993. Approximately 253 farms were inventoried, of which 68 (27%) are commercial and 183 (75%) are non-commercial. However, commercial farms included 84% of the inventoried farm acreage. Approximately 153 (61%) of the farms surveyed were identified as having potential water quality problems with a "moderate" to "high" severity. Only 11% of the farms were considered to have a "very low" potential impact.

Estuarine/Marine Nearshore

The estuarine areas at the mouth of Quilceda Creek and Ebey and Steamboat sloughs have limited diking and are close to the natural historical condition (City of Everett and Pentec Environmental 2001). There is a dike just downstream of the mouth of Sturgeon Creek that impairs natural estuarine function in a 2-acre area (Haas). Log raft storage on Ebey Slough upstream of the mouth of Quilceda Creek has been and continues to be the major industrial use in this area, however, recent declines in timber harvest have substantially reduced the intensity of log raft storage over the estuarine delta in this area.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Quilceda Creek watershed:

- Implement the recommendations of the Quilceda/Allen Watershed Management Plan
- Reduce/eliminate log raft storage in the estuary/nearshore
- Protect integrity of headwater wetlands and forest cover in upper Quilceda and MF Quilceda
- Restore floodplain, wetland, and riparian function in channelized areas in the watershed
- Restore riparian function, where impaired
- Develop and implement a LWD strategy in areas with limited LWD presence and near-term recruitment potential, to increase habitat diversity until riparian function is restored, with particular emphasis on agricultural areas that are not yet developed

Allen Creek 07.0068, Unnamed 07.0068A, Unnamed 07.0068X, Sunnyside (Wood) Creek 07.0070, Munson Creek 07.0073, Unnamed 07.0074, Unnamed 07.0078, Ross Creek 07.0079, Unnamed 07.0081, and tributaries

General

Allen Creek is a RB tributary entering Ebey Slough in the Snohomish River estuary at RM 2.9 (Williams et al. 1975). The Allen Creek watershed drains ~11 mi^2 (Carroll 1999). The watershed is mostly urban except in the upper portion of Allen Creek and associated tributaries, which is dominated by agricultural lands. The Allen Creek watershed (particularly Munson Creek) is facing heavy development pressure, as it is on the rapidly expanding eastern edge of the City of Marysville.

Fish Access

The WDFW Fish Passage Database (February 2002) includes inventory of one culvert in the Allen Creek watershed.

Stream	Road Crossing	River Mile	Barrier Status
Munson Creek	SR 528	2.2	Yes

The WDFW database does not represent a comprehensive inventory of culverts in the watershed. There are a series of 3 culverts near the 67th Avenue crossing of Munson Creek that are fish passage barriers (Bails). The culvert at the 67th Avenue crossing of Sunnyside Creek may also be a fish passage barrier. There is also a bad culvert at a dairy at ~RM 4.1, with an open cattle crossing corridor through the stream. Adopt-A-Stream has recently completed a comprehensive culvert inventory for the Quilceda watershed; the data are currently being reviewed for incorporation into the WDFW Fish Passage Database, and were not available for inclusion in this report (Brian Benson, WDFW, personal communication).

There are 3-4 tidegates at the mouth of Allen Creek that have impaired salmonid access to the Allen Creek watershed at certain tidal levels in past years (Chamblin). Recent additional parcel acquisition in lower Allen Creek completes the block ownership of the historic Snohomish River floodplain of lower Sunnyside/Allen Creek mouth. Plans are in progress to restore tidal connectivity to the historic floodplain area.

Floodplain Modifications

There has been extensive ditching/channelization of much of the Allen Creek watershed, particularly in mainstem Allen Creek upstream of RM 4.0 and tributaries in the north end of the watershed, and in the lower portion of Sunnyside Creek (Brock). Streams have been rerouted to drain current and previous agriculture areas, with many channels routed in ditches along roads. Historically, these channels meandered through a very large wetland system (Carroll). The channels moved as the wetland areas and channels filled with accumulating sediment either from natural wetland processes or beaver activity). Floodplain function should be restored where feasible, particularly in areas that have yet to be developed, with restoration including the reestablishment of natural channel configuration and characteristics, as well as the ability of the channel to move as channels through the floodplain wetlands fill with sediment.

Munson Creek has spawning and rearing habitat throughout, but draining and filling of about 100 acres of adjacent wetlands, sediment from construction activities, fish blockages, and other human impacts have severely degraded the stream (Carroll and Thornburgh 1995). Increased flows have caused downcutting of the channel in places, and it appears that the entire stream will be surrounded by new development in the future. Impacts are likely to increase.

Based on extent of hydric soils, ~75-85% of the wetlands in the Quilceda/Allen Creek watersheds have been lost (Snohomish County 1986, as cited in Carroll 1999). Many of the remaining wetland acres have been altered to some degree by urbanization and agricultural activities.

Channel Conditions

There are few pools and little LWD or recruitment potential throughout the watershed except where the creeks are located in ravines (Chamblin). Allen Creek is choked with reed canary grass through the ditched and channelized reach that runs along 67th Avenue (Bails).

Substrate Condition

No quantitative substrate information is available, but fines appear to be elevated throughout the agricultural and residential areas of the lower watershed (Brock, Bails). From just upstream of the confluence of Munson Creek to the mouth, extensive sediment has been accreting in the channel (Carroll 1999). The channel has filled in from upstream of Jennings Park to Sunnyside Boulevard, where some of the sediment becomes trapped in wetland vegetation. Livestock have unrestricted access to the stream in many areas. Bank stability and sedimentation are impaired due to open livestock access through the stream at a dairy at ~RM 4.1; the landowner has been unreceptive to correction efforts (Bails). Further upstream, there are additional sites with unrestricted livestock access through the channel.

Munson Creek contains more gravel substrate and a smaller percentage of fine silt over a greater distance than other streams in the Allen Creek watershed (Carroll 1999).

Riparian Condition

A 400-foot wide riparian buffer or wetland system protects Allen Creek from Jennings Park south to Sunnyside Boulevard (Carroll and Thornburgh 1995). North of Jennings Park, the buffer is ~1 50 feet, but shrinks as it nears agricultural land and 67th Avenue, where little vegetation has been retained. Allen Creek is choked with reed canary grass through the ditched and channelized reach that runs along 67th Avenue (Bails). Below Sunnyside Boulevard, Allen Creek also flows through a reed canary grass choked wetland between RM 1.0 and 2.0 (Brock). Riparian condition is generally poor throughout the watershed, except where the creeks are located in ravines (Brock, Bails). There is near complete absence of riparian vegetation through the agricultural area upstream of RM 3.0.

Some riparian vegetation has been retained along Munson Creek, but vegetation has been removed where it flows through the golf course (Carroll and Thornburgh 1995). Blackberry vines are found along the creek in the agricultural areas.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Allen Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Allen Cr	0	15	25	34	9	16	2	0

Water Quantity

HSPF flow modeling was conducted as part of the Quilceda Watershed Plan, comparing flows for four future, one current, and one past scenario (Beyerlein and Brascher 1995). Current peak streamflows in the Quilceda/Allen watershed have increased by an average of 40% from pre-development streamflows. Even with implementation of stormwater controls, new development could increase peak streamflows by an additional 35% in lower Quilceda Creek, and could cause greater increase in peak flows in upper Quilceda Creek. The natural characteristics of the basin (outwash soils, flat-gradient floodplains, wetlands, and trees) play the largest role in attenuating current and future flood flows. Preservation of these natural resources combined with stormwater facilities, particularly in the moderate to steep sloped areas, will help to reduce the impacts of future development. Despite the critical importance of peak flows to habitat integrity, there has been limited consideration or implementation of the stormwater runoff control management recommendations in the Quilceda/Allen Watershed Management Plan to date (Brock).

Water Quality

Allen Creek is included on the 1998 303(d) list of impaired waterbodies for dissolved oxygen (3 reaches) and fecal coliform bacteria (4 reaches). Ecology sampling in August 1993 included one dissolved oxygen sample measured at 1.0 mg/l (Cusimano 1995, as cited in the 1998 303(d) Decision Matrices). Water quality sampling conducted in 1993-1994 found that seasonal means (except at upper Allen Creek sampling site) met the dissolved oxygen water quality standard of 8 mg/l, although several samples at the Unnamed 07.0074 sampling site failed to meet the standard (Thornburgh 1994). Sixty-seven percent of the samples at the upper Allen Creek sampling site violated the state standard; salmon eggs may not survive in creek, and the extreme dry season dissolved oxygen levels of 4-5 mg/l are limiting to aquatic life. The Tulalip Tribes found widespread bacteria violations and high nitrate levels during monitoring of eight sites on Quilceda and Allen creeks from 1987-1990 (Thornburgh et al. 1991, as cited in Snohomish County Public Works 2000). Snohomish County SWM sampling in the watershed from 1992-1995 showed that most of the bacteria and nutrient loading was contributed from the north and south forks of Allen Creek, where farming and septic systems predominated (Thornburgh 1996, as cited in Snohomish County Public Works 2000). Development along SF Allen Creek and Munson Creek contributed significant sediment loads to the watershed, including detectable levels of several heavy metals. Biological condition Munson Creek, as measured by B-IBI was also rated as poor, as indicated by few predator and intolerant species (Snohomish County Public Works 2000).

Water temperature monitoring from May 1993 to April 1994 documented dry season mean water temperatures in Allen Creek ranging from 12.5 to 13.4^{o}C; all water temperatures were under 16^{o}C (Thornburgh 1994).

Agricultural lands have been suspected as a major contributor to water quality problems in the Quilceda/Allen watersheds, along with residential and industrial lands (Bachert 1994). Non-point pollution associated with agriculture include mismanagement of livestock wastes, poor pasture conditions, and direct access of livestock to streams and wetlands. Since the majority of agriculture in these watersheds is animal based, pollution problems tend to be livestock management oriented. A survey of livestock-based farms in was conducted in 1993. Approximately 253 farms were inventoried, of which 68 (27%) are commercial and 183 (75%) are non-commercial. However, commercial farms included 84% of the inventoried farm acreage. Approximately 153 (61%) of the farms surveyed were identified as having potential water quality problems with a “moderate” to “high” severity. Only 11% of the farms were considered to have a “very low” potential impact.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Allen Creek watershed:

- Complete the planned estuarine restoration at the mouth of Allen and Sunnyside creeks
- Implement the recommendations of the Quilceda/Allen Watershed Management Plan
- Restore natural channel configuration and floodplain function where feasible, particularly in areas that have yet to be developed

- Eliminate unrestricted livestock access to channels at the dairy at RM 4.1, and upstream
- Restore riparian function, where impaired, including riparian restoration of the reed canary grass wetland between RM 1.0 and 2.0
- Develop and implement a LWD strategy in areas with limited LWD presence and near-term recruitment potential, to increase habitat diversity until riparian function is restored, with particular emphasis on agricultural areas that are not yet developed

Sunnyside Creek 07.0083, Hulbert Creek 07.0086, Weiser Creek 07.0090, and Burri Creek 07.0091

General

These creeks are all right-bank tributaries to Ebey Slough. Sunnyside Creek enters Ebey Slough at RM 4.8; Hulbert Creek enters at RM 6.0; Weiser Creek enters at RM 6.9; Burri Creek enters at RM 7.0 (Williams et al. 1975). Hulbert Creek is currently the least impacted of these watersheds, with much of the headwater area remaining in forested condition (Chamblin).

Tidegates restrict or block anadromous fish access on all these creeks (Haas 2001); although some adult salmon do get above the tidegates (Carroll). Tulalip tribes have identified several blocking culverts upstream as well. The Lake Stevens Master Drainage Plan identifies several culverts that act as partial barriers to fish passage (Snohomish County PDS 2001, as cited in SBSRTC 2002). Some juvenile rearing use occurs in the lower watersheds; it is unknown whether the juveniles originate from spawning in these creeks or elsewhere in the watershed.

An erosion problem was recently identified in the upstream portion of Hulbert Creek; Snohomish County SWM has just received the necessary permits to install bed control structures to reduce the erosion (Carroll).

The Tulalip Tribes monitored water quality during baseflow and storm flow periods in Sunnyside Creek in 1999. Land use is predominately rural (>50%). Drainage area was estimated at 0.82 mi^2. The only WQ problems of note were the high TSS levels and elevated total nitrogen and phosphorous levels during storm events (Nelson 2002).

No additional information was located on habitat conditions specific to these watersheds.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Sunnyside, Hulbert, Weiser, and Burri creek watersheds:

- Preserve forest cover and natural hydrology in Hulbert Creek
- Correct tidegate fish passage barriers at mouths of these creeks
- Assess fish passage status and habitat conditions throughout watershed, correct identified problems

Moshers Creek 07.0096

General

Moshers Creek is a RB tributary to Ebey Slough, entering at RM 10.0 (Williams et al. 1975).

Fish Access

There is open access into the creek at the mouth (Chamblin). Fish passage at the SR 2 crossing is provided by a fishway and baffled culvert (Chamblin). The double stack culvert at ~RM 0.1 may be a partial fish passage barrier at certain flows (Heirman per Chamblin).

Floodplain Modifications

The natural channel configuration has been altered downstream of SR 2 (Haas). Snohomish County is in the process of buying out Drainage District 6, which would allow opportunities to restore natural channel configuration and estuarine function downstream of SR 2. Restoration plans are being delayed by discussions on how to protect the integrity of the powerline corridor supports.

Channel Conditions

The creek is ditched and channelized through Drainage District 6 downstream of SR 2, in a forested ravine for ~0.8 miles upstream of SR 2, and developed for the next 0.5 miles upstream. There is opportunity to restore natural channel configuration and estuarine function downstream of SR 2.

Substrate Condition

No information is available on substrate conditions.

Riparian Condition

Riparian condition is variable; condition is good where the creek is located in a ravine upstream of SR 2, but poor elsewhere (Chamblin).

Water Quantity/Water Quality

No information is available on water quantity or water quality.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Moshers Creek watershed:

- Restore natural channel configuration and floodplain function downstream of SR 2 (through Drainage District 6)
- Assess fish passage status and habitat conditions throughout watershed, correct identified problems

Unnamed 07.0098

General

Unnamed 07.0098 is a RB tributary to Ebey Slough, entering at RM 10.7 (Williams et al. 1975).

Fish Access

Tidegates are located at the mouth of the creek as well as at the mouth of adjacent agricultural ditches (Chamblin). The extent to which these tidegates block fish access is not known.

Floodplain Modifications

The lower ditched portion of the watershed is within the Drainage District 6 buyout area, providing opportunity to restore natural channel configuration and floodplain function (Chamblin).

Channel Conditions/Substrate Condition

No information is available on channel or substrate conditions.

Riparian Condition

Riparian condition is generally intact, except for some ditched reaches within the Drainage District 6 buyout area (Chamblin).

Water Quantity/Water Quality

No information is available on water quantity or water quality.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0098 watershed:

- Correct tidegate barriers at mouth and adjacent agricultural ditches
- Restore natural channel configuration and floodplain function through Drainage District 6
- Assess fish passage status and habitat conditions throughout watershed, correct identified problems

Swan Trail Slough 07.0103

General

Swan Trail Slough is a large (2 hectares surface water) blind tidal/distributary slough entering the right-bank near the upper end of Ebey Slough (RM 11.9, Williams et al. 1975).

Fish Access

Salmonid access is currently precluded at the mouth of the slough by a pump station/tide-gate. Restoration of fish access would involve removal or retrofit of the pump station and tide-gate to restore connection with Ebey Slough (Haas 2001).

Floodplain Modifications/Channel Conditions/Substrate Condition

Natural floodplain function is impaired by agricultural encroachment/confinement. No information is available on channel or substrate conditions.

Riparian Condition

Riparian condition is generally poor where the channels run through agricultural areas, where riparian vegetation is comprised of blackberries or single-tree width riparian stands (Chamblin). Riparian condition improves somewhat where the channel flows along the base of the bluff.

Water Quantity/Water Quality

Water quality sampling in August 1993 indicates that Marshland, Deadwater Slough, and Swan Trail Slough have the poorest water quality in the Snohomish River drainage (Cusimano 1995). The data suggest that diel changes in dissolved oxygen may be high due to productivity. Dissolved oxygen levels of <2.5 mg/l were measured in Marshland and Swan Trail Slough. Levels of chlorophyll *a* indicate the waters are hypereutrophic. High levels of nutrients, turbidity, and fecal coliform bacteria were also found. No measurable flow was observed in Swan Trail Slough during the survey.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Swan Trial Slough:

- Assess water quality conditions upstream of the pumping plant prior to considering fish passage upstream of the pumping plant
- Restore tidal flushing
- Restore riparian function throughout the drainage

Marshland Drainages, Wood Creek 07.0036, Larimer Creek 07.0107, Thomas Creek 07.0108, Batt Slough, Hanson Slough

General

Marshland is comprised of two distinct areas: 1) the floodplain and 2) the uplands (Toth and Houck 2001). The Marshland floodplain is the relatively flat expanse of land north of Lowell-Larimer Road, which is generally within the 100-year floodplain of the Snohomish River. The primary land use in the Marshland floodplain is agriculture. The Marshland uplands comprise the southwest half of the watershed that drains north into the floodplain. The Marshland uplands have a mix of rural and urban residential use.

Marshland is a left bank portion of the Snohomish River floodplain (from RM 7.0 to 15.0) that has been isolated from the Snohomish River by diking. Marshland drains an estimated 14,500 acres, or 22 mi^2, and is supported by 25 small tributaries (Toth and Houck 2001). The conversion of the Marshland marsh for agricultural use in the 1880s was the largest single loss of off-channel habitat in the entire Snohomish River watershed (Haas 2001). Even under conservative estimates of summer and winter rearing capacity, the historic marsh at Marshland would have provided more rearing capacity for coho and chinook than the total rearing capacity of all remaining off-channel habitat within the Snohomish River floodplain between the head of Ebey Slough and the confluence of the Snoqualmie and Skykomish rivers. Estimates of historical production indicate that the Marshland floodplain could have supported 330,000-930,000 juvenile chinook during the summer, 360,000-1,000,000 juvenile coho in the summer, and 2.6-4.3 million juvenile coho in the winter (Collins and Montgomery; as cited in Toth and Houck 2001).

The creeks in the Marshland uplands also contain many miles of potential salmon and trout habitat. Recent habitat surveys indicate that Wood Creek could support ~1,600 coho smolts, with the remaining tributary streams supporting nearly 2,000 more (Tonnes unpublished data, as cited in Toth and Houck 2001). Coho, steelhead, and cutthroat also likely utilized the many tributary streams draining into the floodplain for spawning and rearing.

Fish Access

All natural drainages in Marshland have been consolidated and routed through the Marshland Flood Control District pump station, which is an obstruction to fish passage at all flows. The Marshland dike is designed to overtop during a 5-year (20% chance of occurrence in any given year) flood event (SRSRTC 2002 Draft); it is probable that adult and juvenile salmonids enter the Marshland drainages during flood events that overtop the dikes, but it is unknown whether any resulting juvenile salmonid production is capable of surviving the poor water quality conditions in the lower canal and safely outmigrating to the Snohomish River.

Sediment settling ponds, located where the tributaries transition from the bluff to the floodplain, block upstream access to fish (Haas 2001). Wood, Larimer, and Thomas creeks contain significant coho habitat. The presence of minor passage barriers, such as perched culverts, in the tributaries is referenced in Toth and Houck (2001), with Wood Creek noted as the referenced example. Also presence of several concrete weirs in the middle reach of Wood Creek is noted in Stober et al. (1981), but the current status of these structures is unknown.

Adult chinook and coho have been observed attempting to pass through the tidegate at the Marshland pump station (WA Trout video, Kurt Beardslee). It is unknown to what extent these returning adults are the result of spawning or rearing production originating from within Marshland drainages. A small number of sea-run cutthroat trout successfully enter the Marshland drainages through a tidegate upstream of the pump station (Tonnes 2000, as cited in SBSRTC 2002). Landowners have observed sea-run cutthroat in Wood Creek, some of which had noticeable injuries likely associated with passage difficulties through the tidegate (Haas).

Batt Slough is the only one of a series of sloughs behind the Marshland levee that still retains surface water and connection with the Snohomish River; the other sloughs have been drained and farmed, and would require significant restoration to provide access and habitat for fish (Toth and Houck 2001). Salmonids access Batt Slough on occasion (pink and coho adults were observed in Batt Slough when the tidegates were vandalized ~2 years ago), but tidegates at the mouth of the slough generally preclude access (Haas 2001). The tidegates preclude tidal flushing and were installed without required permits; no followup enforcement or mitigation has occurred.

Floodplain Modifications

Prior to the arrival of non-native settlers, Marshland was a patchwork of open freshwater wetlands, shrub thickets, and mixed deciduous/conifer forest (Toth and Houck 2001). Much of the Marshland floodplain area was seasonally, if not annually, inundated as a result of tidal influence, Snohomish River flooding, and flow from tributary streams. The extent of the Marshland wetland was ~4,900 acres (2,000 ha), according to 1871 General Land Office (GLO) plat maps and 1884-85 USGS charts (Collins 2000, as cited in Toth and Houck 2001). Water levels varied seasonally, but GLO survey notes indicate that 18 of 23 survey locations were saturated or inundated during February (Haas and Collins 2000). The GLO plat maps indicate 2-6 feet of overflow, and a newspaper account reported depths of 1-2 feet.

Ditching and draining of the Marshland area began in 1883 (Interstate Publishing Company 1906, as cited in Toth and Houck 2001). An 1895 map of the area indicates that ditching and draining had altered more than half of the original Marshland wetlands. In 1914, Snohomish County helped engineer floodgates and ditch outlets. By the 1930s, five pump stations were removing water from ditches draining the Marshland floodplain. Even with the extensive drainage network and pumps, much of the Marshland floodplain remained saturated with water late into the spring and even into the summer. By the 1950s, a more concerted effort was made to improve drainage by excavating a central canal and constructing a large pumping plant. The network of ditches, approximately 20 miles in length, drained to the canal, then flowed north to the pumps. The Marshland canal and pumping plant were completed in 1962, and the 5 pumps along the Snohomish River were removed. The Marshland canal is ~6 miles in length, and the width ranges from ~12 feet at the eastern end to 90 feet at the pumping plant. At the Marshland pumping plant, the water level is typically pumped to an elevation approximately 6 feet lower than the average river level (Stocker, as cited in Toth and Houck 2001). This difference in surface water elevation creates significant challenges to restoring salmonid access.

Flooding in the lower Snohomish River is a natural process that has been controlled to some degree by a system of levees (Toth and Houck 2001). The Marshland Flood Control District and the French Slough Flood Control District are the two largest of the 11 organized drainage, diking, or flood control districts in the lower Snohomish Valley. In general, the levee system is designed to be over-topped in many places by a “5-year” design flood (20% chance in any given year that the levee will be over-topped). The levees are constructed in most areas to be 1-foot higher than the 5-year flood elevation. Adult and juvenile access to areas protected by the river dike can and do occur during the over-topping events.

Most of the isolated wetlands on the Marshland floodplain have been under agricultural production for decades, with notable exceptions in the northwest portion of the Marshland floodplain (the “northwest parcel” wetland) and Batt Slough (Toth and Houck 2001). The “northwest parcel” wetland is a forested and scrub-shrub wetland with a high water table that has prevented agricultural activities. Batt Slough is still connected with the Snohomish River; although a tidegate at its outlet has curtailed historical tidal influence, much of the slough remains inundated on an annual basis. Hansen Slough has been totally obliterated and converted to agricultural use, possibly after the 1990 flood; a swale is still apparent, but no surface water remains (Haas).

Channel Conditions

An extensive ditch and channel network has been constructed through Marshland to drain agricultural lands. Most of the tributary streams to the Marshland area are lacking in large wood, which is an important structural element for trapping sediment, creating pools, and reducing the effective gradient of the stream (Toth and Houck 2001).

Wood Creek is described as having by far the most natural stream conditions of the City of Everett drainages, with the largest insect population, large base flow, good riffles and pools, very little encroachment from development, and little impact from erosion or high flow (Brown and Caldwell Undated).

Substrate Condition

Substrate in the tributary channels is composed primarily of small cobbles, gravel, and sand (Toth and Houck 2001). The relatively high proportion of sand currently in the substrate is probably due to natural factors, such as the outwash sand geology, but may also be elevated due to increased erosion caused by development impacts.

Due to the rapid change in stream gradient at the valley edge, creek velocity declines and deposition of a wedge or fan of sediments has occurred historically (Toth and Houck 2001). Many of the dairy facilities and the Lowell-Larimer Road are built on these materials. However, continued sediment transport from the tributaries onto the floodplain portion of Marshlands has been interrupted by creation of 6 sedimentation ponds on the edge of the valley floor to collect transported sediments and avoid transport into the extensive drainage ditch network. The accumulated sediments are periodically dredged from the sedimentation ponds.

Land subsidence has been identified as a concern in the lower Snohomish Valley (Toth and Houck 2001). Settlement of land surface throughout the Marshland Drainage district is a concern because as dikes settle, overtopping locations can change. Recent Snohomish County surveys in the French Creek Drainage District found land surface elevations to be 2-2.5 feet lower than indicated in 1970s USACE maps. City of Everett surveys show similar findings in the northwest part of the Marshland floodplain (Misich, as cited in Toth and Houck 2001). Shallow peat deposits in the floodplain soils were reportedly 3-feet thick prior to pumping from ditches to lower water levels. The peat deposits disappeared, mainly due to oxidation (Buehler, as cited in Toth and Houck 2001). As land elevations in the central portion of the floodplain became lower, ditch gradient toward the Snohomish River became too shallow for effective drainage. As land surface elevation decreases, more pumping will be required to maintain a lower water table for agriculture. More pumping will increase the difference in water pressure between the water table of the interior portion of the levee and the river, and could increase the risk of levee failure.

Riparian Condition

Historically, the Marshland floodplain appears to have been a mix of willow and hardhack thickets, open water, and sparse forest cover (Haas and Collins 2001). Based on GLO field notes from 1871, 43% of the survey points had no trees, 38% has shrub thickets with scattered pine and spruce trees, and the remainder had denser forest stands (Collins 2000, as cited in Toth and Houck 2001). Drainage ditches, sediment settling ponds, and the main canal periodically are dredged of sediment. Brush control and riparian tree removal are also done to maintain access to ditches and the canal.

Currently, riparian cover is generally limited to a single band of trees on armored banks. In the Marshland area, only 7% of the riparian zone along the Snohomish River is forested and not isolated by dikes (Haas and Collins 2000, as cited in Toth and Houck 2001). Levee maintenance prevents the growth of trees that historically were important for wildlife, shading of the river, and aquatic habitat formation.

Riparian condition along Batt Slough is impaired, and would benefit from riparian planting to improve rearing habitat, once fish access is restored (Toth and Houck 2001).

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Marshland watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Marshland	0	12	35	35	4	13	1	0

<u>Water Quantity</u>

Increased peak flows, decreased summer low flow levels, and high sedimentation rates related to high levels of impervious surface in the headwaters of the Marshland tributaries adversely impact the quality of salmonid habitat in the Marshland tributaries (Haas 2001); however, a study by Chris Konrad (USGS hydrologist) of perennial streams in the Puget Sound lowland concluded that while urbanization decreased winter baseflow, it did not affect the quantity of summer base flow (study report interpretation by Dan Mathias, City of Everett). Urbanization has also changed groundwater runoff patterns such that less cool water is being contributed to streams during the drier summer season (Toth and Houck 2001, the basis for this conclusion is questioned by Dan Mathias, City of Everett, see Water Quality section below). The larger of the tributaries to Marshland include Wood Creek in the northwest portion, and Larimer and Thomas creeks in the south-central portion. These creeks are 1-1.5 miles in length, are fairly deeply incised, and appear to obtain a significant proportion of their flow from groundwater seeps and springs. There are about 22 smaller creeks, which range from 0.25 to 0.5 miles in length. The smaller creeks have steeper gradients and are not as deeply incised, and are therefore not expected to derive as much of their flow from groundwater. The smaller creeks may have more extreme fluctuations in flow than do the three larger creeks.

There are current proposals to pipe stormwater from the urban/residential developed areas in the Marshland uplands directly to the Marshland floodplain, to reduce localized flooding and increased erosion in the tributaries (Toth and Houck 2001). Although this proposal would decrease the magnitude of peak flows in the tributary streams, it would also decrease groundwater infiltration that contributes to summer low flows. In addition, piping raises concerns of how to handle the increased delivery of water to the floodplain floor, and also the water quality of stormwater that is piped directly to the valley floor. The effects to existing salmonid habitat and implications to future habitat restoration opportunities, both within the historic floodplain and in the tributary streams, should be fully considered in the final decision on whether to pipe stormwater directly to the valley floor.

<u>Water Quality</u>

Increased water temperatures, turbidity, sediment load, and chemical runoff resulting from urban development can impact both fish habitat and water quality (Toth and Houck 2001). State water quality standards have been exceeded for fecal coliform bacteria, sediment, nutrients, lead, copper, and aluminum in the Marshland streams (Thornburgh 1992, as cited in Toth and Houck 2001). Wood Creek is the only Marshland tributary included on the 1998 303(d) list, for dissolved oxygen (Snohomish County Public Works 2000). Water runoff and associated erosion from agricultural fields wash fertilizers and other chemicals into the ditch drainage system (Toth and Houck 2001). Lack of vegetation along streams and ditches can also cause higher water temperatures. Low dissolved oxygen values have been measured at various points along the canal and may be a result of a combination of high nutrient loads, warm water temperatures, and lack of significant water flow. Marshland tributaries had chronically high values for turbidity and total suspended solids (TSS). Average wet season turbidities ranged from 100 to 240 NTU, while mean TSS values ranged from 150 to 200 mg/l. The high nutrient and sediment measurements may result from development impacts, but natural conditions likely contribute to the relatively high levels as well.

Water quality sampling in August 1993 indicates that Marshland, Deadwater Slough, and Swan Trail Slough have the poorest water quality in the Snohomish River drainage (Cusimano 1995). The data suggest that diel changes in dissolved oxygen may be high due to productivity (between sampling days, dissolve oxygen was 1.7 and 7.1 mg/l for Marshland). Levels of chlorophyll *a* indicate the waters are hypereutrophic. Dissolved oxygen levels of <2.5 mg/l were measured in Marshland and Swan Trail Slough. High levels of nutrients, turbidity, and fecal coliform bacteria were also found. Pumps at the outlet of Marshland were not operating during the survey. The combined water quality problems, particularly in the lower main canal, raise concerns as to whether any adult or juvenile salmonids that enter the Marshland system could effectively survive (Chamblin, Haas).

Water temperature sampling has been conducted in Wood Creek at Lowell-Larimer Road since 1990; average water temperature is 9.5^{o}C, with a maximum observation of 12.4^{o}C (Dan Mathias, City of Everett, personal communication). Water temperature data were collected in the summer of 2000 in forested reaches of three tributaries, three corresponding downstream reaches without forest canopy cover, and two locations within the central canal (Toth an Houck 2001). Results indicate that state temperature standards are met at all locations except in the canal near the pumphouse. The relatively cold and constant temperatures indicate that groundwater is a significant component of these streams during the summer.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Marshland watershed:

- To the extent feasible, restore floodplain function on the Marshland floodplain, specifically focusing on the north and south wetland complex areas, and the Batt Slough/Hanson Slough floodway restoration options identified in Toth and Houck (2001)
- Restore tidal exchange and fish passage into Batt Slough
- Restore riparian function along the Snohomish River, Batt Slough, and along the ditches and canal within the Marshland area
- Assess water quality conditions upstream of the pumping plant prior to considering fish passage restoration upstream of the pumping plant
- Prioritize and correct any fish passage barriers into Marshland tributaries, particularly into Wood, Larimer, and Thomas creeks

Cemetery Creek 07.0117 and tributaries

General

Cemetery Creek is a RB tributary to the Snohomish River, entering at RM 11.5 (Williams et al. 1975). Much of the Cemetery Creek watershed is within the City of Snohomish UGA.

Fish Access

The culvert at the upper SR 9 crossing and at crossings of Harkins Fork on 85th St. are total fish passage barriers (Carroll). In addition, low dissolved oxygen (<4 mg/l) near the mulch plant by the lower crossing of SR 9 may also create an effective fish passage barrier.

Floodplain Modifications

There is a high quality wetland in the lower 0.2 miles of Cemetery Creek (Chamblin, Haas). The middle portion of Myricks Fork has been piped and rerouted; the work was done fairly recently without obtaining required permits (Carroll). A feasibility study has been conducted on potential relocation of the portion of Cemetery Creek that is on the east side of SR 9 to the west side of SR 9. This would eliminate the two stream crossings of SR 9, and would relocate the stream from poor habitat on the east side to better habitat conditions on the west side.

Channel Conditions

LWD and pools are generally absent downstream of SR 9; habitat conditions are reported to be fair to good upstream of SR 9 (Carroll).

Substrate Condition

No quantitative substrate information is available. Gravel substrate is present from 85th St. downstream to approximately Riverview Road, where the substrate is mucky across the Snohomish River floodplain (Carroll).

Riparian Condition

Riparian condition is highly variable throughout the watershed, ranging from poor to good (Carroll).

Water Quantity/Water Quality

No water quantity concerns are identified, although the watershed is within the City of Snohomish UGA and subject to hydrology impacts of increased impervious surfaces. Citizen water quality monitoring in Cemetery Creek has identified low dissolved oxygen levels and high turbidity on occasion (Carroll). The low dissolved oxygen levels were in the vicinity of the lower SR 9 crossing in the vicinity of a mulch plant. Possible causes include the mulch plant or stream flow through a wetland shortly upstream of the mulch plant. The Washington Department of Ecology is requiring a stormwater permit for the mulch plant, which will address water quality impacts to Cemetery Creek. High fecal coliform bacteria levels were also identified from previous water quality studies.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Cemetery Creek watershed:

- Identify and correct the cause of low dissolved oxygen levels in the vicinity of SR 9
- Continue to pursue relocation of that portion of Cemetery Creek on the east side of SR 9 to higher quality habitat on the west side of SR 9
- Correct identified fish passage barriers (note that barrier at SR 9 would be eliminated if creek were to be relocated to west side of SR 9)
- Restore riparian function, where impaired

Swifty Creek 07.0124

General

Swifty Creek is a RB tributary to the Snohomish River, entering at RM 12.9 (note that this creek is identified as Blackmans Lake Creek in Williams et al. 1975). Swifty Creek is the outlet stream from Blackmans Lake. It has been extensively culverted and flows under a heavily urbanized part of the City of Snohomish. The majority of the lower mile of the creek is culverted, including under the Snohomish High School grounds (Carroll). Localized flooding near the high school occurs on a frequent basis.

A study of water quality in Blackmans Lake in 1994 documented dense algal blooms, low dissolved oxygen in the hypolimnion, impaired fisheries and wildlife habitat, and high fecal coliform bacteria numbers (KCM 1994, as cited in 1998 303(d) decision matrix). Stormwater runoff contributes 55% of the phosphorous loading. Summertime in-lake release of phosphorous from bottom sediments is a significant source.

Action Recommendations

There is no current anadromous salmonid value in Swifty Creek, given the extent that it is culverted. Although there is citizen interest in daylighting the creek and restoring a surface water channel and fish habitat, the relative cost would be very high and the certainty of success would likely be low, so Swifty Creek would likely be a low priority for restoration at this time.

Pilchuck River Mainstem 07.0125

General

The Pilchuck River is a large RB tributary to the Snohomish River, entering at RM 13.4 (Williams et al. 1975). The Pilchuck River watershed drains an estimated 83,847 acres, including the 22,035 acres in the Little Pilchuck Creek drainage and the 8,160 acres in the Dubuque Creek drainage (SBSRTC 2002 Draft).

Redd densities for chinook, chum, and pinks (except in 2001) in the Pilchuck River mainstem are lower than in other comparable rivers (e.g., Sultan River, Wallace River) in WRIA 7, including consideration of hatchery influences (Hendrick).

Fish Access

The City of Snohomish operates a domestic water supply diversion dam at RM 26.4. The pool and weir fish ladder for the dam is located on the left-bank, which is the side of the river where sediment and debris tend to accumulate, necessitating regular and frequent maintenance of the fish ladder to ensure unrestricted fish passage (Tom Burns WDFW, personal communication). Impassable conditions over as little as a week during the adult return period could significantly impair salmonid production from the watershed upstream of the dam. The most recent upgrade work to the fish ladder was done in ~1987. Work was done at the existing ladder location and did not include the WDFW recommendation of relocating the ladder to the opposite bank where it would require less maintenance to keep the ladder operable. Poaching of returning adult salmon and steelhead is also a routine concern at the fish ladder.

Floodplain Modifications

The Pilchuck River is diked on both banks downstream of SR 2 (RM 1.9)(Hendrick). Gersib et al. (1999 Draft) estimated that 18% of the lower Pilchuck River floodplain was disconnected from the channel network. Road encroachment affects 15% (5.32 miles) of the shoreline in the middle Pilchuck, and 17% (2.8 miles) of the shoreline in the upper Pilchuck (Savery in prep., as cited in SBSRTC 2002). Greater than 25% of the streambanks in the lower Pilchuck have been hardened/armored (Collins 1991 and Tulalip Tribes unpublished data, as cited in SBSRTC 2002).

Channel Conditions

The Tulalip Tribes conducted salmonid habitat surveys in the Pilchuck River from RM 3.6 (Three Lakes Road bridge) to RM 18.6 (~0.5 mile downstream of Granite Falls) in late summer of 2002 (Savery). Data collected include fish habitat, chinook spawning reaches, riparian condition, large woody debris and jam counts, water and air temperature and areas of hyporheic exchange. Habitat and wood debris data are summarized in Table 9 below. These are preliminary results of the study, written on request for this report. Survey reaches are broken out by road crossings for simplicity of identification. The habitat surveys utilized TFW protocols for identifying salmon habitat. Pool habitat criteria are based on a minimum area and a minimum residual depth for a particular bankfull width. Deep pockets of water, usually along hardened outside bends of the river, were often excluded from being called a pool, due to the lack of a 'pool tail'. These areas were included in glide habitat. The high ratio of glide length to pool length is due to a combination of simplification of the channel by bank hardening, little to no instream wood, and little recruitment from the riparian zone. Pool spacing criteria were taken from Montgomery et al. (1995). Primary pools occupy 50% of the channel width or greater. No information was available regarding pool condition in the upper Pilchuck River (upstream of RM 18.6).

Chinook salmon spawn in the glides, which often are hundreds of meters long and straight, with little to no variation in the channel bed (Savery). Without local topology changes, these areas are less likely to have downwelling of river water through the redds. Shear stress values will be calculated for spawning areas in fall 2002 to determine if scour is an issue in the long glides versus the relatively shorter pool tails.

LWD was tallied for each habitat unit according to TFW protocol, but is reported here by reach. Wood with a diameter smaller than 60 cm was observed as lying parallel to the stream bank or racked onto log jams or lying on top of gravel bars. Wood with a diameter larger than 60 cm was observed to function as key piece LWD in a logjam.

Table 9: Pilchuck River salmonid habitat data (RM 3.6-18.6)(courtesy of Tulalip Tribes)

Reach length (m)	Location	Avg. Channel width (m)	Avg. Bankfull Width (m)	Pools		# Channel widths / pool	Glide:Pool Length (m)	LWD (≥10cm)/ 100m (pieces)	LWD(≥60cm)/ 100 m (pieces)
				Total	Primary				
3356	Three Lakes Road to Dubuque Road	21	28.3	12	9	17.8	5.7:1	9.1	0.4
4309	Dubuque Road to OK Mill Road	17.1	33.5	14	10	16.8	7.0:1	3.1	0.3
2505	OK Mill Road to Russell Road	19	35.8	17	14	9.4	2.0:1	11.8	1.2
2822	Russell Road to 28th Place NE	11.7	29.1	15	12	20.1	2.0:1	4.7	no data
3027	28th Place NE to RM 14.4	14.4	28.6	21	15	14	2.1:1	11.3	1.2
528	RM 14.7 to RM 15 Sidechannel	9.8	33.6	13	11	4.9	1.0:2.2	194.1	10
3848	RM 14.4 to RM 15.8	17.4	39.5	15	12	26.7	1.6:1	4.8	0.2
3937	RM 15.8 to RM 18.6	13.5	28.7	11	8	61.5	5.4:1	20.4	0.4

The banks of the Pilchuck River from RM 3.6 to 18.6 have been systematically hardened and its riparian zone removed for agriculture, forestry, river access and views (Savery). Two improperly aligned bridges at Dubuque Road (RM 5.9) and Russell Road (RM 10.7) constrain the channel, cause deposition of sediment upstream of the bridges and disrupt transportation of wood downstream. The Pilchuck River at Dubuque Road is further constrained by levees built to protect a gravel-mining project on the right bank. Opposite from the levees, Snohomish County has completed a bank-hardening project, which includes root wads, to protect a private road. This project will likely cause the river to scour along the riprap, effectively keeping the river on the left bank. One mile upstream of the Dubuque Road bridge, the river moves from bank to bank, working through the gravel deposits caused by the bridge.

Chinook spawn immediately up and downstream of the Russell Road bridge (RM 10.7)(Savery). In recent past, the river has increased in sinuosity in the immediate vicinity of the bridge. Riprap associated with the bridge and downstream property maintains a series of unnatural bends in the river. Approximately 500 meters downstream of the bend, erosion on the left bank has increased dramatically since the bridge was renovated.

In 1999, a 528-meter long side channel was formed at RM 15, which re-enters the channel at RM 14.7 (Savery). The side channel contains an estimated 40% of the high and low flows. The upstream end of the side channel is maintained by a channel spanning logjam. This logjam contains over 600 pieces of LWD (≥10cm). Cottonwood and conifers serve as key pieces with diameters >70cm and lengths >25 meters. In the side channel, just downstream of the first jam, is a second jam, which is anchored by a 1.3m diameter, 35m long cottonwood tree. Both logjams have large, well covered pools underneath, with depths >2m. Overall, the complexity of habitat in the side channel is high, due to the amount of wood and frequency of logjams. The mainstem is separated from the side channel by a forested island. The right bank of the mainstem is hardened with riprap.

Substrate Condition

Most of the Pilchuck River sediment travels in suspension (Collins 1991, as cited in SBSRTC 2002). The USGS estimated a long-term average suspended sediment yield of 52,000 tons/year for the Pilchuck River. All significant sediment sources (from mass wasting) are in the middle and upper watersheds, many principally composed of clay. No significant sediment sources are found downstream of RM 7.5 (Collins 1991, as referred by Nelson). Gravel mining at rates greater than the annual natural bedload deposition rate is likely to result in continued bed degradation of 500-2,500 yd^3/yr between RM 7.0 and RM 2.0 (Collins 1991, as cited in SBSRTC 2002). There are noticeable levels of fine sediment present in the gravels in the Pilchuck River downstream of Dubuque Creek (Hendrick, Carroll); no qualitative observations were available for upstream areas.

Surface and bank erosion are noted as significant sediment contributors in the middle Pilchuck River. There are active agricultural equipment crossings across a spawning glide at RM 12.8 and RM 13.2. (Savery); crossings occur throughout the year, including during spawning and incubation, but effects have not been evaluated.

Riparian Condition

Riparian condition downstream of Dubuque Creek is poor (Hendrick); riparian function is severely impaired in the leveed reach downstream of SR 2. Gersib et al. (1999 Draft, as cited in SBSRTC 2002) reported that 98%, 84%, and 23% of the stream miles in the lower Pilchuck (mouth to RM 8.5), middle Pilchuck (RM 8.5-28.5), and upper Pilchuck (RM 28.5-headwaters), respectively, were either cleared or in early seral stage (the estimates from Gersib et al. include a composite of mainstem and tributaries within the identified watershed boundaries).

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Pilchuck River watershed (WADNR Types 1-5, include riparian condition on mainstem Pilchuck and tributaries)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Lower Pilchuck	0	27	23	31	3	15	0	0
Middle Pilchuck	1	48	30	13	2	6	0	1
Upper Pilchuck	12	70	13	2	0	1	0	1

Water Quantity

The City of Snohomish has a surface water right for a 5 cfs withdrawal from the Pilchuck River at RM 26.4, which can reduce summer low flow in the river by 10-20% (Pentec Environmental and NW GIS 1999). No instream flow analysis of effects to resulting downstream salmonid production has been done (Hal Beecher, WDFW, personal communication). During the 2002 habitat surveys, the Tulalip Tribes observed 11 private withdrawals on the Pilchuck River, from RM 3.6 to 18.6, for agriculture, lawn watering and other uses (Savery).

Model estimates of impervious surface are 12% for the lower Pilchuck, 7% for the middle Pilchuck, and 1% for the upper Pilchuck (Purser and Simmonds 2001, as cited in SBSRTC 2002). Extensive floodplain alteration, diking, and increases in development suggest that a reduction in base flows should be occurring in the lower Pilchuck, although no data have been analyzed (Purser).

Water Quality

Little systematic water quality sampling has been done for the Pilchuck River (Carroll). The Pilchuck River is included on the 1998 303(d) list of impaired waterbodies for fecal coliform (3 reaches) and temperature (1 reach, RM 9.5). Excursions from the criterion for pH have also been documented at RM 1.8 and RM 8.8, but are thought to be reflective of natural conditions. Water quality monitoring at the City of Snohomish since 1998 shows that the lower Pilchuck River meets Class A standards for dissolved oxygen, turbidity, and pH (Snohomish County Public Works 2000). Water temperatures from July through September violated standards, with a maximum of 21.7°C. Snohomish County SWM placed temperature loggers in the mainstem in the summer of 1999, and found increasing temperatures moving downstream in the river. Temperatures were <13°C 72% of the time upstream of Granite Falls, 31% of the time just downstream of Granite Falls, and only 24% of the time at Machias. Fecal coliform bacteria levels also violated standards from July through September, but usually met the standards during the remainder of the year.

Average 7-day water temperature data collected in 1999 in lower Pilchuck indicate degraded conditions (>15.5°C) in spawning areas, and moderately degraded conditions (13.9-17.8°C) in rearing areas (Loch in prep., as cited in SBSRTC 2002). Monitoring in the middle Pilchuck in 1999 found spawning temperatures to be intact (<13.9°C), and moderately degraded conditions (13.9-17.8°C) in rearing areas. Water quality information for the upper Pilchuck is very limited (SBSRTC 2002).

There are documented past occurrences of raw sewage discharges into the Pilchuck River at the Granite Falls sewer outfall (~RM 19)(Carroll).

Biological Processes

Benthic invertebrate monitoring at RM 2.3 yielded a B-IBI score of 20, with low richness of Ephemeroptera, Plecoptera, and Trichoptera (Loch in prep., as cited in SBSRTC 2002).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Pilchuck River mainstem:

- Add City of Snohomish to the City of Everett water supply, and remove the diversion dam on the Pilchuck River; if this is not feasible and the diversion dam is retained, ensure regular and timely maintenance at the diversion dam to provide unrestricted salmonid passage, and implement design changes to improve adult fish passage
- Restore floodplain function, primarily downstream of SR 2, but also upstream where off-channel/side channel restoration is possible
- Restore riparian function in middle and lower Pilchuck, particularly downstream of Dubuque Rd.

- Ensure that outfall from the Granite Falls water treatment plant is adequately treated prior to release into the Pilchuck River
- Eliminate agricultural equipment crossings across the Pilchuck River at RM 12.8 and RM 13.2

Sexton Creek 07.0126 and tributaries

General

Sexton Creek is a LB tributary to the Pilchuck River, entering at RM 3.1 (Williams et al. 1975).

Fish Access

The culvert at the Sexton Road crossing is a partial fish passage barrier, the culvert at the 44th crossing is 75-100% blocked with sediment and debris, and there is a collapsed 12" culvert ~300 feet south of the Three Lakes Rd/147th SE intersection (Carroll). The SR 2 crossing culverts are not included in the WDFW Fish Passage Database.

Floodplain Modifications

Non-commercial farms are located along much of Sexton Creek. Unrestricted animal access and associated bank erosion, sedimentation, and high presence of nutrients and bacteria were identified as concerns in a 1994 Snohomish County assessment (Carroll).

Channel Conditions/Substrate Condition

No quantitative channel condition or substrate information was available.

Field Reconnaissance surveys in 1993 identified the following areas with streambank erosion and channel downcutting (Snohomish County SWM 1995):

- Unrestricted livestock access and lack of streamside vegetation upstream of 120th Street SE resulting in exposed banks
- Unrestricted livestock access, channelized stream, and lack of streamside vegetation upstream of 125th Avenue SE resulting in sediment deposition
- Unrestricted livestock access, channelized stream, and lack of streamside vegetation along Sexton Creek and tributary upstream and downstream of 131st Avenue SE resulting in exposed raw banks and sediment deposition
- Land clearing, unrestricted livestock access, and lack of streamside vegetation downstream of 147th Avenue SE and Snohomish Golf Course resulting in exposed raw banks
- Land clearing, unrestricted livestock access, and lack of streamside vegetation along the north fork of Sexton Creek downstream of Three Lakes Road resulting in exposed raw banks

Riparian Condition

No quantitative riparian information is available. Review of the 2001 aerial photos provided by Snohomish County SWM indicates apparent good riparian habitat on the left-bank from RM 0.2

to 1.0, and highly variable riparian condition throughout the rest of the watershed. Overall, riparian condition would likely rate as fair/poor.

Water Quantity/Water Quality

No water quantity/quality monitoring information is available. There are potential water quality concerns associated with the large number of non-commercial farms adjacent to the stream and presence of the golf course in the headwaters. Based on field reconnaissance surveys in 1993, overall water quality in Sexton Creek appears to be good (Snohomish County SWM 1995). However, the following water quality concern was identified:

- Extensive unrestricted livestock (dairy cows and horses) access from 125th Avenue SE upstream to 147th Avenue SE, contributing to nutrient and bacteria problems, and erosion from removal streamside vegetation
- Unrestricted livestock (primarily dairy cows) access upstream of 120th Street SE, resulting in nutrient and bacteria inputs

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Sexton Creek watershed:

- Assess passage status of the culverts at the crossing of SR 2; prioritize and correct identified fish passage barriers
- Work proactively with commercial and non-commercial farm owners to eliminate unrestricted livestock access to the stream channel and to restore riparian function where impaired
- Assess salmonid habitat conditions in the watershed; correct identified problems
- Assess potential benefits of acquiring or otherwise protecting the largest contiguous block of forested habitat in the watershed along the left-bank from RM 0.2 to 1.0.

Bunk Foss Creek 07.0130, Unnamed 07.0130X, Collins Creek 07.0132, and Fields Fork Creek 07.0133

General

Bunk Foss Creek is a RB tributary to the Pilchuck River, entering at RM 3.85 (Williams et al. 1975). Unnamed 07.0130X is a LB tributary to Bunk Foss at RM 0.9. Collins Creek is a RB tributary to Bunk Foss at RM 1.0. Fields Fork Creek is a LB tributary to Bunk Foss at RM 1.1 (the routing of 07.0133 is different than indicated in Williams et al. 1975).

Fish Access

The culvert at the New Bunk Foss Road crossing of Fields Fork Creek has a perched outfall and is a barrier to fish passage (Carroll). No information was available on the passage status of the SR 2 crossings. Collins Creek and an Unnamed LB tributary entering Fields Fork Creek at RM 0.1 appear to be of sufficient size to support salmonids, although no current salmonid utilization is known to occur; fish passage status should be assessed in these tributaries.

Floodplain Modifications

There is unrestricted livestock access to the stream just upstream of the mouth of Bunk Foss Creek (Carroll). There is a large left-bank stream adjacent wetland located between the S. Machias Road and SR 2 crossings that may provide good rearing habitat. Further upstream, the headwaters of Bunk Foss Creek are routed through the interchange at the junction of SR 2 and SR 9, and Fields Fork Creek is in a constructed channel between SR 2 and Bunk Foss Road. Beaver activity has been present throughout the watershed, providing good coho and cutthroat rearing habitat conditions. However, the beaver dams were broken in 2002, reducing the amount of rearing habitat in the stream.

Channel Conditions

Fields Fork Creek is located in an armored ditch between SR 2 and Bunk Foss Road. No specific information was available on LWD and pool condition, but conditions are expected to be poor in the unrestricted livestock access area just upstream of the mouth, and in the channelized and armored section of Fields Fork Creek along SR 2 (Hendrick).

Substrate Condition

Gravel substrate exists through much of the watershed, although the quantity and quality are unknown (Carroll). Field Reconnaissance surveys in 1993 identified the following areas with streambank erosion and channel downcutting (Snohomish County SWM 1995):

- Unrestricted livestock access, channelized stream, and lack of streamside vegetation upstream and downstream of S Machias Road resulting in sediment deposition
- Geologic feature where permeable sad overlays relatively impermeable silts and clays west of Old Machias Road resulting in exposed raw banks and bank failure

Riparian Condition

No quantitative riparian information is available. Review of the 2001 aerial photos provided by Snohomish County SWM indicates absence of mature riparian vegetation in the lower mile (although a portion of this reach between S. Machias Road and SR 2 is a stream adjacent wetland) and in the lower 0.5 mile of Fields Fork Creek. Overall, riparian condition would likely rate as poor in the anadromous zone of the watershed.

Water Quantity/Water Quality

No water quantity/quality monitoring information is available. There is no indication of channel incision (Carroll), but the proximity of the creek to roads raises potential concerns related to stormwater runoff. There are potential water quality concerns associated with the large number of non-commercial farms adjacent to the stream and water quality of highway runoff. Based on field reconnaissance surveys in 1993, overall water quality in Bunk Foss Creek appears to be good (Snohomish County SWM 1995). However, the following water quality concern was identified, “Unrestricted livestock access upstream and downstream of S Machias Road, contributing to nutrient and bacteria problems.”

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Bunk Foss Creek watershed:

- Conduct comprehensive fish passage inventory in this watershed; prioritize and correct identified fish passage barriers
- Work proactively with commercial and non-commercial farm owners to eliminate unrestricted livestock access to the stream channel and to restore riparian function where impaired
- Assess salmonid habitat conditions in the watershed; correct identified problems
- Assess potential benefits of acquiring or otherwise protecting the stream adjacent wetland between S. Machias Road and SR 2 and headwater wetlands

Scott Creek 07.0134

General

Scott Creek is a LB tributary to the Pilchuck River, entering at RM 4.5 (Williams et al. 1975).

Fish Access

No known fish passage barriers.

Floodplain Modifications

Scott Creek is channelized and not fenced adjacent to a pasture from ~RM 0.2 to 0.4 (Carroll). Other portions of the creek appear to flow through areas of managed forest, based on review of the 2001 aerial photos provided by Snohomish County.

Channel Conditions/Substrate Condition

No information was available on channel or substrate conditions.

Riparian Condition

No quantitative riparian information is available. The lower ~2,000 feet of Scott Creek flows through a mature wooded parcel, which has been proposed for acquisition or other protection (Carroll). Review of the 2001 aerial photos provided by Snohomish County SWM indicates variable riparian condition elsewhere in the watershed; there are several reaches of wooded riparian area, although stand age appears to be young. Overall, riparian condition would likely rate as fair in the anadromous zone of the watershed.

Water Quantity/Water Quality

No water quantity/quality monitoring information is available. Based on field reconnaissance surveys in 1993, overall water quality in Scott Creek appears to be good (Snohomish County SWM 1995). However, the following water quality concern was identified, "Unrestricted livestock (primarily horses) access upstream of 123rd Avenue SE, contributing to nutrient and bacteria problems."

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Scott Creek watershed:

- Restore floodplain and riparian function in the agricultural area from RM 0.2 to 0.4; restore riparian function where impaired elsewhere in the watershed
- Assess salmonid habitat conditions in the watershed
- Assess benefits and feasibility of acquiring or otherwise protecting the forested parcel in the lower 2,000 feet of Scott Creek

Kuhlman's Creek 07.0135

General

Kuhlman's Creek is a RB tributary to the Pilchuck River, entering at RM 4.8 (Williams et al. 1975). The lower portion of the watershed runs through agricultural area, the upper end of the watershed is located in the Lake Stevens UGA (Carroll).

Fish Access

No known fish passage barriers.

Floodplain Modifications

Much of the lower 1.2 miles of stream runs along the edge of an active dairy pasture, with unrestricted livestock access to the channel (Carroll). There is a large beaver pond and associated wetland complex at RM 2.0 that is named Lake 205. The area adjacent to Lake 205 and wetland has been platted, and is at risk of development. A landowner living adjacent to Lake 205 has repeatedly been removing the beaver dam, and drying up good wetland salmonid rearing habitat; no enforcement action has been taken despite recurrent beaver dam removal (Carroll).

Channel Conditions/Substrate Condition/Riparian Condition

Channel/substrate/riparian conditions are generally poor in the channelized agricultural reach in the lower 1.2 miles (Carroll). Upstream of the agricultural reach to Lake 205, the stream is located in a ravine, with better in-channel diversity and riparian vegetation. Upstream of Lake 205, riparian condition is highly variable, with several reaches with limited riparian vegetation presence. Upstream of Lake 205, riparian and bank conditions have been affected by unrestricted livestock access to the stream; the landowner has volunteered to fence the stream and to improve livestock habitat.

Field Reconnaissance surveys in 1993 identified the following areas with streambank erosion and channel downcutting (Snohomish County SWM 1995):

- Unrestricted livestock access, channelized stream, and lack of streamside vegetation from the ravine area downstream to Old Machias Road resulting in exposed raw banks and sediment deposition.

Water Quantity/Water Quality

No water quantity/quality monitoring information is available. Based on field reconnaissance surveys in 1993, overall water quality in Kuhlman's Creek appears to be good (Snohomish County SWM 1995). However, the following water quality concern was identified:

- Foam and detected odor upstream and downstream of the SR 9 crossing, likely from nutrient inputs from septic systems upstream of SR 9
- Unrestricted dairy cow access to creek from ravine to confluence with Pilchuck River, resulting in loss of streamside vegetation, bank erosion, and bacteria and nutrient problems

Lakes

Lake 205 and associated wetlands provide excellent rearing habitat for coho. This habitat has been repeatedly severely impacted by unauthorized draining of Lake 205 by removal of the beaver dam at the outlet of the lake (Carroll). This action is reportedly being conducted by an adjacent landowner that does not own the property on which the beaver dam is located.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Kuhlman's Creek watershed:

- Restore floodplain and riparian function through the channelized agricultural area in the lower 1.2 miles
- Prevent unrestricted livestock access to the creek
- Actively pursue protection/acquisition of Lake 205 and associated wetlands; take actions to prevent the unauthorized draining of Lake 205
- Assess channel and substrate conditions; address any identified habitat concerns

Williams Creek 07.0137

General

Williams Creek 07.0137 is a RB tributary to the Pilchuck River, entering at RM 6.4 (Williams et al. 1975).

Fish Access

A beaver dam immediately upstream of the culvert at the Machias Cutoff Road crossing may result in a potential fish passage barrier (Carroll). While beaver dams typically contribute to desirable habitat conditions, maintenance modifications may be required at this site to ensure fish passage.

Floodplain Modifications/Channel Conditions

There are numerous non-commercial farms in the reach from S. Machias Road to Machias Cutoff Rd, many of which have unrestricted livestock access to the stream channel (Carroll). The creek has been channelized through the agricultural reach downstream of Machias Cutoff Road. Channel condition is poor throughout, with no LWD and few pools.

Substrate Condition

No information is available on substrate condition. Field Reconnaissance surveys in 1993 identified the following areas with streambank erosion and channel downcutting (Snohomish County SWM 1995):

- Unrestricted livestock access from upstream of the S Machias Road to the Machias Cut-off Road resulting in sediment deposition

Riparian Condition

Riparian condition is poor downstream of Machias Cutoff Rd., with little riparian vegetation present (Carroll). Upstream, riparian condition is variable and would likely rate as fair.

Water Quantity/Water Quality

No water quantity/quality monitoring information is available. Based on field reconnaissance surveys in 1993, overall water quality in Williams Creek appears to be good (Snohomish County SWM 1995). However, the following water quality concern was identified:

- Unrestricted livestock (primarily horses) access, foam, and garbage in the creek downstream of 134th Drive SE
- Unrestricted livestock access through several hobby farms from Machias Cut-off Road to S Machias Road, resulting in loss of streamside vegetation and nutrient and bacteria input

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Williams Creek watershed:

- Restore floodplain and riparian function in agricultural area downstream of Machias Cutoff Rd
- Assess fish passage status of beaver dam immediately upstream of Machias Cutoff Rd
- Assess in-channel habitat conditions; address any identified problems

Dubuque Creek 07.0139, Panther Creek 07.0140, and tributaries

General

Dubuque Creek is a LB tributary to the Pilchuck River, entering at RM 8.8 (Williams et al. 1975). The Dubuque Creek watershed drains an estimated 8,160 acres (SBSRTC 2002 Draft).

Fish Access

No barriers are identified in the WDFW Fish Passage Barrier Database. The upstream end of the culvert at the intersection of Newburg Hill and OK Mill Road is clogged with debris and may be a fish passage barrier (Carroll). Beaver dams have periodically blocked fish passage at the large wetland downstream of Panther Lake, but this is a natural transitory occurrence not requiring any response action.

Coho are widely distributed through the Dubuque Creek watershed, yet spawner surveys have only covered certain areas. A comprehensive survey of fish distribution in this watershed is recommended (Chamblin).

Floodplain Modifications

There are differing professional opinions on the status of floodplain function in the Dubuque Creek watershed. Hendrick/Geise (both with WDFW) indicate that floodplain function is relatively unimpaired, with extensive beaver pond and wetland complexes associated with the channels, particularly on Dubuque and Panther creeks. Purser (Snohomish County SWM) indicates that road encroachment is rampant in this watershed, both crossings and road encroachment parallel to streams. Both of these professional perspectives have merit, and may reflect specific experience at different locations/reaches within the watershed.

Floodplain function and channel conditions are impaired in Unnamed 07.0139Y (LB tributary to Dubuque Creek entering at RM 2.6)(Chamblin). Known coho distribution extends to the upstream end of where the creek flows in a ditch immediately adjacent to Connor Road. Substrate and channel conditions are poor along Connor Road; Snohomish County Roads frequently dredges the creek channel to prevent flooding of Connor Road and adjacent properties. Downstream, the creek is mainly forested with only a few single-family residences that encroach on the stream, and which have degraded riparian condition.

Channel Conditions

There are also differing professional opinions on the status of channel conditions in this watershed. Hendrick (WDFW) rates channel condition as good throughout the watershed; Panther Creek has numerous beaver dams, and Dubuque and Panther creeks have good presence of pools and LWD presence. Purser (Snohomish County SWM) indicates there are significant adverse effects to channel conditions associated with road encroachment. As noted above, both of these professional perspectives has merit, and may reflect specific experience at different locations/reaches within the watershed.

There is substantial shoreline hardening and presence of overwater structures on Panther, Flowing, and Storm lakes (SBSRTC 2002). The impacts of these habitat modifications to rearing salmonids in these lakes are unknown.

Substrate Condition

No quantitative substrate assessment information is available. Most fine sediment is trapped in beaver dams, with good gravel conditions elsewhere. Forest harvest from a steep slope adjacent to Dubuque Creek near ~RM 2.6 resulted in direct fine sediment delivery to the creek (Hendrick); no sampling of substrate conditions has been done in the affected downstream reach.

Riparian Condition

Average riparian stem diameter is <30 cm; <70% shoreline has buffer width greater than 1 site potential tree height (SBSRTC 2002). Riparian function is impaired to some extent by the sporadic breaks in riparian vegetation through the agricultural and non-commercial portions of the watershed (Carroll). Review of the 2001 aerial photos provided by Snohomish County SWM indicates variable riparian condition throughout the watershed, including reaches of what appears to be mature riparian forest interspersed with numerous openings and some reaches with early/mid-seral riparian vegetation. Overall, riparian condition would likely rate as fair in the watershed.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Dubuque Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Dubuque Cr	0	44	27	17	1	10	0	1

Water Quantity

Total impervious area is modeled at 11% (Purser and Simmonds 2002, as cited in SBSRTC 2002). The Dubuque Creek watershed is indicated as likely to be very sensitive to groundwater withdrawals, due to a combination of lack of snowmelt or large lakes, and relatively large areas in residential zoning subject to residential water withdrawals and reduced groundwater recharge due to impervious surfaces (Pentec Environmental and NW GIS 1999). No water quantity concerns are known.

Water Quality

There are no 303(d) listings. Water quality sampling by Snohomish County SWM in 1998-99 indicates that dissolved oxygen and turbidity standards are met; fecal coliform bacteria levels exceeded criteria 20% of the time (Snohomish County Public Works 2000). No temperature criteria exceedance was recorded in 1998; 1999 water temperature data identified 11 of 18 days where stream temperature exceeded 18^{o}C (SBSRTC 2002).

Lakes

Lake habitat on Panther, Flowing and Storm lakes has been altered by shoreline hardening and overwater structures; specific effects to anadromous salmonid production have not been evaluated.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Dubuque Creek watershed:

- Monitor fish access status through beaver dam complex downstream of Panther Lake; modify as necessary to ensure fish passage
- Prioritize and correct identified fish passage barriers
- Address concern of fine sediment delivery from forest harvest unit at ~RM 2.6
- Protect/restore watershed function through protection of forest cover and natural forest hydrology
- Assess floodplain function and channel conditions; correct identified problems

Little Pilchuck Creek 07.0146 and tributaries (excluding Stevens/Catherine Creek watershed)

General

Little Pilchuck Creek is a RB tributary to the Pilchuck River, entering at RM 9.0 (Williams et al. 1975). The Stevens/Catherine Creek watershed is tributary to lower Little Pilchuck Creek, but is discussed in a separate watershed discussion below. The Little Pilchuck Creek watershed drains an estimated 22,035 acres, of which 8,511 acres are in the Stevens/Catherine Creek drainage (SBSRTC 2002 Draft).

Large numbers of coho smolts are produced from this watershed (Hendrick). Smolts have been trapped and marked; subsequent adult returns have been sampled for marks, with only ~50% of the returning adults being marked. This indicates that a significant portion of juvenile coho appear to be exiting the watershed prior to smoltification, and that Little Pilchuck Creek likely provides rearing seeding for other areas in the Pilchuck River/lower Snohomish River watershed.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Little Pilchuck Creek	SR 92	3.7	No

Much of Little Pilchuck Creek flows through a broad flat wetland area, much of which is not conducive to road crossings or residential encroachment (Carroll). Road crossings are primarily bridges from the mouth of Little Pilchuck Creek upstream to near Frontier Air Park; there are a number of culverts at road crossings upstream of Frontier Air Park (Chamblin). Star Creek and other tributaries also have numerous culverts that are not included in the WDFW database.

A dam, located on the north side of the 66th Street NE crossing of Little Pilchuck Creek, impounds a significant amount of water; the dam is fitted with a fish ladder (Carroll).

Snohomish County conducted an assessment of county road crossings of streams in this watershed in 1994 and found no fish passage barriers (Carroll). No salmonid distribution is identified in Unnamed 07.0152, which appears to be of sufficient length to support coho and possibly other species; salmonid utilization of this tributary should be assessed.

Floodplain Modifications

Little Pilchuck Creek watershed is very low gradient, with numerous stream-adjacent beaver dam ponds and wetlands that provide excellent coho rearing habitat (Carroll, Chamblin). There is residential and agricultural encroachment at various locations throughout the watershed, but no significant floodplain modification concerns are identified. However, there have been recurrent problems with human destruction of beaver dams, with associated draining of several acres of pond/wetland habitat (Chamblin, Carroll).

Headwater wetlands that feed the subbasins along the west and northwest side of the Little Pilchuck Creek watershed are shared with Quilceda Creek and Portage Creek to the north (Nelson). Protection of the integrity of these headwater wetlands is critical, as they feed multiple systems.

Channel Conditions

Bank stability in the watershed is generally good with numerous stream adjacent wetlands. However, one identified area of bank instability concern is under the power lines at the county bridge on N. Machias Road (Carroll). Pool frequency and quality are rated as good, and LWD presence is also rated as good (Hendrick).

Substrate Condition

Little Pilchuck Creek appears to carry a moderate to heavy fine sediment load, as evidenced by the cemented nature of the stream substrate (Snohomish County SWM 1995). Much of the headwaters of the watershed were logged within the past twenty years. Erosion from timber harvest areas contributes sediment to Little Pilchuck Creek.

There appears to be a large supply of fine sediment in the Little Pilchuck watershed; the source has not been determined, but unrestricted livestock access at several locations is suspected to be contributing excess fine sediment, as well as removal of beaver dams that release impounded fine sediment to downstream areas (Carroll). A 1994 Snohomish County assessment of stream/road crossings identified cementing of substrate gravels near the stream crossings.

Field reconnaissance in 1993 identified several locations with bank erosion and channel downcutting problems (Snohomish County SWM 1995):

- Unrestricted livestock access and pasture adjacent to Little Pilchuck Creek downstream of 44th Street NE
- Unrestricted horse access and a degraded horse pasture immediately downstream of SR 92 along the N. Machias Road, contributing sediment and nutrient runoff to Little Pilchuck Creek
- Unrestricted horse access downstream of 28th Street NE (Highland Road), contributing sediment and nutrient runoff to Little Pilchuck Creek
- Land clearing for grazing and channel modification along the south side of Little Pilchuck Creek upstream of the N Machias Road bridge

Riparian Condition

Review of the 1998 aerial photos provided by Snohomish County SWM indicates areas where riparian function is impaired by encroachment, but the level of encroachment on streams in the watershed has been limited by the low stream gradient and stream adjacent wetlands (Hendrick, Carroll). Overall, riparian condition in the watershed would likely rate as good.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Little Pilchuck Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Little Pilchuck	0	32	31	25	2	10	0	0

Water Quantity

The Star Creek watershed is indicated as likely to be very sensitive to groundwater withdrawals, due to a combination of lack of snowmelt or large lakes, and relatively large areas in residential zoning subject to residential water withdrawals and reduced groundwater recharge due to impervious surfaces (Pentec Environmental and NW GIS 1999). No water quantity concerns are currently identified.

Water Quality

Water quality sampling by Snohomish County SWM in 1998-99 indicates that dissolved oxygen and turbidity standards are met; fecal coliform bacteria levels exceeded criteria 33% of the time (Snohomish County Public Works 2000).

The areas with greatest encroachment and associated water quality impacts are downstream of the SR 92 crossing. Areas of identified concern with unrestricted livestock access to the channel include (Carroll, Snohomish County SWM 1995):

- Little Pilchuck Creek near 147th, near 44th, east of N. Machias Rd, and near 28th,
- Star Creek north of 108th, and
- Unnamed tributary west of Fir Lane

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Little Pilchuck Creek watershed:

- Protect integrity of beaver dams and associated pond/wetland habitat
- Eliminate unrestricted livestock access to stream channels and stream-adjacent wetlands
- Restore bank stability under power lines at the county bridge on N. Machias Rd
- Conduct comprehensive fish passage barrier inventory in the Little Pilchuck Creek watershed; prioritize and correct any identified fish passage barriers
- Restore riparian function, where impaired

Stevens Creek 07.0147, Catherine Creek 07.0148, and tributaries

General

Stevens Creek is a RB tributary to Little Pilchuck Creek, entering at RM 1.6 (Williams et al. 1975). The Little Pilchuck Creek watershed drains an estimated 22,035 acres, of which 8,511 acres are in the Stevens/Catherine Creek drainage (SBSRTC 2002 Draft). Lundeen Creek (07.0150) enters the north shore of Lake Stevens ~0.25 miles east of the continuation of Stevens Creek upstream of Lake Stevens (Williams et al. 1975). Kokanee Creek enters the north shore of the northeast arm of Lake Stevens, flowing through the western side of the City of Lake Stevens, but is not shown in Williams et al. (1975). Stitch Creek (07.0149) enters the southern end of Lake Stevens (Williams et al. 1975); no habitat information is available for Stitch Creek.

Fish Access

The WDFW Fish Passage Database (February 2002) includes inventory of numerous culverts in the Stevens/Catherine Creek watershed. The following culverts are included in the inventory:

Stream	Road Crossing	River Mile	Barrier Status
Stevens Creek	Lundeen Parkway	3.81	No
Stevens Creek	Vernon Rd	3.81	Yes (Partial)
Stevens Creek	31st Pl NE	4.43	Yes (Partial)
Stevens Creek	Private	4.63	No
Stevens Creek	NA	4.68	No
Stevens Creek	SR 92	4.72	Yes (Total)
Stevens Creek	42nd St NE	5.11	Yes (Partial)
Stevens Creek	96th Ave	5.15	Yes (Total)
Stevens Creek	Private	5.25	Yes (Total)
Stevens Creek	Private	5.29	Yes (Total)
Stevens Creek	Private	5.34	Yes (Total)
Stevens Creek	Private	5.43	Yes (Partial)
Stevens Creek	Private	5.52	Yes (Partial)
Stevens Creek	Private	5.59	No
Stevens Creek	Private	5.66	Yes (Partial)
Stevens Creek	Private	5.93	Yes (Total)
Catherine Creek	28th St NE	0.0	No
Catherine Creek	Private	1.23	No
Catherine Creek	Private	1.61	No
Catherine Creek	Private	1.67	Yes (Partial)
Catherine Creek	Private	2.01	No
Catherine Creek	NA	2.19	No
Catherine Creek	RR Trail	4.36	No
Catherine Creek	84th St NE	5.35	No
Catherine Creek	Private	5.36	No
Lundeen Cr. 07.0150	SR 92	NA	No

The database also identifies a dam at the outlet to Lake Stevens (barrier status unknown), and a dam on an unnamed RB tributary entering Catherine Creek at ~RM 2.05 that is a barrier to fish passage. The WDFW database does not represent a comprehensive inventory of culverts in this watershed; a comprehensive culvert inventory and assessment is recommended, particularly for Lundeen and Kokanee creeks. The barrier culvert at the SR 92 crossing of Stevens Creek upstream of Lake Stevens blocks anadromous fish access to an undetermined amount of habitat upstream; there are additional fish passage barriers further upstream. The SR 92 crossing of Lundeen Creek is noted in the WDFW database as not a barrier, but is identified by Carroll as a total barrier; there is an additional barrier(s) upstream on Lundeen Creek. Known salmonid distribution (coho, cutthroat, kokanee) on Stitch Creek extends to the culvert under S. Davies Road; the culvert should be assessed for fish passage (Chamblin).

Floodplain Modifications

The Lake Stevens outlet channel is currently mostly a trapezoidal channel with high steep banks (Gray and Osbourne 1999). Within the City of Lake Stevens, the streambanks are nearly vertical and armored with riprap. Downstream, there are high banks (10-15 feet) that are covered with grass, vines, and occasional willows. The channel used to exit the lake south of downtown Lake Stevens, cross the current location of the outflow channel, and return to Catherine Creek approximately where the outflow channel currently joins Catherine Creek. Realignment to the historic channel configuration would improve fish habitat.

Housing encroachment along the lower end of Lundeen Creek impairs floodplain function (Carroll). There is an opportunity to improve habitat conditions in lower Lundeen Creek by relocating the channel downstream of Lundeen Parkway away from the house encroachment to flow through a wooded area.

The lower portion of Catherine Creek, from the mouth to 20th Street NE, has the least disturbance to floodplain function (Gray and Osbourne 1999). There are remaining floodways on both sides of the channel, providing a considerable amount of off-stream refuge in and along these channels at high flows. There is a wide floodway in the reach from 2,514-4,341 feet upstream of Hartford Drive. From 36th Street NE to SR 92, Catherine Creek is more sinuous than in downstream reaches. Habitat conditions and floodplain function are good for ~0.33 miles upstream of SR 92. Catherine Creek is channelized through an open field for ~0.48 miles upstream of Hartford Drive and from 4,341 feet upstream of Hartford Drive to 36th Street NE. Upstream of ~0.33 miles above SR 92, Catherine Creek is surrounded by pasture and wetland; the channel is well defined, but the low banks and grassed channel bottom suggest that much of this reach is dry during late summer.

Specific reaches with identified floodplain function impairment on the Lake Stevens outlet channel and Catherine Creek include (Carroll):

- Catherine Creek is channelized for ~0.5-1.0 mile through an old field upstream of Hartford Rd.
- Catherine Creek is channelized through a horse pasture between 84th St. and 99th Ave.
- Recent channel incision and bank cutting in the upper watershed may indicate effects of altered hydrology
- Erosion upstream of the 16th St. bridge crossing of Stevens Creek appears to be associated with channel modifications in the vicinity

Channel Conditions

Mean bankfull channel width was measured at 3.1m (Rosgen C channels) in the Stevens Creek watershed; channel gradient is generally <2% (SCSWM 2002). Streambank instability was estimated at 12%, with bank hydromodifications averaging 10.8% by reach. Mean pool frequency was very low (0.08pools/CW), although mean pool surface area was 67.8%, likely the result of beaver ponds that occasionally span the length of entire sample reaches. LWD frequency is also very low (0.01 pieces/CW) with 27% of the LWD being conifer.

Specific areas of concern in Stevens Creek include unrestricted livestock access between 84th St. and 99th Ave., bank erosion near the 16th St. bridge crossing, and channel incision in the headwaters. Upstream of Lake Stevens, past problems of unrestricted livestock access to the Lundeen Creek channel have been addressed, but some unrestricted livestock access on upper Stevens Creek still remain (Carroll).

Catherine Creek and tributaries have limited habitat diversity (Gray and Osbourne 1999). LWD and high flow refuge areas are scarce. For long reaches, riparian zones provide little overhead cover. The lack of channel complexity may be one of several habitat limiting factors in the Catherine Creek watershed. Lower Catherine Creek has little refuge habitat, because it lacks appropriate pools with adequate depth and cover, as well as eddy areas and side pools. Stream banks are affected by urban development and encroachment, lacking complexity provided by rooted vegetation and rootwads, large logs, and boulders.

Substrate Condition

Mean surface fine sediment (<6.3mm) in areas of spawning gravel was estimated to be 59%; it is unknown whether this meets the WRIA 7 fine sediment criterion, which is based on sediment <0.85 mm (SCSWM 2002).

Substrate in the Lake Stevens outlet channel is gravel in the upper end and silt and sand further downstream (Gray and Osbourne 1999). Substrate in Catherine Creek is noted as gravel from ~0.48 miles upstream of Hartford Drive to ~0.33 miles upstream of SR 92. Downstream of Hartford Drive, substrate in Catherine Creek is composed of silt and sand, with a few areas with gravel. There are substantial areas of this watershed where the substrate consists of, or has been degraded by the addition of, sand and silt. The stream banks in many areas consist of unconsolidated sands that could further degrade existing salmonid spawning gravels.

Riparian Condition

The streams in this watershed flow through the Lake Stevens UGA. Review of the 2001 aerial photos provided by Snohomish County SWM indicates very limited presence of functional riparian vegetation, particularly on Stevens Creek, with overall riparian condition in the watershed likely rating as poor. Notable areas of good riparian condition include Lundeen and Stevens creeks for ~0.25 miles upstream of SR 92, and on the Lundeen Wildlife Area (Carroll).

Riparian condition on the Lake Stevens outlet channel is noted as riprap through the City of Lake Stevens, with grass, vines, and occasional willows further downstream (Gray and Osbourne 1999). Riparian condition on Catherine Creek consists of thick willows with some larger firs from the mouth to 20th Street NE, limited canopy from 20th Street NE to Hartford Drive, reed canary grass for ~0.48 mile upstream of Hartford Drive, undetermined form 0.48 miles upstream of Hartford Drive to SR 92, large conifers on both bank for ~0.33 mile upstream of SR 92, and dense brush and sparse trees with little overhead cover further upstream.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Catherine/Stevens Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Lake Stevens	0	22	21	25	8	19	3	1

Water Quantity

Average precipitation in the watershed is ~40 inches per year, of which ~75% falls during the period October-March (Gray and Osbourne 1999). Groundwater is largely restricted to two aquifers. The upper, outwash aquifer supplies baseflow to creeks. The extent of this outwash aquifer is limited in the Stevens Creek and Lundeen Creek watersheds, which can't support streamflow in late summer. Year-round baseflow is supported in lower Catherine Creek and the Lake Stevens outflow channel. Water level in Lake Stevens may also be supported by the water table in the deeper aquifer.

Recent channel incision and bank cutting in the upper watershed may be indicative of altered hydrology, likely resulting from stormwater runoff from developing areas (Carroll). No flow data were available to verify this concern.

Total impervious area is estimated to be 22% (Purser and Simmonds 2002, as cited in SBSRTC 2002). HSPF modeling of 2-year and 100-year flows under forested and current conditions indicate a 400-500% increase in flows (50% increase in Catherine Creek)(R.W. Beck 1997, as cited in SBSRTC 2002).

Water Quality

Lake Stevens is included on the 1998 303(d) list of impaired waterbodies for total phosphorous; problems are attributed primarily to nutrient inputs in the face of rapid urbanization. Stevens Creek has had past problems associated with chicken farm operations upstream of SR 92 (Carroll); it is unknown to what extent this may still be of concern.

Water temperatures in the Lake Stevens outlet channel in 1997-98 ranged from 18-19.9°C in late May-early June, 25-26°C in July, and 20-22.5°C in September (Gray and Osbourne 1999). Water temperatures in lower Catherine Creek in 1997-98 ranged from 18-18.5°C in June, 23-24°C in July, and 18-21°C in September. The high water temperatures in Catherine Creek most likely reduce fish production from the lake outlet to the confluence with Little Pilchuck Creek. High temperatures also increase the sensitivity of fish to toxic effects of metals and other pollutants that enter the stream during summer storms. In response to high water temperatures, it is likely that cutthroat trout and juvenile coho migrate out Catherine Creek to Little Pilchuck Creek during the summer.

Dissolved oxygen (DO) samples in the Lake Stevens outlet channel in 1997-98 dropped as low as 6.2 mg/L in early September, 1997, and 6.3 mg/L in late September 1998 (Gray and Osbourne 1999). DO samples in lower Catherine Creek dropped as low as 5.3 mg/L in mid September 1997, and 7.4 mg/L in July 1998. DO levels in Stevens Creek were measured as low as 6.2 mg/L in May 1998.

Data in upper Catherine Creek were only collected at 36th Street NE (Gray and Osbourne 1999). In early June, water temperature was 16-18°C and DO was 9 mg/L; in late July, water temperature was 19°C and DO decreased to 7 mg/L; in late September, water temperature was 16°C, but DO reduced to 6 mg/L.

Water quality sampling by Snohomish County SWM in Catherine Creek in 1998-99 indicates that dissolved oxygen and turbidity standards are met; fecal coliform bacteria levels exceeded criteria 73% of the time (Snohomish County Public Works 2000). The fecal coliform bacteria standard and proposed standard for Enterococci were exceeded at two sampling stations in Catherine Creek in 1997-98 (Gray and Osbourne 1999). Given the setback distances of houses along Catherine Creek, livestock access is the likely cause. Livestock or evidence of livestock access were found in Catherine Creek a few hundred yards upstream of the confluence with the Little Pilchuck River, and along the creek north of SR 92. Fecal coliform and Enterococci standards were also exceeded in Stevens Creek (tributary to Lake Stevens) and Lundeen Creek.

Temperature loggers in the summer of 1999 recorded violations in Catherine Creek, where temperatures exceeded 20°C for 23% of the time (Snohomish County Public Works 2000).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Stevens/Catherine Creek watershed:

- Conduct comprehensive culvert inventory in this watershed; prioritize and correct identified fish passage barriers
- Prevent unrestricted livestock access to the channel, particularly on Stevens Creek upstream of SR 92, in the lower 0.5-1.0 mile of Catherine Creek, and through a horse pasture between 84^{th} St. and 99^{th} Ave.
- Restore riparian function, where impaired
- Evaluate and address causes of erosion at the 16^{th} St. bridge
- Assess habitat conditions on Stitch Creek; correct any identified problems

Connor Creek 07.0158

General

Connor Creek is a RB tributary to the Pilchuck River, entering at RM 12.0 (Williams et al. 1975).

Fish Access

Fish distribution extends at least to Connor Lake upstream of Russell Road (Chamblin). The culverts at the 28^{th} Place NE and Russell Road crossings are passable, but probably don't meet WDFW fish passage criteria. Beaver dams at the outlet of Connor Lake may obstruct fish passage during some years. A comprehensive culvert inventory and assessment is recommended for this watershed.

Floodplain Modifications/Channel Conditions/Substrate Condition

Connor Creek flows through a ditch along Russell Road for several hundred feet, then under 28^{th} Place NE, where it turns and flows for ~1,000 feet through second growth forest (Chamblin). No specific habitat information is available.

Riparian Condition

Review of the 2001 aerial photos provided by Snohomish County SWM indicates impaired riparian condition through much of the area downstream of Connor Lake, with good riparian condition upstream of Connor Lake; overall riparian condition in the current anadromous portion of the watershed would likely rate as poor.

Water Quantity/Water Quality

No water quantity/quality monitoring information is available.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Connor Creek watershed:

- Conduct comprehensive fish passage barrier inventory; prioritize and correct any identified fish passage barriers
- Restore riparian function downstream of Connor Lake
- Assess in-channel habitat conditions; address any identified problems
- Protect/restore watershed function through protection of forest cover and natural forest hydrology

Unnamed 07.0159

General

Unnamed 07.0159 is a LB tributary to the Pilchuck River, entering at RM 15.05 (Williams et al. 1975). The lower ~2,000 feet of the creek flows through pasture (Chamblin). Until the late 1980s, the farm was operated as a dairy. There were severe water quality problems, especially by the barn where manure was flushed into the creek. No information was located on the extent of current farming operations and habitat conditions in the watershed. Upstream of the farm, the creek flows through forested area.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0159 watershed:

- Assess habitat conditions, particularly through the farm area from ~RM 0.1 to 0.3; address any identified problems
- Protect/restore watershed function through protection of forest cover and natural forest hydrology

Unnamed 07.0161 and tributaries

General

Unnamed 07.0161 is a LB tributary to the Pilchuck River, entering at RM 15.8 (Williams et al. 1975). No information is available on habitat conditions in this watershed. Review of the 1998 aerial photos provided by Snohomish County SWM indicates that the entirety of the watershed is in forest management.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0161 watershed:

- Assess habitat conditions; address any identified problems
- Protect/restore watershed function through protection of forest cover and natural forest hydrology

Unnamed 07.0161X

General

Unnamed 07.0161X is a LB tributary to the Pilchuck River, entering at RM 17.9 (creek not identified in Williams et al. 1975). About 500 feet from the Pilchuck two streams converge; one is flowing from the south and the other is flowing from the east (Chamblin). The eastern tributary (07.0161X) is the larger drainage, with coho juveniles observed to RM 0.5. Stream gradient in 07.0161X is low, extending upstream of the coho observation. The southern tributary may also be suitable for coho rearing. No information is available on habitat conditions in this watershed. Review of the 1998 aerial photos provided by Snohomish County SWM indicates that the watershed is in forest management, with most all of the watershed in early seral regrowth, except for just upstream of the mouth of the creek.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0161X watershed:

- Assess habitat conditions; correct any identified problems
- Protect/restore watershed function through protection of forest cover and natural forest hydrology

Coon Creek 07.0161B and Black Creek 07.0161A

General

Coon Creek is a RB tributary to the Pilchuck River, entering at RM 20.2 (Williams et al. 1975); Black Creek is a LB tributary to Coon Creek at RM 0.15 (Hendrick).

Fish Access

There is a small dam at ~RM 0.1; WDF constructed a fish ladder at the dam in ~1980, no information is available on current passage status (Hendrick).

Floodplain Modifications/Channel Conditions/Substrate Condition/Riparian Condition

Much of the length of Black Creek is ditched/channelized along the edge of a farm field, with impaired habitat and riparian function (Hendrick). Review of the 1998 aerial photos provided by Snohomish County SWM indicates that most of the Coon Creek drainage is in forest management, with fair/good riparian forest vegetation.

Water Quantity/Water Quality

No water quantity/quality monitoring information is available.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Coon/Black Creek watershed:

- Restore floodplain/channel/riparian function through farm on Black Creek
- Monitor fish ladder status at dam on Coon Creek
- Protect/restore watershed function through protection of forest cover and natural forest hydrology

Swartz Lake Creek 07.0162

General

Swartz Lake Creek is a RB tributary to the Pilchuck River, entering at RM 20.5 (Williams et al. 1975). No information is available on habitat conditions in this watershed. Review of the 1998 aerial photos provided by Snohomish County SWM indicates that the entirety of the watershed is in forest management, with stands of varying age.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Swartz Lake Creek watershed:

- Assess habitat conditions; address any identified problems
- Protect/restore watershed function through protection of forest cover and natural forest hydrology

Bosworth Creek 07.0163

General

Bosworth Creek is a LB tributary to the Pilchuck River, entering at RM 21.7 (Williams et al. 1975). Bosworth Creek mainly provides spawning habitat (Hendrick). Rearing habitat is limited, with the creek drying up at some summer low flows.

Fish Access

A previously impassable culvert at the outlet of Bosworth Lake was replaced two years ago, allowing unrestricted fish passage into the lake (Hendrick). The culvert at the inlet stream to Bosworth Lake was a partial perched barrier, and was replaced in 2002. The culvert at Robe Menzel Road is a barrier at low flows.

Floodplain Modifications

A number of small floodplain lots with residences encroach on the lower 0.3 miles of Bosworth Creek, with abundant trash and debris in the stream and heavy bank disturbance (Hendrick, Carroll). However, floodplain function does not appear to be significantly affected.

Channel Conditions/Riparian Condition

Channel and riparian conditions are generally good except in the lower 0.3 miles, where there is absence of LWD and pools, and riparian function is impaired due to heavy bank disturbance (Hendrick).

Substrate Condition

The spawning substrate appears to be somewhat compacted with fine sediment, but continuing good returns of coho indicate that there is significant survival of eggs to emergence (Hendrick). However, sources of fine sediment should be identified and corrected if exceeding natural levels.

Water Quantity

Bosworth Lake property owners regulate lake level and resulting outflow to Bosworth Creek using a stop log structure at the lake outlet (Carroll). Bosworth Creek downstream of the lake goes dry in certain years, but the effects of lake level management on stream flow have not been determined.

Water Quality

No water quality monitoring information is available.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Bosworth Creek watershed:

- Assess impacts of lake level management on late summer stream flows
- Correct identified fish passage barriers
- Restore in-stream habitat diversity and riparian function in lower 0.3 miles

Boyd Lake Creek 07.0164

General

Boyd Lake Creek is a RB tributary to the Pilchuck River, entering at RM 23.1 (note that the location and stream numbering is different than in Williams et al. (1975)).

Fish Access

Fish passage may be impaired by a beaver dam upstream of the culvert crossing at Menzel Lake Road (Hendrick); flow at this point is intermittent. There is an old abandoned 4-culvert crossing just upstream of the Boyd Lake outlet that could be removed.

Floodplain Modifications

No information available indicating floodplain modifications.

Channel Conditions/Substrate Condition

No information available on channel or substrate conditions downstream of Menzel Lake Road (Hendrick). Channel and substrate conditions are impaired where the creek flows through pasture downstream of Boyd Lake, which also has unrestricted livestock access to the channel.

Riparian Condition

Review of the 1998 aerial photos provided by Snohomish County SWM indicates that most of the Boyd Lake Creek drainage is in forest management. Riparian vegetation is of varying age; overall riparian condition would likely rate as fair/good.

Water Quantity/Water Quality

No water quality monitoring information is available.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Boyd Lake Creek watershed:

- Protect/restore watershed function through protection of forest cover and natural forest hydrology
- Monitor fish passage conditions at beaver dam at Menzel Lake Rd.
- Remove old abandoned 4-culvert crossing just upstream of Boyd Lake outlet

Menzel Lake Creek 07.0164A

General

Menzell Lake Creek is a RB tributary to the Pilchuck River, entering at RM 24.5 (note that the location and stream numbering is different than in Williams et al. (1975)). No information is available on habitat conditions in this watershed.

Known coho and presumed bull trout/Dolly Varden distribution currently shown to RM 1.0. Need to verify fish presence, as there may be confusion associated with spawner survey records and poor hydrology representation in Williams et al. (1975)(Hendrick).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Menzel Lake Creek watershed:

- Verify extent of salmonid utilization in this watershed
- Assess habitat conditions; address any identified problems

Purdy Creek 07.0165

General

Purdy Creek is a RB tributary to the Pilchuck River, entering at RM 25.5 (Williams et al. 1975). No information is available on habitat conditions in this watershed. No information is available on habitat conditions in this watershed.

The Scout Camp just upstream of the mouth of Purdy Creek installs stop logs to create an instream pond during summer months for camp recreation and swimming (Hendrick). There is concern that the stop logs are not always removed by the time adult salmonids return in the fall, impairing/precluding access upstream of the camp. Potential adverse effects on instream summer baseflows downstream of the Scout Camp have also not been assessed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Purdy Creek watershed:

- Protect/restore watershed function through protection of forest cover and natural forest hydrology
- Ensure that stop logs in the control structure at the Scout Camp are removed prior to adult salmonid returns in the fall
- Assess habitat conditions; address any identified problems

Worthy Creek 07.0166 and tributaries

General

Worthy Creek is a RB tributary to the Pilchuck River, entering at RM 28.3 (Williams et al. 1975). The Worthy Creek watershed is a coho factory (Hendrick). Habitat condition knowledge is based on conditions in the spawner survey index at ~RM 3.5. There are extensive beaver dam complexes intermixed with reaches of good quality spawning gravels and abundant LWD. Riparian condition is generally good (Hendrick); however, review of the 1998 aerial photos provided by Snohomish County SWM indicates that most of the Worthy Creek drainage is in forest management, with riparian stands of varying age.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Worthy Creek watershed:

- Protect/restore watershed function through protection of forest cover and natural forest hydrology
- Protect integrity of current highly complex and productive habitat conditions

Kelly Creek 07.0170, Unnamed 07.0173?, Ross Creek 07.0175, Wilson Creek 07.0176, Miller Creek 07.0180, Unnamed 07.0181, and tributaries

General

Kelly Creek is a RB tributary entering the Pilchuck River at RM 30.2; Unnamed 07.0173? is a RB tributary entering the Pilchuck River at RM 30.5; Ross Creek is a LB tributary entering the Pilchuck River at RM 32.8; Wilson Creek is a RB tributary entering the Pilchuck River at RM 35.4; Miller Creek is a LB tributary entering the Pilchuck River at RM 35.5; Unnamed 07.0181 is a RB tributary entering the Pilchuck River at RM 37.7 (Williams et al. 1975).

No information is available on habitat conditions in these watersheds.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the above-referenced watersheds:

- Protect/restore watershed function through protection of forest cover and natural forest hydrology
- Assess habitat conditions; address any identified problems

French Creek 07.0184 and tributaries

General

French Creek is a RB tributary to the Snohomish River, entering at RM 14.7 (Williams et al. 1975). The French Creek watershed drains an estimated 17,909 acres (SBSRTC 2002 Draft). Mainstem French Creek originates in wetlands above Meadow Lake at ~500 feet elevation and is about 19 miles long (Carroll 2000). There are over 117 miles of stream and floodplain drainages in the French Creek watershed.

Approximately 12% of the watershed is in the City of Monroe, 88% is in unincorporated Snohomish County (Carroll 2000). Land use is primarily commercial agriculture downstream of SR 2, and primarily non-commercial farms upstream of SR 2 (Haas, Chamblin).

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed 07.0205	96th St SE (private)	0.35	Yes

There are numerous culverts throughout the watershed that are not included in the current inventory. Most prior fish passage barriers at County road crossings have been corrected. There are numerous culverts (primarily access roads to private residences) on tributaries in the watershed that may be barriers to fish passage. A comprehensive culvert and fish passage barrier inventory is recommended for this watershed.

The French Creek pump station restricts adult migration and blocks juvenile salmonid access into the French Creek watershed (Haas 2001). Flows are insufficient through the fish ladder (Denil type) to pass fish during low flow conditions, and the facility was designed to pass smolts downstream (smolts are diverted to a collection box and pumped out over the dike) but it does not allow juvenile salmonid passage upstream into French Creek (Chamblin). The fish ladder also does not work properly at high river levels (Carroll 2000). Adult pink and chum do not negotiate the fish ladder constructed in the pump station; anadromous species that commonly access into the watershed are coho, steelhead, and sea-run cutthroat (Carroll 2000). There was a kill of adult coho at the pump station fish ladder in 2001, presumably the result of low dissolved oxygen levels (Chamblin). Redesigning, bypassing, or removing the tide-gate and pump station would allow access to 117 miles of spawning and rearing habitat of spawning and rearing habitat throughout the French Creek watershed (Nelson).

Floodplain Modifications

The French Creek watershed once contained one of two 4,000-acre scrub-shrub wetlands in the Snohomish River floodplain (Carroll 2000). The French Creek marsh may not have had the extent of open water as was present in the historic Marshland marsh (Haas). This marsh, now drained for agricultural and urban use, was a rearing area for millions of juvenile coho and chinook salmon (Carroll 2000). The French Creek marsh provided rearing for locally produced salmonids as well as juvenile salmonids moving in from the Pilchuck, Skykomish, and Snoqualmie rivers (Haas, Chamblin). Juvenile salmonids moving downstream have an increased mortality risk as a result of loss of this key wetland rearing area (Chamblin).

French and Cripple creeks have been channelized in the floodplain, and most streamside vegetation removed. Approximately 5 miles of lower French Creek has been straightened and deepened. Cripple Creek has been rerouted and channelized from its original connection to French Creek near RM 5 to its current discharge point near RM 2. In order to maintain water conveyance, the channels are cleaned out about every 3 years, resulting in continued disturbance to rearing and spawning habitat.

Wetlands have been drained and filled or have been degraded by livestock grazing, human trampling, and garbage dumping (Carroll 2000). Over 66% of the wetlands in the watershed are <1 acre in size, making them prime candidates for filling, as their importance in providing water quality treatment in the most needed areas is ignored.

Flooding in the lower Snohomish River is a natural process that has been controlled to some degree by a system of levees (Toth and Houck 2001). The Marshland Flood Control District and the French Slough Flood Control District are the two largest of the 11 organized drainage, diking, or flood control districts in the lower Snohomish Valley. In general, the levee system is designed to be over-topped in many places by a "5-year" flood (20% chance in any given year that the levee will be over-topped). The levees are constructed in most areas to be 1-foot higher than the 5-year flood elevation, resulting in salmonid access to isolated floodplain areas during the over-topping events.

Channel Conditions

Aldrich (1999, as cited in Carroll 2000) identified that most streams in the upper French Creek watershed are lacking in good pool habitat, with existing pools being small and shallow. LWD is absent from many stream reaches. Causes for lack of LWD are likely from a combination of high stream flows flushing out the wood, stream cleaning during logging activities, removal of riparian trees, or cleaning out streams by local residents.

Mean channel width in the French Creek watershed ranged from 2.7-3.6m, with total channel length estimated at 63.96 km (SCSWM 2002). Mean pool frequency was low, ranging from 0.01-0.06 pools/CW, with mean pool surface area ranging from 2.2-29.1%. Mean LWD frequency was also low, ranging from 0.0-0.05 pieces/CW; with conifer representing 40-63% of the LWD present. Mean bank instability ranged from 3.1-17.8%, and mean hydromodifications ranged from 1.2-6.5%. However, the extent of hydromodifications was significantly underrepresented in the sampling; although hydromodifications in the Rosgen X channels were observed to be low, these were typically ditch-type channels that have been extensively modified over time by actions to channelized and maintain channel geometry and conveyance.

Substrate Condition

Gravel bed streams are found throughout most of the watershed; streams with sandy beds are found in the Lords Hill area and small reaches in other areas (Carroll 2000). Good gravel spawning substrate is found upstream of RM 5.0 (Chamblin). Most of the sediment load (85-95%) carried by stream flow is suspended load, consisting of clays, silts, and sands (Carroll 2000). Increased streamflow during storm events increases movement of suspended and bedload downstream. Increased peak flows have caused channel incision and scouring of the stream channels, and have increased streambank erosion. Serious erosion and bank failures have occurred on Lords Hill and Cripple and Trench creeks, caused by increased stormwater runoff from development, discharges of piped water to streambanks, and breaking of beaver dams. Animals pastured along unfenced streams also contribute to streambank erosion and instream sedimentation.

Mean surface fine sediment (<6.3mm) ranged from 10-42% by channel type (SCSWM 2002), with Rosgen B channels being the only channel type that meets the WRIA 7 fine sediment criterion.

Riparian Condition

About 71% of the floodplain and 28% of the upper watershed had a shrub and grass dominated riparian buffer (Carroll and Jacobson 2000, as cited in Carroll 2000; only 15% of streams in the watershed had buffers >100 feet that are required today along most stream reaches (Carroll 2000). However, large riparian buffers remain along about 37 miles of undeveloped streams in the upper watershed. Where riparian trees were present, only 3% of buffer trees were >20-inches dbh, the majority of trees were 12-19-inches dbh (reach specific riparian buffer width and vegetation type data are presented in Carroll 2000). Even where regulated buffers are left along streams, vegetation is removed to create lawns and openings to streams. Farmers clear their land right to the edge of the stream. The result is streambank erosion and fish and wildlife habitat degradation. Carroll (2000, Figure 40) identifies reach-specific riparian restoration recommendations for the entirety of the French Creek watershed.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the French Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
French Cr	0	25	22	38	3	11	0	0

Water Quantity

Low stream flows affect salmon productivity by reducing the amount of rearing habitat. Stream flow can be reduced by over-allocation of groundwater and by creation of impervious surface, both lowering the water table by reducing groundwater recharge to streams. HSPF modeling looked at the potential for low stream flows to affect summer instream habitat (Carroll 2000). The model predicted that at anticipated future development, upper Spada, upper Stables, Ghost Horse, Chain Lake, Upper Cripple, tributary to Cripple, Trench, and Lords Hill tributary creeks would likely go dry in summer. Portions of Cripple Creek, Alston, Stables, and all of Trench Creek currently dry up in summer months. The HSPF modeling identified a corresponding significant increase in peak flow magnitude in the watershed. French Creek peak flows have increased approximately 11-12% from forested conditions; the historic 100-year flood approximately equals the current 50-year flood. Further increase in peak flows is likely as further development occurs in the watershed.

Headwater wetlands are important to streams for their ability to store and discharge water at a slow rate, maintaining base flow during the summer. As noted in the Floodplain Modifications section above, there has been extensive loss of wetlands in this watershed. Residents are continuing to alter headwater wetlands on both Ghost Horse and Stables creeks, changing the hydrology of these important areas through ditching and creating areas of open water, removing important wetland functions (Carroll 2000).

Water Quality

Pollution in watershed streams is preventing juvenile salmon from moving out of the watershed into the Snohomish River (Carroll 2000). High temperatures and low dissolved oxygen in lower French Creek are biological barriers for salmon migrating upstream from the Snohomish River. Dissolved oxygen concentrations have been very low (<5.0 mg/l) in the lower 5.5 miles of French Creek (Carroll 2000). These low oxygen levels are potentially lethal to salmonids and create a biological barrier to upstream and downstream migration of adult and juvenile salmon.

French Creek is included on the 1998 303(d) list of impaired waterbodies for dissolved oxygen (3 reaches) and fecal coliform bacteria (3 reaches). Water quality testing has found high fecal coliform bacteria levels in almost all watershed streams, as well as high nutrient levels (Carroll 2000). Bacteria and nutrient levels are highest in floodplain streams, as are low dissolved oxygen and high temperatures. One of the most visible and destructive types of pollution affecting watershed salmon habitat and aquatic animals is excess fine sediment. The major sediment source occurring today is from land clearing and exposing and moving of earth for all types of development related activities. The pump station at the mouth exacerbates poor water quality conditions in lower French Creek, stressing aquatic species (Haas 2001). French Creek provides an influx of oxygen depleting substances and water with low oxygen content to the Snohomish River, which is thought to lower dissolved oxygen concentrations in the Snohomish River under critical summer low flow conditions (Cusimano 1995, as cited in Snohomish County Public Works 2000).

Water temperature monitoring was conducted pursuant to development of the French Creek Watershed Management Plan (Carroll 2000). Water temperature summary data are shown in Table 10. French Creek is not included on the 1998 303(d) list for water temperature.

Table 10: Water temperature summary data for French Creek (from Carroll 2000)

Sampling Location	<13^{o}C (preferred)	13-20^{o}C (moderately stressful)	>20^{o}C (extremely stressful)	Maximum water temperature
Upper Mainstem – 167th near Westwick Road	25%	75%	0.5%	NA
Lower Cripple Cr – at SR 2 crossing	63%	37%	0%	NA
Lower Mainstem	7%	90%	3%	24.8^{o}C
At pumping station	2%	94%	4%	27.4^{o}C

Action Recommendations

The following ranked habitat restoration actions are recommended for the French Creek watershed:

- Improve upstream/downstream fish passage at the mouth of French Creek and water quality in lower French Creek with installation of a self-regulating tidegate
- Implement the management recommendations in the French Creek Watershed Management Plan (Carroll 2000), particularly those recommendations relating directly to protection/restoration of salmonid habitat
- Protect/enhance remaining forest cover in upper watershed to minimize further hydrology impacts to downstream areas
- Restore riparian function, where impaired, throughout watershed
- Restore natural channel configuration and floodplain/wetland function in historic Snohomish River floodplain portion of lower French Creek
- Conduct comprehensive inventory of culverts and fish passage barriers in this watershed; prioritize and correct identified barriers

Unnamed 07.0206

General

Unnamed 07.0206? is a RB remnant floodplain side channel entering the Snohomish River at RM 16.8 (Williams et al. 1975). This remnant side channel appears to have potential to provide excellent rearing habitat, but fish access is precluded by a field access road fill across the mouth of the wetland (Haas). Review of the 2001 aerial photos provided by Snohomish County indicates presence of some riparian vegetation surrounding the wetland upstream of the fill.

Action Recommendations

The following ranked habitat restoration actions are recommended for the Unnamed 07.0206 watershed:

- Restore fish access and hydrologic connectivity with Snohomish River at field access road at mouth

Lake Beecher Creek 07.0207, Unnamed Side channel 07.0209, Evans Creek 07.0210, Anderson Creek 07.0212, and Elliott Creek 07.0214, and tributaries

General

These creeks/side channels are LB tributaries to the Snohomish River, entering between RM 17.7 and 19.8 (Williams et al. 1975). Snohomish County has recently acquired the right-bank of Lake Beecher and the lake (Haas).

Fish Access

Elliot Creek is modified by five culverts and an abandoned diversion structure in the lower one-half mile; the diversion structure, a County culvert, and the SR 522 culvert are all thought to be impassable to anadromous salmonids (SBSRTC 2002). Fish passage in Anderson Creek is blocked by impassable culverts. There is some diking of the mainstem from SR 522 to lower end of Thomas' Eddy, which may restrict access to off-channel rearing areas.

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Evans Creek	Elliott Rd	0.51	No
Evans Creek	Private rd	0.63	No
Unnamed 07.0211	180th St SE	0.29	Yes
Unnamed 07.0211	Fales Rd	0.74	Yes
Unnamed 07.0211	188 St SE	0.94	Yes
Unnamed 07.0211	Private	1.01	Yes
Unnamed 07.0211	Fales Rd	1.08	Yes
Unnamed 07.0211	Private	1.2	No
Unnamed 07.0211	Private	1.34	Yes
Unnamed 07.0211	Private	1.39	No
Unnamed 07.0211	Fales Rd	1.49	No
Unnamed 07.0211	Private	1.65	Yes
Unnamed 07.0211	Private	1.67	Yes
Unnamed 07.0211	Fales Rd	1.78	Yes
Unnamed 07.0211	NA	1.85	Yes
Unnamed 07.0211	Private	2.0	Yes
Unnamed 07.0211	Downs Rd	2.35	No
Unnamed 07.0211	SR 522	2.43	Yes
Unnamed 07.0211	204th St SE	2.5	No
Unnamed 07.0211	Private	2.53	Yes
Unnamed 07.0211	204th St SE	2.66	Yes
Unnamed RB to 07.0211 at RM 2.53	NA (siteid 992633)	NA	Yes
Unnamed 07.0211	SR 522	3.23	Yes
Unnamed 07.0211	SR 522	3.36	Yes
Unnamed 07.0211	Private	3.91	No
Unnamed 07.0211	BNSF Railroad	3.89	Yes
Unnamed 07.0211	SR 522	3.85	Yes
Anderson Creek	Private	0.05	Yes
Anderson Creek	Private	0.06	No
Anderson Creek	Private	0.19	Yes
Anderson Creek	Private	0.46	No
Anderson Creek	Private	0.87	No
Anderson Creek	Private	1.15	No
Anderson Creek	Elliott R	1.6	No
Anderson Creek	Private	1.92	Yes
Anderson Creek	SR 522	2.55	Yes
Anderson Creek	NA	2.72	Yes
Anderson Creek	Abandoned private	2.82	Yes
Elliot Creek	Private	0.27	Yes
Elliot Creek	Private	0.34	Yes
Elliot Creek	Elliot Rd	0.41	Unknown
Elliot Creek	SR 522	0.45	Yes

Elliot Creek	131st Dr SE	0.48	No

Floodplain Modifications

The Snohomish River has been prevented from lateral migration through the floodplain in this area over the last 100+ years by wood removal, dredging, berms, and bank armor (Haas 2001). Presence of relict channel oxbows indicates that the river migrated more broadly through this area at one time (Haas 2001). Floodplain wetlands and riparian areas of Elliot, Evans, and Anderson creeks are all actively drained, farmed, and roaded (SBSRTC 2002). Opportunities exist to enhance riparian conditions, channel migration, and connectivity between off-channel habitat in the floodplain, and habitat complexity within floodplain tributaries (Haas 2001). Extent of wetland presence has been increasing through the agricultural area just above the mouth of Evans Creek (Bails).

Channel Conditions/Substrate Condition

No information is available on channel or substrate conditions in this watershed.

Riparian Condition

There is a limited riparian buffer on the right-bank of Lake Beecher. Recent acquisition of this property by Snohomish County provides opportunity to conduct riparian enhancement on this shoreline (Haas). Riparian vegetation is generally absent where the creeks flow through the agricultural area on the Snohomish River floodplain, but riparian condition improves as the creeks ascend the bluff. Habitat conditions in Lake Beecher, and Anderson, Elliott, and Evans creeks could be enhanced through riparian planting (Haas 2001), particularly across the valley floor.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Cathcart Drainages watershed (WADNR Types 1-5, includes riparian condition on mainstem Snohomish and Cathcart tributaries)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Cathcart	0	27	28	29	3	11	1	0

Water Quantity/Water Quality

Total impervious surface is modeled at 14% (Purser and Simmonds 2001, as cited in SBSRTC 2002). No water quality sampling data are available for this watershed. However, the following water quality concerns have been identified in Evans Creek (Snohomish County SWM 1995):

- Dairy cows have unrestricted access to Evans Creek upstream from Elliott Road
- Excessive input of fine sediment to the stream at an access road to a sand and gravel operation at Yew Way, 3/8 mile north of 196th
- Unrestricted livestock access to the east fork of Evans Creek at 188th Street SE

Biological Processes

There is high abundance of non-native fishes in Lake Beecher that likely result in heavy predation on juvenile salmonids that attempt to rear in Lake Beecher (Chamblin).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Lake Beecher watershed:

- Control exotic predator fish populations in Lake Beecher
- Restore riparian function, particularly where the creeks cross the Snohomish River floodplain
- Prioritize and correct identified fish passage barriers

Ricci Creek 07.0220

General

Ricci Creek is a LB tributary entering the Snoqualmie River at the confluence with the Skykomish River. There is a natural falls at the mouth of the creek, precluding anadromous access.

Action Recommendations

No action recommendations are made for Ricci Creek

Unnamed 07.0217

General

Unnamed 07.0217 is a RB tributary entering the Snohomish River at ~RM 19.8 (note that the hydrology downstream of the bluff is different than indicated in Williams et al. 1975). The lower 0.2 mile of this creek flows through an old agricultural field on the Snohomish River floodplain (Haas). The creek flowed off the bluff and literally through a barn into the field. The creek was routinely used as the means of cleaning the barn. The floodplain portion of the creek has recently been acquired by Snohomish County, providing excellent opportunity for restoration. The agricultural field has not been recently farmed, and is regaining wetland characteristics. Riparian vegetation is absent through the field, and would greatly benefit from restoration. The Snohomish River bankline adjacent to the property is currently armored; the county is proposing that the armoring be removed to restore floodplain connectivity.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0217 watershed:

- Restore riparian function on the Snohomish River floodplain (along the creek and Snohomish River)

- Develop and implement a LWD strategy in areas with limited LWD presence and near-term recruitment potential, to increase habitat diversity until riparian function is restored
- Remove armoring on adjacent Snohomish River shoreline to restore floodplain function

Snoqualmie River Mainstem 07.0219 (Mouth to Snoqualmie Falls)

General

The Snoqualmie River drains the southern 703 mi^2 of the Snohomish River watershed (Pentec Environmental and NW GIS 1999). The Snoqualmie River flows across a relatively unconfined, alluvial floodplain that is divided into two segments by the major bedrock protrusion at Snoqualmie Falls (Pentec Environmental and NW GIS 1999). The Snoqualmie River downstream of the falls is a low gradient, partially confined, meandering river. Upstream of the falls, the Snoqualmie River is also partially confined, but the stream gradient is much greater. Most of the Snoqualmie River floodplain downstream of Snoqualmie Falls is zoned for low density agricultural uses, specifically 70.4% for agriculture and 22.2% for rural residential land use (Solomon and Boles 2002).

Since the 1970s, the Snoqualmie River watershed has supported relatively healthy fish populations despite harvests and changes in habitat and water quality (1998 subbasin workshop). However, urban development pressures and rural forest conversions will negatively impact habitat quality, particularly on small tributaries to the Snoqualmie River.

An inventory of habitat conditions on the Snoqualmie River mainstem from RM 6 to RM 38 in summer 2000 identified only a few reaches of the mainstem with simultaneous good conditions for a suite of habitat features (e.g., little or no bank hardening, erosion, and cattle access; presence of side channels and back channels; few channel modifications and other artificial structures; mostly native riparian vegetation; relatively mature woody riparian vegetation; and presence of LWD)(Solomon and Boles 2002). Reaches with good habitat conditions included ~RM8-9 (RB only), RM 10-11 (both banks), RM 19.3-21.3 (LB only), RM 22-22.5 (RB only), RM 24-25 (LB only), and RM 37-38 (both banks).

Recovery plans will require an effective working relationship with the agricultural community to address issues related to restoration of riparian habitat, dredging and diking, and water quality (1998 subbasin workshop). Significant potential for restoration of mainstem and valley floor habitats may be present in or adjacent to agricultural areas, although at this time no biological survey has been conducted to quantify and locate specific projects.

Fish Access

Salmonid access in the mainstem Snoqualmie River extends from the mouth upstream to Snoqualmie Falls at RM 40.3. There are no fish passage impairments on the Snoqualmie River mainstem; however, access to many floodplain oxbows, floodplain wetlands, and tributaries has been eliminated/impaired by a combination of diking, bank armoring, and mainstem channel incision.

Floodplain Modifications

Collins and Sheikh (2002) identified seven distinct reaches for the mainstem Snoqualmie River downstream of Snoqualmie Falls:

- Lower River (RM 0-2) – The lower 2 miles are dominated by large relict oxbow depressions (most dating to pre-1870), now filled by ponds or wetlands.
- Duvall Reach (RM 2-12) – This reach was historically an extensive scrub-shrub marsh that occupied nearly the entire valley. Topographically, much of the valley floor through this reach is lower than the riverbanks. The majority of this historic wetland has been ditched and drained, and converted to agriculture.
- Lower (RM 12-23) and Upper (RM 27-36) Meandering Reaches – These two reaches are characterized by extensive meandering through the valley floor, and include nearly all of the oxbow wetlands (40 mapped in these reaches) and ponds in the Snoqualmie River valley. Topography is highly irregular within the meander belt with a number of additional wetlands that formed within the lower-elevation valley margins, outside the elevated meander belt.
- Tolt Fan Reach (RM 23-27) – The Tolt River created an alluvial fan, pushing the Snoqualmie River to the west valley wall. The channel pattern through this reach is straight, with a lack of oxbow lakes and relict channels. While the gradient of the Tolt River fan is low, it effectively acts to topographically confine and backwater the Snoqualmie River.
- Upper Fan Reach (RM 36-38.5) – Conditions are similar to those in the Tolt Fan Reach, again relatively confined by the alluvial fans of the Raging River and the fan complex downstream of Tokul Creek, which limit channel migration.
- Falls Reach (RM 38.5-40.3) – Upstream of Tokul Creek, the Snoqualmie River is confined between sheer valley walls.

Presence of many abandoned oxbows indicates that the Snoqualmie River migrated across its floodplain (Pentec Environmental and NW GIS 1999). However, analysis of historical aerial photographs indicates that the Snoqualmie River has been very stable over the last 50 years (Booth et al. 1991). This conclusion is supported by Collins and Sheikh (2002), who indicate that oxbows are relatively static, with most (39 of 48) having been created earlier than the first map in 1873. From ~1870 to 1936, the river had cut off (avulsed) eight meander bends; from 1936 to 2000 one meander bend avulsed. Although meander avulsion appears to be naturally uncommon, the few river changes in the 1936 to 2000 period may in part be associated with the establishment of bank revetments in the 1960s-1970s. The channel stability may result from extensive presence of bank hardening designed to protect agricultural land from erosion, but it is more likely the result of historical removal of logjams and the lack of LWD recruitment (Booth et al. 1991). Accumulations of LWD may have been the principal agent for initiating channel changes prior to human intervention.

The low rate of change to the mainstem river channel contrasts with extensive historical changes to wetlands and forests, which have been greatly diminished (Collins and Sheikh 2002). The area of valley wetlands in 2000 was only 19% of that present in ~1870. The greatest wetland loss included the ditching and draining of the historic scrub-shrub wetland/marsh in the Duvall Reach that occupied nearly the entire valley floor from RM 2 to RM 12. This wetland/marsh was subject to overflow to a depth of 8 feet, and was likely inundated with surface water through much of the year, providing excellent juvenile salmonid rearing habitat. Another large historic wetland that has been drained was a large wetland area on the south side of the valley about midway between Duvall and Carnation. Combined effects of ditching and draining of floodplain wetlands and bank armoring/diking have likely resulted in downcutting of the river, further disassociating connectivity of oxbows and floodplain wetlands with the river (Anderson).

Agriculture in the lower Snoqualmie River valley is the primary land use that has modified habitat in the mainstem valley floor and lower tributary reaches (1998 subbasin workshop). Hydromodifications in the form of compacted soil dikes and riprap along the mainstem Snoqualmie and the Tolt and Raging Rivers have caused extensive loss of riparian vegetation, floodplain function, and quality and quantity of instream habitat (Pentec Environmental 1998). Poorly placed and designed culverts have caused the loss of spawning and rearing habitat.

While flood control facilities (dikes, levees, revetments) and roads have reduced much of the off-channel rearing habitat, significant opportunities for future restoration efforts are evident in the form of oxbow ponds, side channels, springs, and swales on the valley floor (1998 subbasin workshop). A boat-based assessment of extent of bank armoring on the mainstem Snoqualmie River was conducted in summer 2000, from RM 6 to RM 38 (Solomon and Boles 2002). Bank hardening was observed on 35.5% of the toe of the LB, 29.5% of the upper LB, 30.4% of the toe of the RB, and 29.4% of the upper RB. Specific locations of observed bank armoring are identified in their report. Bank hardening percentages may actually be higher, because some bank hardening is covered with silt and partially vegetated, and therefore not visible from the river. By disconnecting the main channel of the river from its side channels and inhibiting natural channel migration, bank hardening limits the creation of summer rearing habitat and winter refuge habitat for salmonids and restricts salmonid access to off-channel habitat. Bank hardening also accelerates the natural process of bank erosion on adjacent or opposite unprotected banks; excessive erosion can degrade habitat conditions by contributing excessive fine sediment to the river, aggrading the channel bed, or filling pools. Scours, slumps, and other erosional features were observed at many locations directly downstream or on the opposite bank from revetments. Evaluation of aerial photographs indicates that 25.06 miles (24.42%) of the 102.64 miles of bank along the Snoqualmie River are diked (Pentec Environmental and NW GIS 1999). Most revetments and dikes are maintained by King County Rivers Section, with ~6 notable exceptions that are privately maintained (Anderson). Modification or removal of existing dikes at Carnation Farms and downstream of the Raging River fan offer particularly good opportunities for habitat restoration (Anderson, Solomon). There are only 5 roads with bridges that cross the Snoqualmie Valley floodplain downstream of Snoqualmie Falls (Anderson). The road fills and confined openings impair natural floodplain function to some extent, often resulting in scour downstream of the bridge or culvert openings in the fill, but there are no real impacts to spawning, except perhaps at the Carnation Farms crossing.

A limited amount of off-channel habitat exists in the vicinity of Fall City (Snoqualmie Core Area document). For example, one long side channel (about 2000 feet) exists on the left bank just downstream of Fall City. The channel is maintained by flows through a culvert in the levee. The culvert is about 4 feet in diameter. Because of the size of the culvert, the side channel is uncharacteristically small for a floodplain side channel in the Snoqualmie system. Further downstream on the right bank there is a small back channel, which is a relict former main channel. Levee construction has impaired the river's ability to maintain the channel. The mouth of Griffin Creek and the mouth of an unnamed tributary that flows through Carnation Marsh also create small off-channel habitat areas.

<u>Channel Conditions</u>

The mainstem Snoqualmie has substantial deep-water habitat capable of providing cover for adults (1998 subbasin workshop). Sixty-seven large pools (at least as long as the river is wide) were recorded between the King-Snohomish County line and the confluence of the Snoqualmie and Raging Rivers (RM 6-35) (Table 11)(Solomon and Boles 2002). Many of these pools were several channel widths in length. The frequency of pools and the overall area of pool habitat suggest good rearing, refuge, and pre-spawning holding habitat for salmonids. Residual large pool depth was consistent throughout the Snoqualmie River (Table 11). Pools averaged 14.1 feet of residual depth, and ranged between 6 and 28.5 feet deep. The different morphologic reaches varied between an average of 11.9 feet (County Line to Duvall) and 15.9 feet (Carnation Meanders) of residual depth. Almost all of the pools were formed by scour along the riverbanks. A few pools were dammed behind accumulated sediment, such as just upstream of the Tolt River delta. There were not any large pools that had been formed by logjams. Primary mainstem holding pools also exist upstream of the confluence with the Raging and Tolt in the backwater zones and below the falls (Tolt-Snoqualmie Core Area document). However, further research is needed to determine whether the existing mainstem pools are of sufficient structural condition and in proper location to support adult chinook, which typically enter the river in late summer or early fall when flows and temperatures can be a problem, and which require holding pools of sufficient size, hiding cover, depth and proximity to spawning areas to achieve reproductive success.

Table 11: Frequency, Average Residual Depth, and Area of Pools in the mainstem Snoqualmie River (RM 6-35) in Summer 2001 (modified from Solomon and Boles 2002)

RM	Reach	Pools	Pools/mile	Average residual depth (ft)	% Pool area
6-13	County Line to Duvall	12	1.7	11.9	30.4
13-22	Duvall Meanders	25	2.8	14.1	55.3
22-25	Tolt River Delta	5	1.7	13.4	25.3
25-32	Carnation Meanders	19	2.7	15.9	63.7
32-35	Raging River Delta	6	2.0	13.8	N/A
6-35	All	67	2.3	14.2	42.0

The Army Corps of Engineers first described the Snoqualmie River in 1880 (Collins and Sheikh 2002). Unlike most other large Puget Sound rivers (e.g., Skagit, Snohomish, and Stillaguamish), the Snoqualmie description did not include wood. This may or may not suggest that wood was not abundant enough to create problems for navigation; it may instead reflect earlier undocumented clearing of in-channel wood that may have been done by settlers. Snag removal from the Snoqualmie, Snohomish, and Skykomish rivers occurred irregularly from 1887 to 1908; numbers specific to removal from the Snoqualmie River are not available.

LWD is largely lacking in the Snoqualmie River reach downstream of the Tolt River, but where present provides very limited area for juvenile salmonid rearing (Parametrix 2001). Boat–based assessment of LWD presence in summer 2000 from RM 6 to RM 38 identified an overall dearth of wood in the river, with only 25.7 pieces per mile (Solomon and Boles 2002). Much of the existing LWD appeared to be old, indicating a lack of recent significant recruitment. Only a few locations were identified where large alder and cedar trees were leaning over the river and were potential near-term sources of LWD. However, the generally degraded riparian condition results in low LWD recruitment potential to the river. The shortage of LWD in the Snoqualmie River limits the creation of summer rearing habitat and winter refuge habitat (Pentec Environmental and NW GIS 1999). Historic riparian timber harvest and LWD removal from the mainstem has decreased LWD recruitment and instream habitat complexity (1998 subbasin workshop). Cottonwoods and alders dominate the near river riparian zone (1998 subbasin workshop), and there is very limited opportunity for LWD recruitment due to past erosion control projects

(Parametrix 2001). Much of the LWD present in the mainstem is older, and is located primarily downstream of Duvall. Most of the banks of this reach are either revetted or steep, offering little optimum rearing area for salmonids due to higher velocities. There is limited transport of LWD from the upper watershed to the river downstream of Snoqualmie Falls. This conclusion is supported by experiences at the Puget Sound Energy facility at Snoqualmie Falls (Cary Feldmann, personal communication). Leaves and small debris accumulate on the facility trash racks and are passed downstream; there are observations of some large logs moving downstream during peak flow events, but no past problems with significant presence of large material accumulating on the trash racks or impeding operations at the facility. This is also consistent with Tulalip Tribes fish trapping experience at RM 12, which encountered no large logs, however a lot of smaller woody debris < 12-inches dbh (Nelson).

In summer 2000, active bank erosion was observed on 11% of riverbanks from RM 6 to RM 38 (Solomon and Boles 2002). There appeared to be a correlation between riverbank erosion and human or cattle access to the river. Most of the cattle access points were concentrated between the City of Duvall and the mouth of Harris Creek (RM 10-19). Cattle access contributes to excessive erosion of riverbanks, loss of riparian vegetation, and destruction of riparian habitat, and can contribute to nonpoint pollutant loading, especially nutrients and fecal coliform bacteria.

<u>Substrate Condition</u>

The Snoqualmie River geology is distinctly different above and below the Snoqualmie Falls (1998 subbasin workshop). Above the falls, the river is high gradient and sediment poor. Sediments generated in the upper watershed are primarily trapped above the falls in the low gradient Three Forks area. The MF Snoqualmie is the largest contributor of sediments to the Snoqualmie mainstem, caused by lateral movements occurring in its wide floodplain. Several washouts and debris torrents in the past decade indicate the SF Snoqualmie may have experienced the most erosion of the three forks (Lucchetti). However, it is not considered a significant contributor of sediments below the falls. Sediment accumulation studies are underway in the diked portion of the SF Snoqualmie as it flows through the town of North Bend. Results of the study can be obtained from King County DNRP, Rivers Section. Below Snoqualmie Falls, the river gradient is relatively low all the way to Puget Sound. The primary sources of sediment below the falls are the Tolt River and the Raging River, the only two tributaries of sufficient size to transport bedload to the mainstem channel. Tokul Creek is a minor contributor of sediments. Sediments grade to less coarse sands and gravels on the Snoqualmie River several miles downstream of the Raging and Tolt rivers.

The Snoqualmie River transports very little gravel (Collins and Dunn 1990 and Booth et al. 1991, both as cited in Pentec Environmental and NW GIS 1999). Most of the bedload originating from the headwaters of the Snoqualmie River is trapped upstream of Snoqualmie Falls (Booth et al. 1991, as cited in Pentec Environmental and NW GIS 1999). Very little coarse sediment is encountered at the Puget Sound Energy facility at Snoqualmie Falls; course sand does accumulate upstream, but is re-suspended and carried downstream during peak flow events (Cary Feldmann, Puget Sound Energy, personal communication). Downstream of Snoqualmie Falls, sediment deposition in the Snoqualmie River is concentrated downstream of tributaries such as the Raging and Tolt rivers (Booth et al 1991, as cited in Pentec Environmental and NW GIS 1999).

Because of the low gradient and limited gravel availability, salmon spawning habitat is naturally limited downstream of Snoqualmie Falls (Pentec Environmental and NW GIS 1999). Mainstem spawning occurs in only a few locations: gravel riffles downstream of the Tolt River, at the mouth of the Raging River near Fall City, and downstream of Snoqualmie Falls. Primary spawning is also found on the lower mainstem between Snoqualmie Falls and the Raging River (near the mouth of Tokul Creek), and the lower mainstems of the Tolt and Raging Rivers. Chinook spawning conditions are also good within the lower 0.3 miles of the Snoqualmie River, where several pair of spawning chinook were observed in 2000 (Nelson). Outside of these regions, spawning habitat is limited due to poor gravel with a high percentage of fines (Pentec Environmental and NW GIS 1999). Heavy juvenile salmonid rearing occurs near the mouth of Griffin Creek and in the lower portion of Griffin Creek (Anderson, Solomon). Similar rearing use would be expected near the mouths of other key tributaries (e.g., Tolt River, Raging River) once floodplain function is restored in the lower portions of these tributaries. Rearing also occurs in the mainstem, but specific locations and extent of utilization have not been determined.

At the mouth of the Tolt River, the Snoqualmie channel has a bedload transport capacity estimated at 2,000-3,000 yd^3/year (Booth, Bell, and Whipple 1991, as cited in Parametrix 2001). Just downstream, the Snoqualmie River can only transport ~400 yd^3/year, so all of the Tolt River bedload (cobbles, gravel, and much of the sand) deposits within 3 miles downstream of the Tolt River mouth. The average deposition rate in the 3 miles downstream of the Tolt River was ~5,600 yd^3/year between 1995 and 2000. During the 1995-1997 period, which had larger floods, the average deposition rate was 7,800 yd^3/year.

Timber harvests in the watersheds of the Tolt and Raging rivers caused gravel deposition in the mainstem Snoqualmie and may have enhanced the quantity and quality of spawning substrate in those areas (1998 subbasin workshop). However, delta forming processes and bedload transport would have created favorable conditions in the absence of timber harvests. Furthermore, the lower reaches of the Tolt and Raging have been degraded for spawning by this activity.

Riparian Condition

Pentec Environmental (1999) evaluated riparian condition on the banks of the Snoqualmie River (Table 12). Riparian conditions 4, 5, and 7, and possibly 10 would typically be considered to reflect functional riparian conditions for a large mainstem river. Cumulatively, these riparian condition categories include only 27% of the total riparian area evaluated for the Snoqualmie River, indicating lack of current riparian function, as well as limited potential for LWD recruitment. Assessment of riparian condition in the summer of 2000 showed that there is a paucity of mature riparian forests along the banks of the mainstem Snoqualmie; mature trees are now found along only 1.8% of the LB, and 9% of the RB (Solomon and Boles 2002). Lack of riparian vegetation results in decreased riverbank stability, excessive erosion and reduction of shading, which leads to higher water temperatures. Lack of mature trees in the riparian zone also limits LWD recruitment potential to the river, thus reducing the structural and hydraulic complexity of instream habitat. The Snoqualmie River is too wide for the currently existing riparian vegetation to have a significant shading effect. Aerial photograph interpretation indicated that mature riparian forests can shade more than 50% of the Snoqualmie River, which could help create or maintain local temperature refuge areas along the banks of the river, as well as providing cover habitat along the bank (Pentec Environmental and NW GIS 1999). Salmon spawning in the Tolt River has been associated with adjacent presence of overhanging vegetation and in-channel debris; this is likely also the case in the mainstem Snoqualmie, although documentation does not exist (Anderson).

Table 12: Riparian conditions on the Snoqualmie River (right and left banks combined)(from Pentec Environmental and NW GIS 1999)

Riparian Condition	Total Miles	% of Total
1. Grass or brush	46.57	45

2. Single line of trees	15.78	15
3. 20-200 foot forested	8.50	8
4. 200-400 foot forested	9.02	9
5. >400 foot forested	16.88	16
6. Residences or farms, little forest	3.02	3
7. Residences or farms, significant forest	0.28	0
8. Roads or railroads	0.24	0
9. Industrial	0.52	1
10. Unforested wetland	1.83	2
Total	102.64	100

Throughout much of the Snoqualmie Valley, riparian vegetation between ordinary high water and bankfull height is a monoculture of reed canary grass, which is subject to sloughing and does not provide riparian function (Anderson); there is opportunity for improved riparian function in this area, which is not typically used for active agriculture or grazing.

Not all of the Snoqualmie floodplain was historically forested with large trees. General Land Office (GLO) field notes from the 1870s indicate that the extensive marsh area from RM 2 to RM 12 was primarily an almost impassable thick growth of shrubs and small trees, with a scattering of a few scrubby spruce and cedar (Collins and Sheikh 2002). Most streamside trees were hardwoods: alder, willow, vine maple, maple, cottonwood, and crabapple. Of these, only maple, cottonwood, and alder were typically of a large enough size to create stable in-channel wood. Conifers accounted for 7% or less of streamside trees, yet accounted for 43% of streamside basal area, indicating that conifers were the largest trees and would have provided nearly half of the dead wood biomass to rivers from streamside forests.

The Army Corps of Engineers requires removal of all woody vegetation greater than 4 inches in diameter at breast height (dbh) from levees. These riparian vegetation management standards on the levees present a significant habitat impact (1998 subbasin workshop). Given the extensive bank area these standards cover, the cumulative effect of this management practice is quite large.

<u>Water Quantity</u>

Gauged streamflow information is available for the Snoqualmie River near Carnation (gauge 12149000) for the period 1929-1993.

Because a large portion of the Snoqualmie watershed drains high-elevation areas of the Cascade Mountains, snowmelt strongly influences the hydrology of the watershed, although none of these streams are fed by glaciers (Solomon and Boles 2002). There are two distinct periods of high monthly flows: November, December, and January due to winter rainfall and increased meltwater from rain-on-snow events, and May and June due to snowmelt at high elevations. The lowest mean monthly flows occur in August at almost all gauges in the watershed because most of the snow has melted and there is usually little rainfall in western Washington during the summer months. Low elevation tributaries, such as the Raging River, do not benefit from a winter snow pack; thus their flows have no springtime increase. Mean monthly flows in low elevation basins increase from September through January as rainfall increases, and then decrease to the low point in August (Pentec Environmental and NW GIS 1999).

A watershed assessment conducted in 1995 (PGG 1995, as cited in Pentec Environmental and NW GIS 1999) reported that analysis of total annual streamflow at seven gauges within WRIA 7 showed declining streamflow (normalized to precipitation) on the Snohomish, Snoqualmie, and Tolt rivers. Normalized streamflow trends could reflect changes due to land-use activities or water withdrawals. The apparent streamflow declines are too large to be explained by allocated withdrawals alone, and may be partly related to limitations inherent in the analysis. However, data show considerable scatter, and the findings indicate that conclusions should be drawn with caution.

A United States Geological Survey (USGS) study conducted in 1991 found that a significant portion of the surface flow in the Snoqualmie River is contributed by groundwater (as cited in Pentec Environmental and NW GIS 1999). The SF Snoqualmie River received ~25-31 cfs from groundwater discharge, or ~25-31% of its flow in the reach from Edgewick Road to North Bend. The upper Snoqualmie River (Three Forks to downstream of Snoqualmie Falls) gained 88 cfs from groundwater, or ~20% of its flow. From Fall City to Carnation, the river gains an additional 81-93 cfs, or 11-13% of its flow, from groundwater seepage. In total, within the study area, groundwater seepage delivered ~115-133 cfs, or 25-28% of the flow observed at Carnation. It is estimated that groundwater could be contributing as much as 22% of the mean August flow at Carnation or 40% of the median 7-day low flow at Carnation (Pentec Environmental and NW GIS 1999).

Fish resource agencies have reached an agreement with Puget Sound Energy to maintain a minimum 300 cfs flow between the base of the falls and the outfall for Plant 2, approximately 0.5 mile downstream (1998 subbasin workshop). The flow has been set to allow fish access to the plunge pool below Snoqualmie Falls.

Water for agriculture is withdrawn from the river, although the quantities are unknown; effects on instream flow are also unknown (1998 subbasin workshop). In summer 2000, 15 water diversion pumps were located, with 10 of the 15 located between RM 6 and RM 10; no assessment of the effects of these diversions was made (Solomon and Boles 2002). Minimum flows established in 173-507 WAC vary from 700 cfs in late August to September to 2800 cfs between November and the end of June.

Water Quality

The Snoqualmie River is included on the1998 list of impaired waterbodies for water temperature (RM 2.7, 14.7, 23.0, 36.0, 44.0, and at Plant 1 Powerhouse Intake). Excursions from the criterion for fecal coliform bacteria (numerous locations throughout the watershed) and for dissolved oxygen (Plant 1 Powerhouse Intake and SF Snoqualmie) are being addressed through a TMDL adopted by EPA in 1996. Excursions from the criterion for pH (RM 2.5, 2.8, 7.0, 14.7, 23.0, and 36.0) are thought to be reflective of natural conditions (1998 303d List Decision Matrices).

SF Snoqualmie River is included on the 1998 303(d) list of impaired waterbodies for water temperature (RM 17.3), and pH (RM 10.0 and 13.6)(1998 303(d) list Decision Matrices).

Water temperature data loggers recorded the water temperature at the bottom of deep pools at four locations in the Snoqualmie River every hour from July 14 to September 28, 2000, and at three locations in the Snoqualmie River every hour from June 26 to October 19, 2001. Seven-day moving average and average monthly water temperatures increased progressively downstream in both 2000 and 2001, with Duvall being the warmest and the Raging River mouth being the coolest (Table 13 and Table 14)(Solomon and Boles 2002). The difference between minimum and maximum monthly temperatures ranged from 5.3 to 6.6°C at each site in 2000 and from 2.7 to 7.5°C at each site in 2001

Table 13: Seven-Day Moving Average Temperature (^oC) in Mainstem Snoqualmie River in Summer 2000 and Summer 2001 (from Solomon and Boles 2002)

Location	**2000**	**2001**
Duvall	20.5	17.2
Tolt River Mouth	19.8	N/A
Neal Road	19.2	16.5
Raging River Mouth	18.4	16.0

Table 14: Average Temperature (^oC) by Month in Mainstem Snoqualmie River in Summer 2000 and 2001 (from Solomon and Boles 2002)

	2000			
	June	July 14-31	August	Sept 1-28
Duvall	NA	17.3	17.8	14.4
Tolt R. Mouth	NA	16.7	17.3	13.9
Neal Road	NA	16.1	16.4	13.4
Raging R. Mouth	NA	15.8	16.1	13.2
	2001			
	June 26-30	July	August	September
Duvall	13.7	16.7	17.7	15.6
Neal Road	12.8	15.4	16.6	14.4
Raging R. Mouth	12.6	15.2	16.3	14.2

Water temperatures at or above 18 degrees C. (temperatures dangerous to salmonid survival) were recorded for over 300 hours each summer at the Duvall site and at the Tolt River confluence site in 2000 (Table 15)(Solomon and Boles 2002). Overall, water temperatures during the summer/early fall months in 2000 and 2001 were in a temperature range that is considered limiting to salmonid reproduction and rearing. Lack of riparian cover and slow moving water in the channelized lower reaches of the river contribute to elevated temperature. The summer 2000 habitat conditions inventory showed that even where there is a dense riparian canopy, the trees rarely overhang the river by more than five feet.

Table 15: Number of Hours that Water Temperature in Mainstem Snoqualmie River $\geq 18^oC$ in Summer 2000 and Summer 2001 (from Solomon and Boles 2002)

Location	**2000** (hours at or above 18^oC)	**2001** (hours at or above 18^oC)
Duvall	393	469
Tolt River Mouth	317	N/A
Neal Road	175	171
Raging River Mouth	116	120

Examination of diurnal fluctuations in temperatures at each site revealed that the time for peak temperature differed at each site (Solomon and Boles 2002). The Raging River site peaked around 6 PM daily, the Neal Road site peaked around 5 PM daily, and the Duvall and the Tolt River sites peaked around 10 PM. These findings correlate with the water depth of the loggers. The Raging River and Neal Road temperature loggers were in only about 8 feet of water, while the Tolt River and Duvall loggers were in over 10 feet of water. The hottest time of the day in western Washington for summer air temperatures is around 3 to 5 PM, so it may be that water temperature on the surface peaks in the late afternoon and the warmer water slowly mixes with the bottom of the water column, resulting in later peak temperatures registering on the loggers in the deeper pools. The logger at the Raging River site showed two separate temperature peaks per day. The second, more minor peak occurred approximately 12 hours after the primary temperature peak. This second peak is only slightly noticeable on colder days, but is very evident on warmer days. This pattern seems to appear at the Neal Road site as well, but is less evident than at the Raging River site.

Agriculture on the lower Snoqualmie River results in problems of high temperature, nutrients, and bacteria (Snohomish County Public Works 2000). The causes of these problems are unrestricted livestock access on the banks of the river, runoff from manure sprayed on agricultural lands, failing septic systems, fertilizer enriched groundwater, and direct discharge of manure. Livestock access to the water on the mainstem is a concern. King County's Sensitive Areas Ordinance exempts the Snoqualmie floodplain from the animal fencing requirements (1998 subbasin workshop). Solutions to water quality problems on the lower river include implementing farm best management practices, repairing failing septic systems, and planting streamside vegetation (Snohomish County Public Works 2000).

In summer 2000, numerous dumping and discharge points and locations with anthropogenic debris were found in the Snoqualmie River (Solomon and Boles 2002). Cars and car parts, tires, machine and metal parts, and various types of yard waste were identified. At several locations, unidentified liquid was discharging from pipes into the river or seeping into the river. Specific locations of these sites are identified in their report.

Action Recommendations

Several salmonid habitat restoration opportunities have been identified for the Snoqualmie mainstem and associated floodplain off-channel habitats. The Early Action Agenda (Snohomish Watershed Salmon Recovery Forum 2001) recommends that priority be given to projects in focus areas and on restoration efforts that restore natural ecological processes, but there are also excellent habitat restoration opportunities outside of the identified focus areas. Unranked salmonid habitat restoration opportunities include:

- Restore riparian function where impaired (with particular consideration to restoring conifer presence), to increase shading of the channel and provide LWD recruitment
- Connect floodplain oxbow ponds and wetlands with the river to provide off-channel rearing habitat
- Restore valley-marginal wetlands that formerly existed in low-elevation areas outside the meander belt
- Restore natural floodplain configuration of tributary creeks
- Implement agricultural best management practices, including elimination of unrestricted livestock access to the river and associated oxbow ponds and wetlands
- Remove anthropogenic debris from the river; assess and correct discharges identified in Solomon and Boles (2002)

Unnamed 07.0224, Crescent Lake

General

Crescent Lake is a tributary to the lower end of Riley Slough (07.0818), prior to its entry into the lower Snoqualmie River (note that this is different than represented in Williams et al. 1975).

There is an open surface water connection between Crescent Lake and Riley Slough. Riley Slough and tributaries had good abundance of coho spawners documented in the late 1970s. Coho spawner abundance declined over the years, and no coho spawners have been observed in the watershed since 1994 (Kraemer). However, Stillaguamish-Snohomish Task Force, Snohomish Conservation District, and Tulalip Tribe staff observed juvenile coho in the Riley Slough spawning area in 2000 (Ward). Brett Barkdull (WDFW) walked the system in early July 2002, and found no apparent salmonid access through the beaver dams in the lower 1-1.5 miles of Riley Slough. There were no apparent passage obstructions, but there were also no rearing juveniles observed in the beaver ponds. This observation follows the 2001 coho escapement, which is the largest on record for the Snohomish watershed, where coho were seen elsewhere throughout the watershed in areas where they had previously not been observed.

Crescent Lake has a large amount of open water, but water quality appears to be significantly impaired, likely associated with high nutrient input from the Honor Farm, which is immediately adjacent to the lake (Bails). The dairy operation at the Honor Farm was recently closed, providing potential opportunities for restoration. Andy Loch snorkeled Crescent Lake in 2001, with no observations of salmonid use (Ward). Riparian condition around Crescent Lake is variable (Ward). Much of the north shore has substantial, largely deciduous riparian vegetation. The south shore and wetland at the east end of the lake are bordered by a narrow riparian buffer.

Much of the area surrounding Crescent Lake, particularly on the north shore and the southwestern shore, is within the Crescent Lake Unit of the Snoqualmie Wildlife Area (Gower et al. 1998), with the area currently managed to provide public land for waterfowl and pen-reared pheasant hunting and other wildlife oriented activities. However, WDFW ownership may provide excellent opportunities for salmonid habitat restoration.

<u>Action Recommendations</u>

The following ranked habitat restoration actions are recommended for the Unnamed 07.0224 watershed:

- Assess water quality in Crescent Lake and correct identified problems
- Restore riparian function around Crescent Lake
- Include Crescent Lake in the recommended evaluation of adult salmonid passage into Riley Slough during the period of adult coho return; correct identified passage limitations

Unnamed 07.0226

<u>General</u>

A natural falls at the mouth blocks anadromous salmonid use (Chamblin).

Unnamed 07.0227

<u>General</u>

Unnamed 07.0227 is a RB tributary to the Snoqualmie River, entering at RM 2.9 (Williams et al. 1975).

Fish Access

The culvert at the crossing of High Rock Road is a possible barrier to fish passage (Chamblin). The site should be assessed, and corrected if determined to be a barrier. There is confusion regarding connectivity conditions with the Snoqualmie River at the mouth of Unnamed 07.0227. The mouth of the creek flows through culverts with a flapgate, located under the boat ramp (Johnson). The status of fish passage at the mouth of the creek needs to be assessed, and corrected if impaired.

Floodplain Modifications

The majority of this watershed is located on the Snoqualmie River floodplain, and is extensively channelized and ditched through agricultural lands. The upper extent of the main channel is located immediately adjacent to a large gravel mining operation No information is available on channel or substrate conditions. Blasting within the gravel mining site in the mid-1990s opened an artesian well, creating a new creek, resulting in a flood of new water and gravel into the channel downstream (Johnson). The new creek was routed under SR 203 to a created wetland, and then back to lower Unnamed 07.0227.

Channel Conditions/Substrate Condition

No information is available on channel or substrate conditions.

Riparian Condition

Review of aerial photos provided by Snohomish County (2001) indicates absence of riparian vegetation through the agricultural lands on the Snoqualmie River floodplain and impaired riparian function on the right-bank along the gravel mining operation in the headwaters; overall, riparian condition would rate as poor.

Water Quantity/Water Quality

No information is available on water quantity or water quality.

Action Recommendations

The following ranked habitat restoration actions are recommended for the Unnamed 07.0227 watershed:

- Assess fish passage conditions at mouth, correct if impaired
- Restore riparian function, where impaired
- Assess fish passage status elsewhere and habitat conditions, correct identified problems

Pearson Eddy Creek 07.0229

General

Pearson Eddy Creek is a LB tributary to the Snoqualmie River, entering at RM 3.6 (Williams et al. 1975).

Fish Access/Floodplain Modifications

This watershed historically likely provided some spawning potential and good overwinter and rearing potential (Kraemer). Collins and Sheikh (2002) indicate that the lower portion of this watershed was a large historic wetland. Fish access is thought to be precluded by presence of a pump station low in the watershed (Chamblin). Access by Washington Trout staff to assess barriers in this watershed was denied (Glasgow). The majority of this watershed is located in the Snoqualmie River floodplain, and includes several remnant channel wetlands. The floodplain portion of the watershed between High Bridge Road and the Snoqualmie River is mostly in commercial agriculture, and has been extensively channelized and ditched. The confined nature of existing channels limits production potential (Kraemer). However, the Snoqualmie River adjacent to the watershed is undiked and natural floodplain function is unimpaired.

Channel Conditions/Substrate Condition

No information is available on channel or substrate conditions, but habitat conditions are likely impaired through the channelized and ditched channels on the floodplain.

Riparian Condition

Review of aerial photos provided by Snohomish County (2001) indicates absence of riparian vegetation through the most of the agricultural lands on the Snoqualmie River floodplain, although there appears to be good remaining riparian vegetation surrounding the Round Lake wetland; overall, riparian condition would likely rate as poor.

Water Quantity/Water Quality

No information is available on water quantity or water quality. However, the location of large farm buildings directly adjacent to the creek, and the lack of riparian vegetation raise water quality (temperature, dissolved oxygen, nutrients) concerns (Chamblin).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Pearson's Eddy Creek watershed:

- Assess fish access and habitat conditions, correct identified problems
- Restore riparian function, where impaired

Peoples Creek 07.0236

General

Peoples Creek is a RB tributary to the Snoqualmie River, entering at RM 4.3 (Williams et al. 1975). No information is available on habitat conditions in this watershed. There is no significant history of permitted channelization or dredging in the watershed (Chamblin). Indications are that Peoples Creek was included in Washington Trout culvert inventory efforts, but no barriers were located (Glasgow).

Riparian Condition

Review of aerial photos provided by Snohomish County (2001) indicates absence of riparian vegetation in the lower 0.2 miles downstream of the SR 203 crossing, with fair/good riparian vegetation presence throughout the upper forested portion of the watershed; overall, riparian condition would likely rate as fair/good.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Peoples Creek watershed

- Assess habitat conditions, correct identified problems
- Restore riparian function downstream of the SR 203 crossing

Duvall Creek 07.0238

General

Duvall Creek is a RB tributary to the Snoqualmie River, entering at RM 5.7 (Williams et al. 1975). No information is available on habitat conditions in this watershed. It is unknown whether this creek was included in Washington Trout culvert inventory efforts (Glasgow).

Riparian Condition

Review of aerial photos provided by Snohomish County (2001) indicates fair/good riparian vegetation presence throughout the watershed; overall, riparian condition would likely rate as good.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Duvall Creek watershed

- Assess habitat conditions, correct identified problems

Cherry Creek 07.0240, Unnamed 07.0240A, NF Cherry 07.0243, Unnamed 07.0245, Unnamed 07.0247, Margaret Creek 07.0248, Hannan Creek 07.0257, and tributaries

General

Cherry Creek is a RB tributary to the Snoqualmie River, entering at RM 6.7 (Williams et al. 1975). The Cherry Creek watershed drains an estimated 17,536 acres (SBSRTC 2002). Land use is mainly commercial agriculture on the valley floor, and forested above. There is also increasing intensity of rural residential development in the watershed, in what was until recently commercial forestland.

Cherry Creek drains an alluvial area that has been impacted by diking, drainage, and removal of forest cover (Bilby et al. Undated Draft). The average abundance of spawning coho salmon in Cherry Creek over the period-1984-1998 was 2,279 fish/year, placing this watershed in the moderate population size class in the Snohomish basin. The underlying physical attributes of the Cherry Creek watershed suggest that it could support high levels of coho salmon if the factors currently impairing production are corrected. Restoring Cherry Creek to conditions that existed prior to habitat modification would increase abundance of spawning coho to 9,200 fish/year, increasing Snohomish basin total coho production by 7.3%.

Fish Access

The Drainage District pump intake on lower Cherry Creek (just upstream of the State Route 203 bridge) is unscreened and is a significant source of juvenile mortality for several fish species (Glasgow 2001, as cited in SBSRTC 2002).

There are many road crossings to small parcels and forest roads in the watershed (Lucchetti). Washington Trout has conducted a comprehensive inventory of culverts and fish passage barriers in the Cherry Creek watershed. This inventory is included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Rasmussan Lake Creek	NE Cherry Valley Rd	0.01	No
Rasmussan Lake Creek	4th Ave NE	1.8	Yes
Rasmussan Lake Creek	Bird St	1.88	Yes
Rasmussan Lake Creek	4th Ave NE	1.9	Yes
Unnamed RB to Rasmussan Lake Creek	NE Cherry Valley Rd	NA	No
Unnamed LB to Cherry at ~RM 2.2	NE Cherry Valley Rd	0.35	Yes
NF Cherry Creek	318th Ave NE	2.94	Yes
Unnamed 07.0247	NE Kelly Rd	0.05	Yes
Unnamed 07.0247	NE Kelly Rd	0.21	Yes
Unnamed 07.0247	NE Kelly Rd	0.32	Unknown
Unnamed 07.0247	NE Kelly Rd	0.63	Yes
Unnamed 07.0247	NE Kelly Rd	0.73	Unknown
Unnamed RB entering Margaret Creek at RM 0.3	320th Ave NE	1.07	Yes
Unnamed RB entering Margaret Creek at RM 0.37	NE 193rd	1.07	Unknown
Unnamed RB entering Margaret Creek at RM 0.37	320th Ave NE	1.23	Unknown
Lake Margaret overflow	M200-DNR	NA	Yes
Unnamed 07.0254	CV100	0.2	Yes
Unnamed 07.0254	CV100	0.5	No
Unnamed 07.0254	348th Place NE	0.95	Unknown
Unnamed 07.0254	348th Place NE	1.15	Yes
Unnamed 07.0256	CV-6300	0.12	Unknown
Unnamed RB entering Cherry at RM 6.7	CV-6300	0.13	Yes
Hannan Creek	CV-6300	0.04	Yes
Unnamed LB to Hannan at ~RM 0.4	CV-6300	0.07	Yes
Hannan Creek	Unnamed	1.98	Yes

Hannan Creek	High Rock Mainline	2.35	No
Hannan Creek	Camp Hamilton Rd	2.95	Yes
Hannan Creek	Camp Hamilton Rd	3.05	Yes
Hannan Creek	Unnamed	3.1	No
Hannan Creek	Camp Hamilton Rd	3.2	Unknown

This represents a comprehensive inventory of culverts in the Cherry Creek watershed (Glasgow).

Within the Cherry Valley Unit of the WDFW Snoqualmie Valley Wildlife Area, 21 culverts, 1 dam, and 1 pump diversion were encountered (Gower et al. 1998). The dam and 1 culvert are total barriers, 3 culverts are partial barriers, and the pump diversion structure is a partial barrier and migration hazard. The existing water diversion pumps are not screened, allowing the potential entrainment of smolts and fry in the spring when the fish are actively migrating, and the flap gate structure creates a potential barrier to fish passage, particularly for juvenile salmonids.

Floodplain Modifications

Floodplain function has been highly altered in lower Cherry Creek, where a dike is constructed on the lower 1.6 miles of the left bank, primarily to prevent backwater inundation from the Snoqualmie River during winter storms and spring runoff conditions (Chamblin). Conditions in the lower Cherry Creek watershed have been altered from what was likely historically a more meandering stream with fringe wetlands to the current static system in the lower 2.5 miles, with the channel potentially incised through the lower floodplain (Lucchetti). The area to the southwest of the dike has been extensively ditched and channelized, and the resulting drainage passed through a pump station. The pump station affects salmonid access to and from WDFW owned lands near the mouth of Cherry Creek. The entire area behind the dike is considered winter rearing area, and the complex of dikes has little effect on the winter rearing area at the Cherry Valley Unit of the WDFW Snoqualmie Wildlife Area (Gower et al. 1998). If the dike were removed, the only variation would be the valley flooding sooner, but also draining off quicker. Therefore, there would be no substantial change in the duration of available winter rearing habitat if the dike was removed (Curt Young, as cited in Gower et al. 1998). Restoration of floodplain function in the diked reach of lower Cherry Creek would likely also require some modification of SR 203 and the old railroad grade to increase hydrologic connectivity (Chamblin).

Coho production in the watershed is good, but substantially lower than in some other comparable systems in the Snoqualmie River watershed (Chamblin, Kraemer). The most apparent difference between watersheds is the low presence of wetlands in Cherry Creek on the floodplain bottom, compared to historic conditions.

Channel Conditions

Loss of native riparian forest structure and the simplification of the vegetation community have resulted in a significant loss of in-channel LWD and in potential recruitment of LWD (Glasgow 2000, as cited in SBSRTC 2002).

Substrate Condition

No quantitative substrate information is available. Qualitative assessment is that substrate gravel quality is generally good upstream of the agricultural area (Chamblin).

Riparian Condition

Riparian vegetation is absent/sparse through the agricultural lands in the lower watershed. Upstream, the watershed (including riparian areas) is fairly well forested, but impacted in areas by increasing encroachment from residential development, past forest harvest, and conversion of riparian stands to a monoculture (Lucchetti).

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Cherry Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Cherry Cr	2	47	33	11	1	5	0	1

Water Quantity

Total impervious area in the Cherry Creek watershed is estimated at 3.5% (Purser and Simmonds 2001, as cited in SBSRTC 2002). The Cherry Creek watershed is indicated as likely to be very sensitive to groundwater withdrawals, due to a combination of lack of snowmelt or large lakes, and relatively large areas in residential zoning subject to residential water withdrawals and reduced groundwater recharge due to impervious surfaces (Pentec Environmental and NW GIS 1999). Water for much of the development that is occurring higher in the watershed is supplied by exempt wells; the cumulative effects to groundwater and surface water flows is unknown (Lucchetti).

The lake level on Lake Margaret is regulated through the summer months for recreation and aesthetics for development located on the lake. It is unknown to what extent this reduces instream flow in Margaret Creek or downstream in Cherry Creek during base flow periods.

Water Quality

There are no 303(d) listed segments for the Cherry Creek watershed. Fecal coliform bacteria counts and pH measurements have violated state water quality criteria in the past; nutrient levels have been elevated as well (WDOE 1997, Thornburgh et al. 1991, Fricke 1995; all as cited in SBSRTC 2002). Water quality data collected by the Tulalip Tribes in 1999 indicate that the state water quality criteria for fecal coliform bacteria and temperature were consistently exceeded at several sampling sites (McHugh 1999, as cited in SBSRTC 2002). Water quality problems are mainly confined to the lower 2.5 miles.

The excursions from the state water quality standards for pH were documented by Thornburgh et al. (1991, as cited in 303(d) Decision Matrices), but these were determined to be reflective of natural conditions, due to adjacent bogs.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Cherry Creek watershed:

- Maintain/restore forest cover in the watershed to retain natural forest hydrology

- Restore natural channel configuration and floodplain function in the historic wetland area in the lower 1.6 miles
- Correct screening and associated fish passage problems at the pump plant
- Prioritize and correct identified fish passage barriers
- Restore riparian function, where impaired, particularly on agricultural lands

Tuck Creek 07.0267 and tributaries

General

Tuck Creek is a LB tributary to the Snoqualmie River, entering at RM 10.3 (Williams et al. 1975). Tuck Creek drains a ~1,600-acre watershed (Bauman 2000).

Fish Access

A fishway is located at the mouth of Tuck Creek (Bauman 2000). The fishway is impassable during summer and early fall when the water level in the Snoqualmie River falls below the entrance to the fishway. Flood doors at the downstream end of a culvert beneath a farm access road located at the top of the fishway may also be a partial or complete barrier if they are closed or partly closed during fish migration.

The impoundment at the outlet of Tuck Lake is a barrier to all upstream fish passage (Bauman 2000); no information is available on habitat conditions upstream of the Tuck Lake impoundment. There is also an impoundment barrier on Unnamed 07.0272 ~100m upstream of 228th Avenue NE; slow water rearing habitat is present upstream of the impoundment. There is also an abandoned logging road that crosses Unnamed 07.0272 ~10m upstream of the confluence with Tuck Creek; the culvert is slightly perched and may be a hindrance to upstream fish migration during low stream flows.

Two fishways are located within the ravine reach of Tuck Creek (Bauman 2000). King County Department of Transportation maintains the fishway immediately downstream of the culvert crossing beneath NE Woodinville-Duvall Road located between Old Woodinville-Duvall Road and NE 172nd Street. WDFW constructed and maintains a fishway located on private property at 23656 NE Woodinville-Duvall Road. The presence of coho redds upstream of the fishways indicates that they are passable to adult salmonids, but the fishways and weirs may be partial or complete barriers to upstream juvenile migration. There is no indication that the Tuck Creek watershed was included in the Washington Trout culvert inventory (Glasgow).

Floodplain Modifications

The mainstem of Tuck Creek flows out of Tuck Lake, an artificially impounded lake surrounded by low-density single-family residences (Bauman 2000). Three tributaries enter the creek along its course. After exiting Tuck Lake, Tuck Creek flows over relatively flat, upland glacial deposits before entering a steep ravine, where it flows through a straightened channel adjacent to the Woodinville-Duvall Road. The creek exits the ravine and enters the Snoqualmie River valley, where it flows in a straightened channel over a natural alluvial fan located at the gradient change between ravine and valley, and through agricultural land and two in-channel open-water wetlands prior to entering the Snoqualmie River. The creek has a variable gradient, ranging from 0-2% in the upper reaches, 3-14% in the ravine, and <1% across the Snoqualmie River valley.

The channel of Tuck Creek has been straightened through the ravine reach to accommodate NE Woodinville-Duvall Road, which is located along one or the other of its banks for the length of the ravine (Bauman 2000). The rate of bank erosion has increased in the ravine from the stream attempting to redefine its floodplain in the confined area (Anderson). The stream channel appears to be incised throughout much of this reach (Bauman 2000). The straightening through this reach shortened the total length of channel in the ravine, resulting in an increase in stream gradient, which increased stream power so that a larger size fraction of stream substrate is mobilized at a particular discharge than previously. A large alluvial fan is present at the gradient break at the base of the ravine, between the valley wall and floor, just upstream of West Snoqualmie Valley Road NE. Deposition at the upstream end of the culvert beneath West Snoqualmie Valley Road NE requires periodic dredging by King County Roads maintenance crews to prevent road flooding. Also, because Tuck Creek has been confined to an artificial channel downstream of the intersection and within the depositional alluvial fan, the streambed has aggraded so that the bottom of the stream is now elevated above the surrounding floodplain.

Floodplain interaction between lower Tuck Creek and the Snoqualmie River is impaired by presence of a dike on the Snoqualmie River bankline (Anderson). The lower mile of Tuck Creek is ditched and dredged, with continued ditching elsewhere through the agricultural area on the valley floor (Lucchetti). King County has identified options to reconfigure the Tuck Creek channel across the Snoqualmie floodplain, moving the creek away from direct interactions with infrastructure, and restoring a more normal meander configuration (Anderson).

Channel Conditions

There is little LWD and pool condition is poor in the anadromous portion of the watershed (Lucchetti). The presence and recruitment potential of LWD is impaired in Tuck Creek (Bauman 1999). LWD presence was identified as good upstream of the ravine (Bauman 2000), and noted as impaired in the ravine and valley floor, with most of the LWD in those two reaches being located in the ravine (Bauman 1999).

Pool frequency is also impaired in Tuck Creek. Pool presence was noted as good upstream of the ravine (Bauman 2000); pool frequency was 56 pools/mile (80% of target threshold) in the ravine, and 39 pools/mile (56% of target threshold) in the valley reach (Bauman 1999). However, thousands of juvenile coho were observed rearing throughout the ravine reach during site visits in spring and summer 1999 (Bauman 2000).

Substrate Condition

The sandy substrate and low flow velocities characteristic of much of the valley reach do not provide suitable spawning habitat for salmonids (Bauman 2000). Some spawning habitat is present on the alluvial fan at the base of the ravine. Spawning regularly occurs on the gravel fan at the base of the ravine, in an area highly confined by the road intersection, and is subject to scour along the road (Lucchetti). Channel morphology in the ravine reach is cascade/step pool, with bed material consisting primarily of cobbles and boulders (Bauman 2000). The large size of substrate material is likely influenced by the straightening of the creek adjacent to the Woodinville-Duvall Road, resulting in an increase in stream gradient, which increased stream power so that a larger size-fraction of stream substrate is mobilized at a particular discharge than previously. Upstream of the ravine, channel morphology is alternating pool-riffle habitat, with suitable salmonid spawning gravels located in riffles and rearing habitat for juvenile salmonids present in the pools. Substrate function is rated as impaired for salmonid spawning and incubation in Tuck Creek (Bauman 1999). Although gravel dominates the substrate in some locations, sand dominates the substrate in others, and interstices between gravels are mostly filled with sand and fine sediment resulting in moderate to high gravel embeddedness.

Riparian Condition

Riparian vegetation on the valley floor is variable, with some locations with woody vegetation, but with much of the valley floor riparian consisting of reed canarygrass only (Bauman 2000). Riparian vegetation in the ravine on the bank not adjacent to the Woodinville-Duvall Road consists of immature even-aged mixed forest. Riparian function on the bank adjacent to the road is impaired, with riparian buffer width averaging only 30 feet wide, and dominated by red alder, willows, reed canarygrass, and Himalayan blackberry. Riparian vegetation upstream of the ravine consists primarily of mixed coniferous and deciduous second-growth, with a salmonberry understory. Several single-family residences are present in the riparian zone, with lawns extending to the streambank.

Water Quantity

The Tuck Creek watershed is almost entirely underlain by glacial till, so it responds very quickly to rainfall (Burkey 1998, as cited in Bauman 2000). Mean annual flows are ~3.7 cfs; summer base flows range from 0.2 to 1.5 cfs; winter base flows are ~1.1 cfs; and winter high flows are ~37 cfs. There are no significant changes to the hydrology in Tuck Creek (Lucchetti).

Water Quality

The area with greatest risk of elevated water temperature is where Tuck Creek flows across the Snoqualmie Valley floor with impaired riparian function. Water temperatures measured in early September 1998 in the valley reach ranged between $12^{o}$and $14^{o}C$ (Mike McHugh, as cited in Bauman 2000). Water temperature in Tuck Creek is enhanced by spring flow from Unnamed 07.0270, providing cooler than expected water at the base of the ravine and onto the valley floor (Lucchetti). Given the proximity of the Woodinville-Duvall Road to the creek, there is potential for stormwater runoff contaminants to enter the creek (Lucchetti).

Poor water quality in Long Lake (located adjacent to the Woodinville-Duvall Road in the valley reach) likely hinders upstream migration of salmonids in the fall, and may hinder migration of juvenile salmonids between Tuck Creek and the Snoqualmie River, as well as outmigration of smolts (Bauman 2000). Dissolved oxygen (DO) concentrations throughout Long Lake during sampling in summer and fall 1999 were below thresholds for salmon migration and spawning/rearing. High input of oxygen-deficient groundwater to Long Lake is a possible cause of the low DO (Sharon Walton, as cited in Bauman 2000), but this has not been verified.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Tuck Creek:

- Preserve/restore forest cover in the headwaters to maintain natural forest hydrology
- Restore natural channel configuration and floodplain function across the Snoqualmie River floodplain
- Develop and implement an LWD strategy to restore instream habitat diversity until riparian function is restored, including improved presence of LWD in the ravine, consistent with road maintenance needs

- Restore riparian function, where impaired

Duvall Area Independent Creeks (Coe Clemens Creek 07.0267X, Thayer Creek 07.0267Y, and Unnamed 07.0267Z)

General

Coe Clemens Creek is a RB tributary entering the Snoqualmie River almost directly across from Tuck Creek. Thayer Creek 07.0267Y is a RB tributary to the Snoqualmie River at RM 10.3 (flows behind Safeway south of Duvall). Unnamed 07.0267Z is a RB tributary to the Snoqualmie River at RM 11.0.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Coe Clemens	RR Grade	0.05	Yes
Coe Clemens	3rd Ave NE	0.82	Yes
Coe Clemens	Kennedy Drive	0.84	Yes
Unnamed RB entering Snoqualmie River at ~RM 11.0	RR trail	0.7	Unknown
Unnamed RB entering Snoqualmie River at ~RM 11.0	138th Street	0.9	Unknown
Unnamed RB entering Snoqualmie River at ~RM 11.0	SR 203	1.0	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Floodplain Modifications/Channel Conditions/Substrate Condition/Riparian Condition

Coe Clemens and Thayer creeks are channelized and ditched across the Snoqualmie River floodplain (Anderson). The channels are generally choked with reed canary grass downstream of SR 203, and riparian vegetation is absent across the floodplain. LWD is absent from the channels. Much of the land where these creeks flow across the Snoqualmie River floodplain is owned by the City of Duvall, providing excellent opportunities for floodplain and riparian restoration. No information was available on habitat conditions in Unnamed 07.0267Z.

Water Quantity/Water Quality

No water quantity or water quality information is available. Stormwater runoff from substantial commercial and residential development in these watersheds, upstream of the edge of the Snoqualmie River floodplain, is likely to significantly alter the natural hydrology of these creeks (Anderson, Lucchetti).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Duvall Area independent creeks:

- Mitigate impacts of increased stormwater runoff from commercial and residential development in the headwaters of Coe Clemens and Thayer creeks
- Restore natural channel configuration, floodplain function, and riparian function, particularly where Coe Clemens and Thayer creeks flow across the Snoqualmie River floodplain
- Assess habitat conditions in Unnamed 07.0267Z, correct identified problems
- Prioritize and correct identified fish passage barriers

Adair Creek 07.0275

General

Adair Creek is a LB tributary to the Snoqualmie River, entering at RM 13.3 (Williams et al. 1975). Habitat assessment work reported by Comings et al. (2001) was only conducted for the area upstream of West Snoqualmie Valley Road. Habitat conditions across the Snoqualmie Valley floor are substantially different than upstream of West Snoqualmie Valley Road.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	**Road Crossing**	**River Mile**	**Barrier Status**
Adair Creek	Private pasture road	0.29	Unknown
Adair Creek	NA	0.3	Yes
Adair Creek	W Snoqualmie Valley Road	0.4	Yes (barrier has been corrected)
Unnamed RB to Adair at RM 0.15	124th	0.35	No
Unnamed RB to Adair at RM 0.15	124th	0.45	No

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

The main fish passage barrier of concern at the crossing of West Snoqualmie Valley Road has been corrected (Anderson). The remaining barrier is a partial barrier.

Floodplain Modifications/Channel Conditions

The headwaters drain the Blakely Ridge Development (Anderson). The headwaters have numerous wetland complexes; efforts are being made to protect wetland integrity as development proceeds. The creek had been ditched and channelized across the Snoqualmie floodplain. A restoration project has recently been completed which restored a more natural channel configuration across the floodplain, and which included LWD placement and riparian planting.

The reach of the creek that ascends through the ravine upstream of the floodplain has good habitat conditions. Large quantities of LWD influence sediment movement within the channel; there is some visual evidence of recent bank erosion in small patches, but it is not rampant (Comings et al. 2001).

Substrate Condition

No information on substrate condition is available.

Riparian Condition

Riparian condition is poor across the Snoqualmie floodplain, but riparian plantings have recently been done as part of the habitat restoration project across the floodplain (Anderson). Riparian vegetation just upstream of West Snoqualmie Valley Road is primarily Himalayan blackberry (Comings et al. 2001). Riparian condition is good through the ravine that ascends the bluff upstream of the floodplain (Anderson), with the riparian buffer extending >60m on both banks for the full length of the stream with the exception of one house that encroaches near the headwaters (Coming et al. 2001). Extensive development is occurring in the headwaters, but efforts are being made to protect integrity of existing wetlands, including riparian vegetation (Anderson).

Water Quantity/Water Quality

Stormwater from the Blakely Ridge development is being collected, treated, and the intent is to bypass peak stormwater flows to the Snoqualmie floodplain in a manner that avoids hydrology impacts to Adair Creek (Anderson).

Baseline mean temperatures measured for Adair Creek (upstream of West Snoqualmie Valley Road) from late-January to late-August 2000 were 12.4°C for the dry season and 6.7°C for the wet season (Comings et al. 2001).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Adair Creek watershed:

- Monitor the recently completed floodplain restoration project, correct identified problems

Deer Creek 07.0275X

General

Deer Creek is a RB tributary to the Snoqualmie River, entering at RM 14.0 (Williams et al. 1975). No information is available on habitat conditions in Deer Creek, other than the culvert inventory data identified below.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (note that all of these culverts are designated as Unnamed 07.0219 tributary to Snoqualmie River in the database)(February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed RB entering Snoqualmie at ~RM 14.0	RR Trail	0.5	Unknown
Unnamed RB entering Snoqualmie at ~RM 14.0	SR 203	0.51	Unknown
Unnamed RB entering Snoqualmie at ~RM 14.0	In pasture	0.52	No
Unnamed RB entering Snoqualmie at ~RM 14.0	In pasture	0.54	No
Unnamed RB entering Snoqualmie at ~RM 14.0	Private Drive	0.55	Unknown
Unnamed RB entering Snoqualmie at ~RM 14.0	124th	0.62	No

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Deer Creek watershed:

- Assess habitat conditions, correct identified problems

Unnamed 07.0276 (Wallace Creek) and tributaries

General

Unnamed 07.0276 (Wallace Creek) is a LB tributary to the Snoqualmie River, entering at RM 15.1 (Williams et al. 1975). Habitat assessment work reported by Comings et al. (2001) was only conducted for the area upstream of West Snoqualmie Valley Road. Habitat conditions across the Snoqualmie Valley floor are substantially different than upstream of West Snoqualmie Valley Road.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed 07.0276	Private drive	0.2	Unknown
Unnamed 07.0276	W Snoqualmie Valley Rd	0.3	Yes
Unnamed RB entering 07.0276 at ~RM 0.2	Private drive	0.05	Unknown

(Pepper Creek)			
Unnamed RB entering 07.0276 at ~RM 0.2 (Pepper Creek)	W Snoqualmie Valley Rd	0.61	Yes
Unnamed RB entering 07.0276 at ~RM 0.2 (Pepper Creek)	Private rd	0.64	Yes

The identified fish passage barrier at RM 0.2 on Unnamed 07.0276 has been corrected (Anderson). The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Culverts at West Snoqualmie Valley Road and at a downstream constructed sediment pond create fish passage barriers (Comings et al. 2001); the culvert at West Snoqualmie Valley Road is a priority for correction by King County (Anderson). The barrier at RM 0.2 is also to be fixed in the near future. Past observations indicate that the mouth of the creek may not be passable to fish at all Snoqualmie River flows (Chamblin).

Floodplain Modifications

There is a history of dredging the oxbow and the outlet to the Snoqualmie River to maintain agricultural drainage (Chamblin).

Channel Conditions

LWD condition is generally poor across the Snoqualmie Valley floor, but there has been some past addition of LWD in the oxbow pond (Anderson). LWD presence is good upstream of West Snoqualmie Valley Road to the headwaters, with "prodigious" amounts of LWD that preclude observation of the stream at some locations (Comings et al. 2001). There has been significant bank erosion and channel incision through the ravine on Unnamed 07.0276 (Wallace Creek)(Comings et al. 2001), and on Pepper Creek (07.0277)(Anderson), due to stormwater runoff from development in the headwaters.

Substrate Condition

The channel bed through the ravine on Wallace Creek and on Pepper Creek (07.0277) is significantly degraded and incised from directed release of stormwater runoff from development in the headwaters (Chamblin, Anderson).

Riparian Condition

Some woody riparian vegetation is present across the Snoqualmie Valley floor, but riparian condition would rate as poor (Chamblin). The riparian buffer is dominated by deciduous trees for the first 600m upstream of West Snoqualmie Valley Road, and by coniferous forest further upstream to the headwaters (Comings et al. 2001). The whole stream (upstream of West Snoqualmie Valley Road) is shaded by mixed forest canopy, except for one small 50m section of grass lined stream just upstream of West Snoqualmie Valley Road.

Water Quantity/Water Quality

No water quantity or water quality monitoring information is available. The creek is fed by cool springs, maintaining good water temperature (Anderson).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Unnamed 07.0276 (Wallace Creek) watershed:

- Restore natural channel configuration and floodplain function downstream of West Snoqualmie Valley Road
- Restore riparian function downstream of West Snoqualmie Valley Road
- Promote forest retention/restoration in headwaters to avoid further exacerbation of existing stormwater runoff impacts
- Prioritize and correct identified fish passage barriers

Ames Creek 07.0278 and tributaries

General

Ames Creek is a LB tributary to the Snoqualmie River, entering at RM 17.0 (Williams et al. 1975). The Ames Creek watershed drains an estimated 4,941 acres (SBSRTC 2002). Land ownership is 14% private timber and 86% private non-timber (King County Department of Development and Environmental Services 2000, as cited in SBSRTC 2002).

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
LB to Ames at RM 0.1	NE 100th St	0.01	Unknown
LB to Ames at RM 0.1	NE 100th St	0.15	Unknown
Ames Creek	NE 100th St	0.3	No
Unnamed to Sikes Lake	Carnation Farm Road and 284	0.06	Unknown
Unnamed LB to Ames at RM 1.0	W Snoqualmie Valley Rd	0.1	Yes
Ames Creek	NE 80th	1.16	Unknown
Ames Creek	NE 80th	1.17	Unknown
Unnamed LB to Ames at RM 1.16	NE 80th	0.15	Yes
Unnamed LB to Ames at RM 1.16	W Snoqualmie Valley Rd	0.17	No
Unnamed 07.0280	NE 80th	0.51	Unknown
Unnamed 07.0280	NE 80th	0.2 (?)	Unknown
Unnamed 07.0280	NE 80th	0.59	Unknown
Unnamed 07.0280	Ames Lake Rd	1.28	Yes
Unnamed 07.0280	Ames Lake Rd	1.31	Unknown
Unnamed 07.0280	Private Carnation Ames Lake	1.25 (?)	Yes

Ames Creek	SE 52nd	2.84	No
Ames Creek	NE 47th	3.02	Unknown
Little Ames Creek	W Ames Lake Dr	0.05	Yes
Little Ames Creek	NE 40th	0.2	Yes
Little Ames Creek	NE 45th	0.62	No

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations (access was denied to some culvert sites in this watershed (Glasgow)) and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Floodplain Modifications/Channel Conditions

Downstream of West Snoqualmie Valley Road, the creek has been channelized and ditched through agricultural lands (Lucchetti). Upstream, the creek is located in a naturally confined ravine with good habitat conditions. The floodplain reach has little LWD or pool presence.

Substrate Condition

The lower 2 miles of Ames Creek and tributaries are ditched; substrate is primarily fine sediment (Anderson). From ~RM 2.0 to Ames Lake there is good gravel substrate.

Riparian Condition

72% of stream miles are in cleared or early seral stage (Gersib et al. 1999, as cited in SBSRTC 2002); most riparian areas have either no trees or young trees, and average stem diameter is less than 30 cm dbh (SBSRTC 2002). Riparian condition is poor through Sikes Lake and tributary; the lower two miles of Ames Creek are clogged with reed canary grass (Anderson). The creek is forested with young trees through the ravine, and the headwaters upstream of the ravine are mostly forested.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Ames Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Ames Cr	0	34	28	27	2	8	1	0

Water Quantity

Total impervious area in the Ames Creek watershed is modeled at 5.5% (Purser and Simmonds 2001, as cited in SBSRTC 2002). The shoreline surrounding Ames Lake is heavily developed (~0.5 acre plots), but the lake helps temper stormwater runoff impacts from development to the creek downstream of the lake (Anderson). Agricultural landowners on the floodplain have indicated concerns with increased amounts of stormwater runoff from developed areas in small tributaries off the bluff to the west.

Water Quality

High fecal coliform bacteria levels have been identified in the past (Fricke 1994, as cited in SBSRTC 2002). Although recent data are not available, the presence of horse farms in the watershed suggests the potential for ongoing fecal coliform bacteria and nutrient loading. However, there is little grazing that occurs immediately adjacent to the tributaries in this watershed (Anderson).

Lakes

There are substantial populations of invasive predatory fish species in Sikes Lake, raising questions of survival of juvenile salmonids that may enter the lake (Lucchetti).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Ames Creek watershed:

- Restore natural channel configuration, floodplain function, and instream diversity (LWD) downstream of West Snoqualmie Valley Road
- Restore riparian function throughout the watershed, including planting riparian vegetation where none is present and enhancing conifer presence in deciduous stands
- Preserve/restore forest cover in the headwaters to maintain natural forest hydrology
- Resolve fish passage status of inventoried culverts; prioritize and correct identified fish passage barriers

Weiss Creek 07.0281 and tributary

General

Weiss Creek is a RB tributary to the Snoqualmie River, entering at RM 19.9 (note that the mouth of Weiss Creek has been relocated downstream of the location designated in Williams et al. (1975). The lower portion of the creek is floodplain wetland habitat; salmonid spawning occurs from ~400 feet downstream of SR 203 to the headwaters (Glasgow).

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
EF Weiss Creek	296th Ave NE	0.81	Yes
Weiss Creek	N 124th	2.17	Yes
Weiss Creek	Field access	2.25	Yes
Weiss Creek	BPA line access	2.62	Yes
Weiss Creek	Big Rock Rd	2.76	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone. The culvert at the SR 203 crossing of Weiss Creek is notably absent from the database. The culvert on EF Weiss Creek

(296th Ave NE) is a total barrier, precluding access to ~0.75 mile of good habitat upstream, including high quality wetland rearing habitat (Glasgow).

Floodplain Modifications

The lower 5,700 feet of Weiss Creek have been rerouted through a series of wetland ponds prior to entry to the Snoqualmie River, likely resolving the recurrent past need to dredge at the gradient break at the bottom of the hill (Beardslee). Upstream, floodplain function is generally intact. Washington Trout recently completed a restoration project associated with a large wetland at ~RM 2.25 (Glasgow). Four culverts (not included in inventory above) in close proximity to the wetland were also removed, and riparian vegetation was planted.

The culvert at the SR 203 crossing of Weiss Creek does not block fish passage, but does affect sediment routing and deposition (Glasgow). One of the recurrent prior problems in Lower Weiss Creek was deposition of gravels in the channel under SR 203. The realignment of lower Weiss Creek provides ample area for deposition of gravels, but channel and sediment routing would be improved with a realignment of the culvert under SR 203.

Channel Conditions/Substrate Condition

Habitat inventories from the mouth to the wetland at ~RM 2.25 indicate a wetted width of 6-8 feet, and an ordinary high water width of 12-15 feet (Glasgow). This reach was estimated to have 40% pools, and LWD was noted as abundant. There are no identified fine sediment concerns in this reach. Fine sediment presence and elevated turbidity is noted from the powerline crossing to the wetland at ~RM 2.25, but the fine sediment problem does not appear to extend downstream of the wetland. The culvert at the 296th Ave NE crossing of EF Weiss Creek has resulted in severe channel incision and downcutting downstream to the confluence with Weiss Creek, where a fan of gravels has built up in Weiss Creek. This fan may be a barrier to upstream fish passage at some flows.

Riparian Condition

The lower 5,300 feet of Weiss Creek (within the recently rerouted section) flows through a prior pasture (Glasgow). Riparian restoration through this reach was included as part of the rerouting of lower Weiss Creek. Upstream of SR 203, riparian vegetation is ~30 year old mixed second growth (conifer are relatively sparse) with some remnant older trees. The valley is somewhat incised, providing additional shading. The channel is choked with reed canary grass near the wetland at ~RM 2.25; riparian restoration was recently done around the wetland.

Water Quantity/Water Quality

No water quantity or water quality concerns are identified (Glasgow).

Biological Processes

Invasive fish species are present through the floodplain wetlands in the lower 5,300 feet of Weiss Creek (as is the case with most floodplain wetlands in the Snoqualmie Valley), likely resulting in predation on juvenile rearing salmonids and outmigrating smolts (Glasgow).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Weiss Creek watershed:

- Correct culvert fish passage barrier at the 296th Ave NE crossing of EF Weiss Creek
- Prioritize and correct other identified fish passage barriers; modify the alignment of the culvert under SR 203 to improve sediment routing and floodplain function
- Assess extent and cause of fine sediment concern in vicinity of powerline crossing; correct identified problems
- Control or eliminate presence of invasive fish species in floodplain wetlands in lower Weiss Creek

Harris Creek 07.0283, Stillwater Creek 07.0284, Unnamed 07.0285B, Unnamed 07.0285C, Unnamed 07.0285D, Unnamed 07.0286, Unnamed 07.0286A, and Unnamed 07.0289

General

Harris Creek is a RB tributary to the Snoqualmie River, entering at RM 21.3 (Williams et al. 1975). The Harris Creek watershed drains an estimated 8,626 acres (SBSRTC 2002). There is little private/state commercial forestland in the Harris Creek watershed; most land is zoned as rural, and is at increased risk of development impacts associated with non-commercial farms (Lucchetti). However, most lot development to date has occurred with infrastructure located outside the floodplain.

Coho smolt production was measured in Harris Creek from 1979-1981, with annual estimates ranging from 11,800 to 30,000 smolts (WDF, Progress Report #198, as referenced in 1998 subbasin workshop).

Fish Access

Of the 36 inventoried culverts in the watershed 17 are identified as salmonid passage barriers, 10 are not barriers, and passage status at 9 is identified as unknown (Glasgow June 13, 2001, as cited in SBSRTC 2002). The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Stillwater Creek	SR 203	1.71	No
	110th St NE	2.45	Yes
LB to Harris at RM 1.2	SR 203	0.53	No
	NE 77th	0.73	Unknown
Unnamed 07.0285B	Kelly Rd	0.17(?)	Yes
Unnamed 07.0285B	Driveway (10950 Kelly)	0.7	No
Unnamed 07.0285B	Driveway	0.15	Unknown
Unnamed 07.0285B	Powerline rd	1.2	Yes
Unnamed 07.0285B	352nd Ave NE	1.35	Yes
Unnamed 07.0285B	352nd Ave NE	1.6	Unknown
Lake Joy Creek 07.0285D	Kelly Rd	0.59	Yes
Lake Joy Creek 07.0285D	Lake Joy Rd	0.59	No

Lake Joy Creek 07.0285D	Old RR grade	0.9	Yes (culvert was removed in 2002 by Washington Trout)
Moss Lk Cr (trib to Lk Joy)	Lake Joy Rd	0.1	Unknown
Unnamed LB to Harris at RM 4.25	Kelly Rd	0.08	Yes
Unnamed LB to Harris at RM 4.25	Lake Joy Rd	0.36	Unknown
Unnamed LB to Harris at RM 4.25	Lake Joy Rd	0.51	Yes
Unnamed LB to Harris at RM 4.3	Rd to Sherwood Estates	0.81	Yes
Harris Creek	SPU pipeline rd	3.2 (4.4)	Unknown
Harris Creek	Stossel Creek Way	3.72 (4.75)	Unknown
Harris Creek	Stossel Creek Way	4.8	No
Harris Creek	Private driveway	3.85 (4.8)	Unknown
Unnamed 07.0285A	NE 138th Place	0.18	Yes
Unnamed 07.0285A	Private drive	0.3	Yes
Unnamed 07.0285A	NE 138th Place (ext.)	0.44	Yes
Harris Creek	Stossel Creek Way	4.36 (5.2)	No
Harris Creek	Private drive	4.45 (5.6)	No
Harris Creek	Stossel Creek Way	4.66 (5.7)	No
Harris Creek	Stossel Creek Way	4.71 (5.8)	No
Harris Creek	348th Ave NE	5.0 (6.0)	Yes
Harris Creek	Stossel Creek Way	5.29 (6.3)	No
Unnamed 07.0289	Pipeline rd	NA (0.5)	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Floodplain Modifications

Harris Creek currently has a moderately natural shoreline, i.e., shoreline hardening or overwater structures do not affect greater than 20% of shorelines (Anderson).

Channel/shoreline complexity and floodplain connectivity are affected in this watershed by 2.24 road crossings per mile of stream (Gersib et al. 1999, as cited in SBSRTC 2002). Floodplain function is impaired downstream of SR 203 by agricultural encroachment; there are active efforts to restore forested floodplain conditions downstream of SR 203 (Anderson). Kelly Road is located within ~300 feet of Harris Creek for much of its length, but is mostly located on the floodplain bench and does not impair natural floodplain function. Harris Creek crisscrosses Stossel Creek Road, and the roadfill prism is located within the active floodplain, impairing natural floodplain function. Floodplain function is at increased risk from impacts associated with rural zoning and non-commercial farm development; however, most lot development to date has occurred with infrastructure located outside the floodplain (Lucchetti). Although the Harris Creek watershed is a highly productive coho system, it is less productive than the Griffin Creek watershed, with the most obvious difference being the relative lack of large wetland complexes in the Harris Creek watershed (Chamblin).

Channel Conditions/Substrate Condition

There is good presence of pools and beaver dams throughout the Harris Creek watershed, interspersed with good patches of spawning gravels (Chamblin). There is LWD recruitment potential from existing second-growth forest, but Harris Creek is a larger creek and would benefit from larger LWD (Anderson), and greater abundance of LWD throughout (Anderson, Lucchetti).

Riparian Condition

Seventy–one percent of stream miles in this watershed are in cleared or early seral stage (Gersib et al. 1999, as cited in SBSRTC 2002 (the validity of these conclusions are questioned by TAG participants)).

Riparian condition from the mouth to the old railroad grade is good. Riparian condition in the reach from the railroad grade to SR 203 is variable, with good riparian condition on the right bank and poor condition on the left bank. Riparian condition from SR 203 to Stossel Creek Road riparian condition is good. Along the full length of Stossel Creek Road, the road and stream are in the same floodplain alignment, with severely impaired riparian function. Overall riparian function in the Harris Creek watershed would likely rate as fair (Anderson). The reach from the old railroad grade to SR 203 is enrolled in the Farmlands Preservation program, which will preclude future development. King County is working with the property owner in this reach to restore native vegetation to as much of the stream corridor as possible.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Harris Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Harris Cr	0	45	25	18	2	9	1	0

Water Quantity

Total impervious surface in the Harris Creek watershed is modeled at 6.5% (Purser and Simmonds 2001, as cited in SBSRTC 2002). The Harris Creek watershed is indicated as likely to be very sensitive to groundwater withdrawals, due to a combination of lack of snowmelt or large lakes, and relatively large areas in residential zoning subject to residential water withdrawals and reduced groundwater recharge due to impervious surfaces (Pentec Environmental and NW GIS 1999).

The water levels in Lake Joy and Lake Marcel are managed by lakeside resident associations primarily for residential/recreational interests (Anderson). There are anecdotal reports of lake level manipulation (rapid dropping of lake level) without consideration of impacts to downstream resources (Beardslee).

Water Quality

Water temperature monitoring at several locations on single days in early August in 1999, 2000, and 2001identified mean water temperatures of 19.1^{o}C, 17.4^{o}C, and 14.8^{o}C, respectively, and peak water temperatures of 22^{o}C, 21^{o}C, and 20.5^{o}C, respectively (Solomon and Boles 2002).

Kelly Road is located within ~300 feet of Harris Creek for much of its length, and Stossel Creek Road is immediately adjacent to much of the length of Stossel Creek; impacts of stormwater runoff from these roads have not been assessed. There are numerous small-scale livestock and horse farms; the status of unrestricted livestock access to creeks in the watershed is of concern, but has not been assessed (Anderson). Stormwater runoff from increasing development is an ongoing source of water pollution, but specific impacts have not been assessed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Harris Creek watershed:

- Protect/restore watershed function through protection of forest cover and natural forest hydrology
- Promote additional instream habitat diversity, particularly increased abundance of key piece LWD
- Protect existing areas of good riparian function; restore riparian function, where impaired, including restoration of riparian conifer presence
- Develop and implement lake level operating/management criteria to ensure consideration and protection of downstream resources
- Prioritize and correct identified fish passage barriers
- Assess extent of impacts from unrestricted livestock access to the creek; correct identified problems

Unnamed LB tributaries to Snoqualmie River between Harris Creek and the Tolt River

General

There are four left-bank tributaries between Harris Creek and the Tolt River that have inventoried culverts (below) that are identified as fish passage barriers, or have unknown fish passage status. None of these creeks currently have identified salmonid presence.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	**Road Crossing**	**River Mile**	**Barrier Status**
Unnamed LB entering Snoqualmie at ~RM 21.5	Carnation Farm Road (siteid 101A-29)	NA	Yes
Unnamed LB to Snoqualmie at RM 23.7	King Co Rails and Trails	Mouth	Unknown
Unnamed LB to Snoqualmie at RM 24.1	Old RR grade	NA	Unknown
Unnamed LB to Snoqualmie at RM 24.7	Foot trail in park	NA	Unknown

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Action Recommendations

The following salmonid habitat restoration actions are recommended for these watersheds:

- Prioritize and correct identified fish passage barriers

East Horseshoe Lake 07.0290 and tributaries

General

East Horseshoe Lake is a RB tributary to the Snoqualmie River, entering at RM 22.8 (Williams et al. 1975). Horseshoe Lake is a series of old oxbows of the Snoqualmie River that are also fed by spring water.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed to Horseshoe Slough	NE 60th	1.6	Unknown

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Floodplain Modifications

Horseshoe Lake is a series of old oxbows of the Snoqualmie River. Hydrology and connectivity with the Snoqualmie River are impaired by presence of a dike along the Snoqualmie River with a culvert at the mouth of Horseshoe Lake (Anderson). The channel upstream of SR 203 has been dredged and channelized through agricultural and pasture land (Chamblin).

Channel Conditions/Substrate Condition

No salmonid spawning is known to occur in this watershed, but good rearing conditions are presumed to be available if stable outlet connectivity can be maintained with the Snoqualmie River (Lucchetti).

Riparian Condition

Riparian condition is poor, with a narrow scrub/shrub buffer with some trees, surrounded by farmland (Lucchetti).

Water Quantity/Water Quality

Water quality concerns of high water temperature and turbidity have been identified, but no water quality data are available (Lucchetti). Stable hydrology and connectivity is needed at the mouth to utilize available rearing potential. There may be potential to reroute the outlet to avoid having to access through the existing dike. There is current landowner interest in habitat restoration.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Horseshoe Lake watershed:

- Assess habitat conditions and habitat restoration potential
- Assess feasibility of rerouting the outlet of Horseshoe Lake

Tolt/NF Tolt River 07.0291, Unnamed 07.0293, Unnamed 07.0294, Unnamed 07.0294X, Moss Lake Creek 07.0298, Stossel Creek 07.0300, North Fork Creek 07.0329, SF Tolt River 07.0302, and tributaries

General

The Tolt River is a large RB tributary to the Snoqualmie River, entering at RM 24.9 (Williams et al. 1975). The Tolt River watershed drains an estimated 63,289 acres; the NF Tolt drains 32,596 acres, and the SF Tolt drains 20,087 acres, 11,897 acres of which are upstream of the dam (SBSRTC 2002 Draft). The Tolt River headwaters are at the crest of the Cascade Mountains, with an elevation relief difference in the watershed of over 3,000 feet (Parametrix 2001). The confluence of the NF Tolt and SF Tolt is at ~RM 9, with an additional 30 river miles upstream of the confluence in each fork.

The upper reaches of the Tolt watershed are forested lands, many of which are steep slopes (Parametrix 2001). Downstream of the forks, the Tolt River traverses through a relatively narrow valley floor bounded by steep walls that becomes progressively wider downstream. At RM 2, the Tolt valley intersects with the broader Snoqualmie River valley floor. The Tolt watershed is sparsely developed with roads and residences downstream of RM 6 (Powell).

Fish Access

Anadromous salmonid use occurs up to an impassable falls at approximately RM 8.0 of the SF (just below the SF Tolt reservoir), and on the NF up to an impassable falls at approximately RM 10.8. Chinook and chum spawning are limited to the mainstem Tolt, NF Tolt, and SF Tolt (Appendix A, and species distribution maps in the separate Map files included with this report). The Tolt River provides high quality spawning habitat for nearly 20% of the chinook salmon that return to the Snoqualmie watershed to spawn (SBSRF 2001). Coho, pink, and steelhead are present in the mainstem, forks, and several tributaries. Although the SF Tolt Dam (managed by the City of Seattle to provide municipal water supply and electricity) is located at RM 8.5 on the SF Tolt, it is located upstream of a waterfall (RM 8.3) that is a natural barrier; the dam itself does not block the upstream migration of anadromous salmonids. The dam may block the downstream migration of resident stocks located upstream of the dam (Binkley 2000, as cited in SBSRTC 2002).

Several blocking culverts exist on tributaries with potential habitat for steelhead and non-anadromous species. The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed RB to Tolt at RM 0.8	North Dike Trail	0.0	Unknown
Unnamed 07.0294	Private Rd	0.85	Yes
Unnamed RB to 07.0294 at ~RM 1.0	N Tolt River Rd	0.01	Yes
Unnamed RB to Tolt at RM 7.0	352nd Ave NE (two different locations for apparent same culvert)	0.75 (1 noted at 2.2)	Yes
Unnamed 07.0285B (unclear whether trib to Harris or Tolt)	352nd Ave NE	1.6	Unknown
Stossel Creek	Pipeline mainline	1.1	Unknown (evaluation by Powell indicates not a barrier)
Unnamed RB to Stossel at RM 1.4 (WF Stossel)	Rd 25902	0.15	No
Unnamed RB to Stossel at RM 1.4 (WF Stossel)	Pipeline Road – City Water	5.63 (RM in database appears to be an error; actual RM should likely be 0.7)	Yes (evaluation by Powell indicates not a barrier)
Stossel Creek	25720 Rd	2.07	No
Stossel Creek	Private drive	4.01	No
Stossel Creek	Stossel Creek Way	4.26	No
Stossel Creek	Stossel Creek Way	4.51	No
Unnamed LB to Stossel at RM 3.9	Private drive	0.1	Unknown
Unnamed LB to Lynch at ~RM 0.8	25200 Rd	0.1	Yes
Lynch Creek	25200 Rd	1.5	Unknown

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

The identified passage barriers on Stossel Creek are believed to have been fixed, including the installation of trash racks at a potential barrier at the pipeline road crossing on Stossel Creek. This culvert, however, requires maintenance and may require additional attention to ensure the trash rack and velocities are suitable for fish passage (Lucchetti).

The culvert at the pipeline crossing of Stossel Creek is not a fish passage barrier, but requires maintenance to clear beaver activity (Powell). Trash racks were added in 1994 in an attempt to keep the culvert from becoming a barrier, but apparently they were not successful in excluding or discouraging the beavers. The culvert on the tributary to WF Stossel Creek at RM 1.4 does not appear to be a barrier, and there was no evidence of beaver activity because there appears to be little elevation change or flow across the culvert (Powell). The rationale for the barrier designation in the WDFW database is unclear.

Previous identified fish passage barriers upstream of the SF Reservoir have been corrected; no additional passage problems are known to exist upstream of the reservoir (Powell). Washington Trout surveyed ~600 culverts in the Tolt watershed, the majority located in non-anadromous portions of the watershed. Although not fish passage barriers, concerns were identified on the ability of the culverts to effectively pass sediment and debris, with many identified as having latent potential to cause mass wasting and affect downstream anadromous areas.

Floodplain Modifications

Unleveed reaches in the Tolt River have many more side channels than leveed reaches and much greater complexity, resulting from the ability of the river to migrate across its floodplain as well as a greater role of LWD jams (Parametrix 2001). Levees prevent riparian forests from contributing LWD to the river. The unleveed reaches also tend to have a slightly greater length of main channel for a given valley length, due to higher sinuosity. The unleveed reference reaches have a wide variety of channel sizes, flow depths, and velocities. The leveed reaches do not show the same channel patterns and have higher velocity flows due to their smaller channel area and narrower floodplain. Snorkel surveys in the lower 5 miles of the Tolt River in May 2002 showed significantly higher juvenile chinook densities and utilization in the unleveed reach from RM 2.0 to RM 5.0 than in the leveed reach from the mouth to RM 2.0 (Martin and Shreffler 2002).

The Tolt River not far upstream of RM 2.0 has a generally meandering and occasionally anastomosing channel (King County 2002). Historic photos and maps indicate that the lower 2.0 miles was a more sinuous, multiple-threaded channel during the last 100 years prior to levee construction. The mainstem Tolt upstream of the levees is a rapidly migrating river, where ongoing sediment deposition coupled with bank erosion results in the channel moving laterally across its floodplain. Occasionally, the Tolt River also avulses (switches location) to a different position in the floodplain. Two large avulsions occurred within the last two decades on the mainstem Tolt upstream of RM 2.0, where the main flow of the river abruptly shifted to a different channel location hundreds of feet away. Such avulsions mobilize sediments from unconsolidated riverbanks and alluvium as the river widens its new channel location to accommodate flows. The estimate of mobilized sediment from the two avulsions ranged from 200,000 yd^3 (Shannon and Wilson 1993, as cited in King County 2002) and 60,000 yd^3 (Parametrix 2001, as cited in King County 2002).

Riprapping and diking of the lower Tolt has cut off side channel habitat, impacted gravel deposition patterns, and affected natural channel migration (Powell). Levees along the lower 2 miles of the Tolt River constrain the river flow, but do not prevent flooding (Parametrix 2001). The 100-year peak flow is contained along the right-bank from the upstream end of the levee downstream to almost the trail bridge, where flows of 8,000 cfs (~2-year event) exceed the height of much of the right bank between the trail bridge (old railroad right of way) and the SR 203 bridge. Containment of flood flows is not as consistent along the left bank, but there is protection of some areas during the 100-year event. After extension of levees to near RM 1.85, essentially all side channels behind the levees were made inaccessible to juvenile salmonids (Parametrix 2001). Behind the Tolt River levees, the floodplain channels have been disconnected from the river for over 60 years and no new channels have been formed. A foot or more of silt overlies the former gravel beds of these channels. Although there are continuous levees from SR 203 to the mouth, the right bank levee has been officially abandoned by King County with regard to FEMA standards for maintenance (King County 2002). Much of the land immediately adjacent to the Tolt River in this reach is within the County-owned Tolt-MacDonald Park.

Reconnection of the lower end of the right bank Frew side channel at about RM 0.62 in 1995 reestablished about 1,300 lineal feet of spawning and rearing habitat (Parametrix 2001). This channel is currently used by coho and chum salmon, but it may also support some juvenile rearing by chinook as well. The lower 6 miles of the Tolt have moderate rural residential development; some neighborhoods are high priority for acquisition by King County for flood hazard reduction purposes. This reach presents an excellent opportunity for restoration of interrupted floodplain function.

The openings at each of the two bridges (SR 203, Snoqualmie Valley Trail) appear to constrict Tolt River high flows and induce backwater conditions (King County 2002). The resulting decrease in sediment transport capacity associated with backwater conditions results in sediment deposition, as indicated by the existing sediment accumulation at the upstream side of each bridge. The sediment accumulation decreases flood conveyance through the bridges and nearby channel. The presence of a bridge pier in the middle of the channel at the Snoqualmie Valley Trail bridge also increases the hazard potential of a debris jam occurring, potentially decreasing conveyance and inducing levee overtopping upstream.

Comparison of channel bed elevation data from 1975 through 1997 documents show a consistent increase in thalweg elevations at most sampled locations in the lower 2.0 miles of the Tolt River (King County 2002). There appears to be somewhat of a reversal or slowing of sedimentation for the period 1996-2000, with almost half of the thalweg points displaying decreased elevations.

Shoreline hardening in the NF Tolt is limited to isolated points for protection of forest roads; <10% of NF Tolt shorelines are affected (SBSRTC 2002). There is virtually no shoreline hardening in the lower SF Tolt.

Channel Conditions

Reduced channel splitting and isolation of floodplain side channels in the leveed reach of the lower Tolt River has limited the creation of valuable side channel habitat in that reach (Parametrix 2001). Upstream floodplain side channels support higher densities of juvenile salmon than in the mainstem. There is also a dearth of large, deep pools in the Tolt River mainstem that can serve as holding areas for adult salmon and steelhead, or rearing areas for juvenile salmonids. The number of pools in the lower Tolt study reach actually decreased since 1993, and all larger pools were created by LWD jams.

LWD density in the Tolt River may be typical of a stream surrounded by second growth forest, but is well below that seen in old growth systems having a similar drainage area (Parametrix 2001). Due to its size, most LWD in the Tolt River is not creating appreciable habitat in the form of deep pools or side channels. The LWD supply in several reaches of the lower Tolt is not what it could be because the mix of trees consists of smaller and less dense stems that do not last as long in the channel when compared to conditions in a more mature forest. LWD density in the reaches from RM 2.3 to 2.7 and from RM 2.7 to 3.8 is now substantially greater than that seen in any portion of the lower Tolt River in 1936. However, even with this improvement in density, very little has accumulated in ways that create much needed pool and side channel habitat.

LWD inventories in 2001 in the SF Tolt classified a total of 1,122 individual pieces and 124 jams (Parametrix and Earth Systems 2002). Although LWD averaged 182 pieces/mile (excluding the canyon section), only 47 pieces/mile had rootballs, and only 13 pieces/mile were large key pieces with rootballs that make the pieces more stable in the channel during flood flows. An increase was observed in total LWD from 1991 to 2001; however, it was very clear during the field inventory that a lot more small alders had recently fallen in from the streambanks, but very few were providing significant instream function. Larger LWD pieces observed in 1991 had noticeably decayed. Near-term introduction of key piece conifer LWD to the SF Tolt (14 large LWD pieces/mile, for a total of 100 pieces) and enhancement of conifers in riparian areas are recommended.

Since 1964, stream flows on the SF Tolt have been altered by the operation of the City of Seattle dam. Gravel transport is disrupted below the dam and below the natural anadromous barrier (a 30-ft. waterfall) just downstream. Nonetheless, significant gravel supply occurs from lateral bank erosion and natural landslides (Parametrix and Earth Systems 2002). Flow management also reduces peak flows on the SF Tolt. This could reduce instream gravel and LWD recruitment, although prior forest harvest and underlying geology also play important roles. It is hypothesized that the lack of instream LWD may reduce the river's capacity to retain the gravel that is available.

River regulation on the SF Tolt also has altered downstream temperatures, as well as the flow regime. Subsequent changes in physical and biological processes, including instream habitat, fish metabolism, fish behavior, and the availability, abundance and composition of fish prey, may have contributed to the reduced condition of rainbow trout sampled in the SF Tolt, when compared to those sampled in the NF Tolt (Glasgow, 1999).

Primary adult chinook salmon holding pools are located on the mainstem Tolt River between RM 6.0 and the confluence of the NF and SF Tolt (1998 subbasin workshop). [Note: there may be more pools, but lower 6 miles are important chinook spawning area and are the areas surveyed for chinook spawning by WDFW (Powell).] Pool presence in the mainstem Tolt is limited due to a combination of local geology and lack of functional LWD in the river.

<u>Substrate Condition</u>

Past land management in the NF Tolt has greatly elevated sediment supply to the NF Tolt and downstream in the mainstem Tolt River (Parametrix 2001). Timber in the NF Tolt watershed was heavily harvested, with harvest to the edge of most streams, resulting in numerous slides from forest roads (WDNR 1993). This resulted in an increased pulse of sediment being delivered to the mainstem Tolt River, replacing to some extent the interrupted sediment transport from the SF Tolt due to dam construction. Implications of the increased sediment pulse are primarily related to resulting channel changes and scour, rather than elevated presence of fine sediments (Chamblin). It is estimated that it takes 40-70 years for flows to transport gravel deposits from the NF Tolt to the mouth of the Tolt River (WDNR 1993).

The number of riffles in the lower Tolt River (mouth to RM 3.75) dropped 36% between 1936 and 2000, with more of the reduction occurring in the leveed reach than in the unleveed reference reach (Parametrix 2001). An 8% drop in riffle (spawning) area is estimated to diminish the total number of chinook redds that could be supported from 1,050 to 968 (the lower estimate is 16 times the number of redds seen in 2000).

Flows of 6,000 cfs and greater in the Tolt River are expected to transport cobble on the channel bed, putting salmonid redds at risk (Parametrix 2001). Flows of 8,000-10,000 cfs are of a magnitude that causes channel avulsions and rearrangement of LWD into jams that can result in major changes in location and quality of habitat (this has occurred 4 times in the last 30 years), and are the flows most likely to scour to the middle or bottom of egg pockets in the lower Tolt River. Significant redd-damaging floods have ~15% or less chance of occurring in any given year, so redd damage due to widespread scour is not likely a major limiting factor in ~5 out of every 6 years.

Annual bedload sediment supply to the leveed reach of the lower Tolt River is estimated to average 7,900 yd^3/year (Parametrix 2001). In any particular year, sediment influx to the leveed reach could vary by an order of magnitude from the long-term average rate. Due to declining sediment production from landslides and other headwater sources, the annual supply rate is expected to decline to 4,500 yd^3 by the year 2030, and ultimately decline to 2,300 yd^3 by about 2050. The channel within the leveed reach has been aggrading at the rate of about 1-foot/decade from 1975-2000. The streambed under the SR 203 bridge aggraded 3 feet between 1966 and 1975 (shortly after dredging last occurred), and 2 feet from 1975 to 1992. Estimated gravel deposition over the next 30 years will gradually fill the leveed channel another 3 feet, with most of the filling occurring during moderate to large floods. The most rapid deposition will continue to occur at and between the two bridges, where the levees already overtop frequently under present conditions.

Gravel removal from the lower Tolt River occurred from the mid-1930s through the 1960s, primarily downstream of SR 203 (King County 2002). From anecdotal information, it appears that King County crews operated a small gravel processing plant at the mouth of the Tolt River from the ~1940s through the 1960s. There are no records of the volumes of gravel extracted, annually or cumulatively. The last clearly documented gravel removal from the Tolt was excavation of 46,000 yd^3 in 1968 from ~RM 0.1 to the mouth.

Braided reaches in the NF Tolt, found between Yellow and Titicaed creeks, were documented to have significant widening and mobilization of stored sediments. Channels are braided with unstable active channels and bars. The causes are summarized in WDNR Tolt Watershed Analysis Resource Assessment Reports (WDNR 1993, as cited in SBSRTC 2002). Sediment sources have been major active slides and erosion areas near Titicaed Creek (RM 11.8) and along Road 6200 (RM 9.4 and 9.6) and Road 6244 (RM 13.9 and 14.1). Although it is unknown whether road construction in these areas initiated the slides and erosion, runoff from the road and road cuts is the cause of the continuing slide and erosion activity (Morrison-Knudson Engineers 1988, as cited in SBSRTC 2002).

The SF Tolt reservoir has significantly reduced the magnitude and frequency of peak floods, while increasing the duration and magnitude of base flows (Parametrix 2001). It is evident that the presence of SF Tolt River Dam disrupts sediment transport to the lower SF Tolt and Tolt River mainstem, although the net effect to the Tolt mainstem is unclear. However, numerous valley wall landslides downstream of the dam (including a massive landslide in 1976 between RM 7.1 and 7.6 that contributed 40,000-75,000 yd^3 of sediment) deliver 700-1,000 yd^3 annually, of which 300-500 yd^3 remains as bedload. Sediment supply in the SF Tolt downstream of the dam is considered to currently be adequate, except in the first 676 feet below the falls, which is very starved of sediment relative to pre-dam conditions. The retention and stability of sediment is impaired by the lack of channel spanning logs, which help retain sediment. However, Kurt Nelson (Tulalip Tribes) has observed a coarsening of the substrate in the SF Tolt from 1992 to 2002 downstream of the dam, and indicates it is likely that side channels have been disassociated from the main channel in the SF Tolt because of decreases in sediment loads. The Tolt Fish Advisory Committee, chartered under the SF Tolt FERC license and settlement agreement (FERC 1988), has elected not to invest available funds for gravel mitigation in the near term.

The SF Tolt reservoir shows elevated turbidity due to past logging practices, failures of logging roads, and shoreline erosion from wave action (SBSRTC 2002). Logging practices and reservoir filling caused the width of the active inflow channel to the reservoir to more than double, with effects evident 5,000 feet upstream of the reservoir (WDNR 1993, as cited in SBSRTC 2002). At the same time, the reservoir has trapped sediment transport from ~20% of the watershed (Parametrix 2001). The net effect of the reservoir on sediment deposition rates in the lower Tolt is unclear, since it has caused reductions in sediment load while decreased flows have reduced sediment transport capability.

Three sediment samples collected in 2000 in the lower Tolt River ranged from 3 to 10% fines (less than 0.85 mm) in the subsurface sediment (the armor layer was not included). McNeil samples collected in the mainstem Tolt River in previous years included the armor layer and ranged from 6-16% fines. Of the ten samples, seven samples had 10% fines or less, two samples had between 11 and 15% fines, and one sample had greater than 15% fine sediment (Parametrix 2001). Gravel quality is rated as good, with little evidence of impairment by fines that would lead to low egg-to-fry survival rates. A somewhat dated evaluation of SF Tolt sediments gives conflicting results:

- Average of 9 McNeil samples of 11% surface fines.
- More than 25% of available spawning gravel reported at 75-100% embeddedness (EBASCO Environmental, 1993).

Qualitative habitat surveys in summer 2001 from RM 2.9 to RM 5.8 indicate the substrate is cobble (64-256mm) dominated and gravel (2-64mm) subdominated, but noted fine sediment embedding of the gravel throughout the reach (Solomon and Boles 2002).

Riparian Condition

Riparian areas on the Tolt River have been consistently cleared by land development (Solomon and Boles 2002), and have been altered by past forest harvest in the NF and SF Tolt watersheds (Powell). Functional forested riparian habitat is essentially absent in the leveed reach of the lower Tolt River, but is 80-100% recovered in the unleveed reach since 1936 (Parametrix 2001). However, much of the riparian vegetation in the unleveed reach is immature, and largely deciduous; large wood necessary to provide channel structure will still take some time to develop (Powell). The unleveed reach is the only portion of the lower river where LWD recruitment is possible, which can serve to increase pool and side channel habitat.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Tolt River watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Lower Tolt	1	49	32	10	2	5	1	1
NF Tolt	11	60	20	3	1	3	0	2
SF Tolt below dam	12	55	23	5	0	3	0	1
SF Tolt above dam	12	57	19	3	1	2	1	7

Water Quantity

The USGS has five flow gauges in the Tolt River watershed (Parametrix 2001). The most inclusive is located at RM 8.7, with approximately 87 mi^2 of drainage area (USGS gauge 12148500). The other gauges are located on the NF (1 gauge) and SF (3 gauges) Tolt River. Gauged streamflow information is available for the NF Tolt (gauge 12147500) for the period 1953-1994. The 100-year peak flow on the lower Tolt River is 22,000 cfs; the 2-year peak flow is 7,900 cfs (Parametrix 2001). It should be noted that these averages are calculated from the full record of flows on the Tolt River; recent average of peak flows has been reduced by the operation of the SF Tolt dam (Powell). Peak flows in the lower Tolt River occur approximately 18 hours following initiation of the flood event. Flood elevations at the mouth of the Tolt River are generally the result of peak Snoqualmie River flows, rather than peak Tolt River flows. Peak flows on the Tolt River do not coincide with peak flows on the Snoqualmie River, with peak flows on the Snoqualmie River occurring about 15 hours later than peak flows on the Tolt River.

A watershed assessment conducted in 1995 (PGG 1995, as cited in Pentec Environmental and NW GIS 1999) reported that analysis of total annual streamflow at seven gauges within WRIA 7 showed declining streamflow (normalized to precipitation) on the Snohomish, Snoqualmie, and Tolt rivers. Normalized streamflow trends could reflect changes due to land-use activities or water withdrawals. The apparent streamflow declines are too large to be explained by allocated withdrawals alone, and may be partly related to limitations inherent in the analysis. However, data show considerable scatter, and the findings indicate that conclusions should be drawn with caution.

Total impervious area is estimated at 5% for the lower Tolt, 4% for the NF Tolt, and 3% for the SF Tolt (Purser and Simmonds 2001). More than 50% of the lower Tolt is in the forest production zone; the NF Tolt and SF Tolt are entirely within the forest production zone.

Effects of forest harvest on flows in the NF Tolt are unclear. WDNR (1993) includes conflicting conclusions:

- The hydrologic analysis based on the North Fork gauging station showed no impact of forest harvesting on annual peak flows.
- The current state of the vegetation in the NF Tolt watershed is resulting in an increase of about 322 cfs in all flood peaks, or 11% for the 2 year event over a fully mature (large dense) condition.

Regrowth of forests in the NF Tolt should reduce any increase in flows that resulted from lack of forest cover (Chamblin). The mid-mainstem Tolt and NF Tolt have been proposed for inclusion in a proposed land acquisition by the Evergreen Forest Trust. This acquisition, if completed, would provide long-term benefits to salmonid habitat in these areas.

USGS gauge information before and after construction of the SF Tolt dam demonstrates altered peak flows, base flows, and flow timing since dam construction. (EBASCO Environmental 1993, as cited in SBSRTC 2002). The dam and associated reservoir on the SF Tolt were completed in 1963; the intent of the dam was for municipal water supply, not for flood control operations (Parametrix 2001). The SF Tolt flow is regulated by the SF Tolt water supply and hydroelectric projects. Water is withdrawn by the City of Seattle for municipal and industrial uses, under Superceding Reservoir Permit No. R-206 and Superseding Surface Water Permit No S1-10602. Instream flows are governed by a settlement agreement with resource agencies, associated with the federal license for FERC Project 2959 (FERC, 1988). Water storage in the SF reservoir has reduced lower Tolt River flood peaks by 29-36%, depending on the magnitude of the event (Parametrix 2001). Compared to other factors, such as excess coarse sediment supply and reduced supply of LWD, it is unclear whether this significantly affects the ability of the river to maintain its historic morphological character (Powell).

A USGS study conducted in September 1991 found that the Tolt River loses water (16-20% of surface flow) to groundwater in its lower reaches, as it flows across highly permeable deposits on the Snoqualmie floodplain (Turney et al. 1995, as cited in Pentec Environmental and NW GIS 1999).

Water Quality

There are no 303(d) listed segments. Water quality data from Washington Department Ecology stations on the lower Tolt and on the Snoqualmie near Carnation (Station 07D070, 1995, 1996) showed one exceedance of the water temperature criterion (18^{o} C) in August 1992 (WDOE 2002, as cited in SBSRTC 2002). The Tolt Watershed Analysis identifies potential for elevated temperatures, due to forest harvest and lack of shading, but data are not presented demonstrating this effect (WDNR, 1993). One data source shows temperatures in the lower mainstem NF Tolt to be well within target range (Morrison Knudsen 1988, as cited in SBSRTC 2002). Otherwise, reaches downstream are within water quality standards.

The results of temperature monitoring upstream and downstream of the outfall of the SF Tolt Hydroelectric Project indicate that cooler than normal temperatures exist downstream of the project, typically between the months of January and May. The temperature changes are well within the preferred temperature ranges of salmonids using the SF Tolt (Seattle City Light 1998, as cited in SBSRTC 2002). SF Tolt daily average summer water temps were cooler than in the NF Tolt, and the 1998 temperature maximum was reached 74 days later than in the NF Tolt at comparable elevations (Glasgow 1999). These differences between the NF Tolt and SF Tolt water temperature regimes were not observed at comparable elevations upstream from the Tolt Reservoir.

Action Recommendations

The following salmonid habitat restoration actions are recommended for the Tolt River watershed (these proposed actions have not been ranked):

- Restore floodplain function in lower 2 miles of the Tolt River by removal or setback of existing levees
- Restore natural floodplain function through acquisition of floodplain properties in the lower 6 miles of the Tolt River
- Assess opportunities in the NF and SF Tolt rivers for restoration of instream habitat diversity and riparian function
- Prioritize and correct identified fish passage barriers

Langlois Creek 07.0292 and tributaries

General

Langlois Creek is a RB tributary to the Snoqualmie River, entering at RM 26.4 (note that the location of the mouth is different than represented in Williams et al. (1975)).

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Langlois Creek	RR grade	1.0	Unknown
Langlois Creek	NE 24th	1.93	Yes
Langlois Creek	NE 24th private drive	2.2	Yes
Langlois Creek	344th Ave NE	2.4	Yes
LB to Langlois at RM 1.6	NE 20th	0.2	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Weyerhaeuser (1995) indicates presence of 2 fish passage barriers in the Langlois Creek watershed; it is not clear whether these barriers are included in the WDFW inventory due to inaccurate hydrology routing and stream mile designations in Williams et al. (1975).

There are reports of a large beaver dam in the incised channel area shortly upstream of the mouth of Langlois Creek (Chamblin). Although beaver dams are a natural, and often beneficial, component of salmonid habitat, conditions favorable to beaver dam construction may be associated with the rerouting of the mouth of the stream. Fish passage conditions at the beaver dam site should be assessed, and corrected if warranted, maintaining beaver dam functions.

Floodplain Modifications

The natural location of the lower portion of Langlois Creek is unclear. There are currently two outlets with surface flow during low flow conditions from the large wetland between the old railroad and SR 203; there is a minor outlet channel to the Tolt River and the major outlet channel flows to the Snoqualmie River (Lucchetti). In addition, the creek has been channelized and dredged through the agricultural area upstream to the vicinity of where Williams et al. (1975) identifies RM 1.0.

Channel Conditions

Channel conditions through the agricultural area of Langlois Creek have been simplified as a result of channel rerouting, riparian removal, and dredging. There is generally low abundance of LWD (Chamblin, Lucchetti), although some LWD has been placed in the agricultural area as mitigation for past work in the stream (Chamblin).

Substrate Condition

Spawning gravels are generally located upstream of RM 1.5 (mileage as noted in Williams et al. 1975), although there are some pockets of gravel downstream. Substrate is generally fine-grained through the low gradient section from above the old railroad to the mouth.

Riparian Condition

Riparian condition is poor through the agricultural reach downstream of RM 1.5, with farming to the edge of the stream in much of the area. This area is thought to historically have been floodplain forest (Lucchetti). Upstream the creek is in forested area, although no information was obtained regarding riparian condition in this area.

Water Quantity/Water Quality

The municipal water supply for the City of Carnation is drawn from springs located in the Langlois Creek watershed (Weyerhaeuser 1995). Assessment of impacts was not done as part of the Watershed Analysis, as this is not a surface water supply.

No water quality data were located for Langlois Creek. Water quality assessments should be conducted in lower Langlois Creek to identify whether there are adverse water quality effects associated with agricultural practices and lack of riparian vegetation in this reach.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Langlois Creek watershed:

- Restore natural floodplain function and riparian function through the agricultural reach
- Assess fish passage status at the reported beaver dam site upstream from the mouth
- Assess the need and opportunities for LWD restoration/enhancement

Griffin Creek 07.0364 and tributaries

General

Griffin Creek is a RB tributary to the Snoqualmie River, entering at RM 27.2 (Williams et al. 1975). The Griffin Creek watershed drains an estimated 11,257 acres (SBSRTC 2002). The primary land use is forest production (primarily Weyerhaeuser ownership), with some agricultural and suburban residential land use in lower Griffin Creek. Small private recreational lot encroachment on the creek was previously cause for moderate concern, but King County has been actively working to acquire these lots, with 24 of 34 lots acquired to date (Anderson).

Griffin Creek is the tributary that produces the most coho smolts in the Snoqualmie River watershed (Chamblin, Lucchetti). Smolt trapping from 1979-1981 estimated production between 47,300 and 111,000 smolts (WDFW Progress Report #198). Although there are a number of identified habitat concerns and opportunities to improve habitat conditions, this watershed remains highly productive, most likely in large part due to the extensive wetland complexes in the headwaters and at the mouth (Chamblin, Lucchetti). Griffin Creek has abundant rearing habitat, occurring in relatively close proximity to anadromous spawning habitat (Weyerhaeuser 1995). The juxtaposition of these rearing and spawning habitats is likely an important factor that contributes to the high coho salmon productivity of the Griffin Creek watershed. Degradation of the Griffin Creek watershed, currently a highly productive coho watershed, to moderate productivity would lead to a decrease in abundance of spawning coho from 18,763/year to 4,300/year (Bilby et al. Undated Draft). This decrease would correspond to a 15.3% decline in total coho production for the entire Snohomish basin.

Waterways 2000 lists Griffin as high priority for acquisition. Cooperative efforts are in progress to transfer the forestlands in the watershed into non-profit ownership; the lands would continue to be managed for forest production, but also for greater fish and wildlife protection than otherwise typically found in commercial forestlands (Lucchetti).

Fish Access

Road culverts hinder fish passage in tributaries to Griffin Creek. The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	**Road Crossing**	**River Mile**	**Barrier Status**
Unnamed 07.0365	SR 203	0.4	Yes
Unnamed 07.0368	30500 Rd	0.01 (1.05	Unknown
Unnamed 07.0368	30530 Road Weyco	NA (1.2)	Unknown
Unnamed 07.0369	RR Grade	5.99	Yes
Griffin Creek	26700 Rd	9.4	No
Unnamed RB entering Griffin at RM 9.4	26750 Rd	0.4	Unknown
Unnamed RB entering Griffin at RM 9.4	26700 Rd	0.7	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Weyerhaeuser (1995) identifies 13 human-caused partial/complete fish passage barriers in the Griffin Creek watershed, of which 6 are located upstream of natural blockages. Some of these culverts are seasonally impassable; others are totally impassable (Weyerhaeuser 1995). Weyerhaeuser has been working actively to correct identified fish passage barriers on their ownership. All of the barriers in the WDFW database appear to be included in the sites identified in Weyerhaeuser (1995).

Floodplain Modifications

A logging road runs adjacent to the lower 6 miles of Griffin Creek. The road directly encroaches on the stream at several locations, affecting floodplain function, but is mainly constructed on the floodplain terrace outside of the active floodplain area (Chamblin, Lucchetti).

A key element supporting the high productivity of the Griffin Creek watershed is the presence of extensive wetland complexes in the headwater tributaries. In addition, the confluence area of Snoqualmie River (RM 25.5 and 27.8) and Griffin Creek has a number of high quality off-channel habitats that provide rearing and refuge habitat for juvenile salmonids (Griffin Core Area document). Two oxbows and two back-water habitat units associated with the mouths of Griffin Creek and an unnamed left bank tributary, respectively, provide 10-15 acres of slow water habitat. Comparison of 1936 and 1993 aerial photos revealed a much greater occurrence of open water in 1993 (Weyerhaeuser 1995). It is hypothesized that historic harvest of the forested wetlands and riparian zones that were once sunlight-limited removed shade and promoted establishment of deciduous trees and shrubs along the banks, providing ideal food sources and opportunities for beaver to colonize these areas.

Channel Conditions

The lower 1.5 miles of Griffin Creek are in rural residential/agricultural land use, with a history of unrestricted livestock access to the lower channel, and land use encroachment on the channel (Lucchetti). Horses were observed grazing near the mouth of Griffin Creek in 2001; grazing at this location has resulted in trampling of streambanks and absence of riparian vegetation (Solomon and Boles 2002). LWD is rare in this area, except immediately downstream of SR 203, where King County has been cooperatively working with the agricultural landowner in 1998 to add LWD to the channel and restore riparian function (Lucchetti). Some of the placed LWD has moved during high flow events, and has concentrated in a few areas, some collecting in naturally occurring small logjams (Solomon and Boles 2002).

LWD counts on four stream segments with channel width <10m were all greater than 0.5 piece/channel width. LWD counts on lower Griffin Creek (channel width 10-20m) were 0.13 piece/channel width (Weyerhaeuser 1995, as cited in SBSRTC 2002). Lower Griffin Creek has less channel complexity (e.g., less roughness) and therefore less rearing and refuge habitat than elsewhere in the watershed (Weyerhaeuser 1995, as cited in SBSRTC 2002). Qualitative habitat condition surveys in summer 2001 indicated occasional presence of LWD from RM 1.6 to 2.7 and presence of frequent channel-spanning logjams from RM 2.7 to 3.1 (Solomon and Boles 2002).

There is a problem with an old railroad trestle obstructing downstream transport of LWD at approximately RM 1.1 (1998 subbasin workshop).

Substrate Condition

Outside of the wetland areas, gravel quality is subjectively rated as good (Chamblin, Lucchetti).

From the mouth to SR 203 (RM 0.7), the substrate is predominantly fine sediment, with some coarser substrate up to cobble-size (Solomon and Boles 2002). Sediment sizes are mixed from RM 0.8-1.6, dominated by gravel and cobbles from RM 1.6-2.7, and mixed sorted sediments from RM 2.7-3.1. The reach of Griffin Creek from the old railroad upstream to the mouth of Unnamed 07.0366 has lower than expected amounts of spawning gravel, likely associated with lack of LWD resulting in lower retention of gravels (Weyerhaeuser 1995). In most spawning reaches, accumulation of fine sediment was evident. The abundance of fines in the gravels appears inconsistent with the fact that Grizzly and Griffin creeks are considered highly productive spawning areas. Because levels of fines are already high in these areas and further inputs are likely to accumulate in these reaches, fine sediment is a concern in anadromous spawning areas.

There is no indication that redd scour is occurring; the potential for redd scour is unlikely based on the low percentage of the watershed that is in the rain-on-snow zone and the high wetland acreage in the watershed (Weyerhaeuser 1995).

Surface erosion from roads is delivering fine sediment to streams/wetlands at rates significantly greater than the estimated background rate of fine sediment input in the EF Griffin watershed (Weyerhaeuser 1995). Road erosion inputs from this watershed are probably large enough that they could be detected by long-term monitoring and might have an effect on water quality or fish habitat. Griffin Creek is impacted by the 26000 road; fine sediment is delivered from the road and erosion of the road prism, impacting spawning gravel quality. The JML and 26900 roads deliver fine sediments to upper Griffin Creek and Grizzly Creek (tributary to Griffin), impacting spawning gravel quality. Areas on the lower Griffin Creek are susceptible to mass wasting events due to removal of lateral slope support by road cuts, over-steepened cut banks and poor road drainage. Forty percent of the streambanks in lower Griffin Creek are actively eroding. Pebble counts at RM 3.5 show that surface fines range from 6–42% with an average of 24.3% (Savery 2000, as cited in SBSRTC Draft). The 28.4-acre wetland at RM 9 is adversely affected by sediment input (Weyerhaeuser 1995, as cited in SBSRTC 2002). It receives approximately 2.2 tons of sediment from the road network each year, a chronically detectable amount.

Riparian Condition

All the riparian vegetation on Griffin Creek was harvested in the late 1920's or early 1930's (Weyerhaeuser 1995). The right bank of Griffin Creek is bordered by a logging road, which restricts the width of the riparian zone to less than one SPT. The 8% assessed as having low near-term LWD recruitment potential is mostly concentrated in the lower portion of Griffin Creek that flows across the Snoqualmie floodplain. Upstream of the Snoqualmie floodplain is a long section of riparian zone that is dominated by dense, mature deciduous stands. The understory in most of these stands consists of shade tolerant species like cedar and hemlock, but current LWD recruitment is limited to alders. The middle and upper portions of the stream have conifer dominated stands of varying age.

Nearly 38% of the Griffin Creek drainage is designated as naturally low in shade with a bankfull width (BFW) >200 ft., ~38% of the drainage meets canopy closure targets, and 25% has a potential to meet canopy closure requirements, but currently does not (Weyerhaeuser 1995). Forty-five percent of the fish bearing waters in the Griffin-Tokul watershed are vulnerable to shade removal from loss of riparian vegetation.

A high priority for restoration of the riparian corridor along the lower mile is to reduce livestock access to streams (1998 subbasin workshop). King County and Washington Trout have been working with landowners to restore riparian function downstream of SR 203 (Lucchetti).

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Griffin Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Griffin Cr	1	49	33	10	1	5	0	0

Water Quantity

There are 3 public water rights granted to King County Water District 9 for withdrawals from EF Griffin Creek and Beaver Creek (Tokul Creek watershed) for municipal and power supplies (Weyerhaeuser 1995). Personnel with King County Water Districts 119 and 127 and the City Engineer for the City of Carnation municipal water supply were unaware of the existence of these water rights. Water withdrawal pipes, rock weirs, and diversion structures were noted in habitat surveys conducted in summer 2001in the reach from RM 0.8-1.6 (Solomon and Boles 2002).

Total impervious area in the Griffin Creek watershed is estimated at 6% (Purser and Simmonds 2001)(this estimate includes open-water headwater wetlands, which are abundant in this watershed). No portion of the watershed lies in the rain-on-snow zone; flows in the watershed are rain dominated. Griffin Creek flows are stabilized by a large wetland system at RM 9. During summer, the wetland will reach an elevation threshold and cease flowing as a surface water contribution to the stream. Base flows downstream of the wetland are groundwater contributed from the wetland and surrounding hillsides (Savery, as cited in SBSRTC 2002).

Water Quality

There are no 303(d) listed segments in this watershed. Water temperature monitoring at several locations on single days in early August in 1999 and 2001identified mean water temperatures of 17.1°C and 14.3°C, respectively, and peak water temperatures of 20°C and 16.5°C, respectively (Solomon and Boles 2002). Low stream shade as indicated by the riparian assessment may contribute to increased stream temperatures (Weyerhaeuser 1995). Past temperature and dissolved oxygen measurements have generally met Washington State water quality criteria (SBSRTC 2002). There is no evidence that nutrient levels impair water quality in this watershed (Weyerhaeuser 1995). Livestock access has recently been precluded from the channel and riparian restoration area downstream of SR 203 (Lucchetti).

Lakes

There are extensive headwater wetlands in this watershed that contribute to high coho productivity. There are no identified concerns regarding these wetlands at this time, and the integrity of these wetlands should be protected.

Biological Processes

Eastern brook trout (*S. fontinalis*) were planted in Griffin Creek (WDFW Unpublished Data, as cited in Weyerhaeuser 1995), but have not persisted in the watershed.

Action Recommendations

The following ranked habitat restoration actions are recommended for the Griffin Creek watershed:

- Complete the proposed forestland land transfer conservation action, which will ameliorate some of the currently identified forest management impacts and ensure long-term protection of salmonid habitat in this productive system
- Restore natural channel sinuosity and floodplain function in the agricultural/residential portion of the lower watershed
- Eliminate unrestricted livestock access to the channel
- Restore riparian function (where impaired)
- Restore LWD presence and associated channel complexity, where impaired (particularly in the wetland complex at the mouth of the creek)
- Prioritize and correct identified fish passage barriers
- Assess water right status of water diversions and withdrawals from RM 0.8-1.6; eliminate if not associated with legal water right

Patterson Creek 07.0376, Unnamed 07.0377, Canyon Creek 07.0382, Unnamed 07.0383, Dry Creek 07.0383A, and tributaries

General

Patterson Creek is a LB tributary to the Snoqualmie River, entering at RM 31.2 (Williams et al. 1975). Unnamed 07.0377 is a RB tributary to Patterson at RM 1.2; Canyon Creek is a RB tributary to Patterson at RM 2.0; Unnamed 07.0383 is a RB tributary to Patterson at RM 6.5; and Dry Creek is a LB tributary to Patterson at RM 6.8. Patterson Creek flows through one of the most rapidly urbanizing areas of the western Snoqualmie valley along the Redmond-Fall City road. The Patterson Creek watershed drains an estimated 13,220 acres (SBSRTC 2002). Land ownership is 80.1% private non-timber (King County Department of Development and Environmental Services 2000, as cited in SBSRTC 2002).

Primary chinook use on Patterson Creek occurs up to approximately RM 2.5, although juvenile use is documented as far upstream as RM 6.5 (King County SWM 1993). Coho primary summer and winter rearing occurs up to near its headwaters at RM 7.7, with primary spawning occurring on Unnamed 0383 and Canyon Creek.

Fish Access

Twenty-two out of 38 culverts in this watershed are salmonid passage barriers, seven culverts are passable, and the other nine are of unknown status (Glasgow, June 13, 2001). Barriers formed by perched culverts at RM 8.8 prevent access by anadromous fish to the uppermost reaches of Patterson Creek (King County SWM 1993).

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed 07.0377	SR 202	0.4	No
Unnamed 07.0378	SR 202	0.05	No
Unnamed 07.0377	Private rd	0.82	Yes
Unnamed 07.0379	Private drive	0.20	Yes
Unnamed 07.0377	Fall City-Issaquah Rd	1.59	Yes
Unnamed 07.0377	Fall City-Issaquah Rd	1.6	Yes
Unnamed RB entering 07.0377 at SR 202	Fall City-Issaquah Rd	0.02	No
Unnamed RB entering 07.0377 at ~RM 1.0	SE 44th	0.29	Unknown
Unnamed LB entering 07.0377 at ~RM 1.1	Fall City-Issaquah Rd	0.65	Yes
Unnamed RB entering 07.0379 at RM 0.7	Fall City-Issaquah Rd	0.19	Unknown
Unnamed RB entering 07.0379 at RM 0.7	Fall City-Issaquah Rd	0.19	Yes
Unnamed RB entering 07.0379 at RM 0.7	44th St	0.20	Yes
Unnamed 07.0379	Fall City-Issaquah Rd	0.85	No
Unnamed 07.0381	Fall City-Issaquah Rd	0.44	Yes
Unnamed 07.0381	40th	0.56	Yes

Unnamed 07.0381	Fall City-Issaquah Rd	0.73	Unknown
Canyon Creek	SE Issaquah Fall City Rd	2.0	Unknown
Unnamed RB entering Canyon at ~RM 2.0	SE Issaquah Fall City Rd	0.08	Yes
Unnamed RB entering Canyon at ~RM 2.0	Private drive	0.3	Unknown
Unnamed RB entering Canyon at ~RM 2.0	Private drive	0.32	Yes
Unnamed RB entering Canyon at ~RM 2.0	Private drive	0.36	Yes
Unnamed RB entering Canyon at ~RM 2.0	280th Ave SE	0.38	Yes
Unnamed RB entering Canyon at ~RM 2.0	Private drive	0.47	Yes
Unnamed RB entering Canyon at ~RM 2.0	280th Ave SE	0.31	Yes
Unnamed RB entering Patterson at RM 4.0	Private road	0.23	Unknown
Unnamed RB entering Patterson at RM 4.0	Field access	0.3	No
Patterson Creek	SR 202	6.95	No
Unnamed LB entering Patterson at RM 6.95	Private drive	0.0	Yes
Patterson Creek	Entrance road	7.15	Unknown
Patterson Creek	NE 52nd Place	8.85	Yes
Little Patterson/Dry	NE 36th	1.32	No
Little Patterson/Dry	NE 40th	1.65	Yes
Little Patterson/Dry	NE 45th	1.95	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Floodplain Modifications

Patterson Creek is a low gradient wetland dominated system. Inventoried wetlands account for 634 acres in the watershed or 5% of the total watershed area (King County SWM 1993). Patterson Creek is a low gradient watershed, and historically was likely highly sinuous, with deep channels (Lucchetti). Patterson Creek is deeply confined in the channelized agricultural reach from the mouth to SR 202 (Chamblin, Lucchetti). Patterson Creek is moderately confined, but more natural from SR 202 to Canyon Creek. Upstream of Canyon Creek, Patterson Creek floodplain function is more natural with intermittent agricultural/ residential encroachment. Land clearing for agricultural uses and subsequent dredging and deepening of the creek to reduce water levels has changed the wetlands profoundly. Much of the creek is overrun with reed canarygrass and yellow iris, eliminating the native wetland grasses, sedges, and rushes (King County SWM 1993). SR 202 (SE Redmond-Fall City Road) runs along the creek or crosses the creek at many locations.

Floodplain function is impaired by channelization through the agricultural area in the lower 0.5 mile of Canyon Creek, but is rated as good upstream of RM 0.5 (Chamblin). Dry Creek floodplain function is impaired where it has been relocated and channelized into a ditch adjacent to the road.

Channel Conditions

LWD is sparse both in and adjacent to the creek (King County SWM 1993). The frequency is less than 0.15 piece/channel width (likely total rather than key-piece counts) for much of the watershed.

Substrate Condition

The majority of mainstem Patterson Creek is low-gradient, with sand/silt dominated substrate (Chamblin/Lucchetti). Gravel spawning substrates are located primarily in the tributaries, with mainstem patches of gravel in Patterson Creek upstream of SR 202. Gravel condition in Dry and Canyon creeks is subjectively rated as good (Chamblin/Lucchetti).

Development on the upland plateau initiates severe erosion problems in tributaries to Patterson Creek (King County SWM 1993). Sediment, including fine sediment that is eroded from these tributary channels, is deposited in mainstem Patterson Creek, which has insufficient slope to transport the full sediment load. Unrestricted livestock access to streams is identified as a cause of sedimentation and bank instability (King County SWM 1993).

Riparian Condition

Seventy-seven percent of stream miles in the watershed are cleared or early seral stage (Gersib et al. 1999, as cited in SBSRTC 2002). Historic riparian condition on Patterson Creek is unknown, but would likely have been a combination of forested areas and more open wetland areas (Lucchetti). Little woody riparian vegetation is present in the agricultural/residential areas, but riparian condition is good on Canyon Creek upstream of Aldarra Farms, and on Dry Creek downstream of Ames Lake Road (no knowledge of riparian condition upstream of Ames Lake Road)(Chamblin).

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Patterson Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Patterson Cr	0	40	27	24	1	8	0	0

Water Quantity

Total impervious area in the Patterson Creek watershed is estimated at 6.5% (Purser and Simmonds 2001, as cited in SBSRTC 2002). This estimate was based on 1998 Landsat data; significant development has since occurred in the watershed so the current total impervious area is likely to be higher. The Patterson Creek watershed is indicated as likely to be very sensitive to groundwater withdrawals, due to a combination of lack of snowmelt or large lakes, and relatively large areas in residential zoning subject to residential water withdrawals and reduced groundwater recharge due to impervious surfaces (Pentec Environmental and NW GIS 1999). In addition, potential alterations to hydrology resulting from rapid urbanization in the watershed are of concern; alterations to hydrology in the tributaries is likely at greatest risk (Lucchetti).

Water Quality

Water temperature monitoring at several locations on single days in early August in 1999, 2000, and 2001identified mean water temperatures of 15.6^{o}C, 16.1^{o}C, and 13.2^{o}C, respectively, and peak water temperatures of 16^{o}C, 17^{o}C, and 13.5^{o}C, respectively (Solomon and Boles 2002).

Patterson Creek experiences a variety of nonpoint pollution problems associated with agricultural and residential land uses. Metals, nutrients, fecal coliform bacteria, and turbidity are the most significant pollutants. Discharge of runoff from urban development into the erosion-sensitive plateau tributaries contributes to turbidity problems. SE Redmond-Fall City Road (SR 202) runs along several miles of Patterson Creek, and significant traffic volumes occur on the other roads in the watershed. Automobile traffic can be a significant source of copper and lead. High copper and/or lead concentrations that exceeded state water quality criteria were found at 5 of 14 sampling sites in Patterson Creek: high phosphorus and/or nitrate+nitrite concentrations that exceeded state water quality criteria were found at 8 of 14 sampling sites in Patterson Creek (King County SWM 1993). A TMDL for Patterson Creek was accepted by EPA in 1996 (1998 303(d) Decision Matrices).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Patterson Creek watershed:

- Protect/restore natural hydrology, particularly for key salmonid-bearing tributaries; protection of natural hydrology is also important on steep tributaries exhibiting high rates of channel incision and resulting contribution of fine sediments to fish bearing channels downstream
- Restore natural channel configuration and floodplain function, where impaired
- Implement agricultural BMPs, including elimination of unrestricted livestock access to channels, wetlands, and riparian areas
- Prioritize and correct identified fish passage barriers
- Restore riparian function, where impaired

Raging River 07.0384, Unnamed 07.0384X, Unnamed 07.0389, Soderman Creek 07.0390, Unnamed 07.0391, Unnamed 07.0391A, Unnamed 07.0392, Lake Creek 07.0393, Unnamed 07.0394, Deep Creek 07.0396, Unnamed 07.0422, and tributaries

General

The Raging River is a LB tributary to the Snoqualmie River, entering at RM 36.2 (Williams et al. 1975). The Raging River watershed drains an estimated 20,987 acres (SBSRTC 2002). There is an overall relief of ~3,500 feet from the mouth to the headwaters southeast of Tiger Mountain, with a mainstem channel length of ~15 miles (King County 2002).

Ten to 20 percent of the Snohomish fall chinook spawning in the Snoqualmie watershed occurs in the lower 9.3 miles of the Raging River (1998 subbasin workshop), with primary spawning occurring from the mouth to SR 90 at RM 4.7. While pinks have mostly disappeared from the Raging River since the 1950s, a small population still exists in the mainstem up to RM 4.45.

Fish Access

A 48-56-inch diameter culvert with sandbagged margins at the Preston–Fall City crossing (~300 feet from the intersection with Lake Alice Road) of Unnamed 07.0384X (tributary to the Raging River) is a fish passage barrier at a range of flows (Savery). This culvert is a partial barrier, with known coho and steelhead presence upstream of the culvert.

The following additional culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	**Road Crossing**	**River Mile**	**Barrier Status**
Soderman Creek	SR 90	0.12	Yes
Lake Creek	SR 18	1.2	Yes
Lake Creek	Private	1.48	Yes
Deep Creek	Private	3.0	No

The WDFW Fish Passage Database probably does not represent a comprehensive culvert inventory for the Raging River watershed (Glasgow). The Tulalip Tribe may have additional culvert data for this watershed.

Floodplain Modifications

The lower 4.6 miles of the Raging River (out of a total of 15 miles in the mainstem) exhibit highly constrained and degraded channel and floodplain conditions. The Raging River is encased in continuous levees from the mouth to RM 1.4. There is intermittent armoring from RM 1.4 upstream to I-90. Much of the right streambank (particularly adjacent to the trailer park) from I-90 to SR 18 is armored. Little development encroachment or bank armoring occurs upstream of SR 18. Continuous levees topped by access roads from the mouth to RM 1.4 prevent the channel from meandering and developing side channels, and also cut off wetlands (Herrera Environmental Consultants 1995, as cited in SBSRTC 2002). The proximity of Preston-Fall City Road to the river from I-90 downstream to SR 202 also contributes to loss of channel/shoreline complexity and floodplain connectivity; there is virtually no off-channel habitat downstream of I-90. Upstream of I-90, the river gradient is low enough and the floodplain is wide enough in several locations to create depositional reaches.

The containment levees along both sides of the Raging River through Fall City were constructed in 1937 (King County 2002). Prior to human habitation and levee construction, the river shifted laterally to various locations across its alluvial fan in response to sediment deposition in the channel. Since construction of the levees, floodwaters have been contained and channel shifting controlled, but continued sediment deposition decreases channel flood capacity. In some parts of the leveed portion of the lower Raging River, the channel bed is higher than the adjacent floodplain elevations.

Much of the bank armoring is more oriented to bank protection than to flooding concerns (Lucchetti). Recurrent flooding concerns are mainly limited to the trailer park just upstream of I-90, and through the leveed reach downstream of RM 1.4. The river is naturally confined from I-90 downstream to the depositional fan, so the majority of off-channel restoration potential is downstream of RM 1.4 (Lucchetti). There is an identified opportunity to restore off-channel habitat through removal of a dike at ~RM 3.0 (Carlin dike). In addition, there is currently a side channel complex just downstream of SR 18 that is heavily utilized by salmonids.

Channel Conditions

Logging, residential development, recreation, and road construction have reduced the amount of mature forested riparian area and therefore the potential for LWD recruitment in the lower Raging River (Lucchetti). Several bridges over the Raging River impair the transport of LWD throughout the system. LWD that was formerly present in the river was removed for flood protection and navigation purposes.

Historically, the Raging River watershed likely had an abundance of LWD. There is an anecdotal report of harvest of >2 million board feet of timber from a single logjam removed near the trailer park just upstream of I-90 (Lucchetti). There is currently a paucity of LWD in the lower Raging River, due to diking and past LWD removal. For example, during a stream survey of 3,833 feet from the confluence upstream, only nine logs were observed in the wetted channel (Herrera Environmental Consultants 1995, as cited in SBSRTC 2002). A qualitative habitat survey in summer 2001 indicated that a logjam at RM 7.8 comprised most of the LWD in the surveyed portion of the Raging River (Solomon and Boles 2002). Assuming the ability to protect public safety and public and private property, the Raging River may be a good candidate for LWD placement to retain sediments (1998 subbasin workshop). There are also concerns that LWD that does recruit to the stream is being removed because of flooding/bank stability concerns or for firewood (Chamblin/Lucchetti).

Flood protection actions such as levee and revetment construction have reduced the ability of streams to migrate and incorporate LWD into the channel environment (Snoqualmie Core Area document). The Raging River has a number of bridges that impair the transport of LWD through the system. LWD that was present was removed for flood protection and navigation purposes. LWD conditions could improve with changes in land use and river management.

Presence of adult holding pools on the Raging is limited; anecdotal information suggests that deep pools were present in the system and have disappeared (1998 subbasin workshop). Local residents have reported historical presence of large pools big enough to swim in (Lucchetti).

Substrate Condition

A rough sediment budget for the Raging River watershed was prepared as part of the Draft Raging River Watershed Analysis (WADNR Draft 2000, as cited in King County 2002). Aerial photos from 1936, 1964, 1985, and 1998, in combination with calculations for surface erosion and fluvial sediment transport, were used to characterize sediment sources, movement, and deposition during the three time intervals between photos. Mass wasting was indicated as the primary source of current and past sediment through the Raging River watershed. The sediment budget indicates that the period from 1936 to 1964 saw the largest influx of sediment from landslides, and the greatest volumes of transport and subsequent deposition. There has been a decrease in sediment production, transport, and deposition through the three time intervals to the most recent. However, even with evidence of decreases in erosion and sedimentation over the analysis period, available information indicates continued rates of sediment production, transport, and deposition that are high relative to other watersheds. It is assumed that coarse sediment transport into the lower Raging River is not now, and has not been, supply limited for the past several decades.

A qualitative habitat survey in summer 2001 indicates the substrate of the Raging River is cobble (64-256mm) dominated and gravel (2-64mm) subdominated for most of the surveyed section of the river, providing salmonid spawning potential (Solomon and Boles 2002). A landslide on the RB at RM 3.7 was contributing a lot of fine sediment to the river. Embeddedness of fine sediment in the substrate appeared to be the most impacting feature to fish habitat in the Raging River.

Comparison of cross-sections surveyed in 1993 and 1996 indicates significant sediment deposition downstream of the Preston-Fall City bridge (King County 2002). Approximately 75% of the deposition in the lower 1.46 miles occurred downstream of the Preston-Fall City bridge, and 25% occurred between the Preston-Fall City and 328th Street bridges. The short-term annual deposition rate during this period was estimated at 2,800 yd^3/yr. Qualitative habitat assessment in 2001 in the leveed lower 1.3 miles identified the riverbed as higher than the surrounding topography, with gravel bars as much as 4 feet higher than the summer low-flow channel, and with gravels generally embedded with fine sediments (Solomon and Boles 2002).

An investigation of the intrusion of fines in salmon redds was conducted on the Raging River. The study involved placing 78 artificial redds (egg boxes) in the river and retrieving them after a period of time (through the spawning and incubation periods). There was an average of 14.6% fine sediments (<0.85 mm) in the egg boxes (DeVries et al. 2001, as cited in SBSRTC 2002). There are indications of significant gravel scour occurring within the leveed reach (Chamblin). Increased peak hydrology resulting from a combination of river confinement (levees) and logging within the rain-on-snow portion of the watershed may have increased transport of gravel out of the mouth of the Raging River into the Snoqualmie River. Washington State Department of Transportation (WSDOT) heavily armors the right bank of the Snoqualmie River opposite the mouth of the Raging River to reduce erosion from confinement of the Snoqualmie River flow resulting from gravel fan deposition at the mouth of the Raging. The collapse of pink salmon runs to the Raging River appears to coincide with the combined effects of levee construction/bank armoring and initiation of major logging in the watershed (Chamblin/Lucchetti).

Gravel was dredged from the Raging River to construct the levees in ~1937 (King County 2002). Historic files and anecdotal information indicate that from levee construction to 1963, dredging was conducted only from the Preston-Fall City bridge (RM 0.5) to the mouth at a frequency of about every 4 years.

Riparian Condition

Logging, residential development, recreation, and road construction have reduced the amount of mature forested riparian area and therefore the potential for LWD recruitment in the lower Raging River (SBSRTC 2002). There is a narrow band of vegetation in the lower Raging River near the confluence with the mainstem Snoqualmie River. Presence of the levees in the lower 1.4 miles of the Raging River precludes riparian function (Lucchetti). The upper watershed, including tributaries such as Deep Creek, is largely second growth forest (varying age timber, with much in the 40-50 year-old stage), with limited potential for near-term LWD recruitment (Herrera Environmental Consultants 1995, as cited in SBSRTC 2002). Qualitative assessment of habitat conditions in 2001 indicated generally healthy riparian conditions upstream of the leveed reach, except for specific areas around RM 6.2 and 7.5 where land development has confined the river and the riparian forest has been removed (Solomon and Boles 2002). Riparian vegetation in the leveed reach was dominated by invasive shrubs, although cottonwoods aligned the RB in the leveed reach, providing some shade. Some invasive nonnative trees and shrubs were also identified upstream of the leveed reach.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Raging River watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Raging R	4	60	27	5	1	3	0	0

Water Quantity

Gauged streamflow information is available for the Raging River near Fall City (gauge 12145500 located at RM 2.7) for the period 1946-present (excluding 1952)(King County 2002).

The Raging River is not a large system (<35 mi^2)(Snoqualmie Core Area document). However, a significant portion of the watershed lies in the rain-on-snow zone, creating a hydrograph with large low frequency events (20-year event, 100-year event). This had an important impact on the morphology of the river and its sediment transport capacity. The result is an ample supply of spawning sized gravel transported and distributed along nearly two miles of the Snoqualmie River.

Total impervious area in the Raging River watershed is estimated at 5% (Purser and Simmonds 2001). However, the proximity of Preston-Fall City Road to the Raging River for the lower 4.6 miles of this watershed, and the I-90 and Highway 18 crossings of the Raging River (King County 2001, as cited in SBSRTC 2002) suggest ongoing sources of stormwater runoff that could alter peak flow and/or flow timing. In addition, as noted above in the substrate section, the combination of major logging in the 1970s in the rain-on-snow zone of the watershed, loss of floodplain function, and loss of LWD from the river have likely altered peak flows and energy, resulting in increased bank erosion and substrate instability (Chamblin).

The Raging River watershed is indicated as likely to be very sensitive to groundwater withdrawals, due to a combination of lack of snowmelt or large lakes, and relatively large areas in residential zoning subject to residential water withdrawals and reduced groundwater recharge due to impervious surfaces (Pentec Environmental and NW GIS 1999).

Past timber harvest in this watershed may be causing problems with low flows (Pentec Environmental 1998) and increased peak flows (Lucchetti)(both as referenced in 1998 subbasin workshop). The location of a significant portion of the Raging River watershed in the rain-on-snow zone exacerbates the effects of timber harvesting on hydrology (Lucchetti 2002, as cited in SBSRTC 2002).

Water Quality

Water temperature monitoring at several locations on single days in early August in 1999, 2000, and 2001identified mean water temperatures of 17.6^oC, 20.8^oC, and 15^oC, respectively, and peak water temperatures of 19.5^oC, 24.5^oC, and 16^oC, respectively (Solomon and Boles 2002).

The proximity of Preston-Fall City Road to the Raging River for 4.6 miles from I-90 to SR 202 suggests an ongoing source of stormwater runoff that could transport sediment, nutrients, and other pollutants to the river (King County 2001, as cited in SBSRTC 2002). Past water quality sampling has indicated elevated fecal coliform bacteria, temperature, and pH concerns (Fricke

1995, as cited in SBSRTC 2002). Although the Raging River is included on the 1998 303(d) list of impaired waterbodies for pH, excursions from the criterion are thought to be reflective of natural conditions. A TMDL for the Raging River was adopted by EPA in 1996.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Raging River watershed:

- Restore floodplain function in the leveed reach in the lower 1.4 miles of the river, and at other upstream locations with potential for restoring off-channel habitats (e.g. former Carlin property which is now owned by King County).
- Protect ecological and hydrologic integrity of upper watershed currently in active forest management
- Restore riparian function where impaired; develop and implement a short-term LWD strategy to restore instream habitat diversity until anticipated natural LWD recruitment occurs
- Prioritize and correct identified fish passage barriers (determine if further barrier assessment is needed)

Rutherford Slough 07.0427

General

Rutherford Slough is a RB tributary to the Snoqualmie River, entering at RM 35.3 (Williams et al. 1975). Weyerhaeuser (1995) indicates presence of two human-caused fish passage barriers upstream of the wetland. No additional information or personal knowledge was available regarding salmonid habitat conditions in this watershed.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed entering Rutherford Slough	King County Park Rd	0.23	Yes
Unnamed entering Rutherford Slough	RR grade	0.25	Yes
Unnamed entering Rutherford Slough	30000 Rd	1.0	No

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0427:

- Assess salmonid habitat conditions in this watershed; identify and address habitat concerns
- Prioritize and correct identified fish passage barriers

Unnamed 07.0428

General

Unnamed 07.0428 is a RB tributary to the Snoqualmie River, entering at RM 35.5 (Williams et al. 1975). No information or personal knowledge was available regarding salmonid habitat conditions in this watershed, other than the presence of inventoried culverts (below), and that bass and other warmwater species are likely present in Rutherford Slough and are likely predators on juvenile rearing salmonids (Chamblin).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Rutherford Slough and tributaries:

- Assess salmonid habitat conditions in this watershed; identify and address habitat concerns

Unnamed 07.0429

General

Unnamed 07.0429 is a RB tributary to the Snoqualmie River, entering at RM 36.8 (Williams et al. 1975). The culvert at the SR 202 crossing is included in the WDFW Fish Passage Database (February 2002), the status is indicated as not being a fish passage barrier. The channel was scoured 4-5 feet deep during the 1990 flood from the railroad grade to the mouth due to channel incision at a conduit crossing in the railroad fill (Opperman). This channel incision resulted in loss of floodplain function and gravel substrate. Weyerhaeuser (1995) indicates that the stream channel was subsequently modified with a culvert overlain with riprap that now renders the stream impassable. No additional information or personal knowledge was available regarding salmonid habitat conditions in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Unnamed 07.0429:

- Assess salmonid habitat conditions in this watershed; identify and address habitat concerns, including those resulting from the 1990 flood

Unnamed 07.0430

General

Unnamed 07.0430 is a LB tributary to the Snoqualmie River, entering at RM 37.4 (Williams et al. 1975). Other than the fish passage information below, no information or personal knowledge was available regarding salmonid habitat conditions in this watershed.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed 07.0430	David Powell driveway	0.3	Yes
Unnamed 07.0430	David Powell driveway	0.32	No

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0430:

- Correct identified fish passage barrier
- Assess salmonid habitat conditions in this watershed; identify and address habitat concerns

Unnamed LB trib to Snoqualmie at RM 36.4, Unnamed LB trib to Snoqualmie at RM 37.7, Unnamed 07.0431, Unnamed 07.0432, Unnamed 07.0433, Unnamed 07.0437, Unnamed 07.0439, and Unnamed 07.0452

General

These are all small left bank tributaries, entering the Snoqualmie River between RM 36.4 and Snoqualmie Falls; none of these tributaries were identified as having known or presumed salmonid presence. Other than the culvert inventory information below, no information or personal knowledge was available regarding salmonid habitat conditions in these watersheds.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed LB entering Snoqualmie at ~RM 36.4	S Dike Rd	0.0	Yes
Unnamed LB entering Snoqualmie at ~RM 36.4	Campground road	0.01	Yes
Unnamed LB entering Snoqualmie	Golf course	0.09	Yes

at ~RM 36.4			
Unnamed LB entering Snoqualmie at RM 37.7	David Powell Road SE	0.09	Yes
Unnamed 07.0431	David Powell Rd	0.08	Yes
Unnamed 07.0432	David Powell Rd	0.01	Yes
Unnamed 07.0432	David Powell Rd	0.05	No
Unnamed 07.0437	David Powell Rd	0.01	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for these independent tributary watersheds:

- Prioritize and correct identified fish passage barriers
- Assess salmonid habitat conditions in this watershed; identify and address habitat concerns

Skunk Creek 07.0434 and Mud Creek 07.0435

General

Skunk Creek is a RB tributary to the Snoqualmie River, entering at RM 38.6(Williams et al. 1975). Mud Creek is a LB tributary entering Skunk Creek at RM 0.3.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	**Road Crossing**	**River Mile**	**Barrier Status**
Mud Creek (Skunk Creek)	SE 49th St and Hatchery	0.14	Yes
Skunk Creek	SE 47th	0.01 (0.35)	Yes
Skunk Creek	Airport Runway	0.2 (0.5)	Yes
Skunk Creek	Fish Hatchery Rd	0.28 (0.6)	Yes
Skunk Creek	SR 202	0.42 (1.02)	Unknown
Skunk Creek	356th Drive SE	0.46 (1.06)	No
Skunk Creek	356th Drive SE	0.49 (1.09)	Yes
Skunk Creek	356th Drive SE	0.52 (1.12)	Yes
Skunk Creek	356th Drive SE	0.64 (1.24)	Unknown
Skunk Creek	356th Drive SE	0.66 (1.26)	Yes
Skunk Creek	356th Drive SE	0.67 (1.27)	Yes
Skunk Creek	356th Drive SE	0.79 (1.39)	Yes
Skunk Creek	256th SE	0.8	Yes
Skunk Creek	Private Drive	0.8 (1.4)	Yes
Skunk Creek	256th SE	0.81	Yes

Mud Creek	Fish Hatchery Rd	0.49	No
Mud Creek	SR 202	0.69	No
Mud Creek	Private drive	0.79	Yes
Mud Creek	RR grade	1.06	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

The WDFW culvert inventory is much more extensive than the fish barrier inventory identified in Weyerhaeuser (1995), which indicates only 3 human-caused barriers on Skunk Creek upstream of the confluence with Mud Creek.

During the 1970s, a reach of Skunk Creek downstream of SR 202 was rerouted, resulting in headward stream erosion that prevented upstream movement of coho salmon (Weyerhaeuser 1995). Coho spawning and rearing is known downstream of SR 202; additional suitable habitat exists upstream of SR 202, but anadromous use status is unknown (Chamblin).

Floodplain Modifications

There is a history of ditching downstream of SR 202 to improve drainage; the channel is generally straight and confined, lacking a natural meander pattern (Chamblin). There is one residence downstream of SR 202 that has been subject to recurrent flooding concerns.

Channel Conditions

Little LWD and few pools exist in the channelized area downstream of SR 202 (Chamblin).

Substrate Condition

No information on substrate conditions was located.

Riparian Condition

Some trees are present along Mud Creek downstream of SR 202, but riparian condition is generally poor (Chamblin).

Water Quantity/Water Quality

There are 8 active water rights located in the Skunk/Mud Creek watershed; assessment of impacts to instream flows was not conducted as part of the Watershed Analysis (Weyerhaeuser 1995). No additional information was located regarding water quantity or water quality concerns in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Skunk Creek watershed:

- Prioritize and address identified fish passage barriers

- Assess salmonid habitat conditions in this watershed; identify and address habitat concerns

Tokul Creek 07.0440

General

Tokul Creek is a RB tributary to the Snoqualmie River, entering at RM 39.7 (Williams et al. 1975). The Tokul Creek watershed drains an estimated 21,704 acres (SBSRTC 2002). Ninety-six percent of the Tokul Creek watershed is in private timber ownership (King County Department of Development and Environmental Services 2000, as cited in SBSRTC 2002). Cooperative efforts are in progress to transfer the forest lands in the watershed into non-profit ownership; the lands would continue to be managed for forest production, but would also be managed for greater fish and wildlife protection than otherwise typically found in commercial forestlands (Lucchetti).

Fish Access

Access to Tokul Creek is blocked by the WDFW hatchery diversion structure at RM 0.3 (Kraemer). This structure blocks access by anadromous fish to at least one mile of stream. There was a fish ladder in place at the diversion structure, but the fish ladder was destroyed in a 1990 storm, and the diversion has since been impassable (Weyerhaeuser 1995). A temporary hatchery rack has been installed in each of the last two years ~0.2 miles downstream of the diversion to divert some of the adult chinook returning to Tokul Creek into the hatchery, where they are trapped and transported upstream of the diversion to utilize the available spawning and rearing habitat (John Kerwin, WDFW, personal communication). These chinook spawn either upstream of the diversion structure, or fall back downstream of the diversion and spawn between the rack and the diversion. The hatchery rack is removed during the adult return period for coho and steelhead, allowing adult access to the hatchery diversion for those species. However, the hatchery diversion may not be screened to current standards, potentially adversely affecting some of the juvenile chinook production that occurs upstream of it.

A natural ~15-foot waterfall is located at RM 1.4. This falls is a barrier to chinook, chum, pink, and coho; there is uncertainty regarding the historic presence of summer-run steelhead upstream of the falls. If summer steelhead were able to pass upstream of the falls, there are ~53 miles of suitable gradient habitat upstream, which are currently occupied by resident cutthroat and brook trout (Weyerhaeuser 1995). There is also some question as to whether anadromous fish would utilize the full extent of the habitat upstream of the falls; anadromous salmonids would likely use approximately 13 miles of mainstem Tokul habitat upstream of the falls, but it is uncertain to what extent the identified tributaries would provide suitable habitat or be utilized by anadromous salmonids (Chamblin, Lucchetti). Weyerhaeuser (1995) identifies 17 human-caused partial/complete fish passage barriers in the Tokul Creek watershed upstream of the falls, all of which are located on tributaries to Tokul Creek.

Kurt Beardslee (Washington Trout) has anecdotal reports from fishermen who report having historically caught summer-run steelhead upstream of the falls. Curt Kraemer (WDFW) has observed winter-run steelhead jumping at the waterfall, without seeing any success. He indicates that summer-run steelhead are better jumpers, but the waterfall does not have a great plunge pool, and the height of the waterfall is at the upper limit of jumping ability identified in the literature.

Given that the waterfall is at the upper extent of known jumping ability, the numbers of summer steelhead upstream of the waterfall would be very limited even under ideal conditions, and any presence would likely be sporadic over a period of years, resulting in inconsistent year class productivity over time. He also indicates that if summer-run steelhead were historically present in Tokul Creek, this would be the only watershed on the west side of the Cascade Mountains that he is aware of that would have had summer-run steelhead in conjunction with only cutthroat and brook trout. All other areas with summer-run steelhead appear to also have significant presence of resident rainbow.

Floodplain Modifications

Natural floodplain function is impaired in the confined, channelized, and armored (mostly the RB, but also some on the LB) reach downstream of the hatchery diversion (Chamblin, Lucchetti).

Channel Conditions

Downstream of the waterfall, Tokul Creek has low frequency of deep (>1m) pools and low amounts of LWD (Weyerhaeuser 1995).

Limited LWD counts upstream of the waterfall showed that levels of LWD are variable, but high overall. There were 2.1 LWD pieces per channel width in a 50-meter length and 15-meter width of river channel, and 1.8 LWD pieces per channel width in a 100-meter length and 20 meter width of river channel (Weyerhaeuser 1995, as cited in SBSRTC 2002). These limited samples are not likely sufficient to characterize conditions throughout the upper watershed.

Substrate Condition

Tokul Creek downstream of the falls has lower than expected amounts of spawning gravel, likely associated with lack of LWD resulting in lower retention of gravels (Weyerhaeuser 1995). There is no indication that redd scour is occurring; the potential for redd scour is unlikely based on the low percentage of the watershed that is in the rain-on-snow zone and the high wetland acreage in the watershed (Weyerhaeuser 1995).

Timber harvest activities, road construction, filling in the floodplain, and bank hardening have contributed to increased sediment delivery to the creek from mass wasting, road erosion, and surface erosion of hillslopes (Weyerhaeuser 1995, as cited in SBSRTC 2002). Surface erosion from roads is delivering fine sediment to streams/wetlands at rates significantly greater than the estimated background rate of fine sediment input in the Lower Tokul, Beaver Creek, Upper Tokul, Tokul Bench, and Mud Lake watersheds (Weyerhaeuser 1995). Road erosion inputs from these watersheds are probably large enough that they could be detected by long-term monitoring and might have an effect on water quality or fish habitat. Numerous specific road segments of concern are identified in the Griffin-Tokul Watershed Analysis. A landslide between the WDFW Hatchery and SR 202 continues to deliver significant amounts of fine sediment to the creek from the actively eroding bank. Two smaller slides exist just upstream of SR 202 (Chamblin). Erosion problems associated with these slides are likely exacerbated by channel confinement caused by road or floodplain fill (Lucchetti). Efforts to stabilize these slopes may reduce beneficial inputs of gravel and other potential bedload.

Riparian Condition

All the riparian vegetation on Tokul Creek was harvested in the late 1920s or early 1930s (Weyerhaeuser 1995). The lower portion of Tokul Creek has regenerated deciduous-dominated stands. The understory in most of these stands consists of shade tolerant species like cedar and hemlock, but current LWD recruitment is limited to alders. The middle and upper portions of the stream have conifer dominated stands of varying age.

Approximately 48% of the Tokul Creek drainage is designated as having naturally low shade levels, 22% of the drainage meets canopy closure targets, and 30% does not (Weyerhaeuser 1995). The largest contributing factor for riparian zones not meeting canopy closure requirements is past timber harvest practices with the riparian area. Blow down in the riparian zones has contributed to reduced canopy density in some locations. Forty-five percent of the fish-bearing waters in the Griffin-Tokul watershed are vulnerable to shade removal from loss of riparian vegetation. Seventy-six percent of the riparian management zones have moderate to high near-term LWD recruitment potentials (32% and 44% respectively), with the remaining 24% of the watershed having low LWD recruitment potential (Weyerhaeuser 1995, as cited in SBSRTC 2002).

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Tokul Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Tokul Cr	2	47	34	10	1	6	0	1

Water Quantity

There are 3 public water rights granted to King County Water District 9 for withdrawals from EF Griffin Creek and Beaver Creek (Tokul watershed) for municipal and power supplies (Weyerhaeuser 1995). Personnel with King County Water Districts 119 and 127 and the City Engineer for the City of Carnation municipal water supply were unaware of the existence of these water rights (Weyerhaeuser 1995). There are also 3 water rights to WDFW for the Tokul Fish Hatchery.

A modeling effort was conducted to evaluate alterations to groundwater recharge, which estimated a 4% reduction in groundwater recharge from pre-disturbance to current conditions (Gersib et al. 1999, as cited in SBSRTC 2002).

Water Quality

There are no 303(d) listed segments. Limited data are available on water temperature in Tokul Creek; shade is low in the anadromous accessible reach (Weyerhaeuser 1995). Past temperature and dissolved oxygen measurements have generally met Washington State water quality criteria (Weyerhaeuser 1995, as cited in SBSRTC 2002).

The Tokul Creek hatchery at RM 0.3 is one of six NPDES permitted facilities in the Snoqualmie River watershed and is a minor contributor of solids (WDOE, Report #94-71, as referenced in 1998 subbasin workshop).

Biological Processes

A population of eastern brook trout (*S. fontinalis*) is established in Tokul Creek as a result of stocking in the 1950s (WDFW Unpublished Data, as cited in Weyerhaeuser 1995). This population persists upstream of the falls, and may be adversely affecting the natural salmonid species composition and productivity (Chamblin). An assessment of implications of brook trout presence should be conducted to determine the practicality/feasibility of brook trout removal from the upper watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Tokul Creek watershed:

- Complete the proposed forestland land transfer conservation action, which will ameliorate some of the currently identified forest management impacts and ensure long-term protection of salmonid habitat in this productive system
- Correct identified adult and juvenile fish passage problems associated with the hatchery diversion
- Restore natural stability regime at slide locations between the hatchery diversion and the falls, and at the slide sites upstream of SR 202
- Reduce forest road densities and associated surface erosion from roads in the upper watershed
- Assess implications of brook trout presence in upper watershed; assess feasibility of brook trout removal to restore and enhance native salmonids

Snoqualmie River upstream of Snoqualmie Falls, including SF Snoqualmie, MF Snoqualmie, and NF Snoqualmie

General

Salmonid production upstream of Snoqualmie Falls is limited to resident trout only (rainbow and cutthroat trout and mountain whitefish in streams, brook trout in several high mountain lakes and occasionally in streams); no bull trout/Dolly Varden have been observed upstream of Snoqualmie Falls (Berge and Mavros 2001, as cited in Solomon and Boles 2002). Land use upstream of Snoqualmie Falls is largely forest production and wilderness, with urban and rural residential development occurring near the cities of North Bend and Snoqualmie. Salmonid habitat conditions are generally good upstream of the confluence of the three forks, but impacted through the extensively leveed and urbanized reach through North Bend (Pentec Environmental and NW GIS 1999). There are no identified adverse habitat effects from the Snoqualmie River watershed upstream of Snoqualmie Falls that transfer to the anadromous salmonid areas downstream. However, identified habitat problems upstream of Snoqualmie Falls should be corrected to benefit resident salmonids. Furthermore, habitat conditions upstream of Snoqualmie Falls have the potential to affect salmonid habitat conditions below the falls.

There are completed Federal Watershed Analyses for MF Snoqualmie and SF Snoqualmie rivers (Gall), although these reports were not reviewed for this report, due to late awareness of their existence. None has yet been written for NF Snoqualmie River. No USFS Environmental Baselines have been done for the watersheds upstream of Snoqualmie Falls, since WDFW and

USFS formally assume that no anadromous salmon or bull trout/Dolly Varden occur upstream of Snoqualmie Falls.

Fish Access

Snoqualmie Falls is a natural barrier to anadromous salmonid migration. However, there is extensive resident salmonid distribution throughout the watershed upstream of the falls. The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed 07.0475	SR 90	NA (0.01)	No
Mason Creek	SR 90	NA (0.01)	Yes
Talapus Creek	I 90	0.05	Yes
Humpback Creek	I 90	0.05	Yes

The WDFW Fish Passage Database does not include a comprehensive inventory of culverts upstream of Snoqualmie Falls.

Floodplain Modifications

Extensive logging operations have occurred in the past in some of the sub-watersheds within the NF Snoqualmie, SF Snoqualmie, and MF Snoqualmie watersheds (Gall). Reductions in hydrologic maturity resulting from these harvests were likely one of the contributing factors that caused flooding and resulting blowouts and debris flows in some stream reaches in the 1950s. Land managers in some areas, including the area around North Bend, responded by building levees and placing riprap along stream channels to attempt to contain the waters within the channel and prevent flood waters from naturally overtopping banks and spreading over the floodplain during storm events. Channel excavation is being considered by the Army Corps of Engineers and King County on the Snoqualmie River near the City of Snoqualmie to decrease flooding.

Presence of dikes and levees on the lower reaches of the Snoqualmie forks affect floodplain function. There are many levees and revetments on the banks of the lower SF Snoqualmie River between RM 2.0 and 6.5 (King County DNR 2001, as cited in SBSRTC 2002), affecting 10-20% of the shorelines. In addition, the proximity of I-90 to the river throughout this watershed contributes to loss of floodplain connectivity. Levees and revetments along the banks of the lower 3 miles of the MF Snoqualmie River affect 10-20% of the shorelines, eliminating natural streambank and creating a disconnect between the river and associated off-channel floodplain habitat. Levees and revetments on the banks of most of the lower 2 miles of the NF Snoqualmie River affect 10-20% of the shorelines.

Channel Conditions

There is currently limited transport of LWD from the upper watershed to the river downstream of Snoqualmie Falls. This conclusion is supported by experiences at the Puget Sound Energy facility at Snoqualmie Falls (Cary Feldmann, Puget Sound Energy, personal communication). Leaves and small debris accumulate on the facility trash racks and are passed downstream; there are observations of some large logs moving downstream during peak flow events, but no past problems with significant presence of large material accumulating on the trash racks or impeding operations at the facility. It is unknown to what extent the current lack of LWD transport over the falls is related to the history of active logging and LWD removal upstream of the falls, as it seems likely that under natural conditions at least a portion of the LWD in the upper watershed would pass through the relatively low gradient reach above the falls to the river downstream (Lucchetti).

No information was located on pool condition or bank stability upstream of Snoqualmie Falls.

Substrate Condition

Above Snoqualmie Falls, the river is high gradient and sediment poor (1998 subbasin workshop). The geologic formation that creates Snoqualmie Falls also creates a backwater effect, slowing Snoqualmie River velocities upstream of the falls. As a result, only fine sediment is transported as far as the falls (King County DNR 1996, as cited in Snoqualmie Core Area document). Sediments generated in the upper watershed are primarily trapped above the falls in the low gradient Three Forks area. The MF Snoqualmie is the largest contributor of sediments to the Snoqualmie mainstem, caused by lateral movements occurring in its wide floodplain. Several washouts and debris torrents in the past decade indicate that the SF Snoqualmie may have experienced the most erosion of the three forks (G. Lucchetti). However it is not considered a significant contributor of sediments below the falls. Sediment accumulation studies are underway in the diked portion of the SF Snoqualmie as it flows through the town of North Bend. Results of the study can be obtained from King County DNRP, Rivers Section. There is also a lengthy review and discussion of sediment budgets for the SF Snoqualmie River contained within the Federal Watershed Analysis for the SF Snoqualmie River (Gall).

Riparian Condition

Riparian conditions are fair through the towns of Snoqualmie and North Bend; riparian conditions improve dramatically upstream of the confluence of the three forks (Snoqualmie Core Area document).

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the watersheds upstream of Snoqualmie falls (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Coal Cr upper	0	43	26	15	4	8	2	1
Tate Cr	0	52	34	10	1	3	0	0
Lower NF Snoqualmie	18	51	18	3	1	3	0	7
Upper NF Snoqualmie	21	50	17	2	1	3	0	7
Lower SF Snoqualmie	7	51	24	7	4	5	0	2
Upper SF Snoqualmie	15	47	24	4	2	4	0	4
Lower MF Snoqualmie	10	48	29	5	1	3	1	4
Upper MF Snoqualmie	22	36	19	3	2	5	1	12

Pratt R	28	49	10	1	1	3	0	8
Taylor R	18	42	22	3	1	4	0	10

Water Quantity

The upper Snoqualmie River watershed (upstream of Snoqualmie Falls) provides a long-term mean annual flow of 2,800 cfs; a similar measurement at Carnation is 3,800 cfs, indicating that the upper watershed contributes over two-thirds of the Snoqualmie River flow at Carnation (numeric estimates based on USGS Open-File Report 84-144-B, reflecting flow data available through water year 1979; no similar summary data were available including more recent data)(Bean). Current estimates of 100-year flood magnitude in the NF Snoqualmie River exceed previous estimates (King County Rivers Section 1995 flood study), however it is unclear whether this is indicative of a time trend in the data, or is an artifact of the longer-term database yielding a different estimate. The 7Q10 is 386 cfs for the Snoqualmie River near Snoqualmie.

A USGS study conducted in 1991 found that a significant portion of the surface flow in the Snoqualmie River is contributed by groundwater (as cited in Pentec Environmental and NW GIS 1999). The SF Snoqualmie River received ~25-31 cfs from groundwater discharge, or ~25-31% of its flow in the reach from Edgewick Road to North Bend. The upper Snoqualmie River (Three Forks to downstream of Snoqualmie Falls) gained 88 cfs from groundwater, or ~20% of its flow. From Fall City to Carnation, the river gains an additional 81-93 cfs, or 11-13% of its flow, from groundwater seepage. In total, within the study area, groundwater seepage delivered ~115-133 cfs, or 25-28% of the flow observed at Carnation. It is estimated that groundwater could be contributing as much as 22% of the mean August flow at Carnation or 40% of the median 7-day low flow at Carnation (Pentec Environmental and NW GIS 1999).

There is a water use proposal (River Augmentation/Snoqualmie Aquifer Pilot Project, project description available at www.cityofseattle.net/forum/outlookdocs/outlookcomplete/sec9.pdf) by the East King County Regional Water Association to withdraw groundwater, pump it into the Snoqualmie River, and remove it from the river downstream to augment the regional water supply. The East King County Regional Water Association has submitted the proposal to the Central Puget Sound Initiative. To date, there has been no formal analysis of the fish habitat or overall environmental impacts of the proposal (Solomon).

Water Quality

The Snoqualmie River is included on the1998 303(d) list of impaired waterbodies for water temperature (RM 2.7, 14.7, 23.0, 36.0, 44.0, and at Plant 1 Powerhouse Intake). Excursions from the criterion for fecal coliform bacteria (numerous locations throughout the watershed) and for dissolved oxygen (Plant 1 Powerhouse Intake and SF Snoqualmie) are being addressed through a TMDL adopted by EPA in 1996. Excursions from the criterion for pH (RM 2.5, 2.8, 7.0, 14.7, 23.0, and 36.0) are thought to be reflective of natural conditions.

At certain water temperatures and low flow conditions, the pool above Snoqualmie Falls can reach dissolved oxygen concentrations that do not meet the state criterion for Class A waters (1998 subbasin workshop). The primary contributor to the problem is the North Bend treatment facility, which discharges effluent with high biochemical oxygen demand (BOD). The low dissolved oxygen situation is largely an artifact of the residence time of water in the pool above the falls. The pool elevation can be reduced by altering the weir structure at the Puget Sound Energy plant, thereby reducing the residence time of water in the pool and reducing the amount of respiration that takes place (WDOE Report #94-17, as cited in 1998 subbasin workshop).

However, the sampling site where low dissolved oxygen was identified is immediately upstream of the dam; it is unknown to what extent this sample may be representative of conditions towards the upstream end of the pool (Bob Barnes, Puget Sound Energy, personal communication). As the water passes over the falls, it is thoroughly aerated and the dissolved oxygen problem is eliminated. Discussions of potential modifications to the weir at the crest of the dam are anticipated as part of the re-licensing of the hydroelectric project at Snoqualmie Falls, but no resolution has occurred to date (Bob Barnes, Puget Sound Energy, personal communication).

There is additional information on water quality conditions for the SF Snoqualmie River included in the Federal Watershed Analysis for the SF Snoqualmie watershed (Gall).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Snoqualmie River watershed to benefit resident salmonids upstream of Snoqualmie Falls:

- Restore floodplain function through the cities of North Bend and Snoqualmie
- Reduce weir height at Snoqualmie Falls diversion to reduce the residence time of water in the backwater pool
- Restore riparian function where impaired
- Assess implications of stream-dwelling brook trout presence in upper Snoqualmie watershed; assess feasibility of brook trout removal to restore and enhance native salmonids

Skykomish River Mainstem 07.0012 (upstream continuation of Snohomish River)

General

The Skykomish and Snoqualmie rivers merge near the town of Monroe to form the Snohomish River (RM 21). The assessment description in this section includes the Skykomish River mainstem from the Snohomish River upstream to the confluence of the NF and SF Skykomish rivers at RM 49.6.

Snohomish County will be conducting salmonid habitat surveys in the mainstem Snohomish and Skykomish rivers (from Sultan to Everett) in summer 2003 (Michael Purser).

Fish Access

There are no identified fish passage barriers on the mainstem Skykomish River. However, several areas of the Skykomish River are isolated from side channel/off-channel habitats by dikes, levees, roads, and railroads.

Floodplain Modifications

The mainstem Skykomish River from the mouth to the forks is often described as having four distinct reaches. The reach from the forks downstream to just above Goldbar is a naturally confined transport reach where sediment and woody debris are passed downstream. The reach from Goldbar to Sultan is a lower gradient depositional reach, where sediment and wood are actively deposited. This reach is braided and very dynamic. The reach from Sultan to just downstream of Monroe is currently primarily a single-thread mainstem channel, with multiple historic side channel spawning and rearing complexes (Ward). Natural floodplain function in this reach is affected by encroachment of SR 2 and the BNSF Railroad, and by presence of short dikes that limit natural channel dynamics within the channel migration zone. These dikes and other alterations have blocked access to and formation of habitat features. This reach was probably historically a deposition reach, but is now considered as a transitional reach, with much of the historic deposition shifted downstream to the confluence. Downstream of Monroe to the confluence with the Snoqualmie River, the Skykomish River is again characterized as a dynamic broad depositional area.

Natural floodplain function is impaired by presence of private and public roads and the BNSF Railroad, which encroach on approximately 40% (11.64 river miles) of the mainstem Skykomish River shoreline upstream of the town of Sultan (Savery in prep., as cited in SBSRTC 2002).

Approximately 18% of shoreline is hardened between Gold Bar and Monroe (Pentec Environmental and NW GIS 1999, as cited in SBSRTC 2002). Evaluation of aerial photographs indicates that 1.09 miles (1.6%) of the 67.99 miles of bank along the Skykomish River are diked (Pentec Environmental and NW GIS 1999). In the reach between Gold Bar and Monroe, 28.87 miles (81.39%) of the banks have no dikes or riprap, 0.4 miles (1.23%) are diked, 5.98 miles (16.87%) are riprapped with no dikes, and 0.18 miles (0.51%) are diked and riprapped. Diking on the Skykomish River is primarily for directing river current, rather than for flood control as along the Snohomish River (Ward, Chamblin). There are six large training dikes (short dikes primarily designed to direct/redirect the thalweg of the river, rather than to provide flood control along a long length of river shoreline) located on the Skykomish River, including the Schlamp dike (RM 22.5), Hansen dike (RM 23.6), Haskel Slough dike (RM 26.8), Fern Bluff dike (RM 28.8), Sultan dike (RM 34.3), and the Startup levee and training levee (~RM 39)(Snohomish County Public Works 1994). Although the extent of diking on the Skykomish River is limited, most of the dikes are located such that they directly impair fish access, hydrology, and habitat formation in key off-channel habitat areas, and hydrology and sediment transport and storage within the floodplain. Snohomish County facilitated development of a draft Flood Hazard Management Plan for Skykomish River floodplain (Snohomish County Public Works 1995, Snohomish County Public Works 1994); the draft plan has not been formally adopted, but some sections have been implemented as dike repairs were required (Chamblin).

Floodplain function is impaired at several locations where crossings constrict the active channel, as well as preclude floodplain function outside of the active channel (Ward). Specific locations of concern include the abandoned railroad fill across the floodplain and bridge at RM 25.6, the SR 203 (Lewis St.) bridge, and the Mann Road bridge.

Channel Conditions

Because the Skykomish River is very powerful, woody debris creates habitat mainly by forming debris jams. However, single LWD pieces can create edge habitat complexity and individual pieces may form habitat in side channels (Haas). Because of the wide active channel and high sediment load, habitat conditions are strongly influenced by summer flows; significantly more habitat is available in side channels and backwaters during higher summer flows.

Substrate Condition

Estimates of sediment loading in the Skykomish River vary widely. Dunne (1979, as cited in SBSRTC 2002) estimates total average sediment load for the entire Skykomish River is 358,000 tons/year; the estimate of bedload is 36,000 tons/year and estimated suspended load is 322,000 tons/year.

Collins and Dunne (1990, as cited in Pentec Environmental and NW GIS 1999) estimate that the Skykomish River transports an annual bedload and suspended sediment load of 21,000yd^3/year. The Skykomish River is sediment limited between Index and Startup, eroding terraces along the river. Between Startup and Sultan, the channel gradient decreases, depositing sediments and resulting in a very wide braided reach. From Sultan to Monroe, there is no net erosion or deposition. There are many dikes in this reach that may alter the natural sediment transport regime. Between Monroe and the confluence with the Snoqualmie River, the Skykomish River deposits much of its sediment load. This stretch of the Skykomish River is unstable, and is marked by frequent channel changes.

There are no known studies of fine sediment presence for the mainstem Skykomish River (SBSRTC 2002).

Riparian Condition

Approximately 60% of riparian corridor between Gold Bar and Monroe is greater than 200 feet wide (Pentec Environmental and NW GIS 1999). Transportation infrastructure (SR 2 and the BNSF Railroad), agricultural practices, and the town of Gold Bar limit riparian condition. Approximately 35% of the riparian zone upstream of the town of Sultan is less than 1 SPTH wide (Michalak 2001, as cited in SBSRTC 2002).

Pentec Environmental and NW GIS (1999) evaluated riparian condition on the banks of the Skykomish River (Table 16). Riparian conditions 4, 5, and 7, and possibly 10 would typically be considered to reflect functional riparian conditions for a large mainstem river. Cumulatively, these riparian condition categories include 67% of the total riparian area evaluated for the Skykomish River. Riparian function is impaired in a number of areas, but overall riparian condition and LWD recruitment potential is better than for either the mainstem Snoqualmie or mainstem Snohomish rivers. However, riparian restoration should be pursued, where feasible.

Table 16: Riparian conditions on the Skykomish River (right and left banks combined)(from Pentec Environmental and NW GIS 1999)

Riparian Condition	Total Miles	% of Total
1. Grass or brush	2.92	4
2. Single line of trees	8.03	12
3. 20-200 foot forested	4.12	6
4. 200-400 foot forested	5.52	8
5. >400 foot forested	40.10	59
6. Residences or farms, little forest	3.48	5
7. Residences or farms, significant forest	1.76	3
8. Roads or railroads	2.06	3
9. Industrial	0	0
10. Unforested wetland	0	0
Total	67.99	100

Water Quantity

Gauged streamflow information is available for Skykomish River at Monroe (gauge 12141100) for the period 1951-1974, and at Goldbar (gauge 12134500) for the period 1928-1994(as cited in Pentec Environmental and NW GIS 1999). Gauge data are also available for the SF Skykomish near Index (gauge 12133000) for the period 1896-1982. Mean annual discharge for the mainstem Skykomish River at Gold Bar (RM 43) over the 50-year period from 1929-1979 ranged from 2,210 to 5,884 cfs, averaging 3975 cfs (USFS 1997). The mainstem Skykomish River, as well as the NF Skykomish and SF Skykomish rivers all exhibit a bi-modal annual hydrograph. The highest average monthly flows at Gold Bar occurred during May and June, equaling about 6,900 and 7,035 cfs, respectively. The next highest average monthly flows occurred in December, November, and April, but all were below 5,000 cfs. Peak flows during any one month were much more varied, with the largest average peak flows during any one month occurring in December or June (14,490 and 13,610 cfs, respectively). While annual average flows vary approximately between 3,000 and 5,000 cfs, annual peak flows can exceed 100,000 cfs (102,000 cfs in 1991, >100,000 cfs in 1995). August and September typically have the lowest discharges, usually far lower than either July or October. The average monthly flow from 1929-1979 was 1,472 cfs in August and 1,432 in September. The minimum average monthly flow recorded during any year ranged from 612 to 515 cfs, in August and September, respectively.

No flow trend analyses were located for the Skykomish River. There is some speculation that peak flows have decreased in recent years. The causal relationship is unknown, but may in part be related to forest regrowth in upper watershed areas that were heavily harvested, reduction in glaciers/permanent snowfields in upper watershed and associated snowmelt runoff, etc. (Ward).

Water Quality

The Skykomish River is included in the 1998 303(d) list of impaired waterbodies for fecal coliform bacteria (RM 25.7 and 43.7), temperature (RM 43.7), and copper, silver, and lead in the mixing zone of the Monroe WWTP.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Skykomish River mainstem (mouth to forks):

- Restore/improve floodplain and channel migration zone functions, where impaired. Particular areas of concern include key floodplain constrictions (abandoned railroad fill and bridge at RM 25.6, SR 203 (Lewis St.) bridge, Mann Road bridge), and areas where side channel habitat access and functions are impaired (side channel areas downstream of Skykomish River dikes). This should also include consideration of opportunities to reduce/eliminate floodplain encroachment of SR 2 and BNSF Railroad, where feasible, as opportunities for modification arise.
- Restore riparian function along mainstem Skykomish, along floodplain side channels, and across the active channel migration zone

Unnamed 07.0814 and tributaries

General

Unnamed 07.0814 is a RB tributary to the Skykomish River, entering at RM 21 (Williams et al 1975). The portion of this watershed downstream of SR 522 is an historic remnant oxbow channel within the floodplain at the Snohomish/Skykomish River confluence.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed 07.0814	Tester Rd	0.85	Yes
Unnamed 07.0814	SR 522	0.9	Yes
RB to Unnamed 07.0814 at ~RM 0.85	SR 522	0.0	Yes
Unnamed 07.0815	Sky Meadow Lane	0.2	Yes
Unnamed 07.0815	Private rd	0.22	No
Unnamed 07.0815	Private drive	0.3	Yes
Unnamed 07.0815	Tester Rd	0.35	Unknown
Unnamed 07.0816	Cadman Gravel Pit Access	0.5	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Snohomish Conservation District is in the process of replacing a private culvert just downstream of SR 522 (believed to be in addition to those listed in the WDFW culvert database above) with a bridge (Bails).

Floodplain Modifications

There is a large floodplain wetland complex in the lower 0.5 mile of Unnamed 07.0814 (Bails). From the upstream end of the wetland to just downstream of SR 522, the creek flows through a pasture and along the edge of agricultural land; the creek has been dredged through this area. Upstream of SR 522, there are numerous beaver dams complexes along Unnamed 07.0814.

Channel Conditions

LWD is generally absent where the creek flows through agricultural lands (Bails). Most of the channel adjacent to agricultural lands has been dredged to improve drainage. No information is available regarding pool condition outside of the beaver dam complexes.

Substrate Condition

No information is available on substrate condition. Substrate is fine-grained material in the beaver dam complexes.

Riparian Condition

Riparian condition in the beaver dam complexes near the mouth and upstream of SR 522 is good (Bails). There is unrestricted livestock access where the creek flows through a pasture in the 0.5 mile upstream of the beaver dam complex at the mouth; riparian condition in this area is poor, but the Snohomish Conservation District is attempting to work with the landowner to improve riparian function.

Water Quantity/Water Quality

Perennial surface water is present in the beaver dam complexes above the mouth and in the headwaters, but the creek goes dry in summer where it flows adjacent to or across agricultural land (Bails).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0814 watershed:

- Protect forest cover and forest hydrology in the headwaters
- Protect the integrity of existing beaver dam complexes in the lower 0.5 mile and in the headwaters
- Eliminate unrestricted livestock access to the creek downstream of SR 522
- Prioritize and correct identified fish passage barriers

Riley Slough 07.0818, Foye Creek 07.0819, High Rock Creek 07.0820, Unnamed 07.0821, Unnamed 07.0822, Unnamed 07.0823

General

Riley Slough is a RB tributary to the Snoqualmie River, entering near RM 1.7 (note that the location of the mouth is different than represented in Williams et al. (1975), which identifies Riley Slough as a tributary to the Skykomish River; the mouth of Riley Slough has likely historically moved back and forth between these river systems).

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Riley Slough	N High Rock Rd	3.5 (4.1)	Unknown
Foye Creek	N High Rock Rd	1.3	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations (there were landowner access limitations in this watershed (Glasgow)) and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone

Riley Slough and tributaries had good abundance of coho spawners documented in the late 1970s. Coho spawner abundance declined over the years, and no coho spawners have been observed in the watershed since 1994 (Kraemer). However, Stillaguamish-Snohomish Task Force, Snohomish Conservation District, and Tulalip Tribe staff observed juvenile coho in the Riley Slough spawning area in 2000 (Ward). Brett Barkdull (WDFW) walked the system in early July 2002, and found no apparent salmonid access through the beaver dams in the lower 1-1.5 miles of Riley Slough. There were no apparent passage obstructions, but there were also no rearing juveniles observed in the beaver ponds. This observation follows the 2001 coho escapement, which is the largest on record for the Snohomish watershed, where coho were seen elsewhere throughout the watershed in areas where they had previously not been observed.

Floodplain Modifications

The lower portion of High Rock and Foye creeks, and most of Riley Slough, are located on agricultural lands on the valley floor, within the floodplain at the confluence of the Snoqualmie and Skykomish rivers. Although the channel appears to be confined in comparison to likely historic condition, Riley Slough still has a well-defined meander pattern.

There is a very large beaver dam/wetland complex just upstream of the mouth of Riley Slough. This area should provide excellent rearing habitat, but does not appear to be getting populated with anadromous salmonids.

Channel Conditions/Substrate Condition

No information is available on channel or substrate conditions.

Riparian Condition

Review of aerial photos provided by Snohomish County (2001) indicates that riparian vegetation is generally sparse to absent in the agricultural lands on the valley floor west SR 203. The upper mile of Riley Slough appears to have been channelized and relocated against the bluff, and there is also unrestricted livestock access in this reach (Bails). Upstream, High Rock and Foye creeks, and the tributaries to the northeast are forested and riparian condition appears to be fair/good. The lower ~0.8 mile of Riley Slough flows through a forested wetland with dense deciduous vegetation, but the stand lacks large conifer presence (Ward).

Water Quantity/Water Quality

Most hydrology maps indicate a connection from Haskell Slough to the upper end of Riley Slough. There is a clearly identifiable swale from Haskell Slough, which only carries surface water during flood flows (Ward). Since construction of the Haskell Slough dike in 1941, the primary water sources for upper Riley Slough are the unnamed hillslope tributaries (07.0821-07.0823) and several smaller unmapped tributaries. The Haskell Slough dike impairs flushing flows into Haskell and Riley sloughs, and impairs groundwater connectivity between the Skykomish River and the upper end of Riley Slough, particularly affecting base flows in Riley Slough (Kraemer, Chamblin, Ward). Perennial surface water is present in those sections of Riley Slough where beaver dams are present; sections without beaver dams often go dry in summer (Bails).

The Snohomish Conservation District has collected three years of water quality data in Riley Slough, but the data were not available for this report.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Riley Slough watershed:

- Restore groundwater and surface water connectivity with the Skykomish River/Haskell Slough, to improve flows in Riley Slough, particularly during base flow periods
- Assess fish passage during the coho spawning period in the fall to determine what is causing the lack of fish access into the watershed
- Restore riparian function, where impaired, to shade out grasses and improve salmonid productivity; enhance riparian conifer presence through wetland in lower 0.5 mile
- Assess habitat conditions in the watershed, correct identified problems

Haskel Slough 07.0825

General

Haskel Slough is a LB tributary to the Skykomish River, entering at RM 24.3 (Williams et al. 1975). Haskell Slough is a relict historic channel of the Skykomish River.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Haskel Slough	Private drive	1.6	Unknown

There are numerous additional driveway culverts that are not included in the inventory above (Bails). Several culverts downstream of SR 203 have been upgraded to large arch culverts. There are several remaining culverts upstream of the old railroad grade that are smaller and that may impair fish passage.

Floodplain Modifications/Channel Conditions

Concerns of impaired fish passage in Haskell Slough led to implementation of a habitat restoration project (Ward). Pre-project channel conditions had evolved to a series of pools/with limited surface water connection. A habitat restoration project was implemented to dredge the slough and improve surface water connectivity through the slough. Most of the dredged material was sidecast and spread on the banks and floodplain. There is a general lack of LWD in the slough; some LWD was placed coincident with the dredging of the slough, but additional LWD would increase the in-channel habitat diversity (Ward, Bails).

The Haskell Slough dike is a 1,340-foot long dike that was constructed in 1941 along the left bank of the Skykomish River at the head of Haskel Slough (Snohomish County Public Works 1994). The purpose of the dike was to prevent the Skykomish River from making a major channel shift into Haskell Slough, an historic river channel. The Haskell Slough dike impairs flushing flows into Haskell Slough, and impairs groundwater connectivity between the Skykomish River and the upper end of the slough, particularly affecting base flows (Chamblin, Ward).

Beaver have attempted to colonize areas of Haskell Slough since the dredging occurred, but the beaver dams are being actively removed throughout the system to maintain flow (Ward). Beaver dams provide excellent rearing habitat for coho, and should be encouraged in this watershed that was historically likely a large beaver dam complex.

Substrate Condition

No information was available on substrate condition.

Riparian Condition

Riparian condition is variable along Haskell Slough, ranging from fairly wide vegetated buffers to reaches with little riparian vegetation (Ward). When the slough was dredged to improve surface water connectivity, dredge spoils were spread on the banks of the slough, creating open gravel bar areas on the banks. There has only been limited effort to revegetate the disturbed banks. The riparian zone along Haskell Slough has 0.57 mile of dense, young vegetation and 0.30 mile of bare earth (Michalak in prep., as cited in SBSRTC 2002).

Water Quantity

The Haskell Slough dike impairs flushing flows into Haskell Slough, and impairs groundwater connectivity between the Skykomish River and the upper end of the slough, particularly affecting base flows (Chamblin, Ward). Habitat creation would likely benefit from periodic flushing flows through Haskell Slough.

Water Quality

No information was available on water quality.

Action Recommendations

The following ranked habitat restoration actions are recommended for the Haskel Slough watershed:

- Modify or remove Haskell Slough dike to restore surface water and groundwater connectivity between the Skykomish River and Haskell Slough
- Restore/actively encourage beaver recolonization in the watershed
- Restore riparian function, where impaired

Woods/EF Woods Creek 07.0826, Richardson Creek 07.0828, WF Woods Creek 07.0831,Carpenter Creek 07.0836, Unnamed 07.0841, and tributaries

General

Woods Creek is a RB tributary to the Skykomish River, entering at RM 25.05 (Williams et al. 1975). The Woods Creek watershed drains an estimated 41,280 acres (SBSRTC 2002 Draft).

Fish Access

The WDFW Fish Passage Database (February 2002) includes inventory of 61 culverts in the Woods Creek watershed. The following culverts are included in the inventory:

Stream	Road Crossing	River Mile	Barrier Status
Cutthroat Creek	Woods Creek Rd	0.038	Yes
Richardson Creek	132nd St SE	1.06	Yes
Unnamed 07.0829	Private driveway	0.055	Unknown
Unnamed LB to Woods at RM 5.0	Florence Acres Rd	0.02	Yes
Unnamed 07.0841	Hand Rd	0.025	Yes
Unnamed 07.0841	275th	0.4	Yes
Unnamed 07.0841	275th	0.65	Yes
Unnamed LB to Woods at RM 7.0	Hand Rd	0.3	No
Unnamed RB to EF Woods at RM 6.7	263rd St	0.4	Unknown
Unnamed RB to EF Woods at RM 6.7	263 spur rd	0.25	Unknown
Unnamed 07.0842	Private Drive	0.5	Yes
Unnamed 07.0842	263rd St	0.55	No
Unnamed 07.0842	Port Blakely log Road	0.55	Unknown
Unnamed 07.0832	227th Ave SE	0.4	Yes
Unnamed 07.0832	116th St SE	0.45	Yes
Unnamed 07.0832	Private	1.35	Unknown
Unnamed 07.0832	Private	1.45	Yes
Unnamed 07.0832	Powerline rd	1.5	Yes
Unnamed 07.0832	Wagner Rd	1.51	Yes
Unnamed 07.0832	Wagner Rd	1.57	Yes
Unnamed 07.0832	Private	1.6	Yes
Unnamed 07.0832	Wagner Rd	1.65	Yes
Unnamed 07.0832	Wagner Rd/powerline	1.85	Yes
Sorgenfrei Creek	Private Road (217th)	0.1	Yes
Sorgenfrei Creek	Driveway	0.35	Yes
Sorgenfrei Creek	Private field access	0.6	Unknown
Sorgenfrei Creek	Private field access	0.65	Unknown
Sorgenfrei Creek	Private rd	0.68	No
Sorgenfrei Creek	Dubuque Rd	0.85	Yes
Unnamed LB to Carpenter at RM 1.1	Dubuque Rd	0.1	Yes
Unnamed LB to Carpenter at RM 1.15	Dubuque Rd	0.2	Yes
Unnamed LB to Carpenter at RM 1.2	Pipeline rd	0.4	Yes
Unnamed RB to Carpenter at RM 1.2 (0836C)	183rd	0.35	Yes
Unnamed RB to Carpenter at RM 1.2 (0836C)	Pipeline rd	0.65	Yes
Unnamed LB to Carpenter at	Creswell Rd	0.15	Unknown

RM 3			
Unnamed LB to Carpenter at RM 3	Abandoned rd	0.14	Unknown
Unnamed RB to Carpenter at RM 2.85	OK Mill Rd	0.25	Yes
Unnamed RB to Carpenter at RM 2.85	Creswell Rd/191 Dr SE	0.6	No
Unnamed RB to Carpenter at RM 3.3	Carpenter Creek Rd	0.1	Yes
Unnamed 07.0837	Sanders Rd	0.2	Yes
Unnamed 07.0837	Private rd	0.22	Yes
Unnamed 07.0837	Logging rd	0.62	Unknown
Unnamed 07.0837	Sanders Road extension	0.65	Yes
Unnamed RB to Carpenter ~1.4 RM N of 0837	Carpenter Creek Rd	0.5	Unknown
Unnamed LB trib to Carpenter at RM 3.3	201st St	0.4	Yes
Unnamed RB to Carpenter (0836B)	N Carpenter Creek Rd	0.15	Yes
Unnamed RB to Carpenter entering just east of 0836B	N Carpenter Creek Rd	0.15	Yes
Unnamed RB to Carpenter entering ~0.95 miles west of Robe-Menzel/ Carpenter Road intersection	N Carpenter Creek Rd	0.15	Yes
Unnamed RB to Carpenter entering ~0.45 miles west of Robe-Menzel/ Carpenter Road intersection	N Carpenter Creek Rd	0.15	Yes
Carpenter Creek	N Carpenter Creek Rd	5.0	Unknown
Carpenter Creek	Gravel pit access	5.27	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone. There is an apparent absence of culvert inventory information for the upper portion of WF Woods Creek.

Additionally, there are two perched culverts (upstream of OK Mill Road and along 191st) that are likely barriers on the right-bank tributary of Carpenter Creek at RM 2.85 (Carroll). In total, approximately 780 m (.44 miles) of stream in the Woods Creek watershed are encased in culverts. Of the 50 culvert crossings that have been evaluated, 46 are either identified as barriers (partial or complete) or have unknown barrier status. Many of these block fish access to good upstream low-gradient spawning and/or rearing habitat. Many of the identified barriers are partial barriers that block adult access at certain flows and likely block upstream juvenile access. There are numerous barriers on the Wagner Hill tributaries, of which many are complete barriers (Ward). Identified culvert barriers with the greatest restoration potential are likely those located on Unnamed 07.0832 and Unnamed 07.0833 (Chamblin, Ward). Although the culvert inventory may be relatively complete for anadromous waters in the Woods Creek watershed, there are additional culverts upstream of impassable natural barriers that impede/preclude resident salmonid passage that are not included in the inventory (e.g., culverts under Lake Roesiger Road)(Chamblin).

Anadromous access in Woods Creek extends to a natural impassable falls at RM 7.3 (Williams et al. 1975). Resident cutthroat are present throughout the watershed upstream of the falls, and there is a self-perpetuating population of kokanee in Lake Roesiger that utilize most of the tributaries to the lake for spawning (Chamblin). Culverts around the lake impair kokanee access upstream of the lakeshore roads (Chamblin); Snohomish County replaced the two major culverts that were blocking upstream passage of kokanee in 2000 (Carroll).

Floodplain Modifications

Availability of suitable off-channel habitat has been reduced, with the most significant losses occurring in the lower reaches (Thorn et al. 1992, as cited in SBSRTC 2000). Aerial photos show numerous historic channels in lower Woods Creek (Ward). Disconneciton of these channels from Woods Creek appears to be the result of channel migration, rather than from disconnection by human activity. Some of the remnant channels currently function as wetland habitat, while others have been filled. There are no dikes or levees to control flooding, but floodplain wetlands have been drained and filled. Residential and agricultural filling of wetlands has been the main cause. Lack of beaver activity has reduced floodplain function throughout the watershed. The lower ends of tributaries to Lake Roesiger (downstream of the lakeshore roads) are encroached on and confined by residential development on the lake shoreline.

Channel Conditions

LWD recruitment has been reduced by logging and agricultural/residential use of the riparian area, leaving predominantly deciduous stands, degrading summer and winter rearing habitat, pool habitat, and increasing predation (Woods Creek Watershed Analysis 1993, as cited in Loch 2000). LWD sampling indicated 1.1 pieces/bankfull width in Timber Creek, 3.53 pieces/bankfull width in Lake Roesiger Creek (both samples upstream of anadromous zone), 0.1 pieces/bankfull width in Sister of Friar Creek (07.0832), 0.41 pieces/bankfull width in Richardson Creek, and 0.43 pieces/bankfull width in Sorgenfrei Creek (07.0840)(Loch 2000). LWD presence is characterized as somewhat better in upper WF Woods and Carpenter creeks than through the rest of the watershed, but even there LWD condition would likely rate as fair/poor (Chamblin, Ward).

Increased bank erosion and channel incision are evident on Woods Creek downstream of the forks and in the lower 2 miles of WF Woods Creek, likely associated with lack of riparian function through this area (Ward).

Substrate Condition

Woods Creek carries high levels of sediment during storm events (Cusimano and Coots 1997, as cited in SBSRTC 2002). Pebble count data from the Tulalip Tribes indicate fine sediment (grain size less than 2 mm) levels of 51.74% in Timber Creek, 19.73% in Lake Roesiger Creek (both upstream of natural anadromous barrier), 17.78% in Sorgenfrei Creek (07.0840), 19.61% in Sister of Friar (07.0832), and 28.31% in Richardson Creek (Loch 2000, as cited in SBSRTC 2002 Draft). A 1984 physical stream survey by the Tulalip Tribes estimated cobble embeddedness >35% throughout the watershed, exceptions being in higher gradient reaches where scour occurs (Thorn et al. 1992, as cited in SBSRTC 2002). Fine sediment from timber harvest, mass wasting, residential development, and agriculture on slopes and soils of all classes is reducing pool volume and spawning gravel area, and degrading spawning and winter rearing habitat watershed-wide

(Woods Creek Watershed Analysis 1993, as cited in Loch 2000). TAG participants question whether the limited samples can be effectively utilized to characterize the very diverse substrate conditions found through the watershed (Chamblin, Ward, Bails).

Riparian Condition

Riparian shade from existing stands, or resulting from residential, agricultural, and road construction is not meeting target shade values, which degrades summer rearing habitat (Woods Creek Watershed Analysis 1993, as cited in Loch 2000). Shade sampling by Andy Loch of the Tulalip Tribes in 4 reaches of WF Woods Creek in 1993 identified shade ranging from 0-30%. Sampling in 5 reaches in 2000 found one reach on Sister of Friar Creek with 56% canopy closure, Richardson and Lake Roesiger creeks ranging from 83-87% canopy closure, and Timber and Sorgenfrei creeks ranging from 90-99% canopy closure (Loch 2000).

Review of aerial photos provided by Snohomish County (2001) indicates that riparian condition is highly variable throughout the watershed. Areas with notable absence of riparian vegetation include Woods Creek below the forks, the lower 2 miles of WF Woods Creek, Sister of Friar Creek (07.0832), and pasture areas on upper WF Woods and Carpenter Creek. Opportunities for riparian restoration exist, particularly where large commercial farms are being subdivided into smaller non-commercial farms (Ward). Most of the watershed area upstream of the falls on Woods Creek and in the Lake Roesiger watershed is currently in forest management. Much of the forest cover has been recently harvested, and review of aerial photos indicates limited remaining mature riparian forest cover, although the kokanee spawning occurs mostly in confined ravines upstream of the lake where riparian condition is generally good (Ward).

EF Woods Creek has 56% Mixed Forest, 3% Mature Evergreen Forest, and 59% Total Forest Cover w/in 300 feet of streams and waterbodies; lower Woods Creek has 26% Mixed Forest, 0% Mature Evergreen Forest, and 26% Total Forest Cover within 300 feet of streams and waterbodies; WF Woods has 45% Mixed Forest, 0% Mature Evergreen Forest, and 45% Total Forest Cover within 300' of streams and waterbodies (Purser and Simmonds, 2001, as cited in SBSRTC 2002). While there is little mature evergreen forest, there is a relatively high percentage of mixed forest.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Woods Creek watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Lower Woods Cr	0	26	20	38	3	12	1	0
Woods Cr	3	56	28	9	0	3	0	0
WF Woods Cr	0	45	35	14	1	5	0	0

Water Quantity

WF Woods Creek maintains a flow year round even during drought conditions (Thorn et al. 1992, as cited in SBSRTC 2002). Woods Creek drains ~60 mi^2, with an average annual flow of 155 cfs (Loch 2000). Summer low flows have been recorded at ~20 cfs, and winter peak flows near 300 cfs (Williams et al. 1975, as cited in Loch 2000). Rain-on-snow zone associated peak flow impacts are probably occurring and could increase; however, evidence of adverse effects on fish habitat, channel conditions, and public works was not observed (Woods Creek Watershed Analysis 1993, as cited in Loch 2000).

Total impervious area is modeled at 19% in lower Woods Creek, at 3% for EF Woods Creek, and at 5% for WF Woods Creek (Purser and Simmonds 2001, as cited in SBSRTC 2002).

Water Quality

Ecology water quality sampling in 1993 indicated that Woods Creek appears to be the most anthropogenically affected tributary to the Skykomish River (Cusimano 1995). Nutrients, total organic carbon, and chlorophyll *a* were high, suggesting the creek may be eutrophic.

Water quality in the upper watershed meets state standards for dissolved oxygen, temperature, and turbidity; however, fecal coliform bacteria standards were violated 39% of the time, and nitrate concentrations were elevated (1.0 mg/l)(Snohomish County Public Works 2000). The water quality site near the mouth of Woods Creek has consistently violated fecal coliform bacteria standards, and Ecology has found high nutrients, total organic carbon, and chlorophyll *a* concentrations in Woods Creek in the summer, indicating that the creek is impacted by development (Cusimano 1995, as cited in Snohomish County Public Works 2000). Woods Creek is on the 1998 303(d) list for fecal coliform bacteria (5 reaches including the WF).

Water temperature monitoring data for the Woods Creek watershed are limited. Timber Creek had a maximum average temperature of 13.23°C for 19 days in August; Lake Roesiger Creek had a maximum average temperature of 13.31°C (56 °F) for 27 days in August; Richardson Creek had a maximum average temperature of 15.84°C for 19.4 days in August, and 14.21°C for 30 days in September (Loch 2000).

A Metal Tolerance Index (MTI) of 2.37 indicates that Lake Roesiger Creek may have significant loading of metals (Loch 2000).

Biological Processes

Electrofishing in 1998 found similar total numbers of salmonids caught at each of the 5 sampling sites (Loch 2000). Casual observations indicate that sample sites not accessible to coho, resident trout are utilizing the habitat that otherwise might have been occupied by coho. Richardson Creek had an interesting anomaly. Research has shown that cutthroat trout tend to dominate over coho in degraded streams; Richardson Creek was the most degraded stream surveyed. Coho outnumbered cutthroat 39 to 3 in the sample from Richardson Creek. One possibility is that the mussel population (*Margaritifera falcate*) population in Richardson Creek may be suppressing cutthroat populations. Resident cutthroat are exposed to a parasitic life stage (glochidia) of the mussels, which increases susceptibility to secondary infection by bacteria or fungi and causes death (Trotter 1997, as cited in Loch 2000). An alternative possibility is that the increased coho productivity in upper WF Woods and Carpenter creeks may be associated with greater presence of large beaver ponds (Chamblin).

Action Recommendations

The following ranked habitat restoration actions are recommended for the Woods Creek/Carpenter Creek watershed:

- Protect forest cover and forest hydrology where remaining

- Restore riparian function, where impaired, with particular emphasis on lower Woods Creek, the lower 2 miles of WF Woods Creek, and where impaired through agricultural areas in upper WF Woods and Carpenter creeks
- Prevent unrestricted livestock access to streams
- Prioritize and correct identified barriers in anadromous portion of watershed; assess and correct barriers that impair kokanee access to spawning areas in tributaries to Lake Roesiger, and that impair resident trout access in the upper watershed

Unnamed 07.0857

General

Unnamed 07.0857 is a RB tributary to the Skykomish River, entering at RM 26.4 (Williams et al. 1975).

Fish Access

The WDFW Fish Passage Database (February 2002) includes inventory of the following culverts in the Unnamed 07.0857 watershed:

Stream	Road Crossing	River Mile	Barrier Status
Unnamed 07.0857	SR 2	0.01	No
Unnamed 07.0857	BNSF Railroad	0.02	Yes
Unnamed 07.0857	BNSF Railroad	0.7	Unknown
Unnamed 07.0857	SR 2	0.85	Unknown
Unnamed 07.0857	Private drive	1.25	Unknown
Unnamed 07.0857	Private field access	1.27	Yes
Unnamed 07.0857	Private drive	1.5	Unknown
Unnamed RB to 07.0857 at RM 1.9	Sophie Rd	Mouth	Unknown
Unnamed RB to 07.0857 at RM 1.9	BNSF Railroad	0.21	Unknown
Unnamed 07.0857	Sophie Rd	1.9 (2.3)	Yes
Unnamed 07.0857	BNSF Railroad	0.24 (2.4)	Unknown

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Floodplain Modifications

Unnamed 07.0857 is a relict floodplain river channel. There are no identified floodplain concerns.

Channel Conditions

The channel is composed mainly of pools and glides; there is a lack of LWD throughout (Chamblin).

Substrate Condition

Substrate is composed primarily of fines across the floodplain, with some gravels as the creek moves up off the valley floor (Chamblin).

Riparian Condition

Riparian condition is variable, but generally poor (Chamblin). The lower end of the channel is choked with reed canary grass, and there are a few short reaches with riparian trees.

Water Quantity

Contributing hydrology from the bluff to the north appears to be intercepted by SR 2 and BNSF Railroad fills (properties to the north of the fills are substantially wetter than properties to the south of the fill), and routed to the western end of the channel (Chamblin). There appears to be substantial contribution of groundwater flow on the floodplain, as there is more flow than would be indicated by runoff from the bluff.

Water Quality

No water quality data are available.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0857 watershed:

- Restore riparian function throughout agricultural lands on the floodplain
- Restore LWD presence to provide instream habitat diversity until riparian function is restored
- Assess, prioritize and correct identified barriers

Barr Creek 07.0858 and Kissee Creek 07.0859

General

Barr Creek is a LB tributary to the Skykomish River, entering at RM 28.2(Williams et al. 1975). Unnamed 07.0859 is a RB tributary to Barr Creek at RM 0.1.

Fish Access

Anadromous salmonid access to Barr Creek for species other than steelhead is blocked by a natural falls at RM 0.9, upstream Ben Howard Road; steelhead are capable of accessing further upstream to the next natural falls at RM 1.4.

The following culverts are included in the WDFW Fish Passage Database (February 2002) for the Barr Creek watershed:

Stream	Road Crossing	River Mile	Barrier Status
Lk Fontal trib 07.0858	20600 Rd	NA	Yes
Unnamed 07.0859	Ben Howard	0.5	Yes

Unnamed 07.0859	Wilner	0.5	Yes
Unnamed 07.0859	Ben Howard	0.6	Unknown
Unnamed 07.0861	2800 Rd	0.75	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Floodplain Modifications

No floodplain concerns are identified for Barr Creek. Except for two reaches, most of Kissee Creek is channelized in a ditch along Ben Howard Road. Upstream of Ben Howard Road, there is a 400-foot reach crossing a developed parcel after coming off the hill; most of this reach has been meandered through a wetland along a private drive. The lower 1,000 feet of Kissee Creek diverges from Ben Howard Road across a field before meeting Barr Creek and flowing into the Snohomish River. In the past, Snohomish County has dredged the channel along Ben Howard Road to avoid road flooding (Chamblin, Carroll). There has been some discussion of relocating the channel in a more normal channel configuration away from the road on the north side.

Channel Conditions

LWD and pools are generally absent in the channelized/ditched portions of Kissee Creek.

Substrate Condition

No information is available on substrate conditions, although substrate in Kissee Creek is affected by repeated dredging of the roadside ditch along Ben Howard Rd.

Riparian Condition

Riparian vegetation is generally absent on the anadromous accessible portions of Barr and Kissee creeks. Recent riparian restoration projects have been done upstream of Ben Howard Road on Kissee Creek and just north of Ben Howard Road on Barr Creek (Bails).

Water Quantity/Water Quality

No water quantity or water quality data are available.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Barr/Kissee Creek watershed:

- Restore natural channel configuration, floodplain function, riparian function, and beaver presence on Kissee Creek north of Ben Howard Rd
- Prioritize and correct identified fish passage barriers

Eagle Creek 07.0862

General

Eagle Creek is a RB tributary to the Skykomish River, entering at RM 28.25 (Williams et al. 1975).

Fish Access

The WDFW Fish Passage Database (February 2002) includes inventory of the following culverts in the Unnamed 07.0857 watershed (note that culverts on 07.0862 are designated in the culvert database as on 07.0857):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed 07.0862	BNSF Railroad	0.85	Yes
Unnamed 07.0862	151st	0.25	Yes
Unnamed 07.0862	Abandoned rd	0.95 (1.6)	Yes
Unnamed 07.0862	Old Owen Rd	1.0	No
Unnamed 07.0862	Private rd	1.1	Unknown
Unnamed 07.0862	Private rd	1.25	Yes
Unnamed 07.0862	Field access	1.29	Unknown
Unnamed 07.0862	Private field access	1.31	Yes
Unnamed 07.0862	Private field access	1.32	Unknown
Unnamed 07.0862	259th Ave SE	1.35	Unknown

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Floodplain Modifications/Channel Conditions/Substrate Condition

No information is available on floodplain modifications, channel conditions, or substrate conditions.

Riparian Condition

Review of aerial photos provided by Snohomish County (2001) indicates that the lower 0.5 mile (located on the Skykomish floodplain) is wooded, but there appears to be a lack of species or age diversity. Riparian condition in the upstream 0.4 miles appears to be poor where the creek flows through residential and agricultural areas. Riparian condition where the creek flows off the bluff appears to be good.

Water Quantity/Water Quality

No water quantity or water quality information is available.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0862 watershed:

- Assess habitat conditions, correct identified problems

- Restore riparian function through residential and agricultural areas in middle portion of watershed; enhance riparian species and age diversity in lower 0.5 mile

Unnamed 07.0863 and Unnamed to east

General

Unnamed 07.0863 is a RM tributary entering the Skykomish River at RM 29.3 (Williams et al. 1975). The Unnamed RB slough to the east enters the Skykomish River at RM 29.6.

Fish Access

No salmonid presence is known in either of these tributaries, but both are low gradient channels located on the Skykomish River floodplain that should be capable of supporting salmonid rearing and possible spawning (Chamblin, Ward).

The WDFW Fish Passage Database (February 2002) includes inventory of the following culverts in the Unnamed 07.0857 watershed (note that culverts on 07.0862 are designated in the culvert database as on 07.0857):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed 07.0863	BNSF Railroad	0.0	Unknown
Unnamed 07.0863	Below SR 2, old access	0.25	No
Unnamed 07.0863	SR 2	0.3	No
Unnamed east of 07.0863	SR 2	0.8	Unknown
Unnamed east of 07.0863	SR 2	1.6	Unknown

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Floodplain Modifications/Channel Conditions/Riparian Condition

Floodplain and channel conditions have been highly modified in Unnamed 07.0863, where the lower 0.25 mile is channelized between SR 2 and BNSF Railroad. The creek receives groundwater input from the Skykomish floodplain to the east, as well as runoff from the bluff to the north. Riparian vegetation is limited to grass downstream of SR 2.

The Unnamed slough located ~0.3 mile east of Unnamed 07.0863 is a relict historic floodplain river channel. It provides excellent side channel slough habitat conditions, and is fringed on the left-bank side by a parcel of mature forest with beaver dams and crisscrossed channels (Ward). This entire area backwaters during high flows in the Skykomish River, but it is unclear whether there is an open water connection between the slough and the river at low river flows. Riparian condition on the left-bank of the slough is good, but condition on the right-bank is fair/poor along the edge of an agricultural field.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0863 and Unnamed slough to the east watersheds:

- Protect integrity of Unnamed slough entering the Skykomish River at RM 29.6, and the parcel of high quality floodplain habitat between the slough and the Skykomish River
- Assess opportunities to improve open water connection with slough at low river flows
- Assess fish passage status at inventoried culverts with unknown passage status, correct any identified barriers
- Assess opportunities to reconfigure channel on Unnamed 07.0863 in a manner that would restore habitat functions

Unnamed 07.0864

General

Unnamed 07.0864 is a RB tributary to the Skykomish River, entering at RM 31.2 (Williams et al. 1975).

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed 07.0864	Fern Bluff Rd	0.6	Yes
Unnamed 07.0864	BNSF Railroad	0.65	Yes
Unnamed 07.0864	SR 2	0.67	No
Unnamed RB to 07.0864 at SR 2	SR 2	0.0	Yes

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

There are a couple of known bad culverts in the watershed, one of which may be the culvert on Fern Bluff Rd, but formal fish passage status has not been evaluated (Bails).

Floodplain Modifications

Downstream of SR 2, the creek flows through agricultural land; the channel has been dredged several times over the years in this reach, likely affecting natural channel configuration (Bails).

Channel Conditions/Substrate Condition

No data are available on channel or substrate conditions. Repeated dredging and lack of riparian vegetation through the agricultural area likely contributes to a lack of LWD. Landowners indicate there was substantial fine sediment runoff subsequent to timber harvest on the bluff upstream of SR 2, but specific impacts to substrate condition have not been evaluated (Bails).

Riparian Condition

The creek downstream of SR 2 is filled with reed canary grass, and there is a lack of riparian vegetation (Bails). Little riparian vegetation was left through the forest harvest unit upstream of SR 2.

Water Quantity/Water Quality

No water quantity information is available. No quantitative water quality information is available, but water temperature is likely high due to lack of riparian cover, and water quality may be adversely impacted by close proximity to manure storage areas on farms (Bails).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0864 watershed:

- Restore riparian function through the agricultural area downstream of SR 2, and through the forest harvest unit upstream of SR 2
- Assess fish passage status at culverts, correct identified fish passage barriers
- Implement land use alternatives that eliminate the need for repeated dredging of the channel through the agricultural area

Groeneveld Creek 07.0864B

General

Groeneveld Creek (Unnamed 07.0864B) is a RB tributary to the Skykomish River, entering at RM 32.4 (Williams et al. 1975).

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002)(note that culverts in this tributary are noted in the database as located on 07.0012):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed 07.0864B	Private drive	0.19	Unknown
Unnamed 07.0864B	BNSF Railroad	0.2	Yes
Unnamed 07.0864B	SR 2	0.2	Yes
Unnamed 07.0864B	Old Owen Rd	0.4	Unknown

Problem culverts downstream of SR 2 have been upgraded for fish passage (Bails). The culverts at SR 2, BNSF Railroad, and a private driveway just below SR 2 remain as partial barriers to upstream migration.

Floodplain Modifications

Most of the area from SR 2 to the mouth has unrestricted livestock access, and has been channelized and dredged to maintain agricultural drainage (Bails). Old Owen Road severely constricts the creek through a deep narrow ravine, resulting in heavy bank erosion and sediment transport to the end of the ravine near Reiner Rd.

Channel Conditions/Substrate Condition/Riparian Condition

LWD is absent from the channel downstream of SR 2, and there is substantial bank erosion through this reach due to unrestricted livestock access and lack of riparian vegetation (Bails). A riparian restoration project was recently completed, restoring riparian vegetation on ~2,000 feet of bank, including some LWD placement.

Water Quantity/Water Quality

Water temperature monitoring in 2001 found that temperatures were below state water quality standards (Bails).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Groeneveld Creek watershed:

- Restore riparian function downstream of SR 2
- Correct identified fish passage barriers in the vicinity of SR 2
- Implement land use alternatives that eliminate the need for repeated dredging of the channel through the agricultural area

Unnamed 07.0864A (Groeneveld Slough)

General

Unnamed 07.0864A is a RB tributary/slough/side channel to the Skykomish River, with the upstream end diverging form the Skykomish River at the downstream end of the Sultan training dike, and rejoining the Skykomish mainstem at RM 32.9 (Williams et al. 1975). There is one prominent channel and several smaller flood channels that braid around it (Ward). It backwaters frequently each winter since the downstream confluence is quite low. The upstream end floods during high water conditions, just enough to receive a good flush nearly every year. In low water, there are several deep pools that persist through summer, likely supported by substantial groundwater flow. The riparian condition is good, although primarily deciduous. It was logged in the 1920s and has regenerated naturally; the landowner is interested in harvesting the timber again. It is mostly mature black cottonwood and big-leaf maple with a dense understory. The entire length of the channel is well-shaded. Juvenile coho and adult chum have been observed in the pools; juvenile salmonids could easily over-summer in the pools. Potential restoration activity would include establishment of a coniferous component in the riparian forest and a feasibility study to enhance flow frequency. A first round SRFB grant was approved to excavate the channel, although the necessary permits could not be secured by the project sponsor and the funding has since expired.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0864A watershed:

- Protect integrity of current mature riparian forest
- Restore conifer presence in riparian forest

- Assess feasibility and potential benefit of enhancing Skykomish River flows through this watershed

Elwell Creek 07.0865, Unnamed 07.0866, and Youngs Creek 07.0870

General

Elwell Creek is a LB tributary to the Skykomish River, entering at RM 31.8 (Williams et al. 1975). Land use in the entire watershed is forestry, except in the lower 0.5 mile, which has some residential development adjacent to the creek (Chamblin).

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Elwell Creek	Logging spur rd	4.9	Yes
Elwell Creek	21000 Rd	5.25	Yes
Unnamed 07.0866	Cedar Ponds Rd	NA	Yes
RB to 07.0866 at RM 0.07	Cedar Ponds Rd	0.1	Yes
RB to RB to 07.0866 at RM 0.07	Private drive	0.01	Yes
Unnamed 07.0869	NA	0.5	Unknown

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Floodplain Modifications

The right-bank is diked for ~400 feet upstream of Ben Howard Road to protect the bridge structure at peak flows, and the left-bank is armored to protect bank erosion at residences (Chamblin).

Channel Conditions/Substrate Condition/Riparian Condition

Little information is available on habitat conditions in the watershed. Stream gradient is pretty steep upstream of ~RM 2. Riparian condition of the lower 0.5 mile is generally <40 year old regrowth, with little riparian buffer left at the time it was logged (Chamblin).

Water Quantity/Water Quality

Habitat is low-flow limited in the summer, but there is no indication that flows have been significantly altered from natural conditions (Chamblin).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Elwell/Youngs Creek watershed:

- Protect watershed function through protection of forest cover and natural forest hydrology
- Assess habitat conditions, correct identified problems
- Prioritize and correct identified fish passage barriers

McCoy Creek 07.0876, Tychman Slough 07.0877, and tributaries

General

McCoy Creek is a LB tributary to the Skykomish River, entering at RM 33.4 (Williams et al. 1975). Tychman Slough is a floodplain side channel of the Skykomish River (from RM 33.4 to RM 36.0) that enters McCoy Creek just downstream of Mann Road Unnamed 07.0878 and 07.0879 are RB tributaries to Tychman Slough entering at RM 1.0 and 1.5, respectively.

Fish Access

Anadromous salmonid access to upper McCoy Creek for species other than steelhead is blocked by a natural falls at RM 0.3, just upstream of Mann Rd.; steelhead are capable of accessing further upstream to the next natural falls at RM 1.6.

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
McCoy Creek	Ben Howard Rd	0.15	No
Unnamed LB to Unnamed 07.0877 at RM 0.5	Ben Howard Rd	0.0	Yes
Unnamed LB to Unnamed 07.0877 at ~RM 0.5	Mann Rd	0.0	Yes
Unnamed 07.0878	Mann Rd	0.01	Unknown
Unnamed 07.0879	Private drive	0.2	Unknown
Unnamed 07.0879	Driveway	0.35	Unknown
Unnamed 07.0879	Private drive	0.4	No
Unnamed 07.0879	Mann Rd	0.5	No
Unnamed 07.0879	Mann Rd	0.55	No

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Don Farwell (City of Everett watershed forester) indicates presence of an old hydro dam further upstream; the base of the dam has a hole blown through it, so there is no storage. The stream gradient in the reach where the old dam is located may be too steep for salmonids, but fish passage status is unknown. He also indicates there are more stream crossings present than indicated in the WDFW culvert database.

Floodplain Modifications

Unnamed 07.0879 from Mann Road downstream for some distance has been dredged several times over recent years to remove accumulated gravels being transported from upstream (Chamblin). The dredging occurs where the streams transitions from higher gradient to the floodplain, and it is unknown to what extent gravel deposition has been affected by upstream land use activities. No information was available on floodplain modifications in the other streams in this watershed.

Channel Conditions

LWD condition is poor or absent in the dredged section of Unnamed 07.0879. No information was available on LWD presence in the other streams in this watershed, although LWD recruitment is likely limited in Tychman Slough and Unnamed 07.0879, which flow through agricultural areas with little riparian vegetation. LWD recruitment in McCoy Creek and Unnamed 07.0878 is likely also limited due to past timber harvest activities.

Substrate Condition

No information was available on gravel availability or quality in this watershed. See the Floodplain Modifications section above regarding dredging of gravel from Unnamed 07.0879

Riparian Condition

Review of aerial photos provided by Snohomish County (2001) indicates that riparian condition is generally poor through the agricultural/residential areas on Tychman Slough and Unnamed 07.0879, and that riparian vegetation on McCoy Creek and Unnamed 07.0878 is generally regenerating forest stands.

Water Quantity/Water Quality

No information was available on water quantity or water quality concerns in the streams in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the McCoy Creek watershed:

- Prioritize and correct identified fish passage barriers
- Restore natural floodplain function in Unnamed 07.0879 downstream of Mann Road
- Restore riparian function where impaired on Tychman Slough and Unnamed 07.0879

Yonkers Slough 07.0877A

General

Yonkers Slough was a LB floodplain side channel slough of the Snohomish River entering at ~RM 34.7, and extending upstream to ~RM 35.6 (Williams et al. 1975). The 1996 flood resulted in a channel change, eliminating surface flow into Yonkers Slough (Chamblin). The landowner placed fill in the lower 0.3 miles of the dry channel and converted the area to agriculture, eliminating floodplain function and associated salmonid habitat. No information was available on what surface hydrology remains in the upper portion of Yonkers Slough. Review of aerial photos provided by Snohomish County (2001) indicates that some good stands of riparian vegetation remain along portions of the channel that existed prior to the 1996 channel alterations.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Yonkers Slough:

- Assess whether surface hydrology remains in the upper portion of Yonkers Slough
- Restore opportunity for natural floodplain function in this naturally braided section of the Skykomish River floodplain
- Protect parcels of remaining mature vegetation in this naturally braided portion of the Skykomish River floodplain

Sultan River 07.0881, Trout Farm Creek 07.0881A, Winters Creek 07.0882, Ames Creek 07.0883

General

The Sultan River is a RB tributary to the Skykomish River, entering at RM 34.4 (Williams et al. 1975). The Sultan River watershed drains an estimated 110 mi^2 (FERC 1981).

Most logging activity ceased several years ago on public lands in the Sultan River watershed upstream of Culmback Dam. Future timber sales are anticipated to be very limited on public lands and many miles of logging roads have been decommissioned. Over 20,000 acres of State DNR land have been transferred from trust to Natural Resource Conservation Area status (WDNR 1992).

Habitat conditions in Winters Creek are at risk due to rapid development occurring in the watershed (Metzgar, Chamblin). Habitat on Ames Creek is at lower current risk of development, with most of the watershed zoned as 10-acre lots (Metzgar).

Fish Access

The Sultan watershed supports known production of chinook, chum, pink, coho, steelhead, and bull trout/Dolly Varden (see Appendix A and species fish distribution maps). No bull trout/Dolly Varden have been found in creel surveys and net sampling upstream of Culmback Dam (Pfeifer et al. 1998, as referred by Metzgar), or upstream of the diversion dam at RM 9.7 (Metzgar).

The City of Everett diversion dam (RM 9.7) for municipal water supply has blocked fish passage to at least 6.8 miles of river since early in the last century (SBSRTC 2002). Culmback Dam (RM

16.5) blocks upstream and downstream fish passage, but it is not known whether or not anadromous fish could have passed upstream of the site historically. Information available on pre-dam conditions is inadequate to determine suitability for fish passage, although it is assumed that the dam was located upstream of the anadromous zone.

Anadromous salmonid spawning habitat in the Sultan River occurs primarily in the lower river. Pink salmon primarily utilize the lower 3 miles of the river, chum primarily congregate in a RB side channel near Kien's Bar (RM 1.5), chinook and steelhead use the entire river downstream of the RM 9.7 to varying degrees, and coho use side channels and tributaries (Metzgar). Although the diversion dam precludes anadromous salmonid access to 6.8 miles of potential habitat, there are natural factors that limit productivity potential in this area. Channel gradient is steep (≥10%) in the upper end of the reach, but gradient in most of the reach is ~2% . In addition, frequency of natural peak flows impaired upstream migration of adult salmonids and associated spawning activity, resulted in a high risk of scour to redds and alevins, and prematurely flushed fry and juveniles downstream (Metzgar). Habitat conditions upstream of the diversion dam likely favored only steelhead trout because of their freshwater life history. Restoration of steelhead passage upstream of the diversion dam was considered in Sultan River/Jackson Project Stage II mitigation discussions, with the resource agencies accepting hatchery production mitigation in lieu of diversion dam passage. The potential benefits associated with restored passage upstream of the diversion dam are also offset by significantly increased flows during the seasonal low flow period downstream of the diversion dam, and by limiting peak flows in the lower river during the fall spawning season. Restoring anadromous salmonid presence upstream of the diversion dam at RM 9.7 is possible, but would require an associated increase in instream flows in the reach, as well as needing to address other significant technical and environmental issues (Metzgar).

Resident trout (cutthroat, rainbow, and hybrid populations) in Spada Lake are infected with *Diphyllobothrium*, a cestode parasite, which limits growth and recruitment into advanced age groups. Elimination or direct control of the parasite in Spada Lake is virtually impossible (Pfeifer et al. 1998, as cited in SBSRTC 2002 Draft). Thus, restoration of downstream fish passage is of questionable value under present biotic conditions. *Diphyllobothrium* appears to only affect older salmonids rearing in the reservoir, and no effects to salmonid production downstream of the reservoir have been identified (Metzgar).

Trout Farm Creek is accessible year-round; Winters and Ames creeks have limited fish access during low flow periods due to a combination of low tributary flows and shallow higher gradient drops where the creeks enter the Sultan River (Metzgar, Chamblin).

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	**Road Crossing**	**River Mile**	**Barrier Status**
Winters Creek	Trout Farm Rd	0.35	Unknown
Winters Creek	Gohr Rd	0.65	Unknown
Winters Creek	135th St SE	0.8	Unknown
Unnamed LB to Sultan (location NA)	Trout Farm Rd	777 (~0.25)	Unknown
Ames Creek	Reiner Rd	0.5	Yes
Ames Creek	Logging /powerhouse	0.65	Unknown
Ames Creek	Pasture access	0.7	Unknown
Ames Creek	Reiner Rd	0.12 (1.0)	Yes
Ames Creek	Logging access rd	NA (1.2)	Yes

Unnamed LB entering Sultan near RM 2.0 (Trout Farm Creek)	Driveway	0.15	Unknown
Unnamed LB entering Sultan near RM 2.0 (Trout Farm Creek)	Trout Farm Road driveway	0.25	Yes
Unnamed LB entering Sultan near RM 2.0 (Trout Farm Creek)	Trout Farm Rd	0.37	Yes
Ames Creek	Logging access rd	NA (1.4)	Yes
Unnamed RB entering Sultan at RM 3.0	No road name	NA (0.36)	Yes
Unnamed RB to Sultan at ~RM 3.5	Reiner Road (SiteID 101SULT-12)	0.35	Yes
Woods Creek	Pipeline Rd	0.25	Yes
Chaplain Creek	Logging rd	2.0	Yes (resident salmonids only)

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Floodplain Modifications

Floodplain and side channel habitat on the Sultan River are naturally limited downstream of Culmback Dam, due to local geology. Most of the river channel is deeply incised in bedrock from RM 16.5 to RM 3.3. Some off-channel habitat in the lower 3 miles is disconnected from the river from time-to-time due to reduced frequency and duration of high flows, although frequent high flows have been assessed as limiting fish production (Eicher 1981, as cited in SBSRTC 2002). Near the mouth, the shoreline has been mildly affected by residential development and bank hardening, including bank armoring and floodplain confinement upstream of Sportsmens Park in Sultan (Chamblin). Also, there is limited bank armoring (about 100 ft.) and a dam wing-wall at the diversion dam (RM 9.7)(SBSRTC 2002). Less than 10% of the entire shoreline is hardened.

The active channel has likely decreased in width as a result of reduced frequency and magnitude of peak flows resulting from the Sultan Project (Metzgar). Prior exposed gravel bars are being stabilized by vegetation growth, potentially affecting the natural channel dynamics in peak flows.

Five miles of streams are inundated by the reservoir upstream of Culmback Dam (FERC 1981). Water level fluctuations impair benthic productivity in the lower reaches of tributaries to the reservoir and in the reservoir. However, resident fish passage is unimpaired between the reservoir and tributaries (Pfeifer et al. 1998).

Winters Creek has been dredged and straightened through the lower agricultural portion of the watershed (Chamblin, Aldrich). As a result, most coho spawning is limited to the upstream forested portion of the watershed. There is beaver activity in the side channel of the Sultan at the mouth of Winters Creek. No information of floodplain modifications was available for other Sultan River tributaries.

Channel Conditions

The probable source area for much of the historic LWD (channel migration zones) was likely in the upper basin, which has been disconnected from the rest of the lower system since 1965 (SBSRTC 2002). However, LWD produced in areas above the dam would probably have remained there due to the low gradient, extensive braided channel system on the valley floor. The frequency of high flows prior to 1965 through the steep confined canyon reach from Culmback Dam downstream to the BPA powerline crossing at RM 3.3 probably resulted in naturally low LWD presence in the canyon (Metzgar, Chamblin). Any lodging of LWD between the dam site and the mouth of the canyon would likely have lasted only for a short time, until another frequent high peak flow would have overwhelmed the log jam, creating a debris torrent in the channel (Metzgar). Most LWD accumulations downstream of the dam occur primarily in the lower gradient open reach from the base of the canyon (RM 3.3) to the mouth. LWD recruitment to the lower basin is primarily from blow down, root rot, landslide or other natural events, because most of the channel is incised in rock and unable to migrate.

Winters Creek is devoid of LWD and functional pools through the agricultural portion of the lower watershed (Chamblin). No information was available on channel conditions for Ames Creek.

Substrate Condition

Previous and ongoing monitoring document that gravel quantity and quality are being maintained, although Culmback Dam and Spada Lake intercept previous contributions from upstream. Results from four sampling years (1982, 1984, 1987 and 1994) indicate that the percentage of fine sediment in surface gravels is <12% (Miller et al. 1984, as cited in SBSRTC 2002). The sampling period covers pre-and post-construction of Stage II of the Jackson Project. Samples were obtained by tri-tube freeze cores at five locations in four channel bed strata, with gravel sampling sites in productive spawning areas of the river. Those areas are also monitored for scour depth of river channel gravel. Although the frequency and peaks of high flows have been reduced, effective gravel scour still occurs, although the depth of scour has likely reduced (Metzgar). The mean average depth of scour ranges from less than one inch to over 10 inches (SBSRTC 2002).

The amount of sedimentary material produced and transported from the principal source of supply (the Blue Mountain area) is estimated to be in the range of 3,000 yd^3/year (Miller et al. 1984, as cited in SBSRTC). Reduced frequency of peak flows associated with the Jackson Project (see Water Quantity section below) may result in increased deposition of gravels in existing spawning areas, potentially resulting in a net increase of useable spawning habitat (Schuh and Meaker 1995, as cited in SBSRTC 2002). The delivery of sediment has likely increased due to increased numbers of landslides resulting from past timber harvest on unstable slopes, but overall sediment transport in the river has likely reduced due to lower frequency and magnitude of peak flows (Metzgar). Although the sediment transport process has been changed from natural conditions, 17 years of monitoring indicate successful mitigation, thus far, with gravel (SBSRTC 2002).

Gravel presence is naturally limited in the steep confined canyon reach from Culmback Dam downstream to the BPA powerline crossing (RM 3.3), although patches of suitable spawning gravel do exist through the canyon (Metzgar). Sediment transport occurs when the flow reaches 2,500 cfs (SBSRTC 2002). A one-day flow event of 5,000 cfs in the lower reach of the river is capable of transporting accumulated sedimentary material. The lower river historically was gravel supply limited because of natural deposition in a braided channel area above Culmback Dam, which stored gravels delivered from upstream. However, sufficient supply sources exist downstream (Miller et al. 1984, as cited in SBSRTC 2002).

Substrate in the lower portion of Winters Creek has likely been adversely impacted by past dredging and straightening of the channel through the agricultural area (Chamblin). There have also been recent observations of increased turbidity associated with subdivision development in the Winters Creek watershed. In addition, the Sultan Water District has been discharging water at the top of a slope near RM 2.0 on Winters Creek, resulting in erosion of major gullies and delivery of large amounts of sediment to Winters Creek (Carroll). The City of Sultan is looking at alternatives to correct this problem. No information was available on substrate conditions in Ames or Trout Farm creeks.

Riparian Condition

Downstream from Culmback Dam, over 14 miles (85%) are considered to have intact riparian function, with a mature conifer buffer at least 60 years old with a minimum 150-foot width (SBSRTC 2002). From RM 16.5 to RM 9.7, mostly old growth forest lines the banks of the river. From the City of Everett's diversion dam (RM 9.7) to the BPA power lines crossing (RM 3.3) the riparian forest is at least 60 years old and averages about 50 cm in diameter. In addition, good shade is also provided within the canyon reach by the canyon itself (Metzgar). From the powerlines to the confluence with the Skykomish River, riparian vegetation is 30-60 years old, with an estimated ~80% cover.

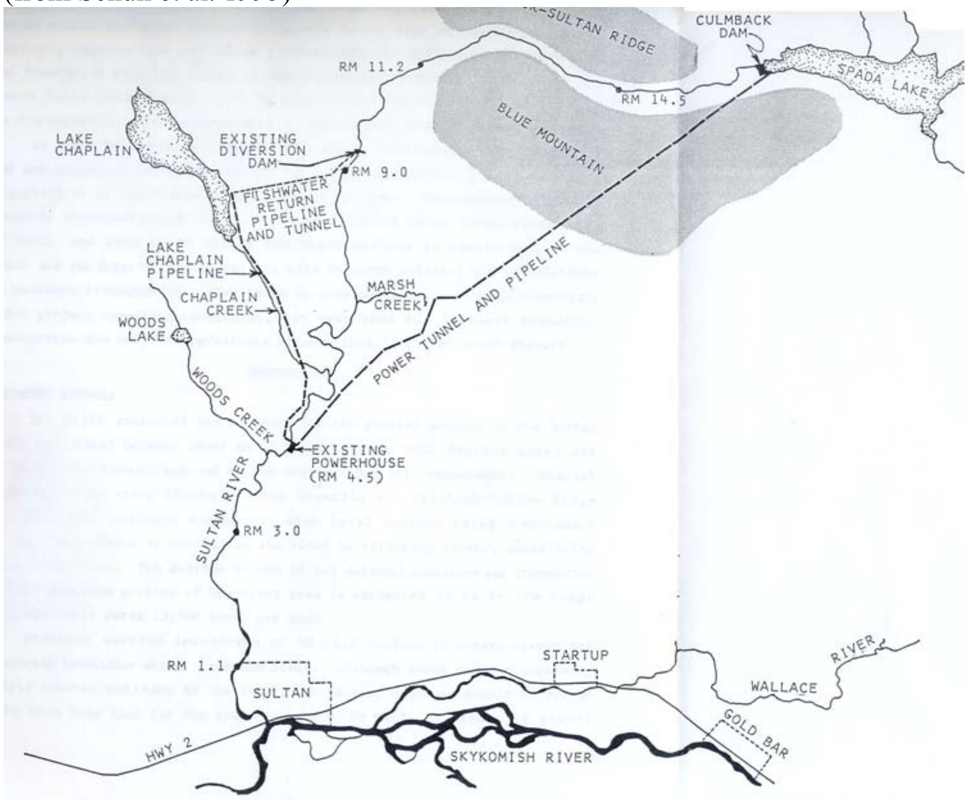
Riparian condition in the lower 2.5 miles of the Sultan River is rated as "moderately degraded" (SBSRTC 2002). From RM 2.5 to RM 1.25, riparian vegetation is composed of a well-stocked mix of conifer and hardwood, about 40 years old. In the lower 1.25 miles of the Sultan River, there is no riparian buffer outside of the channel migration zone (CMZ), although the CMZ probably has always looked like it does now (Farwell 2001, as cited in SBSRTC 2002). Acquisition/protection of riparian areas downstream of the BPA powerlines (RM 3.3) is identified as a priority for chinook protection/restoration in WRIA 7 (SBSRF 2000).

Riparian condition on Winters Creek is rated as poor; much of the riparian zone has been in non-commercial agriculture, and is rapidly being converted to residential (Aldrich, Chamblin). Review of aerial photos provided by Snohomish County (2001) indicates that riparian vegetation is generally sparse to absent on Trout Farm and Ames creeks, and young or absent on Winters Creek; overall, riparian condition on the tributaries rates as poor.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Sultan River watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Lower Sultan	12	62	16	5	1	3	1	2
Upper Sultan	15	45	24	3	1	3	1	8

Figure 20: Map of water delivery infrastructure and routing for Jackson Project (from Schuh et al. 1995)

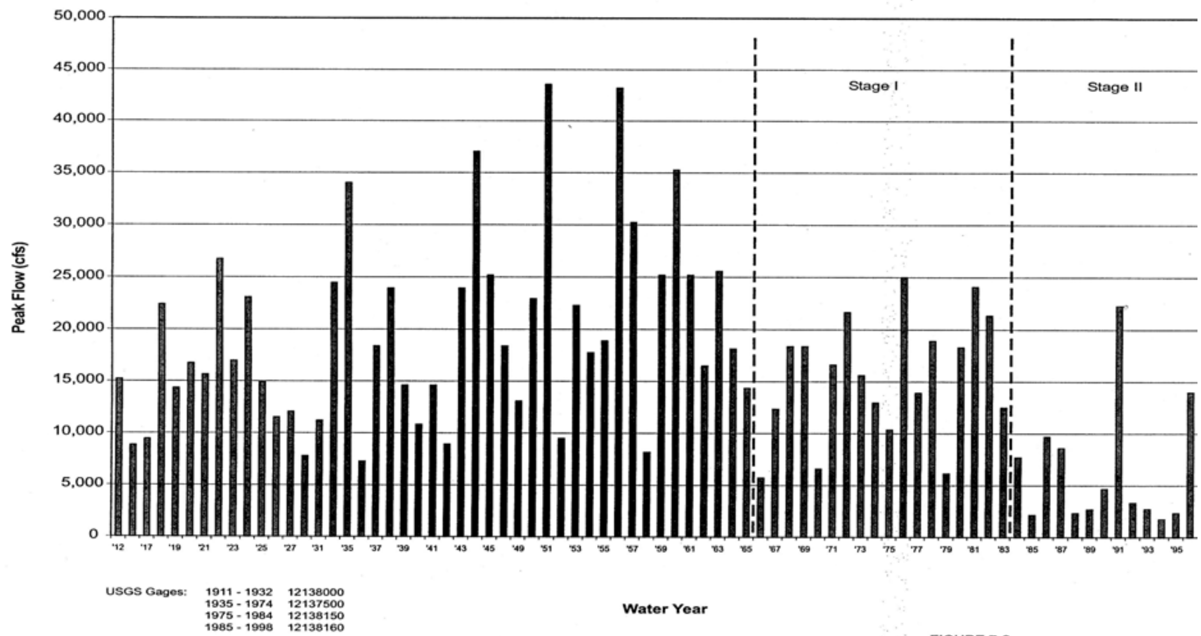


Water Quantity

There are pronounced changes in the hydrograph due to regulation of high flows and augmentation to low flows by Jackson Project operation. Water stored in Spada Reservoir is used for hydroelectric generation, domestic use, and to meet instream flows downstream of Culmback Dam (Metzgar). Water from the reservoir is conveyed through a tunnel and pipe directly to the powerhouse at ~RM 5.5 (Figure 20). Some of the water is spilled to the river at this point, with the remainder conveyed through an enclosed pipe back up to Lake Chaplain, where it is available for instream flow requirements (return flow to the diversion dam through City water diversion facilities), and municipal and industrial use. A minimum instream flow schedule has been established by Federal license and State water rights permit for habitat protection and enhancement. There is an instream flow requirement of 20 cfs plus tributary inflow in the reach from Culmback Dam (RM 16.5) downstream to the diversion dam at RM 9.7. The instream flow schedule ranges from 95 cfs up to 175 cfs at the diversion dam (RM 9.7) and a minimum flow range of 165 to 200 cfs downstream from the powerhouse (RM 5.5) (FERC 1981, 1982, 1983, as cited in SBSRTC 2002). Those requirements are being fulfilled and verified with continuous monitoring and reporting.

Historically, habitat in the reach between the dams (Culmback dam and City of Everett diversion dam) and in the lower river was limited by frequent occurrence of high flows (Eicher 1981, as cited in SBSRTC 2002). Reduction of the frequency, duration and velocity of peak flows has decreased damage to redds, alevins, and juvenile rearing. Under natural (pre-1965) conditions, flows between 2,000 and 5,000 cfs occurred every year on the average of 22 days per year at the diversion dam (Figure 21). The Sultan Project reduces this to only 1 day in 3 years. Flows (pre-

Figure 21: Jackson Project effects to Sultan River peak flow magnitude and frequency (from Snohomish County PUD and City of Everett – Draft 2002)



1965) between 5,000 and 10,000 cfs occurred an average of 2.8 days per year, and for over 10,000 cfs 1 day in 2.4 years (Eicher 1981, as cited in SBSRTC 2002). The Sultan Project reduces these to 1 day in 4 years, and 1 day in 10 years, respectively. Peak flows (22,000 cfs in 1991) still occur, but only about once every six years (USGS, various, as cited in SBSRTC 2002). If greater frequency of high flows is needed sufficient to maintain habitat conditions, they can and will be allowed to occur (Schuh and Meaker 1995, as cited in SBSRTC 2002). Projected net benefits to fish production associated with construction and operation of the Jackson Project (Eicher 1981 and FERC 1981, both as cited in SBSRTC 2002), appear to be substantiated by years of spawner surveys that indicate increasing adult salmon returns (Snohomish County PUD and City of Everett in prep., as cited in SBSRTC 2002). In current FERC discussions, the agencies have requested that fall flows not be allowed to increase naturally or artificially during spawning, to prevent redds from being deposited where they might later be dewatered due to low water releases from restricted power operations (Metzgar).

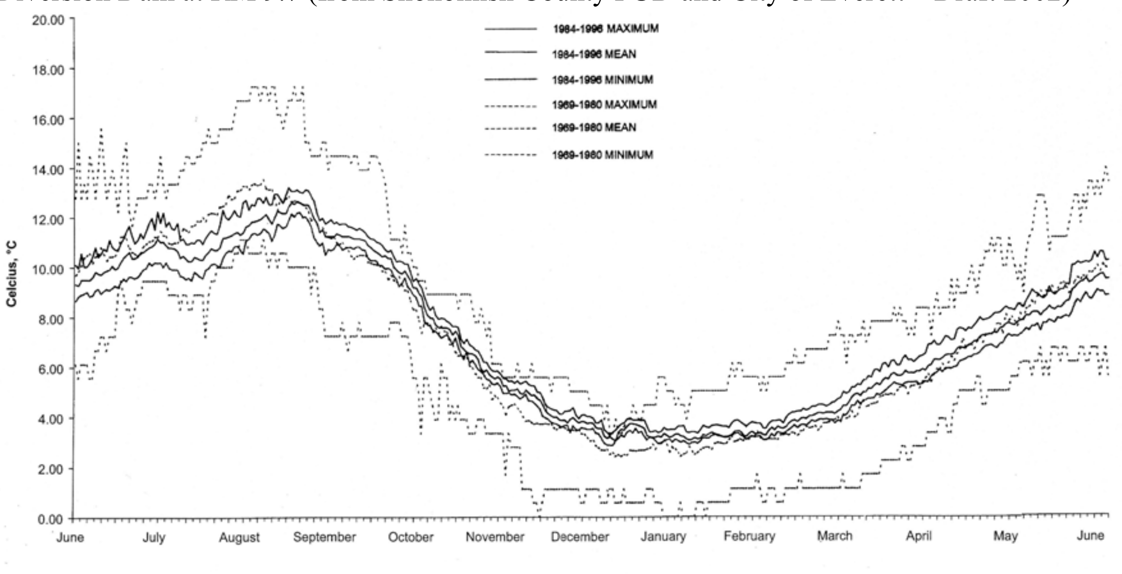
Water Quality

There are no 303(d) listings. Flow releases from the reservoir are regulated to match historical seasonal average water temperature patterns, although some warming has occurred during winter due to temperature of stored reservoir waters (Figure 22)(SBSRTC 2002). The land use management plan for USFS lands in the upper portion of the watershed is directed to protection of the municipal water supply (USFS 1990, as cited in SBSRTC 2002), while WADNR forest and private lands (City of Everett) are managed to protect water quality (Metzgar).

Excessive turbidity was noted in Spada Lake in the early-1970s (1998 303(d) Decision Matrices), but data collected from 1992 to 1997 by the City of Everett show that the criterion for turbidity is being met.

There have been recent problems with increased turbidity in Winters Creek associated with subdivision development (Chamblin); erosion and siltation resulting from water releases by the

Figure 22: Comparison of Sultan River Water Temperatures (1969-1980 vs. 1984-1996) at the Diversion Dam at RM 9.7 (from Snohomish County PUD and City of Everett – Draft 2002)



Sultan Water District have also been noted (Carroll, see Substrate Condition section above).. Although no water quality monitoring information is available for Winters Creek, there are concerns of potential water temperature and fecal coliform bacteria problems.

<u>Action Recommendations</u>

The following ranked salmonid habitat restoration actions are recommended for the Sultan River watershed:

- Protect/restore floodplain and riparian function in the lower 3.3 miles of the Sultan River
- Correct siltation problems associated with Sultan Water District spill near RM 2.0 on Winters Creek
- Restore floodplain and riparian function through the agricultural/residential portion of lower Winters Creek
- Prioritize and correct identified fish passage barriers on tributaries
- Conduct comprehensive assessment of habitat conditions on tributaries; address identified habitat problems
- Consider restoration of anadromous access upstream of the City of Everett diversion dam (RM 9.7) in the FERC process; restored access would also likely require flow modifications in the reach from Culmback Dam downstream to the diversion dam

Wagleys Creek 07.0939 and tributaries

<u>General</u>

Wagleys Creek is a RB tributary to the Skykomish River, entering at RM 35.2 (Williams et al. 1975).

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	**Road Crossing**	**River Mile**	**Barrier Status**
Wagleys Creek	Dyer Rd	0.04	Unknown
Wagleys Creek	BNSF RR	0.15	Unknown
Wagleys Creek	E Main St	0.4	Unknown
Wagleys Creek	Sultan Watershed Rd	0.7	Yes
Wagleys Creek	Hummer Hill private rd	0.75	Unknown
Wagleys Creek	Hummer Hill private rd	1.0	No
Wagleys Creek	EMC NW Plant Rd	1.5	Yes
Wagleys Creek	Rice Rd	1.6	Yes
Wagleys Creek	140th St	1.9	Unknown
Unnamed RB entering Wagleys at RM 2.2	Rice Rd	0.05	Yes
Wagleys Creek	Rice Rd	2.3	No
Wagleys Creek	132nd St SE	2.6	Yes
Unnamed RB entering Wagleys at RM 2.45	132nd St SE	0.6	No
Unnamed RB entering Wagleys at RM 2.45	Sultan Watershed Rd	1.1	No

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

There are a series of instream ponds constructed in the lower portion of Wagleys Creek, but they are thought to be passable to returning adult coho (Chamblin).

Floodplain Modifications

Landuse in the Wagleys Creek watershed is primarily residential and industrial downstream of SR 2, and agricultural upstream of SR 2. The creek has been channelized through the residential and industrial area downstream of SR 2, and portions have been channelized through the anadromous area upstream of SR 2 (Chamblin).

Channel Conditions

LWD is generally absent in the lower 3 miles of Wagleys Creek (Chamblin). Natural instream pools are generally absent, but there are a series of constructed instream ponds through the lower portion of Wagleys Creek; the effects of these ponds to instream flows and water temperatures is unknown.

Substrate Condition

No information was available on substrate condition in this watershed.

Riparian Condition

Review of aerial photos provided by Snohomish County (2001) indicates that riparian vegetation is generally sparse to absent in the lower 2.5 miles of Wagleys Creek; overall, riparian condition would rate as poor.

Water Quantity/Water Quality

It is unclear to what extent the series of constructed instream ponds on Wagleys Creek are regulated during low flow periods, and how the ponding affects water quality (particularly water temperatures) during low flow periods (Chamblin). No water quality sampling information is available for Wagleys Creek, although there are potential concerns associated with lack of riparian vegetation and water quality impacts associated with adjacent agriculture and animal access.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Wagleys Creek watershed:

- Restore floodplain and riparian function in anadromous area
- Prioritize and correct identified fish passage barriers
- Assess effects of instream ponds on instream flows and water quality during low flow periods; address any identified problems
- Assess status of livestock access to the stream; eliminate any unrestricted livestock access

Wallace River 07.0940 and Unnamed 07.0940A, Unnamed 07.0940B, Unnamed 07.0940C, Ruggs Slough 07.0940D, NF Wallace River 07.0951, Bear Creek 07.0942, May Creek 07.0943 and tributaries, Olney Creek 07.0946

General

The Wallace River is a RB tributary to the Skykomish River, entering at RM 35.7 (Williams et al. 1975). The Wallace River watershed drains an estimated 38,057 acres (SBSRTC 2002 Draft). The main tributaries include NF Wallace River (RB at RM 8.4, drains 3,789 acres), Olney Creek (RB at RM 4.5, drains 12,213 acres), May Creek (LB at RM 4.0, drains 6,473 acres), and Bear Creek (RB at RM 3.85)(Williams et al. 1975). In addition, there are several smaller tributaries that are not designated in Williams et al. (1975).

Fish Access

Natural anadromous access in the watershed is limited by Wallace Falls at RM 8.8, an impassable cascade on NF Wallace at RM 0.7, and an impassable falls on Olney Creek at RM 0.7.

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Bear Creek	Olney Falls Rd	0.3	Yes
Bear Creek	Olney Falls Rd	0.3	Unknown

Unnamed RB entering Bear at RM 0.34	Olney Falls Rd	0.15	No
Unnamed RB entering Bear at RM 0.34	Kellog Lake Rd	0.34	Yes
Bear Creek	Kellog Lake Rd	1.38	Yes
Unnamed RB entering Wallace at RM 5.0	Private rd	0.25	Unknown
Unnamed RB entering Wallace at RM 5.1	144th St SE	0.01	Unknown
Unnamed RB entering Wallace at RM 5.1	144th St SE	0.1	Unknown
Unnamed RB entering Wallace at RM 5.1	144th St SE	0.3	Yes
Unnamed RB entering Wallace at RM 5.1	399th St SE	0.35	Unknown
Unnamed RB entering Wallace at RM 5.1	145th private rd	0.25	No
Unnamed LB entering Wallace at RM 6.2	May Creek Rd	0.2	Yes
Unnamed LB entering Wallace at RM 6.2	May Creek Rd	0.4	Unknown
Unnamed LB entering Wallace at RM 6.2	Private drive	0.39	No
Unnamed LB entering Wallace at RM 6.2	May Creek Rd	0.4	Yes
Unnamed RB entering May at RM 2.5	Goldbar Blvd	0.15	Unknown
Unnamed RB to May near RM 2.8	164th	0.2	Yes
Unnamed 07.0944	429th	1.4	No
Unnamed LB entering May at RM 5.0	May Creek Rd	0.02	No
Unnamed LB entering May at RM 5.0	May Creek Rd	0.3	Unknown
Unnamed LB entering May at RM 5.0	May Creek Rd	0.5	Unknown
Unnamed RB entering Skykomish at ~RM 38	BNSF RR	0.8	Unknown
Unnamed RB entering Skykomish at ~RM 38	383rd	1.0	Unknown

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

The Skykomish Hatchery operates hatchery weirs on May Creek and the Wallace River that preclude/impair upstream adult salmonid migration at times during the year (Doug Hatfield, WDFW Hatchery Complex Manager, personal communication). The May Creek weir is installed from ~June 1 through mid-December (approximate completion of the hatchery coho egg-take goal). No adult salmonids are passed upstream of the May Creek weir during this period; a few late coho and all steelhead adults have free access upstream from mid-December through May.

The Wallace River weir is installed from ~June 1 through ~October 1 (approximate completion of the hatchery chinook egg-take goal), to guide adult chinook into the adult holding pond. During this period, 100-250 pairs of chinook (2001 intent is to pass ~150 females and ~250 males upstream) are passed upstream of the weir to spawn naturally. Adult salmonids, (some pinks, and all coho, chum, and steelhead) returning after weir removal on ~October 1 through May can freely access upstream of the hatchery weir.

Floodplain Modifications

Data are limited on bank armoring on the Wallace River. Approximately 0.5 mile of shoreline is hardened between RM 6-6.5 (WDFW 1998, as cited in SBSRTC 2002). The left bank shoreline is also diked through the Skykomish Hatchery, and where the river runs adjacent to SR 2 just upstream of the bridge east of Startup (Chamblin). Floodplain function on the Wallace River is generally intact except in limited areas where development encroaches on the channel.

Floodplain function on May Creek is highly modified through the Skykomish Hatchery. Much of May Creek also appears to be impacted by residential or agricultural encroachment and possible channelization, based on review of 2001 aerial photos provided by Snohomish County.

Most of the Bear Creek, Olney Creek, and NF Wallace River watersheds are in forest management, with no identified concerns related to floodplain function.

Channel Conditions

No quantitative assessment of pool or LWD condition is available for the Wallace River, but personal experience indicates good pool presence and presence of some logjams, but additional LWD presence would be better (Chamblin). LWD abundance is impaired by active removal by local homeowners of new LWD recruited to the channel.

No information was available on LWD presence in Olney Creek; pool condition in the lower 0.7 miles of Olney Creek is rated as good (Chamblin). No information was available on channel conditions in Bear Creek. LWD is generally absent from May Creek, with most/all removed under the guise of flood control; pool condition is unknown.

Substrate Condition

Dunne (1979, as cited in SBSRTC 2002) estimates the total sediment load for the Wallace River (at Gold Bar) to be 2,000 tons/year; bedload is estimated to be 200 tons/year and suspended load is estimated to be 1,800 tons/year.

No information was available on substrate condition in the Wallace River or Bear Creek. Substrate condition in the lower 0.7 miles of Olney Creek is rated as good; a landslide upstream of the falls was causing turbidity downstream, the cause, current status, and impact to substrate condition downstream are unknown (Chamblin). Substrate condition in upper May Creek is rated as good (Chamblin), but there appears to be significant accumulation of fine sediment immediately upstream of the hatchery rack (Haring).

Riparian Condition

There is good riparian buffer width adjacent to most of the Wallace River, although most riparian vegetation in the floodplain is early-mid seral deciduous; one would expect a greater natural conifer presence (Chamblin). Overall, riparian function would likely rate as fair-good for the Wallace River. Riparian function is rated as good for Olney Creek. Most of Bear Creek is in forest production; although most of the watershed has been harvested, riparian condition would likely rate as fair-good, based on review of the 2001 aerial photos provided by Snohomish County. Riparian condition on the lower 4.8 miles of May Creek are rated as poor, particularly through much of Goldbar (Chamblin).

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Wallace River watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
May Cr	13	47	17	8	2	6	0	7
Upper Wallace R	17	52	18	4	0	2	0	6
Olney Cr	17	65	13	1	0	1	0	2
Bear Cr	0	52	31	11	0	3	1	1

Water Quantity

Snohomish County PUD operates several wells adjacent to May Creek; no information was available on whether these are in hydraulic continuity to either May Creek or the Wallace River, or impacts to low flows (Chamblin).

The domestic water supplies for the cities of Goldbar and Startup come from a diversion on Olney Creek just upstream of an impassable waterfall at RM 0.6 (USFS 1997). The WDFW Hatchery near Startup diverts 10-25 cfs from the Wallace River. The maximum withdrawal occurs from March to mid-May, with minimum withdrawals occurring from late-May to mid-August (Doug Hatfield, as cited in USFS 1997). The hatchery also diverts ~3-9 cfs from May Creek from late spring through mid-late summer. These diversions cause reduced summer flows in both creeks and in the downstream portion of Wallace River. The reduced low flows sometimes limit fish production by reducing habitat area and increasing summer temperatures.

Water Quality

The Wallace River is included on the 1998 303(d) list of impaired waterbodies for water temperature, based on data collected by WDFW at Wallace Hatchery. Recent logging activities between May Creek and the Wallace River upstream of the Skykomish Hatchery are reported to have increased turbidity, particularly in May Creek (Doug Hatfield, WDFW Hatchery Complex Manager, personal communication).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Wallace River watershed:

- Restore fish passage upstream of Skykomish Hatchery on May Creek
- Protect integrity of riparian and floodplain functions on the Wallace River; enhance riparian function where impaired, and through increased presence of conifer

- Develop and implement a strategy to promote recruitment and retention of LWD in the Wallace River; determine whether interim LWD enhancement is appropriate until full riparian function is achieved
- Prioritize and correct identified fish passage barriers
- Restore riparian function on May Creek and other tributaries, where impaired
- Conduct comprehensive assessment of habitat conditions in the watershed

Sky Slough 07.0961 and tributaries

General

Sky Slough is a LB tributary to the Skykomish River, entering at RM 36.5 (Williams et al. 1975). The Sky Slough complex is a highly active and dynamic side channel complex in the braided reach of the Skykomish River.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	**Road Crossing**	**River Mile**	**Barrier Status**
Unnamed 07.0962	Mann Rd	0.5	No
Unnamed RB to Unnamed 07.0962	Mann Rd	0.5	Unknown
Unnamed RB to Unnamed 07.0962	Private drive	0.66	Unknown
Unnamed RB to Unnamed 07.0962	Private drive	0.67	Yes
Unnamed 07.0962	Mann Rd	0.5	No
Unnamed 07.0962	Mann Rd	0.65	Unknown
Unnamed 07.0962	Private drive	0.66	Unknown
Unnamed 07.0962	Private drive	0.67	Yes
Unnamed 07.0962A	157th Pl SE	0.35	No/Unknown

The culverts represented in the WDFW Fish Passage Database for this watershed are the result of efforts to conduct a comprehensive inventory of culverts and other fish passage barriers, but which may not be complete due to landowner access limitations and limited surveys other than at mapped road crossings of streams within the anadromous accessible zone.

Floodplain Modifications

The channel network in the Sky Slough complex actively migrates during large flood events; there was a major active channel change that occurred in the 1996 flood. Despite the transitory nature of the channels in this complex, and perhaps as a result of it, the area is highly utilized by spawning salmonids and appears to be a very important salmonid production area.

Channel Conditions/Substrate Condition

No information was available on channel or substrate conditions in Sky Slough.

Riparian Condition

Riparian condition in the Sky Slough complex is highly variable, based on review of the 2001 aerial photos provided by Snohomish County, but would likely rate overall as fair/poor. Riparian condition is primarily influenced by natural channel migration in the floodplain, rather than by land-use actions.

Water Quantity/Water Quality

No information was available on water quantity or water quality conditions in Sky Slough.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Sky Slough watershed:

- Protect the integrity of this natural side channel complex; prevent encroachment or development within the CMZ
- Prioritize and correct identified fish passage barriers

Berry Farm Slough 07.0961X

General

Berry Farm Slough was a slough entering the RB of the Skykomish River at RM 36.5 (Williams et al. 1975). It is part of the highly active and dynamic floodplain in the braided reach of the Skykomish River. The Skykomish River captured Berry Farm Slough in the 1996 flood (Hendrick), although there is potential for the river to move away sometime in the future, potentially restoring the existence of the side channel slough.

Action Recommendations

The following salmonid habitat restoration action is recommended for Berry Farm Slough:

- Protect the integrity of this part of the braided section of the Skykomish River; prevent encroachment or development within the CMZ

Unnamed 07.0961Y

General

Unnamed 07.0961Y is a RB slough entering the Skykomish River at RM 37.6 (Williams et al. 1975). It is part of the highly active and dynamic floodplain in the braided reach of the Skykomish River. Exiting Snohomish County ordinances do not effectively address single-family low-density development in floodplain areas (Chamblin). The floodplain area surrounding this side channel has been platted into 20-acre residential sites. Although habitat quality and functions are currently mostly intact, future riparian, channel, and floodplain function are likely to be adversely impacted if the platted development proceeds in the active channel migration zone.

Action Recommendations

The following salmonid habitat restoration action is recommended for Unnamed 07.0961Y:

- Pursue acquisition and protection of platted areas in the channel migration zone; prevent encroachment or development within the CMZ

Unnamed 07.0962X, Unnamed 07.0963, and Unnamed 07.0963A

General

Unnamed 07.0963 is a LB tributary to the Skykomish River, entering at RM 38.9 (Williams et al. 1975). Unnamed 07.0963A (not noted in Williams et al.) is a LB tributary entering Unnamed 07.0963 just upstream of the mouth. Unnamed 07.0962X (not noted in Williams et al.) is a LB tributary entering the Skykomish River ~0.2 miles downstream of Unnamed 07.0963. Land use in these watersheds is forest management. Access opportunities are limited, and no information is available on habitat conditions other than the culvert information below.

Fish Access

The following culverts have been assessed and are included in the WDFW Fish Passage Database (February 2002)(identified WRIA numbers may not agree with report description above, or with Williams et al. (1975)):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed 07.0964	22720 Rd	0.5	Yes
Unnamed 07.0964	22700 Rd	0.8	No
Unnamed 07.0964	22740 Rd	0.95	Yes
Unnamed 07.0964	22740 Rd	1.1	Yes
Unnamed RB to 07.0964 near RM 0.5	22700 Rd	0.6	Yes
Unnamed LB entering Skykomish at RM 40.8	22720 forest rd	0.3	Yes

It is unknown whether this watershed was included in the Washington Trout culvert inventory (Glasgow).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0962X and Unnamed 07.0963 watersheds:

- Conduct comprehensive assessment of habitat conditions in these watersheds; address identified habitat concerns
- Prioritize and correct identified fish passage barriers

Duffey Creek 07.0965

General

Duffey Creek is a LB tributary to the Skykomish River, entering at RM 42.0 (Williams et al. 1975). The Duffey Creek watershed drains 2,440acres (USFS 1997). It is a high gradient watershed with a history of road failures and landslides in the upper watershed, resulting in high turbidity (Chamblin). It is unknown whether this watershed was included in the Washington Trout culvert inventory (Glasgow). No information is available on habitat conditions in the watershed.

The Hydrologic Cumulative Effects Analysis for the MBS Forest Plan (MBS LRMP 1990, as cited in USFS 1997) recommends that areas that have more than 12% vegetation disturbance may exhibit undesirable cumulative effects, including but not limited to alteration of the magnitude and duration of snowmelt, and possible increased peak flows that can result in increased bank slumping and bed scour. Duffey Creek had an estimated 27.3% vegetation disturbance in the 1997 analysis (USFS 1997), indicating increased potential for habitat alterations.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Duffey Creek watershed:

- Assess habitat conditions; correct identified habitat problems

Game Trail Slough 07.0965A

General

Game Trail Slough is a RB tributary slough to the Skykomish River, entering at RM 41.0 (Williams et al. 1975). It is part of the highly active and dynamic floodplain in the braided reach of the Skykomish River. No information is available on habitat conditions.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Unnamed 07.0965A watershed:

- Protect the integrity of this part of the braided section of the Skykomish River; prevent encroachment or development within the CMZ
- Conduct comprehensive assessment of habitat conditions in this watershed; address identified habitat concerns

Proctor Creek 07.0970 and tributary

General

Proctor Creek is a LB tributary to the Skykomish River, entering at RM 44.5 (Williams et al. 1975). The Proctor Creek watershed drains 6,260 acres (USFS 1997). During the last glaciation, the upper Skykomish flow was blocked by the glacier and actually diverted across into the upper

Tolt River watershed, eventually draining through the Snoqualmie River to Puget Sound (Pess per Aldrich).

Fish Access

Anadromous salmon distribution extends upstream to an impassable cascade at RM 1.2; steelhead further upstream to an impassable falls at RM 1.6. No human-caused fish passage barriers are known to occur in the anadromous portion of this watershed. It is unknown whether this watershed was included in the Washington Trout culvert inventory (Glasgow).

Floodplain Modifications

The lower ~0.5 mile of Proctor Creek is heavily developed with associated encroachment on the creek. Upstream the watershed is in forest management.

Channel Conditions/Substrate Condition

There is a naturally high occurrence of slides in the upper watershed, which have disturbed the highly sensitive lacustrine deposits in the upper watershed, but the rate and extent of slides have likely been exacerbated by forest management and road construction (Aldrich). The slides have resulted in high sediment and LWD transport through the lower watershed. No information was available on pool presence or condition, LWD abundance, or substrate condition.

Riparian Condition

Review of aerial photos provided by Snohomish County (2001) indicates limited riparian vegetation in the developed lower 0.5 mile of Proctor Creek, and what appears to be mid-seral regenerating riparian forest stands throughout the rest of the watershed; overall, riparian condition would probably rate as fair.

Water Quantity/Water Quality

No water quality or quantity data were available for Proctor Creek.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Proctor Creek watershed:

- Complete comprehensive forest road inventory in the upper watershed; address identified problems leading to increased landslide activity and sediment delivery to streams in the upper watershed

Hogarty Creek 07.0972

General

Hogarty Creek is a RB tributary to the Skykomish River, entering at RM 45.6 (Williams et al. 1975). The Hogarty Creek watershed drains 1,297 acres (USFS 1997).

Fish Access

Coho utilization is known to an impassable cascade at RM 0.85. The Reiter Ponds steelhead acclimation ponds are located near the mouth of Hogarty Creek. The facility gets its water from both Hogarty and Austin creeks (Doug Hatfield, WDFW Hatchery Complex Manager, personal communication). The water intake dam on Hogarty is located at ~RM 0.25-0.5, and has a fish ladder. It is unknown whether this watershed was included in the Washington Trout culvert inventory (Glasgow).

Floodplain Modifications

The entirety of the watershed is in forest management; there are no identified concerns with floodplain modifications.

Channel Conditions/Substrate Condition

No information was available on channel conditions or substrate condition, although Doug Hatfield indicates the watershed has been quite stable, with no recent water quality or sediment problems encountered at the Reiter Pond hatchery facility.

Riparian Condition

Review of aerial photos provided by Snohomish County (2001) indicates fairly young regenerating forest stands along the lower 1.0 mile of Hogarty Creek and road encroachment in the left-bank riparian zone from ~RM 0.6 to 1.1; overall, riparian condition would rate as poor/fair in the anadromous zone. Upstream, regenerating forest stands appear to be older and riparian condition better.

Water Quantity/Water Quality

No water quality or quantity data are available; Doug Hatfield was not aware of any water related concerns at the Reiter Pond facility.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Proctor Creek watershed:

- Protect/restore watershed function through protection of forest cover and natural forest hydrology

Anderson Creek 07.0975

General

Anderson Creek is a LB tributary to the Skykomish River, entering at RM 48.6 (Williams et al. 1975), just downstream of the confluence of the NF and SF Skykomish rivers. The Anderson Creek watershed drains 2,313 acres (USFS 1997).

Fish Access

There are no known barriers to fish passage downstream of the impassable cascade at RM 0.6. Water quality problems may impair usability by salmonids (see Water Quality section below). It is unknown whether this watershed was included in the Washington Trout culvert inventory (Glasgow).

Floodplain Modifications

The natural floodplain is constrained by the SR 2 bridge just upstream of the mouth. Past floods have deposited gravels at and upstream of the bridge; gravels have been removed/repositioned/ channelized to improve hydraulic efficiency in the lower creek, resulting in loss of instream and riparian habitat complexity and suitability for salmonids through the reach where work was done.

Channel Conditions/ Substrate Condition

No information was available on channel or substrate conditions.

Riparian Condition

Riparian function has been adversely impacted in the lower portion of the creek where past flood remediation/channelization work has been done. Review of aerial photos provided by Snohomish County (2001) indicates what appears to be varying ages of regenerating forest upstream.

Water Quantity/Water Quality

Salmonid productivity may be impaired by high arsenic concentrations in Anderson Creek. Spawner surveys in the late 1970s documented a conspicuous absence of salmonids in Anderson Creek despite apparent presence of excellent physical habitat and substrate conditions upstream of the mouth, and presence of coho spawners in other tributaries in the area (juvenile steelhead presence has been observed by Kraemer in lower Anderson Creek, see Appendix A and species distribution maps in the separate Maps files included with this report). In 1978, Haring had a conversation with one of the riparian landowners in the lower watershed, who indicated presence of high arsenic concentrations in Anderson Creek. Subsequent qualitative observations by Haring also indicated a conspicuous absence of benthic invertebrates. No water quality sampling information is available. Some streams in the upper Skykomish are known to have high natural arsenic presence, and there are no known records of past mines in the Anderson Creek watershed (Pat Toman, Skykomish Ranger District, personal communication).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Anderson Creek watershed:

- Assess water quality; determine if arsenic is impairing salmonid and/or benthic invertebrate productivity
- Assess floodplain and riparian function in lower portion of stream that has been dredged; restore functions where impaired

Deer Creek 07.0979, Son of Deer 07.0979A, Unnamed 07.0979B

General

Deer Creek is a RB tributary to the Skykomish River, entering at RM 49.3 (Williams et al, 1975. Deer and Son of Deer creeks are spawner index areas, with spawning evaluated annually since the late 1970s. Unnamed 07.0979B has observed spawner records in the WDFW Spawner Survey Database, but location could not be determined from information on the spawner records. The Deer Creek watershed drains 1,945 acres (USFS 1997).

Fish Access

There are no identified human-caused fish passage barriers in this watershed.

Floodplain Modifications/Channel Conditions/Substrate Condition

No floodplain modification concerns are identified. No information is available on channel or substrate conditions, although adult spawner counts have consistently shown high redd densities/mile.

Riparian Condition

Riparian condition was not readily evident from 2001 aerial photos provided by Snohomish County. No riparian concerns are identified.

Water Quantity/Water Quality

No water quantity or water quality data are available.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Deer Creek watersheds:

- Protect watershed function through protection of forest cover and natural forest hydrology

NF Skykomish River Mainstem 07.0982

General

The NF Skykomish River watershed (including tributaries) drains an estimated 93,960 acres, of which 94% is controlled by the USFS (David Evans 1998). Results of habitat and fisheries surveys conducted during the low flow period of 1998 indicate the NF Skykomish provides important spawning and rearing habitat, as well as a primary travel corridor for numerous anadromous salmonids (David Evans 1998). Fish species observed during this survey included bull trout/Dolly Varden, rainbow/steelhead, chinook, coho, and mountain whitefish; no cutthroat were observed from the mouth to upstream of Bear Creek Falls. Chinook, coho, pinks and steelhead use the lower NF Skykomish (1998 subbasin workshop). Primary spawning for chinook occurs from RM 0.0 to RM 2.9 and primary rearing from RM 0.0 to 0.5 (west end of the Town of Index).

A key strategy and goal for the NF Skykomish is to generally manage the watershed for protection and restoration; with limited timber harvesting on federal lands and limited development within riparian zones on private lands (1998 subbasin workshop).

Fish Access

The following culverts, on tributary streams to NF Skykomish River that are not currently known to support anadromous salmonids, have been assessed and are included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed RB entering NF Skykomish at RM 1.0	Ave A/Reiter Rd	0.01	Unknown
Unnamed RB entering NF Skykomish at RM 1.0	County Trail	0.05	Yes
Unnamed LB entering NF Skykomish at RM 1.3	Index Galena Rd	0.0	Yes
Unnamed RB in town of Index	BNSF Railroad	0.2	Yes
Unnamed RB in town of Index	Recycling Center Drive	0.02	Yes
Unnamed RB in town of Index	Fifth St	0.03	No
Unnamed LB near NF Skykomish at RM 2.7	Ninth Ave	0.15	No
Unnamed LB near NF Skykomish at RM 2.7	Index Galena Rd	0.2	Yes
Unnamed LB entering NF Skykomish near RM 3.2	9th Ave	0.25	Yes
Unnamed LB entering NF Skykomish near RM 6.0	Northfork River Rd	0.05	Yes
Unnamed LB entering NF Skykomish near RM 6.0	Northfork River Rd	0.1	No
Unnamed LB entering NF Skykomish near RM 7.0	Index Galena Rd	0.05	Yes
Unnamed LB entering NF Skykomish near RM 7.5	Index Galena Rd	0.0	No
Unnamed 07.1052	Index Galena Rd	0.05	Yes

Unnamed RB entering NF Skykomish at RM 16.1	USFS Road 65	0.01	No

Floodplain Modifications

Most of the lower NF Skykomish (mouth to Bear Creek Falls (RM 13.0)) flows in a relatively confined, incised channel (1998 subbasin workshop). This high-energy sediment source zone, with a gradient of approximately 1 to 2 percent, is heavily armored with cobbles and boulders. Sections of this reach have exhibited channel widening of approximately 30 percent since 1962 (earliest aerial photos examined thus far, Gall). The reach is highly subject to rain-on-snow events with the highest precipitation in the Skykomish Forks watershed. This could result in significant chinook redd scour given the reach characteristics. From Bear Creek Falls (RM 13.0) to the headwaters, the NF Skykomish is relatively pristine and flat compared to lower NF. The ownership of the upper watershed is mostly USFS except for one small in-holding of private property at Garland Springs. Channel widening and braiding occurs between RM 15 and RM 18.5 creating high quality spawning habitat, particularly for summer-run steelhead. Geologic stability is relatively high except for several areas on Quartz Creek where there are some bank and hillside failures.

Side channel habitat and floodplain connectivity are limited on the left bank of the NF Skykomish due to county road and residential encroachment in the floodplain; west of Galena (RM 10.0), the road crosses to the right bank of the river and further encroaches on the floodplain (SBSRTC 2002). Approximately 36% (7.26 river miles) of the banks downstream of RM 10.0, and approximately 12% of shoreline (4.86 river miles) upstream of RM 10.0, are affected by private and public road encroachment (Savery in prep., as cited in SBSRTC 2002). There have been problems with periodic washout of the Index-Galena Road (at ~RM 9.3) approximately 0.6 miles downstream of the mouth of Lost Creek, requiring repeated placement of fill and bank armoring (Chamblin).

Natural floodplain function has been substantially altered in the vicinity of the Jacks Pass bridge (RM 16.1)(Kraemer). The bridge and associated armoring constrict the floodplain, reducing channel sinuosity and increasing channel gradient upstream and downstream of the bridge. This area provides approximately 25-30% of the identified prime bull trout/Dolly Varden spawning and rearing habitat within the NF Skykomish watershed, which is impaired by the channel confinement.

Channel Conditions

Long riffles with numerous runs/glides were the dominant habitat type from the mouth to Bear Creek; pools were scarce (<5%)(David Evans 1998). Cascades and plunge pools were the dominant habitat type from Bear Creek to 0.44 miles upstream of Bear Creek Falls.

Mean bankfull channel width in upper NF Skykomish ranged from 8.2m (Rosgen Aa+ channels) to 33.4m (Rosgen C channels)(Table 17, SCSWM 2002). Streambank conditions appear to be generally stable and good, although there are notable exceptions along the mainstem NF Skykomish and some tributaries (e.g., Silver Creek and downstream in the mainstem NF Skykomish)(SBSRTC 2002). Overall, streambanks are "functioning appropriately" (David Evans and Associates 1999, as cited in SBSRTC 2002). Assessment by Purser (2002) in upper NF Skykomish estimated that bank instability ranged from 0.0-3.5% by reach (Table 17); bank instability in Aa+ channels located within the Mt. Baker-Snoqualmie National Forest and subject to a greater degree of aquatic resource protection (FEMAT 1993) was measured at 0%. Bank instability is generally accelerated where road or development abuts the river (Purser).

Table 17: Channel conditions for upper NF Skykomish River (courtesy of Michael Purser)

	Rosgen Class	Reach Length (m)	Ave BFW (m)	Ave LWD/CW	Bank Instability (%)	Pool Freq/CW	Pool Area (%)	Substrate Fines (%)
Upper NF	A	1885.3	14.1	0.50	0.3	0.91	37.8	6.2
Upper NF	Aa+	454.9	8.2	0.38	0.0	0.33	27.3	2.4
Upper NF	B	1735.8	32.4	1.02	3.5	0.50	33.1	1.4
Upper NF	C	2312.7	33.4	1.54	1.3	0.30	18.9	16.1
Upper NF	D	1755.2	28.0	1.93	3.2	0.43	12.4	26.9

LWD is generally low in the lower NF Skykomish, compared to the reaches above Bear Creek Falls (1998 subbasin workshop). Surveys in 1991-92 upstream of RM 9.9 found overall LWD occurrence to be 211 pieces/mile or 0.12 pieces/CW (CW 10-20m)(David Evans and Associates 1999, as cited in SBSRTC 2002). Instream habitat surveys from Index (RM 1.4) to RM 10.4 found 26.6 pieces of LWD/mile or 0.33 pieces of wood per channel width (channel width exceeds 20m); these counts excluded wood in logjams and side channels (David Evans and Associates 1998, as cited in SBSRTC 2002). LWD loading in upper NF Skykomish ranged from 30-76 pieces/km (0.38-1.93pieces/CW), depending on Rosgen channel type (Table 17), in assessments conducted in 2001 (SCSWM 2002). LWD loading increased with decreasing channel gradient, with the highest frequency of LWD loading occurring in Rosgen C and D channels, likely due to the low gradient and local recruitment through lateral channel migration. LWD in these channels has also formed jams, which in turn trap more wood. There is adequate LWD recruitment from upstream through the NF Skykomish; one of the biggest limitations to LWD presence is the continual removal of LWD from the channel for firewood/flood protection/etc. (Purser/ Chamblin). Overall riparian condition and LWD recruitment are sufficient in the NF Skykomish and tributaries that LWD restoration can likely be accomplished through passive means. It will take tens if not hundreds of years to provide the quantity and quality of LWD (>36 inches dbh) required to improve instream conditions (David Evans 1998). However, the gradual recruitment of LWD will improve the habitat diversity and stability of the NF Skykomish and its tributaries. USFS ceased removal of LWD from the channel by 1984, and is not aware of any ongoing removal without USFS consent (Gall).

Pool sampling in upper NF Skykomish in 2001 found pool frequency varied from 0.30-0.99 pools/CW (channel width ranged from 8.2-33.4m) depending on Rosgen channel type (Table 17, SCSWM 2002). Mean wetted pool surface area ranged from 12.4-37.8%. These values generally fall in the fair-poor condition rating for pools, but do not pose a significant concern (Purser).

<u>Substrate Condition</u>

High quality gravels provide generally good spawning habitat on the mainstem forks and tributaries downstream of Bear Falls (RM 13) on the NF Skykomish (1998 subbasin workshop). Low summer flows limit access and available spawning habitat for summer spawning stocks in some mainstem areas and tributaries.

Based on known channel widening over a 30 year period in the lower watershed since 1962 (162 feet wide in 1962 and 201 feet wide in 1991in the lower watershed; 150 feet wide in 1962 and 200 feet wide in 1991 in the upper watershed)(USFS 1997, as cited in SBSRTC 2002), known areas of unstable soils, and very limited quantitative data on rates of sediment delivery to channels from surface erosion, bank avulsions, and mass failures, substrate embeddedness and sediment in spawning/incubation areas were rated as "functioning at risk" (David Evans and Associates 1999, as cited in SBSRTC 2002). Surface fine sediment (<6.3 mm) measured in 2001 ranged from 1-27% by reach (SCSWM 2002), with Rosgen Aa+, A, and B channels meeting the WRIA 7 fine sediment criterion.

Road density in the NF Skykomish watershed is 0.58 mi/mi^2 (USFS 1997). SBSRTC (1999) included a project proposal to stormproof forest roads in the NF Skykomish watershed. Although the forest road density in the NF Skykomish watershed would likely be of greater concern in different geology, and does cause some increased turbidity in the NF Skykomish during peak flow events, sedimentation from forest roads is not a primary concern in the NF Skykomish (Kraemer).

Riparian Condition

Riparian habitat is largely second growth deciduous along the North Fork Skykomish (1998 subbasin workshop). While there is generally good riparian habitat along much of the reach, roads parallel the river for several miles and floodplain and riparian function are impaired where roads impinge on the river.

Most logging in the NF Skykomish watershed was conducted prior to the 1960s, with some logging continuing in the Goblin and Quartz creek watersheds into the 1980s (Kraemer). USFS (1997) reports riparian reserve vegetative structure as sapling 2%, non-forest 28%, immature 39%, and mature 7%. [Note: the remaining 24% is outside USFS boundaries and was not assessed]

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the NF Skykomish watershed (WADNR Types 1-5, includes riparian vegetation on mainstem and tributaries)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Lower NF Skykomish	20	40	23	3	2	4	0	8
Upper NF Skykomish	21	35	22	3	2	6	0	11

Water Quantity

The NF Skykomish has the greatest rainfall average (~135 inches/year) in the upper Skykomish watershed, and also the greatest range (90 to 170 inches per year)(USFS 1997). Storm events in the NF Skykomish watershed can be very intense; the 10-year, 24-hour maximum storm event averages just over 6.5 inches of precipitation in the SF Skykomish. Approximately 47% of the NF Skykomish watershed is in the combined rain-on-snow/snow dominated zones; 18.8% of the NF Skykomish watershed is in the rain on snow zone (USFS 1997). The high rate of precipitation in the NF Skykomish, coupled with its potentially higher snowpack levels, result in greater amounts of surface runoff due to rain-on-snow events per acre in the NF Skykomish watershed than in the SF Skykomish. The surface runoff would affect channel conditions in the NF Skykomish and downstream in the mainstem Skykomish.

The NF has approximately one half of the discharge of the SF Skykomish (USGS, as referenced in 1998 subbasin workshop). Peak discharges usually occur in the period of October to January, and are generally influenced by rain-on-snow events. The highest average monthly discharges occur in May and June and are influenced by annual snow pack melt.

Historic gauging occurred on the river between 1911 and 1948. In 1994, Snohomish County installed a telemetric river stage recorder, but there is currently no rating curve constructed so that discharges can be estimated. Water may be over-appropriated in the reach based on claims filed in Ecology's Water Rights database (Bob Newman, DOE).

Past timber harvest practices in the watershed have altered hydrologic processes by increasing the amount of open area available for snow accumulation (David Evans and Associates 1999, as cited in SBSRTC 2002). However, there has also been a persistent loss of permanent snow fields that contribute to summer base flows (Kraemer). Hydrologic maturity of the forest is generally high with greater than 70 percent canopy closure, consisting mostly of mature trees.

<u>Water Quality</u>

The NF Skykomish from the mouth to Bear Creek Falls (RM 13.0) is designated by the Department of Ecology as Class AA and has the highest water quality in the Skykomish Forks. Peak temperatures of 13.4°C and peak turbidities of 15 NTUs were measured by the Tulalip Tribes in 1996 (Nelson 2002). Water quality upstream of Bear Creek Falls is as good or better than the reach below. Headwaters water quality is classified as excellent by Ecology.

No waterbody segments in the NF Skykomish watershed are on the 303(d) list for water temperature. Temperatures measured in late September and October at several locations (including Silver Creek and the mainstem NF Skykomish River) ranged from 9.4-16.7ºC (David Evans and Associates 1999, USFS 1997; both as cited in SBSRTC 2002).

<u>Action Recommendations</u>

The following ranked salmonid habitat restoration actions are recommended for the NF Skykomish River mainstem:

- Restore natural floodplain function upstream and downstream of Jacks Pass bridge
- Protect/restore watershed function through protection of forest cover and natural forest hydrology
- Restore floodplain function where Index-Galena Road encroaches into floodplain near the mouth of Howard Creek
- Restore natural floodplain integrity in the Skyco development area
- Decommission forest roads, where possible
- Avoid LWD removal from the NF Skykomish for flood control or other reasons (USFS ceased removal of LWD from the channel by 1984 (Gall))

Lewis Creek 07.0983, Son of Lewis 07.0983A, Unnamed 07.0983B

General

Lewis Creek is a LB tributary to the NF Skykomish River, entering at RM 2.85 (Williams et al. 1975).

Fish Access/Floodplain Modifications

Fish Access

The following culvert on a tributary to Lewis Creek is included in the WDFW Fish Passage Database (February 2002):

Stream	Road Crossing	River Mile	Barrier Status
Unnamed LB entering Lewis at RM 0.2	Index Galena Rd	0.4	Yes

No anthropogenic fish passage barriers are known in the Lewis Creek watershed, but there are several culverts (likely undersized) in the lower portion of the watershed that affect sediment and debris transport (Chamblin).

There is recreational use encroachment near the mouth of Lewis Creek; there are numerous recreational camping lots, with regular creek manipulation (e.g., creation of spanning gravel rock dams to create swimming holes) during summer months (Chamblin). This channel manipulation may impair fish passage in early fall prior to the first large flow event.

There are beaver/highway conflicts where the creek is directed down a ditch line along the highway in the same area preferred by beavers. Beaver dams should be retained wherever possible.

Channel Conditions

LWD presence is limited in the lower portion of the creek; there is likely past removal of LWD in the vicinity of the recreational lots, and LWD is still removed to minimize potential of clogging culverts through this area (Chamblin). No information is available on pool presence or condition.

Substrate Condition

No quantitative substrate sampling information is available; TAG participants have no identified substrate concerns.

Riparian Condition

Riparian function is impaired through the recreational lot area at the mouth of Lewis Creek (Chamblin). Upstream, riparian vegetation is generally second growth, resulting from past and ongoing forest harvest.

Water Quantity/Water Quality

The tributary just upstream of the road has been observed to be highly turbid during peak flows, the cause is unknown at this time (Chamblin). No quantitative water quality information is available for Lewis Creek.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Lewis Creek watershed:

- Protect/restore watershed function through protection of forest cover and natural forest hydrology; protect and restore riparian integrity
- Eliminate channel manipulation and disturbance through recreational lot area at the mouth
- Upgrade culverts to ensure unrestricted passage of sediment and debris
- Assess cause of high turbidity from tributary just upstream of road

Bitter Creek 07.0985

General

Bitter Creek is a LB tributary to the NF Skykomish River, entering at RM 4.5 (Williams et al. 1975). There are no identified habitat concerns, although TAG participants had little knowledge of habitat conditions in the watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Bitter Creek watershed:

- Assess habitat conditions, correct identified problems

Snowslide Creek 07.0994

General

Snowslide Creek is a RB tributary to the NF Skykomish River, entering at RM 5.9 (Williams et al. 1975). Snowslide Creek is located on the opposite bank of the NF Skykomish from the highway. Little is known of habitat conditions due to lack of access, but habitat should be generally reflective of wilderness conditions.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Snowslide Creek watershed:

- Protect/restore watershed function through protection of forest cover and natural forest hydrology
- No restoration actions are recommended due to the lack of access and use in this watershed

Excelsior Creek 07.0995

General

Excelsior Creek is a RB tributary to the NF Skykomish River, entering at RM 6.8 (Williams et al. 1975). Excelsior Creek is located on the opposite bank of the NF Skykomish from the highway. Little is known of habitat conditions due to lack of access, but habitat should be generally reflective of wilderness conditions.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Excelsior Creek watershed:

- Protect/restore watershed function through protection of forest cover and natural forest hydrology
- No restoration actions are recommended due to the lack of access and use in this watershed

Trout Creek 07.0997 and tributary

General

Trout Creek is a LB tributary to the NF Skykomish River, entering at RM 6.9 (Williams et al. 1975). The Trout Creek watershed drains 9,836 acres (USFS 1997).

Fish Access

Anadromous salmonid production is limited to the lower 3.6 miles of stream due to a series of natural falls just below the confluence of SF Trout Creek (David Evans 1998). Trout Creek is primarily utilized by *O. mykiss* based on results of daytime snorkeling during periods of low flow. Utilization by other salmonids during this period is minimal. It is unlikely that either coho or chinook salmon could utilize the spawning habitat in Reach 3 due to the steep cascades in Reaches 1 and 2, but can use Reach 1 for refuge when flow allows access.

During the 1998 survey, both the NF Skykomish and Trout Creek were experiencing low flow, which created a barrier at the mouth of Trout Creek, in that fish trying to enter Trout Creek would have to jump up into an area where the flow was dispersed between cobbles. The dispersed flow at the mouth did not provide continuous upstream access and therefore likely limited entrance to potential upstream habitat.

Floodplain Modifications

The 3.6 miles of accessible anadromous channel were delineated into four reaches based on guidelines described in Rosgen and Silvey (1998, as cited in David Evans 1998). Reach 1 (lowermost) consists of 1.2 miles of A-type channel, Reach 2 consists of 1.4 miles of B-type channel, Reach 3 consists of 0.7 miles of C-type channel, and Reach 4 consists of 0.3 miles of A-type channel.

Floodplain function may be impaired by presence of an old logging road that is no longer used, and by presence of the main road associated with the old Sunset Mine (copper), which is also no longer active (Kraemer, Chamblin). No information on the effects of these roads was included in the survey by David Evans (1998), other than an indication of no observed effects from prior mining operations other than presence of old rails in the channel. The effects of these roads should be assessed, and opportunities for road abandonment should be explored.

Channel Conditions/Substrate Condition

A likely contributing factor to the low use by salmonid species other than *O. mykiss* is the lack of pools (David Evans 1998). Percent pools in reaches 1 through 3 were 4.7, 3.0, and 5.2%, respectively. These low percentages reduce the pool/riffle ratios in those reaches to inadequate levels. LWD is generally lacking, as was the case for all NF Skykomish tributaries surveyed during 1998.

Substrate conditions in the lower 3.6 miles consisted primarily of large cobble and small boulders, a few moderate riffles, and scattered plunge and mid-channel scour pools (David Evans 1998). The lack of pools in Trout Creek is considered a hindrance to salmonid productivity by minimizing habitat diversity.

Riparian Condition

Riparian condition in Reaches 1 through 3 was characterized as primarily small young deciduous vegetation, although the vegetation was considered capable of providing bank stabilization and some thermal protection (David Evans 1998). Continued growth will increase future riparian function and LWD recruitment potential.

Water Quantity/Water Quality

Instream flow measured on August 11, 1998 at a site 186 feet upstream of the mouth was 20.6 cfs (David Evans 1998). Water temperatures measured on the same date in Reaches 1 through 4 were 59, 52, 53, and 52 degrees Fahrenheit, respectively. Water temperature monitoring in Trout Creek at the County road bridge from mid-October 2001 to late June 2002 indicated no days where the average temperature exceeded 6^{o}C, and 17 days when the maximum temperature exceeded 6^{o}C (Tulalip Tribes Data 2002). No water temperature concerns were identified.

The Hydrologic Cumulative Effects Analysis for the MBS Forest Plan (MBS LRMP 1990, as cited in USFS 1997) recommends that areas that have more than 12% vegetation disturbance may exhibit undesirable cumulative effects, including but not limited to alteration of the magnitude and duration of snowmelt, and possible increased peak flows that can result in increased bank slumping and bed scour. Upper Trout Creek had an estimated 42% vegetation disturbance in the 1997 analysis; Lower Trout Creek had 11% vegetation disturbance (USFS 1997).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Trout Creek watershed:

- Protect/restore watershed function through protection of forest cover and natural forest hydrology

- Assess effects of the logging and mining roads that are no longer utilized; identify and implement road abandonment, where feasible
- Habitat condition would benefit from greater presence of LWD; TAG participants recommend this occur passively over time through riparian protection

Unnamed 07.1030

General

Unnamed 07.1030 is a LB tributary to the NF Skykomish River, entering at RM 8.3 (Williams et al. 1975). There are no identified habitat concerns, although TAG participants had little knowledge of habitat conditions in the watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Bitter Creek watershed:

- Assess habitat conditions, correct identified problems

Salmon Creek 07.1031

General

Salmon Creek is a RB tributary to the NF Skykomish River, entering at RM 8.6 (Williams et al. 1975). The Salmon Creek watershed drains 5,328 acres (USFS 1997). An assessment of habitat conditions was conducted in 1998 in the lower 2.8 miles of the main channel and 0.7 mile of SF Salmon Creek; the total length of Salmon Creek is 4.9 miles, plus 2.2 miles in SF Salmon Creek (David Evans 1998).

Fish Access

No anthropogenic fish passage barriers are known in the anadromous portion of the Salmon Creek watershed. Fish access to Salmon Creek upstream of the confluence of SF Salmon Creek was precluded during low flows in 1998 by a dry section of creek just upstream of the confluence (David Evans 1998). Anadromous salmonid access in SF Salmon Creek extends to a series of waterfalls located between RM 0.36 and RM 0.70.

Floodplain Modifications

The mouth of Salmon Creek was noted in 1998 as having shifted from that represented on the USGS Monte Cristo quadrangle (1982), with the NF Skykomish decreasing the length of the mouth of Salmon Creek by at least 0.5 mile (David Evans 1998). No other floodplain modifications were noted, although the forest road that parallels the east side of Salmon Creek is identified as having potential to deliver sediment to Salmon Creek.

Residential/recreational development is encroaching on the left bank of lower Salmon Creek (Kraemer). There are no identified current concerns, but conditions should be monitored, and any impacts addressed.

Channel Conditions

LWD was generally lacking throughout the 1998 sample area (David Evans 1998). Percent pool habitat was also low, ranging from 4.3% to 19.5% by reach, although Reach 1 in the lower 0.34 miles had significant off-channel pool habitat (35.26%). Channel gradient averaged ~2% in the lower 0.34 mile, increasing to 6.75% in the next 1.8 miles, and to 11.2% upstream of the confluence of SF Salmon Creek. Lower SF Salmon Creek gradient was 5.9%

Substrate Condition

The dominant substrate material was cobble in the lower 2.2 miles, and small boulders upstream of the forks (David Evans 1998). Based on Wolmann pebble counts and observation, fines are not a limiting factor in Salmon Creek. Two landslides were observed from RM 0.34 to RM 2.2, apparently the result of failure of the road paralleling the east side of Salmon Creek. The landslides are unstable and if disturbed could contribute a significant amount of sediment to Salmon Creek. The road should be actively considered for decommissioning.

Riparian Condition

Riparian vegetation species diversity was variable, with greater presence of deciduous trees in Reach 1 (lower 0.34 miles) and increasing presence of conifers upstream (David Evans 1998). Riparian vegetation was generally small (9.0 to 20.9 inches dbh), with some presence of large trees on lower SF Salmon Creek. Riparian vegetation was noted as not being able to provide LWD recruitment in the near future, but currently provides adequate shading and bank stability.

Water Quantity/Water Quality

Adverse flow patterns caused by rain-on-snow events are the primary controllable event with the Salmon Creek watershed (David Evans 1998). Increased snow accumulation on timber harvest units followed by a rapid snowmelt will cause increased stream runoff, which will adversely affect all salmonids. Based on review of aerial photos, timber harvest within the Salmon Creek watershed has greatly increased the percentage of open area and therefore negatively impacted salmonids.

Water temperatures during the 1998 assessment period were 15^{o}C in the lower creek, 11-12^{o}C in the mainstem upstream of the confluence of SF Salmon, and 13-14^{o}C in lower SF Salmon Creek (David Evans 1998). Water temperature monitoring in Salmon Creek at RM 0.3 from mid-October 2001 to late June 2002 showed 8 days when the average temperature exceeded 6^{o}C (Tulalip Tribes Data 2002). No water temperature concerns were identified.

The amount of flow at the lower end of Reach 2 (~RM 0.35) is greater than at the mouth of Salmon Creek (David Evans 1998). Some flow is going subsurface at the downstream end of Reach 2.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Salmon Creek watershed:

- Protect/restore watershed function through protection of forest cover and natural forest hydrology

- Decommission forest road that parallels the east side of Salmon Creek; stabilize existing landslides associated with the road
- Assess residential/recreational impacts to floodplain/riparian function in lower Salmon Creek; correct any identified problems
- Habitat condition would benefit from greater presence of LWD; TAG participants recommend this occur passively over time through riparian protection

Lost Creek 07.1041

General

Lost Creek is a LB tributary to the NF Skykomish River, entering at RM 9.6 (Williams et al. 1975). The lower portion of Lost Creek intermingles with an active channel of SF Skykomish for ~0.5 mile, with excellent habitat conditions.

Fish Access

No fish access concerns are identified.

Floodplain Modifications

The Index-Galena Road bridge crossing of Lost Creek does not impair floodplain function (Kraemer). Active mineral prospecting occurs in lower Lost Creek, but cumulative impacts have not been assessed (Chamblin).

There are past limited impacts associated with creation of an instream steelhead conditioning pond by placement of a sandbag dam across the channel upstream of the Index-Galena Road to impound flow (Kraemer). This affected floodplain function during flood flows and resulted in quick drawdown when the sandbags were removed. The conditioning pond has been discontinued.

Channel Conditions

LWD presence is good downstream of the Index-Galena Road; LWD condition is unknown upstream of the road (Chamblin).

Substrate Condition

No quantitative substrate information is available, but qualitative substrate condition is rated as good (Chamblin, Kraemer).

Riparian Condition

No information was available on riparian condition on Lost Creek.

Water Quantity/Water Quality

No information was available on water quantity or water quality for Lost Creek.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Lost Creek watershed:

- No actions are recommended at this time

Howard Creek 07.1042

General

Howard Creek is a LB tributary to the NF Skykomish River, entering at RM 9.7 (Williams et al. 1975). The Howard Creek watershed drains 1,916acres (USFS 1997). Anadromous salmonid distribution extends to a natural falls 0.5 miles upstream of the mouth. No information was available on habitat conditions in Howard Creek.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Howard Creek watershed:

- Assess habitat conditions; correct identified problems

Silver Creek 07.1053

General

Silver Creek is a RB tributary to the NF Skykomish River, entering at RM 10.3 (Williams et al. 1975). The Silver Creek watershed drains 8,030 acres of Forest Service land (USFS 1997). David Evans surveyed habitat conditions in the lower 3.85 miles of the watershed in 1998, excluding the lower 1,000 feet, which were privately owned and for which survey access was not granted.

Fish Access

Anadromous salmonid distribution appears to be possible to a natural falls passage barrier at RM 3.65 (David Evans 1998), although steelhead distribution is only known to occur to RM 3.2 (see Appendix A and the fish distribution maps in the separate map files included with this report).

Fish have been planted several times in Silver Lake, but have not survived (Kraemer). David Evans (1998) theorizes that the falls at RM 4.7 may be an unsurvivable barrier to downstream fish migration.

Floodplain Modifications

Three large landslides were identified in the lower 1.3 miles in 1998, two possibly due to timber harvest units (David Evans 1998). The landslides all appeared to be actively sloughing directly into the stream channel. Three large landslides were also identified from RM 2.0 to RM 2.7.

Four landslides were identified from RM 2.7 to RM 3.5, stemming from timber harvest and road construction.

Silver Creek is one of two watersheds (the other being the Miller River) with significant ongoing recreational mining; the Silver Creek Road currently displays several patented mining claims (David Evans 1998). There was previously a commercial mining operation at ~RM 3.3, with past problems of landslides downstream (Chamblin). The mining operation is currently inactive, with limited use of the access road, providing opportunities to abandon the road to eliminate potential for landslides.

Channel Conditions

Stream gradient ranged from 4.8 to 5.7 % in the lower 3.5 miles, increasing to 10% from RM 3.5 to RM 4.7 (David Evans 1998). Channel stability in the lower 2.7 miles (excluding the unsurveyed reach from RM 1.3 to RM 2.0) was rated as fair in a 1998 survey, with channel stability concerns including steep sideslopes, active bank failure, recruitment of colluvial material, and active scour and deposition of channel substrate (David Evans 1998).

Percent pools in Reach 1 (RM 0.2-1.3) was estimated at 28% in 1998; Reach 2 (RM 1.3-2.0) was not surveyed, but had numerous large deep pools; Reach 3 (RM 2.0-2.7) had 23% pools (David Evans 1998).

Large LWD was three times more abundant in the lower 1.3 miles than in areas upstream, with ~14 pieces/mile (David Evans 1998). LWD recruitment potential was also greater in the lower portion of the creek than further upstream, where riparian vegetation was comprised of small trees.

Substrate Condition

The dominant substrate type in the lower 2.0 miles is small cobble, with large cobble dominant upstream to the falls at RM 4.7 (David Evans 1998). The extreme channel gradient and coarse channel substrate probably limit the suitability of habitat for both resident and anadromous salmonids.

Riparian Condition

Riparian vegetation structure for fish-bearing stream miles is 51% mature and 33% immature (USFS 1997, as cited in David Evans 1998). Riparian structure in the entire Silver Creek watershed is 35% mature (>80 yrs old), 37% non-forest, 23% immature, and 5% sapling.

Water Quantity

Flow in Reach 1 on August 12, 1998 was measured at 16.7 cfs (David Evans 1998).

Water Quality

Water temperatures measured in August 1998 were 62-63^{o}F in the lower 3.5 miles and 52^{o}F in the reach from RM 3.5 to RM 4.7 (David Evans 1998). The warm water temperatures in the lower portion of the creek are thought to possibly be too warm for bull trout/Dolly Varden.

Water quality samples taken directly from mine sites on Silver Creek did not indicate acid mine drainage into Silver Creek (David Evans 1998). There are unquantified water quality impacts from landslides associated with road failures and timber harvest units (Chamblin).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Silver Creek watershed:

- Protect/restore watershed function through protection of forest cover and natural forest hydrology
- Decommission the Silver Creek Road
- Habitat condition would benefit from greater presence of LWD; TAG participants recommend this occur passively over time through riparian protection

Troublesome Creek 07.1085

General

Troublesome Creek is a RB tributary to the NF Skykomish River, entering at RM 12.0 (Williams et al. 1975). The Troublesome Creek watershed drains 4,695 acres (USFS 1997). The upper portion of the Troublesome Creek watershed is in the Henry M. Jackson Wilderness. Anadromous salmonid access extends upstream to an impassable falls at RM 0.25 (Kraemer). Known resident bull trout/Dolly Varden presence extends upstream to RM 2.5.

Floodplain and riparian functions are impaired to some extent through the campground area at the mouth of the creek (Chamblin). Riparian function is impaired within the ~24 campsite areas. There is a trail associated with the campground that goes underneath the bridge over Troublesome Creek that may constrain natural floodplain function.

Troublesome Creek is the only tributary creek in the upper Skykomish watershed that has been gauged, although gauge data are only available for the period 1929-1941 (USFS 1997). In the 12 years that Troublesome Creek was gauged, it had the lowest mean monthly discharges during the winter, when neither snowfall nor the snowpack contributed much water directly or through interflow or groundwater. Water temperature monitoring in Troublesome Creek at the campground from mid-October 2001 to late June 2002 showed 18 days in November where the average daily temperature exceeded 6^{o}C; the 7-day moving average was above 6^{o}C for 7 days (Tulalip Tribes Data 2002). No water temperature concerns were identified.

Action Recommendations

The following salmonid habitat restoration actions are recommended for the Troublesome Creek watershed:

- No actions are recommended at this time

Bear Creek 07.1120

General

Bear Creek is a LB tributary entering the NF Skykomish River at RM 13.1 (Williams et al. 1975). The Bear Creek watershed drains 3,293 acres (USFS 1997). Bear Creek supports known coho, known steelhead, and presumed bulltrout to a cascades at RM 0.2. No information is available on habitat conditions in this watershed. The creek is located on the opposite side of the NF Skykomish from the access road, and there are no roads within the Bear Creek watershed, so habitat conditions are likely representative of natural conditions.

Action Recommendations

The following salmonid habitat restoration actions are recommended for the Bear Creek watershed:

- No actions are recommended at this time

West Cady Creek 07.1142

General

West Cady Creek is a LB tributary to the NF Skykomish River, entering at RM 16.95 (Williams et al. 1975). The West Cady Creek watershed drains 11,561 acres (USFS 1997). Anadromous salmonid access extends upstream to an impassable falls at RM 0.7. TAG participants identified extensive road networks on both sides of the watershed, with unknown extent of impacts. However, USFS (1997) indicates 5.07 miles of road, with a road density of 0.28 mi/mi^2, which is below the typical road density threshold of concern.

Water temperature monitoring in West Cady Creek below the first cascades from mid-October 2001 to late June 2002 indicates that water temperatures do not exceed 6^oC (Tulalip Tribes Data 2002).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the West Cady Creek watershed:

- Assess road conditions and associated habitat impacts; correct any identified problems

Goblin Creek 07.1182

General

Goblin Creek is a RB tributary to the NF Skykomish River, entering at RM 18.45 (Williams et al. 1975). The Goblin Creek watershed drains 3,132 acres (USFS 1997).

Fish Access

A log jam at RM 0.5 is a barrier to anadromous fish passage (Kraemer), although known salmonid distribution does not extend that far; no actions are proposed regarding the log jam.

Floodplain Modifications/Channel Conditions/Substrate Condition

The average frequency of LWD/100 lineal feet in Goblin Creek was estimated at 4.5 pieces±3.5 (USFS 1997). Surveys in 1992 by USFS fisheries technicians of the lower 0.6 miles of Goblin Creek found riffles to be the dominant aquatic habitat type (90%), followed by glides (10%), pools (9%), and side channel (1%)(USFS 1997). Riffle habitat was heavily dominated by cobble (92%); glides had equal amounts of gravel and cobble, pools were 80% gravel and 20% cobble.

The only identified habitat concern is the potential for sediment delivery from the forest road crossing of Goblin Creek (Kraemer). The bridge has an adequate span to avoid impacts to floodplain function, but the approaches to the bridge are dished in the swale, with potential road sediment runoff routing to the creek.

Riparian Condition

Surveys in 1992 by USFS fisheries technicians of the lower 0.6 miles of Goblin Creek indicate that riparian vegetation was dominated by Douglas fir and western red cedar in the large tree seral class, providing high quality LWD recruitment potential.

Water Quantity/Water Quality

No water quantity or water quality information is available.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the West Cady Creek watershed:

- Assess forest road sediment delivery at bridge crossing; correct any identified problems

SF Skykomish River 07.0012 (continued upstream from Snohomish River and Skykomish River)

General

A key strategy and goal for the SF Skykomish is to generally manage the watershed for protection and restoration; with limited timber harvesting on federal lands and limited development within riparian zones on private lands (1998 subbasin workshop).

Fish Access

There are 91.6 miles of accessible habitat above Sunset Falls (Seiler 1991, as cited in 1998 subbasin workshop). There are several falls on the SF that are anadromous barriers. Sunset Falls (RM 51.7) is the first upstream anadromous fish barrier. Additional barriers on the South Fork are Canyon and Eagle Falls, within 3.5 miles upstream of Sunset Falls, and Alpine Falls on the

Tye River at river mile 73.5. Historically, anadromy extended upstream only to the base of Sunset Falls. In 1958, WDFW installed a trap and haul facility at Sunset Falls. The trap is operated generally from July through December, with fish hauled around the 3 lower falls and returned to the SF Skykomish at ~RM 56.0. There is ongoing debate regarding the appropriateness of establishing anadromy in this extensive upper watershed area, with associated implications to natural resident salmonids.

Anadromous fish use the mainstem and tributaries above the confluence of the Skykomish forks, with the major chinook utilization on the SF to RM 51.2 (1998 subbasin workshop). Fifteen percent of the chinook and 10% of the bull trout/Dolly Varden adult escapement in the Snohomish River watershed occurs above the three falls on the SF Skykomish (SASSI 1992).

Floodplain Modifications

Encroachment by public roads, private roads, and BNSF Railroad affect 46.5% of the shoreline (7.07 miles) downstream of Index Creek, 41.8% of the shoreline (11.8 miles) from Index Creek to the mouth of the Miller River, and 39% of the shoreline (4.08 miles) from the mouth of the Miller to the mouth of the Foss River (Savery in prep., as cited in SBSRTC 2002).

The north bank of the SF Skykomish downstream of Index Creek has been armored and is constrained by SR 2 and BNSF Railroad (SBSRTC 2002). Additionally the BPA utility corridor restricts the channel on the north bank. The south bank of the river in this reach is constrained by a county road, which extends to Eagle Falls, cutting the river off from the majority of its floodplain. As a result, the river has been cut off from the majority of its floodplain.

Generally, the SF Skykomish is isolated from its floodplain in the reach from Index Creek to the Miller River (SBSRTC 2002). The riverbanks have been armored in developed areas in and near the town of Baring.

The north bank of the SF Skykomish from the Miller to Foss rivers has been armored and is constrained by SR 2 in two places and at one crossing (SBSRTC 2002). The south bank has been armored and is constrained by BNSF Railroad and part of the USFS road network. Revetments, bridges, and development associated with the City of Skykomish have especially impacted the left bank (south side) of the SF Skykomish River throughout its length (David Evans and Associates 1999, as cited in SBSRTC 2002).

Aerial photography and qualitative observations from stream walks indicates that side channel habitat is limited in the SF Skykomish River and some of its tributaries (USFS 1997), the result of a combination of natural confinement and land use encroachment (Haas).

Channel Conditions

Wetted width/maximum depth ratios in the Skykomish watershed above the forks tended to range from 11-20, which is too high for the designated Rosgen channel type, resulting in an overall assessment of "functioning at risk" (David Evans and Associates 1999, as cited in SBSRTC 2002 Draft). However, TAG participants did not feel this was of significant concern (Purser).

LWD was historically removed, in conjunction with timber harvesting (primarily on the Beckler River), to increase flow capacity and fish passage. LWD removal caused lower pool frequency and higher velocities negatively impacting spawning and rearing habitat. Bank hardening has occurred to protect the many small recreational lots and their structures from erosion of the loose alluvial materials in the floodplain.

Substrate Condition

High quality gravels provide generally good spawning habitat on the mainstem forks and tributaries downstream of Alpine Falls (RM 73.5) on the SF Skykomish River (1998 subbasin workshop). Low summer flows limit access and available spawning habitat for summer spawning stocks in some mainstem areas and tributaries.

Road density in the South Fork is 1.71 mi/mi^2. Forty-six percent of the SF Skykomish watershed is in the high hazard category for human-induced mass wasting potential (USFS 1997).

Riparian Condition

LWD recruitment needs are not fully being met by hardwood stands along the SF Skykomish River (USFS 1997). Overall riparian condition would likely rate as fair.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the SF Skykomish watershed (WADNR Types 1-5, includes riparian condition on mainstem and tributaries)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Lower SF Skykomish	17	48	19	2	2	3	1	8
Upper SF Skykomish	22	42	22	3	2	2	1	5

Water Quantity

Precipitation in the SF Skykomish watershed averages ~120 inches per year (range from 85 to 135 inches per year)(USFS 1997). Storm events in the SF Skykomish watershed can be very intense; the 10-year, 24-hour maximum storm event averages just under 6 inches of precipitation in the SF Skykomish. Over 50% of the SF Skykomish watershed is in the combined rain-on-snow/snow dominated zone; 27.2% of the SF Skykomish watershed is in the rain-on-snow zone.

Hydrologic cumulative effects analysis in the Mount Baker Snoqualmie Forest plan states that areas with greater than 12% vegetative disturbance are of concern; the upper SF Skykomish is estimated to have 16% vegetative disturbance (SBSRTC 2002).

Low summer flows and high spring, rain-on-snow influenced, flood flows are thought to limit spawning and rearing productivity in the Skykomish Forks. Rain-on-snow events generally occur during the early winter and are caused by warm rains falling on relatively low elevation snow. These winter flood events can scour salmon redds constructed during the fall and winter, causing high egg and alevin mortality. Heavy timber harvest on Federal lands into the 1980's, logging roads, large stand replacing forest fires, removal of Large Woody Debris (LWD) and potential over-allocation of water (Bob Newman WDOE) may all have contributed to exacerbate these problems.

Water Quality

Low naturally occurring water temperatures in the upper watershed of the Skykomish Forks may limit anadromous salmonid productivity. However, the causes are natural and beyond human control and should not be considered as a habitat limiting factor (1998 subbasin workshop).

Although there are no 303(d) listings for the SF Skykomish, available information indicates that water quality is "moderately degraded". Water pollution sources and miscellaneous observations of elevated fecal coliform bacteria counts have been reported downstream of the City of Skykomish (USFS 1997). Stockpiles of ore concentrates and flue dusts at active and abandoned mines near Money Creek contribute metals to the river and may also locally alter pH (USFS 1997). USFS measured suspended solids ranging from 1-251 mg/L in 1967-8 (David Evans and Associates 1999, as cited in SBSRTC 2002).

Explorative studies conducted from 1972 to 1992 by various investigators identified petroleum-related products in soil and groundwater at the BNSF RR maintenance site in Skykomish, and the presence of oily seeps to the SF Skykomish River (RETEC 1996, as cited in USFS 1997). The BNSF RR maintenance facility was historically used to refuel and maintain locomotives, provide electricity for electric engines, store snow removal equipment, and as a base of operations for local track repair and maintenance. Ecology documented statements from residents who had observed oil seeping into the river for roughly 40 years. A site hazard assessment of the facility was completed in 1991; compounds of concern were identified as total petroleum hydrocarbons (TPH), benzene, lead, polychlorinated biphenyls (PCBs), toluene, and pyrene (E&E 1991, as cited in USFS 1997). In 1993, BNSF RR signed an Agreed Order to conduct the remedial investigation and feasibility study with Ecology, in accordance with the Model Toxics Control Act.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the SF Skykomish River mainstem:

- Restore or improve floodplain function where constricted
- Complete cleanup of BNSF RR maintenance site in Skykomish
- Enhance riparian function through increased presence of conifers and restored riparian function in areas where the floodplain is currently constricted

Bridal Veil Creek 07.1248, Payton Creek 07.1248A

General

Bridal Veil Creek is a LB tributary to the SF Skykomish River, entering at RM 50.9 (Williams et al. 1975). Knowledge of habitat conditions is limited to only the anadromous accessible portion of the watershed (Bridal Veil to RM 0.3, Payton to RM 0.2); upstream the watershed is in pristine condition.

Fish Access

No fish passage concerns are known in the anadromous accessible portion of the watershed. There have been regular problems with poaching and harassment of salmonid spawners by local residents and dogs (Kraemer, Chamblin).

Floodplain Modifications

Local access roads and the bridge crossing in the anadromous area may constrict natural floodplain function; the extent of effects is not known.

Channel Conditions/Substrate Condition

No quantitative information on channel or substrate conditions is available. Bridal Veil and Payton creeks are regularly used by good numbers of spawners.

Riparian Condition

There is housing encroachment and impaired riparian function in the anadromous accessible portion of the lower watershed, but extent of impairment is not known.

Water Quantity/Water Quality

No water quantity or water quality information is available. Turbid water conditions have been observed in Payton Creek during peak flows, but source and cause are not known.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Bridal Veil Creek watershed:

- Assess extent of impacts of bridge and roads to floodplain and riparian function; correct any identified problems
- Increase public education and enforcement to reduce poaching and harassment of adult spawners
- Assess source and impacts of turbid discharge from Payton Creek during peak flows

Barclay Creek 07.1252

General

Barclay Creek is a RB tributary to the SF Skykomish River, entering at RM 55.4 (Williams et al. 1975). The Barclay Creek watershed drains 5,518 acres (USFS 1997).

Fish Access

No fish passage barriers are known to occur. Anadromous access is limited to downstream of a cascade at RM 0.6.

Floodplain Modifications

Effects of the BNSF RR and SR2 crossings on floodplain function have not been assessed.

Channel Conditions

No information is available on channel conditions.

Substrate Condition

No quantitative information is available on substrate conditions. Road density is 0.35 mi/mi^2 (USFS 1997). Fifty–six percent of the watershed is in the rain-on-snow zone, and 51% of the soils are rated as high-risk. A survey of the lower 0.3 mile in December 1980 indicates substrate is composed mostly of larger rock and cascades, with very little presence of spawning gravels (Ackley 1980).

Riparian Condition

Riparian function is impaired in the vicinity of the BNSF RR and SR 2 crossings; there are no identified concerns upstream.

Water Quantity

Barclay Creek has the highest stream density (9.02 mi/mi^2) of any of the tributaries to the SF Skykomish, increasing the potential for impacts with any land use alterations in the watershed (Purser).

Water Quality

No water quality information is available.

Action Recommendations

The following salmonid habitat restoration actions are recommended for the Barclay Creek watershed:

- Assess habitat conditions; correct identified problems

Unnamed 07.1252A

General

Unnamed 07.1252A is a RB tributary to the SF Skykomish River, entering at RM 55.5 (Williams et al. 1975), immediately upstream of Barclay Creek. No habitat information is available for this watershed.

Action Recommendations

The following salmonid habitat restoration actions are recommended for the Unnamed 1252A watershed:

- Assess habitat conditions; correct identified problems

Baring Creek 07.1252X, Unnamed 07.1263, Unnamed 07.1280, Unnamed 07.1280X, Unnamed 07.1285, Unnamed 07.1296, Unnamed 07.1298, Unnamed 07.1326

General

Baring Creek is a RB tributary to the SF Skykomish River, entering at RM 56.3; Unnamed 07.1263 is a RB tributary to the SF Skykomish River, entering at RM 57.1; Unnamed 07.1280 is a RB tributary to the SF Skykomish River, entering at RM 57.6; Unnamed 07.1280X is a RB tributary to the SF Skykomish River, entering at RM 58.7; Unnamed 07.1285 is a RB tributary to the SF Skykomish River, entering at RM 59.8; Unnamed 07.1296 is a RB tributary to the SF Skykomish River, entering at RM 61.15; Unnamed 07.1298 is a RB tributary to the SF Skykomish River, entering at RM 61.7; Unnamed 07.1326 is a RB tributary to the SF Skykomish River, entering at RM 62.7 (Williams et al. 1975).

Although these are each independent right-bank tributaries to the Skykomish River between Barclay Creek and Grotto, they are all being included in a combined discussion because of similarity of habitat conditions and concerns. These streams provide spawning potential and significant cumulative salmonid rearing potential, but have not been recognized as salmonid streams in management of the railroad, highway, and powerline corridor right of ways.

Fish Access

All of these wall-based channels have anadromous access only for a short distance to the base of the bluff. Most of the creeks have bridges at the SR 2 crossings, but most of the BNSF RR crossings are box culverts, with passage concerns particularly at low flows (Chamblin).

Floodplain Modifications/Channel Conditions

The short anadromous accessible reach of many of these streams is intersected by railroad, highway, and BPA powerline corridors. Natural floodplain function and channel conditions are impaired by a combination of ditching along the railroad, confined stream crossings (particularly under the railroad, and regular removal of beaver dams by WSDOT (Chamblin).

Substrate Condition

No information is available on substrate conditions

Riparian Condition

Riparian function is impaired along most of these streams as a result of vegetation maintenance along the BNSF RR and SR2 corridors, and by regular vegetation maintenance/removal through the BPA powerline corridor, which intersects the anadromous reach in these streams (Chamblin).

Water Quantity/Water Quality

No information is available on water quantity or water quality.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for these right-bank wall-based tributaries to SF Skykomish River:

- Prioritize and correct passage barriers at the BNSF RR crossings
- Actively promote recognition of these streams as salmonid habitat
- Assess options and opportunities to restore floodplain and riparian function; will require discussions with WSDOT, BNSF RR, and BPA

Unnamed 07.1263X

General

Unnamed 07.1263X is a LB tributary to the SF Skykomish River, entering at RM 57.4 (Williams et al. 1975). No information is available on habitat conditions in this watershed.

Action Recommendations

The following salmonid habitat restoration actions are recommended for the Unnamed 07.1263X watershed:

- Assess habitat conditions; correct identified problems

Index Creek 07.1264

General

Index Creek is a LB tributary to the SF Skykomish River, entering at RM 57.3 (Williams et al. 1975). Index Creek watershed drains 5,965 acres (USFS 1997). The lower 0.25 mile consists of pools and riffles, and contains most of the spawning area (Ackley 1980). From RM 0.25-1.0 the main creek channel consists of large rock with increasing channel gradient; there are several small channel braids that provide some additional spawning gravels. Flow was estimated at 216 cfs in November 1980. No additional information is available on habitat conditions in this watershed, except a reference to Index Creek as a tributary that either goes subsurface or dries up during the summer (USFS 1985).

Action Recommendations

The following salmonid habitat restoration actions are recommended for the Unnamed 1263X watershed:

- Assess habitat conditions; correct identified problems

Unnamed 07.1283, Unnamed 07.1284, Unnamed 07.1287, Lowe Creek 07.1288

General

Unnamed 07.1283 is a LB tributary entering the SF Skykomish River at RM 58.0; Unnamed 07.1284 is a LB tributary entering the SF Skykomish River at RM 58.6; Unnamed 07.1287 is a

LB tributary entering the SF Skykomish River at RM 59.9 (Williams et al. 1975). No salmonid presence has been identified in these creeks. There was no surface flow in the lower 90m of Unnamed 07.1283 in November 1980; numerous log and rock passage barriers were also present to RM 0.5 (Ackley 1980). Flow in Unnamed 07.1283 was estimated at 0.5 cfs. Unnamed 07.1284 was surveyed to RM 0.3, but was impassable to a blockage at the mouth. Unnamed 07.1287 went subsurface upstream of the mouth. Lowe Creek was surveyed to RM 0.5. The lower 100m were identified as passable during low flows; flow on November 12, 1980 was estimated at 1.0 cfs, and substrate was identified as too large for spawning.

Unnamed 07.1294

General

Unnamed 07.1294 is a LB tributary to the SF Skykomish River, entering at RM 60.8 (Williams et al. 1975). The creek was identified as having good spawning gravel from the mouth upstream to an impassable logjam 50m upstream of the road (Ackley 1980). No additional information is available on habitat conditions in this watershed.

Action Recommendations

The following salmonid habitat restoration actions are recommended for the Unnamed 07.1294 watershed:
- Assess habitat conditions; correct identified problems

Unnamed 07.1295, Unnamed 07.1299

General

Unnamed 07.1295 is a LB tributary entering the SF Skykomish River at RM 61.0; Unnamed 07.1299 is a LB tributary entering the SF Skykomish River at RM 61.4 (Williams et al. 1975). No salmonid presence has been identified in these creeks. On Unnamed 07.1295, there is an impassable cascade upstream of the road and substrate is identified as too large for spawning (Ackley 1980). Flow in Unnamed 07.1295 was estimated at 0.5 cfs. On Unnamed 07.1299, flow was estimated at 1.0 cfs; the creek is impassable upstream of the road, but there are some spawning gravels in the lower 0.1 mile.

Money Creek 07.1300 and tributaries

General

Money Creek is a LB tributary to the SF Skykomish River, entering at RM 61.45 (Williams et al. 1975). The Money Creek watershed drains 6,163 acres (USFS 1997).

Fish Access

Water quality conditions in lower Money Creek may be a barrier to upstream/downstream salmonid migration (see Water Quantity/Water Quality section below).

Floodplain Modifications

No floodplain modification concerns were identified.

Channel Conditions

USFS surveys in 1979 of the lower 6.6 miles of Money Creek indicate channel gradient averaged 5%, and ranged from <1% in the lower reaches to 22% in the uppermost reaches (USFS 1997). Pool habitat made up ~37% of the aquatic habitat for six reaches in which fish habitat units were recorded. Many sections of Money Creek from stream mile 3.0-6.6 were completely dewatered during the August 1979 survey, likely the result of large areas of aggradation behind several LWD jams and one large rock slide.

Substrate Condition

Dominant substrate in the upper reaches of Money Creek were rubble and gravel, with bedrock being dominant upstream of RM 6.1 (USFS 1997).

Riparian Condition

Stream shading provided by riparian vegetation averaged ~50% over the entire stream length surveyed (USFS 1997). Riparian vegetation is dominated by conifers in the mid-seral class in the lower 3.0 miles, and in the mature seral class from RM 3.0 to 7.0. Riparian condition is generally good with the exception of the campground at the mouth (Purser).

Water Quantity/Water Quality

Historic mining of metals, primarily gold, has increased rates of sedimentation and acid leachate contamination. A sample taken at the site of the Lillian Leon Mine (part of the Kimball Creek group of mines) in the Money Creek watershed in 1996 yielded a pH reading of 4.0, which is quite acidic (USFS 1997). Fish populations require a pH to be within the range of 6.0 to 9.0 for normal development. This mine and possibly others in the drainage has probably been producing acid mine leachate for decades. Forest Service stream surveys conducted in 1980 stated that Money Creek appeared to be “biologically dead” (Skykomish Ranger District, MBSNF 1980, as cited in USFS 1997), and noted that arsenic had been detected in surface water samples taken from Money Creek. Reclamation of contaminated gold mine sites (the Kimble Group of mines and others) on Money Creek represents an important restoration opportunity.

Mine tailings, probably from the Apex Mine, were observed entering Money Creek at ~RM 6.3 (USFS 1997). Arsenic contamination of the creek was noted in a 1982 hand-written note. The degree and extent of contamination was not indicated.

The Cashman Mill site (located in the SW quarter of Sec 21, T26N, R11E) contained 2,000 tons of ore concentrate and 300 tons of flue dust, both containing arsenic. The site was located near Money Creek and the Miller River on private property but had spilled onto federal land (USFS 1997). The material was stored on unprotected ground and was uncovered for much of the time since the initial import of the flu dust in 1983 and the concentrate in 1991. The site was designated as a CERCLA site; some of the material has been removed from the site, some is still to be removed (Gall). None of the sampling conducted to date has found heavy metal contamination in Money Creek.

Water temperatures were monitored at the mouth and the headwaters of Money Creek in July-August 1979 (USFS 1997). Maximum temperatures at the mouth ranged from 53-55^{o}F; maximum temperatures in the headwaters ranged from 64-71^{o}F.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Money Creek watershed:

- Remediate mine leachates resulting in presence of toxics and acidic pH conditions in Money Creek

Miller River 07.1329 and tributaries

General

The Miller River is a LB tributary to the SF Skykomish River, entering at RM 63.5 (Williams et al. 1975). The Miller River watershed drains an estimated 29,335 acres (SBSRTC 2002 Draft). Approximately 79% of the watershed is within the Alpine Lakes Wilderness (USFS 2000).

Fish Access

No man-made barriers to anadromous passage are known to exist (USFS 2000).

Floodplain Modifications

Only 23% of the watershed has any level of land management activities, and actions are relatively limited in those areas. The river system largely remains in natural conditions, and the mainstem and the lower reaches of some of its tributaries have gradient and channel configurations that retain floodplain connectivity (USFS 2000). Natural floodplain function is impaired by bridge confinement and bank armoring at RM 0.3, and by road encroachment and a levee from RM 0.8 to 1.0 (Chamblin). The road and levee encroachment may impair side channel development in lower Miller River.

Forest roads are located adjacent to much of the EF and WF Miller rivers. Natural floodplain function is constricted and impaired at some locations, although both forks are predominantly located in narrow V-shaped valleys, with the roads located mainly outside the floodplain (Gall). However, the roads along the forks do significantly impair riparian function in some stretches. There have been 2 mass failures associated with the road system in the last 7 years, but the USFS has “repaired” both slides.

Channel Conditions

Limited stream survey information of the lower reaches of the mainstem, and visual inspection of large-scale videography and photography of the river estimate that ~80% of the streambanks are stable (USFS 2000). Semi-quantitative measurements of aerial photography indicate wetted width/depth ratios of 10-15 in the lower reaches of the Miller River. Wetted width to depth ratio conditions are thought to be functioning appropriately (USFS 2000); however, based on habitat observations, ratios are suspected to be much greater than optimal (Nelson).

Surveys in November-December 1980 identified pools and riffles with good coho spawning habitat in the lower mile of Miller River, similar conditions with some side channels from RM 1-2, and increasing stream gradient with reduced spawning substrate from RM 2-3 (Ackley 1980).

Substrate Condition

No sediment budgets have been estimated for this watershed; no bedload or suspended load samples are known to have been collected (USFS 2000). Approximately 77% of this watershed lies in the Alpine Lakes Wilderness, no timber harvests have occurred in the remaining forested lands since 1990, road density is low (0.5 mi/mi^2), and inspection of aerial photos shows few mass failures. It is assumed that current sediment delivery rates approximate natural background delivery rates. Stream surveys indicate relatively low levels of sediment deposition in the lower reaches of the mainstem Miller River.

Riparian Condition

The existing riparian reserve network within the Miller watershed provides adequate shade, LWD recruitment, and habitat protection and connectivity (USFS 2000), largely due to 79% of the watershed being in Wilderness.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Miller River watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Miller R	26	32	22	3	1	4	0	11

Water Quantity

There are no active or past flow gauges in the Miller River watershed. Past and present management of this watershed has not affected the annual watershed hydrograph; peak flow, base flow, and flow timing are comparable to an undisturbed watershed of similar size (USFS 2000).

Water Quality

Water temperature monitoring has been conducted by the Tulalip Tribes in the mouth of the Miller River (RM 0.1) from 1994-1999 (USFS 2000). Mean annual dry season temperatures ranged from 9.8°C to 13.3°C (SBSRTC 2002). Stream temperatures collected May-September 1998 averaged 10.3°C. Temperatures exceeded rearing requirements for bull trout/Dolly Varden. Additionally, single day temperatures exceeded 21°C in July 1998. No known water samples have been collected for chemical or biological contamination analysis, although there are no potential concerns identified.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Miller River watershed:

- Restore floodplain function in the lower river, where impaired

- Assess habitat conditions; correct identified problems

Maloney Creek 07.1407

General

Maloney Creek is a LB tributary to the SF Skykomish River, entering at RM 65.2 (Williams et al. 1975). The Maloney Creek watershed drains 2,313 acres (USFS 1997).

Fish Access

Maloney Creek goes subsurface at the Old Cascade Highway bridge during low flow conditions due to aggradation of the streambed.

Floodplain Modifications

The town of Skykomish is built on the alluvial fan of Maloney Creek at the base of a gorge (Collins). The creek has been routed and confined through Skykomish. Maloney Creek frequently floods on the edge of the town of Skykomish (Chamblin). A sediment trap pond was constructed by the USFS at the request of the town of Skykomish in the early 1990s. The desired purpose was to trap some of the sediments that had been aggrading the channel below it, which were greatly reducing the channel capacity during high flow events, resulting in some flooding of portions of the town of Skykomish. The trap is full and no longer trapping sediments.

Maloney Creek was re-routed into its present location along the edge of the town of Skykomish (likely in the 1920s-1930s) to reduce exposure of BNSF RR, BPA, and USFS administration facilities to flooding (anecdotal per Barry Gall). The slope of the current channel is likely shallower than the original channel, likely increasing the already high natural aggradation in Maloney Creek. Sediment presence may be elevated; there are reportedly one or more mass failures in the upper watershed that may be spatially, if not causally linked to past land use practices, although no evaluation has been conducted. The lower portion of Maloney Creek has been dredged, although only once in recent history (anecdotal per Barry Gall).

Channel Conditions/Substrate Condition

Surveys in December 1980 indicate that most of the lower 0.6 mile of Maloney Creek contained good gravel and pools, providing excellent spawning conditions (Ackley 1980). The upper 300m of the survey area consisted of a sediment pool and large rock. Flow was estimated at 50 cfs.

Riparian Condition

No information is available on riparian condition.

Water Quantity/Water Quality

Maloney Creek goes subsurface at the Old Cascade Highway bridge during low flow conditions due to aggradation of the streambed. There are anecdotal reports of possible oil seepage contamination to Maloney Creek from the BNSF RR fuel storage site in the City of Skykomish (Gall). Remediation plans under discussion with the Washington Department of Ecology may include considerations to address this concern. No additional water quality information is available.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Maloney Creek watershed:

- Assess opportunities to restore floodplain function where constricted through the town of Skykomish
- Assess habitat conditions; correct identified problems

Beckler River 07.1413, Eagle Creek 07.1416, Harlan Creek 07.1436, Bullbucker Creek 07.1540, and Rapid River 07.1461

General

The Beckler River is a major RB tributary entering the SF Skykomish River at RM 66.6 (Williams et al. 1975), just upstream of the town of Skykomish. Rapid River is a major left-bank tributary entering the Beckler at RM 7.7. The Beckler/Rapid River watershed drains an estimated 64,317 acres (USFS 1995).

The Beckler River is the most impacted sub-watershed in the Skykomish Forks, due primarily to removal of large woody debris, logging, high road density, road failures and large stand replacing fires (1998 subbasin workshop). Railroad logging (beginning in the 1920s and 1930s) cut the forests in the lower Beckler watershed (USFS 1995). Patch clearcutting and road building in the 1950s began moving up the slopes above the railroad logged areas and into the upper Beckler and upper Rapid watersheds. Extensive salvage harvests followed the fire on Evergreen Mountain. Accelerated clearcutting in the 1970s and 1980s was concentrated on the non-Forest Service lands in the lower Beckler and also in the upper Beckler and upper Rapid River areas.

Fish Access

The total length of stream channels in the Beckler watershed is currently estimated at 636 miles (USFS 1995). This includes 68 miles of stream thought to be the primary reaches supporting anadromous and resident fish, along with 568 miles of streams that do not appear to support significant numbers of fish as defined by Forest Service classification. The upstream extent of anadromous salmon access is a natural 12-foot high waterfall at RM 11.8 in the Beckler River, and a falls at RM 3.3 on the Rapid River.

There is only one known human-made barrier in the accessible anadromous reaches within the Beckler River watershed; this is a seasonal barrier to upstream passage at the mouth of Fourth of July Creek, a RB tributary to the Beckler River at approximately river mile 8.3 (Gall). The USFS began planning and design work began in 2002 to replace the existing culverts with a bridge.

Floodplain Modifications

Several sections of the Beckler River Road and associated riprap constrain the river, however the majority of the watershed has no development in the floodplain or riparian areas, and channels have remained connected to associated off-channel and overflow channels (USFS 1999, as cited in SBSRTC 2002).

Channel Conditions

Logging of the riparian habitat and removal of large woody debris from the mainstem of the lower several miles have impacted fish habitat. Removal of LWD has caused a concomitant decrease in pool density between 1980 and 1991 (USFS 1995).

The Beckler watershed has a low frequency of LWD compared to undisturbed regions, likely due to changes in riparian forest composition, past wood removal, and the 1990 flood (USFS 1995). Only 8.1 pieces of LWD/mile were documented in a 1996 stream survey of the lower 8.5 miles, and 21.8 pieces of LWD/ mile between RM 8.5 and RM 13.3 (USFS 1999, as cited in SBSRTC 2002). The Forest Service rated the Rapid River watershed as "degraded" due to low frequency of LWD in the lower river compared to undisturbed regions (USFS 1995, as cited in SBSRTC 2002); the upper Rapid River is in wilderness designation and is presumed to be intact.

Throughout the main channels of the watershed, the habitat types that contain the highest levels of LWD (>5 pieces/100 lineal feet of stream) are pools and side channels in the upper Rapid, and pools in the upper Beckler (Wissmar and Beer, as cited in USFS 1995). Much of the LWD in these channels is composed of small coniferous and deciduous trees recruited from young riparian stands. The average frequencies per 100 feet of stream for large coniferous LWD (>2 feet diameter) ranged from 1.1±0.9 for the lower Beckler, 2.1±for the upper Beckler, and 2.9±1.9 for the tributaries in these drainages (Wissmar and Beer, as cited in USFS 1995). The average frequencies in the Rapid are higher in both the lower and upper channels (3.0±1.3 and 8.6±5.5, respectively).

Removal of LWD in the late-1970s, in an effort to reduce flood hazards, sharply reduced both the frequency and volume of LWD in many channels, especially the lower ones (USFS 1995). Timber harvest and past fires significantly lowered levels of LWD, but stream cleaning likely caused the largest negative impact in many areas. The removal of LWD began in 1978 and was completed by 1981. In 1980, stream surveys were conducted in some reaches of the Beckler and Rapid drainages (Cyr 1992, as cited in USFS 1995). Forest Service stream surveys were repeated for many of the same reaches in 1989, and again in 1991, to characterize instream conditions following the 1990 flood.
Table 18 compares LWD and pool frequencies in the lower reaches of the Beckler for these surveys. Removal of LWD from the channel (stream cleanout) had been completed in these reaches in the 1-2 years preceding the 1980 survey, hence very few pieces were found in 1980 (LWD was not removed from the upper Beckler mainstem in the wood removal contract). In the 9 years following the 1980 survey, LWD was recruited into the reaches from riparian stands or transported downstream into these reaches from higher in the watershed. The flood of 1990 evidently flushed much of the wood (which had accumulated by 1989) downstream and out of the Beckler.

The large number of pools (189) present in the summer of 1980 (Table 18) in the lower mainstem of the Beckler) were likely remnants of the pools that were present prior to the stream cleanout effort, and which had not yet filled in (USFS 1995). By 1991, numbers of pools in the reaches from RM 0-5.6 and 5.6-7.7 had been reduced by 94% and 97%, respectively. Some of the difference in numbers of pools from 1980 to 1989 may have been due to differences in definitions and methods used to identify pools.

Table 18: Number of pools and LWD observed in the lower reaches of mainstem Beckler River in 1980, 1989, and 1991 (modified from USFS 1995)

			LWD - Pieces		
River Mile	Year	# Pools	# Brush	#Small	#Large
0-2.8	1980	47	54	5	2
0-2.6	1989	1	35	15	1
2.8-5.6	1980	59	86	9	4
2.6-5.6	1989	4	429	155	47
0-5.6	1991	6	221	83	42
5.6-7.2	1980	83	46	16	8
5.6-7.7	1989	1	94	58	13
5.6-7.7	1991	2	90	39	1

Streambank stability is relatively poor throughout much of the Beckler watershed. Wissmar and Beer (1994, as cited in USFS 1995) estimated streambank instability at 28-32% on the upper mainstem Beckler, and 38-100% on the lower Beckler. Conditions were much more variable and generally more unstable in many of the tributaries than they were in the mainstem. Bolt, Harlan, Boulder, and Evergreen creeks all had mass wasting in >50% of the channels surveyed. Streambanks were unstable over ~31% of channel length of the lower Rapid River due to mass wasting, debris jams, and bank erosion.

Substrate Condition

Debris torrents and culvert failures are common within the Beckler, and particularly concentrated in the upper Beckler, where both harvest and roading have been focused since the 1950s (USFS 1995). Several large earthflows have occurred within the last 10 years in Meadow, Boulder, and Fourth of July Creeks (USFS 1999, as cited in SBSRTC 2002). Continual culvert failures have occurred where steep tributary channels are crossed by roads, associated with rain-on-snow events on at least a 10-year cycle. Most of the stream crossing culverts on the main roads within the Beckler have had 2-3 failures since their construction, with successive rain-on-snow events. Culverts have been upgraded in size several times; on some crossings, bridges were finally installed. For example, the road crossings on Evergreen, Boulder, Bullbucker, Johnson, Harlan, and Eagle creeks and several Beckler crossings have all had bridges installed after one or two major failures. The sediment that would have naturally been transported without the road fill added to it frequently may not have been significant. Including the road fill, most failures deposit 200-1,000 yd^3 of sand-size sediment directly into the channel. Estimates by the University of Washington Center for Streamside Studies of mass wasting in the Beckler watershed include both calculations based on dimensions from culvert failure sites, to visual estimates from debris piles or material lost (Glen Katzenberger, as cited in USFS 1995). Estimates from the 1990 flood alone due to road fill and culvert failures are ~88,000 yd^3. In addition, because the roads were constructed for the purpose of timber sales, a loss of large trees adjacent to channels has compounded the effect of rain-on-snow events on the channels, with greater reaches of stream scoured and affected by the event.

Road density has been shown to be an important factor influencing mass wasting (Wissmar and Beer 1994, as cited in USFS 1995). The Beckler River watershed has relatively high road densities, and has had the most significant effort to date by the Forest Service to decommission old logging roads in the Skykomish Forks (1998 subbasin workshop). Road densities in Bolt

(5.29), Eagle (2.7), Harlan (2.61), Bullbucker (2.81), and Windfall (3.91) creeks exceed the USFS road density threshold of concern of 2.5 mi/mi^2 (USFS, 1995). Watershed inventories have shown that roads in the Bolt, Rapid Mouth, Windfall, and Johnson creek watersheds have a known high risk of failure, with cracking road fills or failing culverts.

Riparian Condition

With the exception of the upper Rapid watersheds in the wilderness, all watersheds are about 30-55% below the historic levels of mature conifer forest within their riparian reserves (USFS 1995). Particularly low levels of old growth riparian reserves are located in the Bolt (10%), Eagle (20%), mid-Beckler (28%), Boulder (32%), and Rapid Mouth (23%) watersheds. Evergreen and Bullbucker have the highest percentage of stream adjacent old growth, with 65% and 59%, respectively. Total Becker watershed distributions are averaged at 38% mature, 32% immature, 14% sapling, and 17% small/non-forested. Bolt, mid-Beckler, and Rapid Mouth riparian reserves are dominated by mid-seral forest. Most of the lower mainstem of the Beckler River is currently bordered by immature stands of timber. Additional inputs of LWD from these stands into the channel will not begin to occur for about 50 years, and historic frequencies of instream LWD may not be approached for about 200 years.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Beckler River watershed (WADNR Types 1-5):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Beckler R	24	39	25	3	1	3	0	5
Rapid R	34	32	18	1	1	2	0	13

Water Quantity

There are no specific data available, although there are anecdotal observations of a relatively rapid flood response to storm events on the Beckler River (1998 subbasin workshop). This can mobilize and accelerate bedload transport, affecting intergravel egg survival.

There are currently no discharge gauges operating in the Beckler River watershed. Limited gauge data are available for the Beckler River from 1930-33 and 1946-49 (RM 2.5, USGS gauge 12131000)(USFS 1995). Limited gauge data are also available for Bullbucker Creek for 1971-75 (USGS gauge 12130800). Estimated peak flows for the Beckler for the 2-year, 10-year, and 100-year events are 5,602, 10,413, and 17,158 cfs, respectively (USFS 1995). However, hydrologic conditions in the watershed are probably not the same today as they were from 1930-1970, due to post-1970 timber harvest and related road construction, and because of faster rates of snowmelt in areas where canopy has been removed. Forty-five percent of the watershed lies within the rain-on-snow zone elevations of 1,500-3,000 feet.

Water Quality

Water quality on the Beckler is generally good with the exception of relatively high turbidity levels (1998 subbasin workshop). While specific turbidity sources have not been identified, increased turbidity appears to partially originate near Jacks Pass. Fire damage and salvage logging in the 1970s on the Rapid River may also be contributing to the higher turbidity levels.

However, qualitative visual observations of the lower Beckler made by several USFS employees over the last 5-15 years (Woolley et al 1995, as cited in USFS 1995) indicate that the river rarely has high concentrations of suspended solids during storms, and appears quite clear at all other times.

The Tulalip Tribe documented a spot summer water temperature measurement of 23.2°C in September 1994 (Progress Report 96-3). Surveys in 1996 identified rearing temperatures exceeding 14°C (USFS 1999, as cited in SBSRTC 2002). The Tulalip Tribes also documented temperatures in the lower Beckler River in excess of 15°C in August 1996 and 15°C in July of 1998 (Nelson 2002). It is unknown to what extent these temperatures reflect human impacts (i.e., clearing of the riparian forest) or natural conditions. Limited water quality sampling for fecal coliform bacteria at RM 2 identified no violations of state water quality standards (USFS 1995). However, past sampling efforts in the spring of 1990, fall of 1989, and in the 1960s revealed fecal coliform bacteria levels in excess of state water quality standards upstream and downstream of the campground at RM 1.9.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Beckler River watershed:

- Develop and implement a comprehensive forest road management plan that addresses the identified concerns of culvert failures and fine sediment contribution from roads; decommission roads where possible
- Restore riparian function throughout the watershed
- Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until riparian function is restored

Anthracite Creek 07.1561

General

Anthracite Creek is a LB tributary to the SF Skykomish River, entering at RM 67.6 (Williams et al. 1975). A survey of the lower 0.3 mile in December 1980 indicated some spawning area available, but most of the substrate consisting of fine sediment and large rock; flow was estimated at 16 cfs (Ackley 1980). No additional information is available on habitat conditions in this watershed.

Action Recommendations

The following salmonid habitat restoration actions are recommended for the Anthracite Creek watershed:

- Assess habitat conditions; correct identified problems

Foss River 07.1562, WF Foss 07.1573, Burn Creek 07.1596, and tributaries

General

The Foss River is a major LB tributary to the SF Skykomish River, entering at RM 69.1 (Williams et al. 1975). The Foss River watershed drains an estimated 35,459 acres (SBSRTC 2002 Draft).

In 1997, approximately 27 bull trout/Dolly Varden were transported over Sunset Falls; a radio-telemetry study indicated that the majority of these fish spawned in the Foss River watershed (USFS 2000).

Fish Access

No man-made barriers to anadromous passage are known to exist (USFS 2000).

Floodplain Modifications

Only 23% of the watershed has any level of land management activities, and actions are relatively limited in those areas (USFS 2000)(this likely does not recognize potential impacts from trail building and maintenance in the wilderness area (Haas)). The river system largely remains in natural conditions, and the mainstem and the lower reaches of some of its tributaries have gradient and channel configurations that retain floodplain connectivity.

Channel Conditions

Limited stream survey information of the lower reaches of the mainstem, and visual inspection of large-scale videography and photography of the river estimate that ~80% of the streambanks are stable (USFS 2000). Semi-quantitative measurements of aerial photography indicate wetted width/depth ratios of 10-15 in the lower reaches of the Foss River. Wetted width to depth ratio conditions are thought to be functioning appropriately.

Substrate Condition

No sediment budgets have been estimated for this watershed; no bedload or suspended load samples are known to have been collected (USFS 2000). Approximately 77% of this watershed lies in the Alpine Lakes Wilderness, no timber harvests have occurred in the remaining forested lands since 1990, road densities are low (0.5 mi/mi^2), and inspection of aerial photos shows few mass failures. It is assumed that current sediment delivery rates approximate natural background delivery rates. Stream surveys indicate relatively low levels of sediment deposition in the lower reaches of the mainstem Foss River.

Riparian Condition

The existing riparian reserve network within the Foss watershed provides adequate shade, LWD recruitment, and habitat protection and connectivity (USFS 2000), largely due to 77% of the watershed being in Wilderness.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the Foss River watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Foss River	29	40	15	2	2	5	1	7

Water Quantity

There are no active or past flow gauges in the Foss River watershed. Past and present management of this watershed have not affected the annual watershed hydrograph; peak flow, base flow, and flow timing are comparable to an undisturbed watershed of similar size (USFS 2000).

Water Quality

Water temperature monitoring has been conducted by the Tulalip Tribes in the mainstem Foss River since 1995 (USFS 2000). No water temperature concerns have been identified. No known water samples have been collected for chemical or biological contamination analysis, although there are no potential concerns identified.

Action Recommendations

No salmonid habitat restoration actions are recommended for the Foss River watershed at this time.

Tye River 07.0012 (cont. from SF Skykomish), Profits Pond Creek 07.1621, Alpine Creek 07.1622, Unnamed 07.1626, Unnamed 07.1627

General

The Tye River is the continuation of the SF Skykomish River at RM 69.11 (Williams et al. 1975). The Tye River watershed drains an estimated 51,772 acres (SBSRTC 2002 Draft). Prior to development in the watershed, the primary mechanisms that provided LWD and sediment inputs to streams were fire and snow avalanches (USFS 1998). The watershed was heavily burned during major stand replacement fires in 1508 and 1701.

Fish Access

Anadromous access extends upstream to Alpine Falls, about 3.0 miles above the mouth of the Tye River. No human-made barriers to anadromous passage are known to exist (USFS 1998).

Floodplain Modifications

SR 2, other roads, powerline right of ways, BNSF Railroad, and townsites along the Tye River have constricted the floodplain. Old meander flats have been cut-off by highway and road fills. It appears that there has been some loss of historic floodplain capacity as a result (USFS 1998).

Channel Conditions

Habitat assessments conducted on the Tye River downstream of Alpine Falls in 1989-1990 reported the following habitat conditions (USFS 1998):

- 6-20% pool habitat
- 2-8 pools over 5-feet residual depth per mile
- width:depth ratio of 11
- 6-40% cover, with side channels
- 16-20 pieces of LWD per mile
- Maximum stream temperature of 52^{o}F
- Embeddedness >35% in the depositional flats, and
- Riparian vegetation dominated by alder, vine maple, and small Douglas fir

LWD abundance was higher upstream of the falls and in the tributaries, but embeddedness remained high in most of the surveyed reaches (USFS, 1998). The USFS rated overall anadromous habitat condition downstream of Alpine Falls as fair to good (USFS 1998), but comparison to LFA habitat rating standards would indicate a lower habitat condition rating due to the low amount of pool habitat, limited cover, limited abundance of LWD and high surface embeddedness. In addition, LWD recruitment potential is limited in the short-term; old growth and mature tree habitats make up only 39% of the riparian reserves. Much of the remaining old growth and mature forest is in the higher tributaries, with little potential for any resulting LWD contribution to the lower river.

Substrate Condition

Sediment loading appears to be high and may be causing excessive bar formation in the Tye River downstream of Alpine Falls (USFS 1998). Major sediment sources are roads, as evidenced in road surveys and by mass failures in Alpine and Martin creeks, and drainages on the south side of Beckler Peak and Alpine Baldy.

There are 125 miles of roads in the Tye watershed, resulting in an overall road density of 1.48 mi/mi^2 (USFS 1998). Road density varies significantly, with the highest densities of 3.2 and 1.9 mi/mi^2 being in the upper and lower Tye River watersheds, respectively. Road densities >2.0 mi/mi^2 are generally felt to approach a threshold where road effects on slope hydrology and mass wasting may be damaging to the watershed (Megahan, as cited in USFS 1998). A 1991 road inventory evaluated the Beckler Peak Road (6066, 6067), Martin Creek Road (6710), and the Tonga Ridge Road (6830), that affect Alpine, Carroll, and a portion of Deception creeks (USFS 1998). Over 7 acres of landslides, cutslopes, fillslopes, and plugged culverts directly threatened streams. The greatest hazards to streams are the Martin Creek and Beckler Peak roads. One of the primary sources of sediment input is road crossings of steep tributary streams through unconsolidated silts and gravel outwash deposits.

Sanding of SR 2 is also a chronic contributor of fine sediment, but the extent of the impact is unknown (USFS 1998).Winter sanding of SR 2 has contributed an undetermined amount of the 2,500-7,000 yd^3 of sand applied to the highway annually (USFS 1998). Approximately 9 miles of the highway lie within riparian reserves below Scenic, and numerous sites exist where the highway abuts the Tye River. If only 1% of this sand gets into the river, that amounts to 25-70 yd^3, or the equivalent of a small landslide each year.

Sediment from bank erosion will continue to contribute to channel embeddedness and limit success of spawning within the Tye River (USFS 1998). Prominent sediment sources consist of a large (>2 acre) bank failure in fine-grained lacustrine and glacial till deposits across from the Timberline development, the Wellington townsite fill material, and river terrace deposits along SR 2.

Riparian Condition

Ski area development and maintenance as well as timber harvest, powerline corridor maintenance, and highway construction have fragmented riparian buffers (USFS 1998); the extent of the impact has not been quantified. Openings along SR 2 and the BPA transmission line will persist, leaving sections of the river exposed to sunlight, especially downstream of Alpine Falls. While increases in stream temperature will continue in these sections, overall stream temperatures are expected to decrease over time as riparian vegetation matures.

Land cover data prepared by Snohomish County identifies the following percentages of different vegetation classifications within 300 feet of streams and water bodies in the T ye River watershed (WADNR Types 1-5)(Purser):

Watershed	Mature Evergreen Forest	Mixed Forest	Scrub/ Shrub	Crops/Grass/ Marsh	High Impervious	Medium Impervious	Open Water	Unknown
Tye R	30	38	22	3	1	2	0	5

Water Quantity

One-third of the Tye River watershed falls in the rain-on-snow zone; rain-on-snow events are thought to be the dominant process generating peak flows and floods. Given the low level of vegetative disturbance in this zone (15%), the Forest Service characterizes the watershed as "hydrologically mature" (USFS 1998, as cited in SBSRTC 2002).

Data are lacking, however, peak and base flows in the Tye watershed are at risk of alteration due to the degree of disturbance on the upper watershed (USFS 1998).

Water Quality

There are no 303(d) listed segments in the Tye River watershed. The Tulalip Tribes sampled water temperature on a monthly basis between 1994 and 1999. Temperatures exceeded 14^{o}C during sampling in August 1997 and 1998 (Tulalip Tribes unpublished data, as cited in SBSRTC 2002).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Tye River watershed:

- Restore riparian function on the Tye River and tributaries where impaired by encroachment by SR 2 or BPA transmission lines, or where impacted by prior timber harvest
- Stabilize existing and high-risk road failure sites, including reducing road mileage in the upper and lower Tye River watersheds
- Address causes of chronic bank erosion sites at Wellington and across from Timberline

- Continue efforts with WSDOT to devise ways to minimize entry of sand into the river and minimize floodplain and wetland encroachment, especially downstream of Scenic

Everett Independent Drainages

General

There are nine small independent drainages that enter directly into Possession Sound along the western boundary of Everett (Williams et al. 1975). Only two of these (Pigeon #1 Creek 07.1722 and Japanese Gulch 07.1729) are known to currently support coho. Coho were observed in lower Pigeon #2 Creek in 1980 (Stober et al. 1981), but no coho presence has been observed in recent years. The streams have some potential to support cutthroat, chum, and coho, assuming adults and juveniles can negotiate migration impediments (Golder 2001, as cited in SBSRTC 2002). Cutthroat were sampled in 1993 in Pigeon Creek #1, Glenwood Creek, and Japanese Gulch Creek (Daley 1993).

Fish Access

Each of these streams flows through a culvert (typically 3-foot diameter) passing under the railroad track, located right on the marine shoreline (SBSRTC 2002). Fish access to the streams can only be negotiated at high tide because the culverts are often elevated above the sandy substrate or riprap along the nearshore marine environment. Even in a pristine state, access to the creeks by anadromous fishes would likely be limited to high tide because stream volume is low and the stream channels are ill-defined across the broad sand and mud intertidal area, which would expose emigrating juvenile salmon smolts to avian predators during low tide (Golder 2001, as cited in SBSRTC 2002).

Japanese Gulch Creek has a known culvert fish passage barrier at Mukilteo Boulevard (Chamblin); additional barriers were noted by Daley (1993), including a velocity barrier at the culvert crossing under the BNSF tracks (access by returning adult salmonids is limited to a very narrow period when the tides are very high and the streamflow is sufficient to remove the velocity barrier), and presence of a concrete dam at the culvert crossing under the Boeing railroad spur that appeared to be a total barrier to adult migration. Despite the apparent fish passage barrier at the mouth of Japanese Gulch Creek, anadromous salmonids have repeatedly been found upstream of this fish barrier both during fish surveys and during benthic invertebrate sampling (Mathias).

Anadromous salmonid passage in Pigeon #1 Creek extends to an instream stormwater detention pond ~0.5 miles upstream of Mukilteo Boulevard; the instream pond was constructed prior to restoring fish passage upstream of the Mukilteo Boulevard culvert. Further assessment in the other creeks is needed to determine the extent of passage limitations at the BNSF RR culverts or elsewhere in the watersheds.

Floodplain Modifications

The steep-walled ravines typical of these drainages have discouraged disturbance within the ravines. Floodplain function within the ravines is generally intact. However, the creeks are routed through culverts under the BNSF RR track right-of-way, separating the streams and their riparian corridors from Possession Sound. This has likely altered natural floodplain/estuarine habitat conditions at the mouths of these creeks. Several of the creeks continue to route sediment through the culverts, creating alluvial fans on the marine nearshore (Chamblin, Houghton).

Channel Conditions/Substrate Condition

Pigeon Creek #1 suffers from failure of streambanks and steep slopes in the ravine, which are contributing a significant level of sand and silt in the streambed (Daley 1993). Major siltation was also noted as a problem in Pigeon Creek #2 (Daley 1993); however, a new channel has been cut through the depositional area and the depositional area has re-vegetated completely, eliminating the prior identified concern (Mathias). McNeil sediment samples from Pigeon #2 Creek in 1980 indicated 14% and 22% fines (.841mm) in the lower and upper reach, respectively (Stober et al. 1981). In addition to Pigeon #2 Creek, measured fine sediment in Japanese Gulch, Edgewater, and Glenwood creeks also exceeded 12% fines in 1980. The instream stormwater detention pond in Pigeon #1 Creek alters sediment transport and hydrology, but the effects on downstream habitat have not been assessed (Chamblin). There is potential of high fine sediment presence in all of these creeks due to the development that has occurred outside the ravines. In addition, the naturally steep gradient in these streams (up to 10%) predisposes them to a high sediment production regime (Mathias).

Glenwood Creek was noted as having the best combination of spawning gravels of all the Everett Independent Drainages, but only cutthroat were found in the stream (Daley 1993).

Riparian Condition

The riparian buffer width for Narbeck Creek exceeds one site potential tree height for greater than 80% of its shoreline, while all others are below the 70% threshold (SBSRTC 2002). Glennwood Creek was noted as having excellent riparian habitat (Daley 1993). Furthermore, as these creeks are all small and are located in steep-walled ravines vegetated with trees, riparian function is generally good.

Water Quantity

Total impervious area for Glenwood Creek is estimated to be below 7%; one of the creeks has an estimated total impervious area between 7% and 12%, and seven of these drainages have an estimated total impervious area exceeding 12% (Purser and Simmonds 2002, as cited in SBSRTC 2002).

The instream stormwater detention pond in Pigeon #1 Creek alters sediment transport and hydrology, but the effects on downstream habitat have not been assessed; the City of Everett is currently designing a stormwater bypass for Pigeon Creek #1, which will significantly reduce sediment loading (Mathias). Japanese Gulch Creek is noted as being "essentially a stormwater conduit, serving to drain Paine Field and Boeing facilities" (Brown and Caldwell Undated). However subsequent fish surveys that repeatedly show utilization by anadromous salmonids in the lower reaches of Japanese Gulch suggest that Brown and Caldwell's assessment is not entirely accurate (Mathias).

Water Quality

There are no 303(d) listed segments in any of these drainages. Eight of the coastal drainages have been monitored for water quality since 1990 (SBSRTC 2002). There are known water quality standards violations in four of the drainages for fecal coliform bacteria and lead. Over a 12-year period, mean temperatures for all monitored Everett coastal drainages are below 10º C.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Everett Independent Drainages:

- Correct identified fish passage barrier on Japanese Gulch Creek
- Assess fish access limitations in these creeks; prioritize and correct identified fish passage barriers
- Complete design and construction of stormwater bypass on Pigeon Creek #1
- Assess habitat conditions; correct any identified problems

ASSESSMENT OF HABITAT LIMITING FACTORS

The intent of HB 2496 and watershed restoration is to determine what stream restoration actions are appropriate to provide healthy, productive populations of salmon for future generations that will support sport, commercial, and tribal fisheries. This goal requires a higher standard of habitat protection than would be necessary to just ensure continued existence of the species. Although there remains some debate on specific habitat thresholds necessary for productive salmon habitat, there is broad consensus that salmon require:

- cool, clean, well-oxygenated water,
- instream flows that mimic the natural hydrology of the watershed, maintaining adequate flows during low flow periods and minimizing the frequency and magnitude of peak flows (stormwater),
- clean spawning gravels not clogged with fine sediment or toxic materials,
- presence of instream pools that will support juvenile rearing and resting areas for returning adults,
- abundance of instream large woody debris, particularly large key pieces, that provide cover, create pools, and provide habitat diversity,
- free, unobstructed migration for juveniles and adults to and from the stream of origin,
- broad, dense riparian stands of mature native trees (preferably conifer, where historically present) that provide cover, shade, LWD recruitment, etc., and
- estuarine conditions that provide nearshore migration corridors and support production of prey organisms for juvenile outmigrants, as well as for juvenile salmonid rearing and for returning adults.

A more detailed discussion of the role of healthy habitat is included in a previous chapter of this report.

Salmonid Habitat Concerns

The Snohomish River watershed, with its multitude of tributary streams, is the second largest watershed in Puget Sound. There are 720 miles of streams in WRIA 7 that are known to support anadromous salmonids and bull trout/Dolly Varden. In addition, WRIA 7 includes ~25 miles of marine shoreline that support local anadromous salmonid stocks, as well as salmonid stocks from other Puget Sound WRIAs.

The occurrence and severity of habitat limiting factors varies among watersheds within WRIA 7 and among reaches within individual watersheds. Combined, these limiting factors significantly reduce the salmonid productivity potential of these rivers and streams. Initial significant impacts date back to early European settlement (mid to late-1800s). Subsequent land use modifications (including agriculture, logging, and the increasing conversion to commercial/rural residential/urban development) have adversely impacted the quantity and quality of salmonid habitat, and accessibility to habitat in these rivers and streams. Current habitat condition has even been compromised by past well-intended actions to restore habitat, such as removal of large woody debris (LWD) to ensure fish passage, that are now known to have been very detrimental to habitat quality and diversity.

Logging, agriculture, and commercial/residential development have caused increased erosion and sedimentation; natural stream channels have been ditched and channelized, streambanks and shorelines have been diked and armored, and some streams have been completely confined within culverts to facilitate development. Many roadway/railroad crossings of streams have created complete/partial barriers to anadromous salmonid migration. Numerous small private dams have been built to create instream ponds, most of which are also barriers to fish migration. Roadways constructed along stream corridors and associated ditching/channelization constrict the natural floodplain and eliminate access to historic off-channel wetland habitats. Extensive historical floodplain wetlands have been ditched and drained, and converted to agricultural use.

Riparian condition is rated as fair/poor along many streams, or portions of streams. Riparian trees have been eliminated, and even in many areas with remaining woody riparian vegetation, historic conifer presence has been eliminated (or is sparse), limiting bank stability, year-round canopy cover, and LWD recruitment potential. LWD is noted as absent or severely lacking in many of the WRIA 7 rivers and streams, particularly large key pieces that are stable and capable of influencing channel form. Lack of LWD is also directly associated with low instream pool frequency and lack of deep pools that are critical for juvenile and resident salmonid rearing and adult salmonid holding and resting prior to spawning. Presence of high levels of fines in the substrate is noted for numerous streams, although quantitative substrate sampling is very limited for WRIA 7 streams.

Land use conversion from natural forested condition to agricultural/residential/commercial uses has resulted in filling of floodplain wetlands, compaction of soils, and increased impervious surface. These all contribute to increased magnitude and frequency of peak streamflows and reduced groundwater and wetland storage, reducing base flows. Land use conversion, coupled with the current lack of LWD in many WRIA 7 streams, has significantly altered channel stability and substrate condition. In order to maintain the integrity of streams, it is imperative to maintain natural hydrology, including maintaining hydrologic maturity in forest management portions of the watershed (particularly in rain-on-snow zones), and implementing state-of-the-art stormwater controls in developed watersheds.

Productivity potential is also positively influenced by ensuring healthy returns of adult salmonid spawners, whose carcasses provide the marine nutrient base that serves as the foundation of the food web for juvenile salmonids and other stream associated invertebrates, fish, and wildlife. Adult salmonid spawners have also been documented to influence the nature of channel substrate and even channel dimensions. Large numbers of spawning salmonids modify riverine habitat in ways beneficial to future generations of salmonids; loss of these functions contributes to further habitat degradation.

Estuaries provide critical rearing and transition habitat for salmonids as they move as juveniles from fresh to saltwater, and as adults from the marine environment back to freshwater. Marine nearshore areas support juvenile salmonid rearing and migration and production of food fish and other organisms on which salmonids prey. The estuarine and nearshore habitats of WRIA 7 are critically important for salmonids originating from the Snohomish River watershed, and for juvenile salmonids originating from other WRIAs in Puget Sound, including juvenile chinook that are listed as Threatened under the Endangered Species Act. The habitat quality and natural physical processes of estuarine and nearshore environments have been severely impacted in WRIA 7. Since the mid-1800s, the lower Snohomish River and estuary have undergone major alterations. Bortleson et al. (1980, as cited in Golder Associates 2001) estimated a 74% loss of subaerial wetlands, and a 32% loss of intertidal wetlands. Most of the subaerial wetlands were impacted by diking for agricultural uses. Intertidal areas have been impacted by dredging and removal of LWD to enhance navigation, and by diking and filling of side-channels. Nearshore habitat has been significantly altered due to extensive armoring and alteration of the marine shoreline, dredging of the lower river and nearshore habitats, and log raft storage.

Habitat Condition Rating

Composite habitat observations and data are summarized in Table 19 as representative habitat condition ratings (Good (G), Fair (F), and Poor (P)) by watershed, for each of the identified habitat elements in the previous chapter of this report. The Salmonid Habitat Condition Rating Standards used to develop these habitat condition ratings are included for reference in Appendix B. Stream or reach-specific salmonid habitat information is provided, where available, in the Habitat Limiting Factors by Sub-Basin chapter.

Watershed/habitat elements for which insufficient information was available to make a habitat condition assessment are noted in Table 19 as Data Gap (DG). Although the majority of streams in WRIA 7 are readily accessible to spawner and habitat surveys, it is interesting that there is little known regarding habitat conditions in a large number of the watersheds. In addition, there are certain habitat elements, such as alterations to peak and base flows, water quality assessment, or substrate condition, where information is very limited, even for streams with the greatest amount of overall available habitat information.

The ratings in Table 19 generally represent the composite habitat condition for the anadromous accessible portion of each watershed; some reaches of a watershed may be better or worse. A range of habitat condition ratings is presented where there is significant habitat quality variation between reaches within a watershed. Many of the habitat condition ratings for these watersheds are based on qualitative observations and experience of the TAG participants, due to the lack of quantitative habitat assessments for many of the watersheds in WRIA 7.

Action recommendations to address identified habitat limiting factors for each watershed are included in the Habitat Limiting Factors by Subbasin chapter. The common thread between the action recommendations is restoration of channel and floodplain ecological function (represented by "good" habitat ratings for each of the specific habitat elements). These functions are not only critical to restoring salmonid populations in these watersheds, but are also critical to other overall watershed functions in WRIA 7 (e.g., prevention of flooding impacts and maintaining water quality for instream and domestic use).

The purpose of Table 19 is to provide a quick visual reference to indicate the relative health and knowledge base of salmonid habitat in individual streams. For watersheds where habitat information is available, Table 19 also may provide a relative comparison of habitat condition within and among streams. However, caution is recommended when comparing watershed conditions due to the wide diversity in quality and quantity of habitat information and knowledge for each watershed. The summary information in Table 19 is useful as a general guide to habitat problem "hot spots" that warrant restoration consideration, or additional assessment data collection to guide habitat restoration. However, the Habitat Limiting Factors by Subbasin chapter should be consulted for specific stream information and action recommendations on which to base specific salmonid habitat restoration proposals. The potential benefit of proposed habitat restoration actions may be limited due to the number of habitat problems in a stream, higher priority limiting factors that should be addressed first, sequencing of projects to ensure effectiveness, etc.

Habitat Restoration Potential

Despite the extensive impacts that have occurred to fresh and marine water habitats in WRIA 7, and the large number of fair, poor, or data gap habitat ratings that exist throughout the area, there are a number of reasons to be optimistic regarding the future of salmonid habitat and productivity in WRIA 7. The greatest habitat protection/restoration potential in WRIA 7 is in the watersheds that still have a significant portion of the watershed in forest or agriculture, and which do not have significant development encroachment. However, habitat restoration in other smaller streams should also be actively considered, as they contribute to the overall productivity of WRIA 7, and cumulatively contribute significant overall salmonid production. Restoration of estuarine and nearshore habitat is also critical, as these habitats are actively utilized by all salmonid species and stocks originating in WRIA 7, as well as stocks originating from other Puget Sound WRIAs. Prioritized habitat protection and restoration action recommendations for individual streams and estuarine/nearshore habitats are identified in the Habitat Limiting Factors by Subbasin chapter of this report. Habitat protection and restoration actions are prioritized within each watershed area, but there was no consensus within the TAG regarding prioritization between watersheds. Cross-watershed protection/restoration prioritization is considered to be the purview of the WRIA 7 Lead Entity and the Snohomish Forum.

Restoration projects in WRIA 7 should be considered in relation to the production potential of the stream and the anticipated benefits. Several streams have areas where habitat is currently in relatively good condition, and these areas should be protected (see Habitat In Need Of Protection chapter of this report). Other degraded habitats have potential to provide excellent habitat and warrant special consideration. Unfortunately, the habitat in some streams (particularly those in densely developed watersheds) has been severely impacted, limiting the potential benefits of restoration.

Table 19: Assessment of Habitat Limiting Factors for Salmonid-Bearing Watersheds within WRIA 7

				Channel Conditions				Water Quality[1]		Hydrology		
Stream	**WRIA Index**	**Fish Access**	**Floodplain Connectivity**	**LWD**	**Pools**	**Substrate**	**Riparian Condition**	**Temp/ DO**	**Toxics**	**Peak Flow**	**Low Flow**	**Estuarine**
Tulalip Creek	07.0001	P	G	G	DG	P	F	G	DG	G	F	DG
Battle (Mission) Creek	07.0005	P	G	G	DG	P	F	G	DG	G	G	DG
Snohomish River	07.0012	G	P	P	G	F	P	P	G	G	G	P
Deadwater Slough	07.0024	P	P	P	P	DG	P	DG	DG	DG	DG	P
Bigelow Creek/Wetlands	07.0035?	G	P	DG	DG	G	P/F	DG	DG	DG	DG	P
Quilceda Creek	07.0044	F	P	P	P	P	P	P	DG	P	DG	G
Allen Creek	07.0068	P	P	P	P	P	P	P	P	P	DG	P
Sunnyside Creek, Hulbert Creek, Weiser Creek, and Burri Creek	07.0083, 07.0086, 07.0090, 07.0091	P	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Unnamed	07.0096	DG	P	DG	DG	DG	P-G	DG	DG	DG	DG	NA
Moshers Creek	07.0098	DG	P	DG	DG	DG	F	DG	DG	DG	DG	NA
Swan Trail Slough	07.0103	P	P	DG	DG	DG	P	P	DG	DG	DG	NA
Marshland Drainages		P	P	P	P	P	P	P	P	P	P	NA
Cemetary Creek	07.0117	P	P	P	P	DG	P-G	P	DG	DG	DG	NA
Swifty Creek	07.0124	P	P	P	P	DG	P	DG	DG	P	DG	NA
Pilchuck River Mainstem	07.0125	F	P	DG	F-DG	F	P-F	P	DG	DG	DG	NA
Sexton Creek 07.0126	07.0126	P	DG	DG	DG	DG	F-P	DG	DG	DG	DG	NA

[1] Numerous streams in WRIA 7 are included on the 1998 303(d) list for fecal coliform bacteria. Although fecal coliform listings are included in the individual watershed discussions in the Habitat Limiting Factors by Subbasin chapter, they are not included in watershed habitat ratings due to the lack of identified effects to salmonid habitat or survival.

				Channel Conditions				Water Quality[1]		Hydrology		
Stream	**WRIA Index**	**Fish Access**	**Floodplain Connectivity**	**LWD**	**Pools**	**Substrate**	**Riparian Condition**	**Temp/ DO**	**Toxics**	**Peak Flow**	**Low Flow**	**Estuarine**
Bunk Foss Creek	07.0130	P-DG	P	DG-P	DG-P	DG	P	DG	DG	DG	DG	NA
Scott Creek	07.0134	G	F	DG	DG	DG	F	DG	DG	DG	DG	NA
Kuhlman's Creek	07.0135	G	P	P	P	P	P	DG	DG	DG	DG	NA
Williams Creek	07.0137	DG	P	P	P	DG	P-F	DG	DG	DG	DG	NA
Dubuque/Panther Creek	07.0139	DG	G	G	G	DG	F	F	DG	DG	DG	NA
Little Pilchuck Creek	07.0146	DG	G	G	G	F-P	G	G	DG	G	G	NA
Stevens/ Catherine Creek	07.0147	P	F	P	F	DG	P	P	DG	P	DG	NA
Connor Creek	07.0158	DG	DG	DG	DG	DG	P	DG	DG	DG	DG	NA
Unnamed	07.0159	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Unnamed	07.0161	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Coon/Black Creek	07.0161B	DG	P	P	P	DG	DG	DG	DG	DG	DG	NA
Swartz Lake Creek	07.0162	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Bosworth Creek	07.0163	F	G	F	F	G	G	DG	DG	DG	P	NA
Boyd Lake Creek	07.0164	F	G	DG	DG	DG	F-G	DG	DG	DG	DG	NA
Menzel Lake Creek	07.0164A	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Purdy Creek	07.0165	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Worthy Creek	07.0166	G	G	G	G	G	F	DG	DG	G	G	NA
Kelly Creek	07.0170	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Unnamed	07.0173?	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Ross Creek	07.0175	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Wilson Creek	07.0176	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Miller Creek	07.0180	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Unnamed	07.0181	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
French Creek	07.0184	P	P	P	P	F	P	P	DG	P	P	NA
Unnamed	07.0206?	P	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Cathcart Drainages	07.0207-	P	P	DG	DG	DG	P	DG	DG	DG	DG	NA

				Channel Conditions				Water Quality[1]		Hydrology		
Stream	**WRIA Index**	**Fish Access**	**Floodplain Connectivity**	**LWD**	**Pools**	**Substrate**	**Riparian Condition**	**Temp/ DO**	**Toxics**	**Peak Flow**	**Low Flow**	**Estuarine**
	07.0214											
Unnamed	07.0217	P	P	P	P	DG	P	DG	DG	DG	DG	NA
Snoqualmie River Mainstem	07.0219	P (to tribs)	P	P	F-G	G	P	P	DG	G	G	NA
Unnamed/ Crescent Lake	07.0224	P	F	DG	G	G	P	DG	DG	G	G	NA
Unnamed	07.0227	DG	P	DG	DG	DG	P	DG	DG	DG	DG	NA
Pearson Eddy Creek	07.0229	DG	P	DG	DG	DG	P	DG	DG	DG	DG	NA
Peoples Creek 07.0236	07.0229	DG	DG	DG	DG	DG	F-G	DG	DG	DG	DG	NA
Duvall Creek	07.0238	DG	DG	DG	DG	DG	G	DG	DG	DG	DG	NA
Cherry Creek	07.0240	P	P	P	DG	DG	P	P	DG	DG	DG	NA
Tuck Creek	07.0267	P	P	P	F	F	P	P	DG	G	G	NA
Duvall Area Independents	07.0267X 07.0267Y 07.0267Z	P	P	P	P	DG	P	DG	DG	DG	DG	NA
Adair Creek	07.0275	G	P	P	P	DG	P	DG	DG	DG	DG	NA
Deer Creek	07.0275X	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Unnamed (Wallace Creek)	07.0276	P	P	P	P	P	P	DG	DG	P	DG	NA
Ames Creek	07.0278	P	P	P	P	G	P	DG	DG	DG	DG	NA
Weiss Creek	07.0281	P	G	G	G	G	G	DG	DG	DG	DG	NA
Harris Creek	07.0283	P	F	F	G	G	F	DG	DG	DG	DG	NA
Unnamed LB tributaries to Snoqualmie River between Harris Creek and the Tolt River	NA	P	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA

				Channel Conditions				Water Quality[1]		Hydrology		
Stream	**WRIA Index**	**Fish Access**	**Floodplain Connectivity**	**LWD**	**Pools**	**Substrate**	**Riparian Condition**	**Temp/ DO**	**Toxics**	**Peak Flow**	**Low Flow**	**Estuarine**
East Horseshoe Lake	07.0290	DG	P	DG	DG	DG	P	DG	DG	DG	P	NA
Tolt River watershed	07.0291 and tribs	F	P	P	F	F	F	G	DG	P	DG	NA
Langlois Creek	07.0292	P	P	P	DG	DG	P	DG	DG	DG	DG	NA
Griffin Creek	07.0364	P	G	G	G	F	F-G	DG	DG	DG	F	NA
Patterson Creek	07.0376	P	P	P	DG	P	P	DG	P	DG	DG	NA
Raging River	07.0384	P	P	P	P	P	P	P	DG	P	DG	NA
Unnamed	07.0427	P	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Rutherford Slough Tributary	07.0428	P	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Unnamed	07.0429	P	P	DG	DG	P	DG	DG	DG	DG	DG	NA
Unnamed	07.0430	P	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Unnamed LB tribs upstream of 07.0430	07.0431-07.0452	P	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Skunk/Mud Creek	07.0434	P	P	P	P	DG	P	DG	DG	DG	DG	NA
Tokul Creek	07.0440	P	P	P	P	P	G	DG	DG	G	G	NA
Snoqualmie River upstream of Snoqualmie Falls, inc. forks		P	F	F	DG	F	F	P	DG	G	DG	NA
Skykomish River Mainstem	07.0012	G	P	DG	DG	G	F	P	P	G	G	NA
Unnamed	07.0814	P	F	P	DG	DG	F	DG	DG	DG	DG	NA
Riley Slough	07.0818	P	F	DG	DG	DG	P	DG	DG	P	P	NA
Haskel Slough	07.0825	DG	P	P	DG	DG	F	DG	DG	P	P	NA
Woods Creek	07.0826	P	G	P	DG	F-DG	F	G	DG	DG	DG	NA
Unnamed	07.0857	P-DG	G	P	G	DG	P	DG	DG	DG	DG	NA

				Channel Conditions				Water Quality[1]		Hydrology		
Stream	**WRIA Index**	**Fish Access**	**Floodplain Connectivity**	**LWD**	**Pools**	**Substrate**	**Riparian Condition**	**Temp/ DO**	**Toxics**	**Peak Flow**	**Low Flow**	**Estuarine**
Barr/Kissee Creek	07.0858	P	P	P	P	DG	P	DG	DG	DG	DG	NA
Eagle Creek	07.0862	P	DG	DG	DG	DG	F	DG	DG	DG	DG	NA
Unnamed and Unnamed to east	07.0863	DG	P-G	DG	DG	DG	P-G	DG	DG	DG	DG	NA
Unnamed	07.0864	P	P	DG	DG	DG	P	DG	DG	DG	DG	NA
Groeneveld Creek	07.0864B	F	P	P	DG	P	P	G	DG	DG	DG	NA
Unnamed	07.0864A	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Elwell/Youngs Creek	07.0865	P	F	DG	DG	DG	F	DG	DG	G	G	NA
McCoy Creek, Tychman Slough	07.0876	P	P	P	DG	DG	P	DG	DG	DG	DG	NA
Yonkers Slough	07.0877A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sultan River	07.0881	P	G-DG	P-DG	DG	G-DG	G-P	G-DG	DG	G	G	NA
Wagleys Creek	07.0939	P	P	P	P	DG	P	DG	DG	DG	DG	NA
Wallace River	07.0940	P	G-P	F-P	DG	G-DG	F/G-P	P	DG	DG	F	NA
Sky Slough	07.0961	DG	G	DG	DG	DG	F-P	DG	DG	DG	DG	NA
Berry Farm Slough	07.0961X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unnamed	07.0961Y	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Unnamed	07.0962X 07.0963	P	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Duffey Creek	07.0965	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Game Trail Slough	07.0965A	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Proctor Creek	07.0970	G	F	DG	DG	DG	F	DG	DG	DG	DG	NA
Hogarty Creek	07.0972	G	G	DG	DG	DG	P-F	DG	DG	DG	DG	NA
Anderson Creek	07.0975	G	F	DG	DG	DG	F	DG	DG	G	G	NA
Deer Creek	07.0979	G	G	DG	DG	DG	G	DG	DG	DG	DG	NA
NF Skykomish River Mainstem	07.0982	G	F	P	F-P	F	F	G	G	DG	DG	NA
Lewis Creek	07.0983	F	F	P	DG	DG	F	DG	DG	DG	DG	NA

				Channel Conditions				Water Quality[1]		Hydrology		
Stream	**WRIA Index**	**Fish Access**	**Floodplain Connectivity**	**LWD**	**Pools**	**Substrate**	**Riparian Condition**	**Temp/ DO**	**Toxics**	**Peak Flow**	**Low Flow**	**Estuarine**
Bitter Creek	07.0985	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Snowslide Creek	07.0994	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Excelsior Creek	07.0995	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Trout Creek	07.0997	G	DG	P	P	DG	DG	G	DG	DG	DG	NA
Unnamed	07.1030	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Salmon Creek	07.1031	G	G	P	P	G	F	G	DG	P	DG	NA
Lost Creek	07.0141	G	DG	DG	DG	G	DG	DG	DG	DG	DG	NA
Howard Creek	07.0142	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Silver Creek	07.1053	G	P	P	F	DG	DG	F	DG	DG	DG	NA
Troublesome Creek	07.1085	G	F	DG	DG	DG	F	G	DG	DG	DG	NA
Bear Creek	07.1120	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
West Cady Creek	07.1142	G	DG	DG	DG	DG	DG	G	DG	DG	DG	NA
Goblin Creek	07.1182	G	DG	G	P	DG	G	DG	DG	DG	DG	NA
SF Skykomish River	07.0012	G	P	P	P	G	F	G	F	DG	DG	NA
Bridal Veil Creek	07.1248	G	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Barclay Creek	07.1252	G	DG	DG	DG	DG	F	DG	DG	DG	DG	NA
Unnamed	07.1252A	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Baring Area RB tributaries	07.1252X, 07.1263, 07.1280, 07.1280X, 07.1285, 07.1296, 07.1298, 07.1326	P	P	DG	DG	DG	P	DG	DG	DG	DG	NA
Unnamed	07.1263X	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Index Creek	07.1264	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Unnamed	07.1294	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Money Creek	07.1300	P	G	DG	F	DG	G	P	P	DG	DG	NA

Stream	WRIA Index	Fish Access	Floodplain Connectivity	Channel Conditions: LWD	Channel Conditions: Pools	Channel Conditions: Substrate	Riparian Condition	Water Quality[1]: Temp/ DO	Water Quality[1]: Toxics	Hydrology: Peak Flow	Hydrology: Low Flow	Estuarine
Miller River	07.1329	G	F	G-DG	DG	G	G	G	DG	G	G	NA
Maloney Creek	07.1407	F	P	DG	DG	DG	DG	DG	DG	DG	P	NA
Beckler/Rapid River	07.1413	G	G-DG	P	P	P	P	P	DG	P	DG	NA
Anthracite Creek	07.1561	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	NA
Foss River	07.1562	G	G	DG	DG	G	G	G	DG	G	G	NA
Tye River	07.0012	G	P	P	P	P	P	G	DG	DG	DG	NA
Everett Independent Drainages	07.1722-07.1730	P	F	DG	DG	P	G	G	DG	P	DG	P

HABITAT NEEDING PROTECTION

Previous chapters in this report identify salmonid habitat limiting factors throughout WRIA7 (resulting from adverse impacts caused by the broad suite of land use practices that exist in the watershed), which would benefit from habitat restoration projects. However, there are a number of habitat areas that remain in relatively good condition, where existing habitat functions should be protected, or where acquisition/easement is considered critical to future restoration success. These areas serve as the foundation upon which habitat restoration and salmonid recovery efforts are most effectively built. Protection of functional salmonid habitat is typically more cost effective and provides greater certainty of long-term success than restoration of degraded habitat. Habitat protection can be provided through acquisition, conservation easement, or specific protection under critical area ordinances or other regulatory processes administered by local land use managers.

It is not practicable to prioritize areas recommended for acquisition or conservation easement, as opportunities often only arise as willing sellers surface, with typically a very limited timeframe in which to respond. Certain stream reaches and/or protection strategies are identified as important to ensure continued function of high quality salmonid habitat, or areas that are critical to restoration of natural floodplain function:

The Snohomish Basin Salmonid Recovery Technical Committee identified several key chinook focus areas (SBSRF 2001). The focus areas were determined from analysis of biological data, and support high levels of spawning, rearing, holding, and/or refuge for chinook salmon. Chinook focus areas in SBSRF (2001) include:

- Snohomish River estuary from the mouth of the Snohomish River to SR 2, including all sloughs – The estuary is critical for smolt production and all salmonid species depend on the estuary for rearing and migration. Analysis suggests that limited rearing habitat in the estuary may constrain chinook and coho salmon production in the WRIA 7 (Haas and Collins 2001). Much of the historic estuary is diked, and existing land uses in diked areas may limit potential for tidal and floodplain restoration. Acquisition of historic diked floodplain areas, where possible, is likely necessary to facilitate tidal habitat restoration.
- Mainstem Snohomish River from the mouth of the Pilchuck River to the confluence of the Skykomish and Snoqualmie rivers – This focus area is a biologically rich zone; all species of salmon spend at least a portion of their life cycle in this reach, as it includes extensive refuge areas, large riffles, and several important spawning areas. This area is also the primary overwintering area for sub-adult bull trout/Dolly Varden (Pentec 2002). Much of the land adjacent to the river is already in public ownership, in the form of easements or Snohomish County owned parkland.
- Snoqualmie River/Skykomish River confluence area – This area is also part of the biologically rich confluence area of the Snoqualmie and Skykomish rivers. Although much of this area is currently in private ownership, there is some public ownership, and the area has good restoration potential.
- Mainstem Snoqualmie River from the mouth of Harris Creek to the mouth of the Tolt River – This area has a significant concentration of high quality spawning habitat and diversity of salmonid use. This 3-mile reach is one of two reaches of the Snoqualmie River that provide spawning habitat for anadromous salmonids. About 20% of the chinook salmon that return to the Snoqualmie River watershed spawn in this area. Approximately 50% of the shorelines in this reach are in public ownership, providing considerable opportunity to restore impaired habitat functions.

- Lower Tolt River, SF Tolt River to RM 1.6, and the Tolt/Snoqualmie River confluence downstream to ~1 mile downstream of the Carnation Farms Road bridge – The Tolt River is the largest Snoqualmie River tributary that is accessible to anadromous salmonids. It provides high quality spawning habitat for nearly 20% of the chinook salmon that return to the Snoqualmie River watershed. Spawning gravel transported by the Tolt River creates high quality spawning habitat in the otherwise gravel-poor Snoqualmie River. The lower 5 miles of the Tolt River floodplain lie in an extensive , active floodplain, averaging ~1,300 feet wide. Floodplain function in the lower 1.6 miles is constrained by dikes and levees; acquisition of historic floodplain is critical to desired floodplain restoration in this area.
- Mainstem Snoqualmie River at the confluence with Griffin Creek – Several off-channel refuge areas and oxbows are present in the reach of the Snoqualmie River just upstream and downstream of the confluence of Griffin Creek. These areas provide important rearing and refuge habitat for juvenile salmonids. The presence of these habitats in close proximity to important spawning habitat suggest they play an important role in the survival of newly-emerged chinook salmon fry and in coho production originating from the Griffin Creek watershed.
- Mainstem Snoqualmie River near the confluence of the Raging River – This reach of the Snoqualmie River provides spawning habitat for up to half of the chinook salmon that spawn in the Snoqualmie River watershed. The reach is characterized by extensive riffle and run combinations; ample gravel is supplied by the Raging River. Remnant side channels are evident downstream of the confluence of the Raging River, indicating the presence of greater channel diversity in the past. There are opportunities to modify flood and erosion control facilities to enhance habitat.
- Mainstem Skykomish River at the confluence with the Snoqualmie River – This area is biologically active, hydrologically complex, and is an important spawning area for chinook salmon and a major migration corridor for salmonids to the upper Skykomish River watershed. Although currently diked, floodplain function still includes numerous wooded islands, distributary sloughs, and side channels. The area is experiencing urban/residential development pressure.
- Sultan River from the mouth to the diversion dam at RM 9.7 – The Sultan River supports chinook salmon spawning and rearing, with increasing production since the mid-1980s. Approximately 85% of the land in the basin is in public ownership. Floodplain function in the lower 3 miles (downstream of the BPA powerline crossing) is currently affected by residential development and bank hardening on the right bank.
- Mainstem Skykomish River from the mouth of the Sultan river to Gold Bar – Known as the “braided reach”, this area of the Skykomish River has a great deal of hydraulic complexity, although the lack of LWD and intact riparian reserves are very noticeable. This area is subject to frequent flooding and significant channel movements. There are many important resting pools in this reach, as well as large side channels, creating excellent rearing, spawning, and refuge habitat for all of the anadromous salmonid species present in WRIA 7.
- Wallace River from the mouth to Gold Bar – The Wallace River is one of the largest tributaries to the Skykomish River, providing spawning and rearing habitat for all anadromous salmonid species present in WRIA 7. Floodplain and riparian functions are relatively intact, but the watershed is experiencing development pressure.
- SF Skykomish River from the confluence with NF Skykomish upstream to Sunset Falls, including Bridal Veil Creek – This area, including Bridal Veil Creek, provides important spawning and rearing habitat for chinook salmon. Habitat on Bridal Veil Creek is at risk from recreational lot development pressures.

Although the Focus Areas identified in the Snohomish River Basin Chinook Near-Term Action Agenda (SBSRF 2001) are primarily oriented to protection for ESA-listed chinook salmon, they also provide benefits to other salmonid species in WRIA 7. However, the Focus Areas do not include other highly productive coho, steelhead, and bull trout/Dolly Varden habitat areas located in smaller tributary habitats in the watershed. These tributary habitats are at high risk of alteration throughout WRIA 7 due to commercial/residential development, as well as ongoing agricultural and forest management.

Bull trout/Dolly Varden require very specialized water temperature and other habitat conditions for spawning and early rearing. The extent of known bull trout/Dolly Varden spawning areas in WRIA 7 is very limited. Special habitat protection consideration is warranted in these areas to ensure that necessary habitat conditions are maintained.

The Snohomish Basin Salmonid Recovery Technical Committee has yet to fully consider prioritization of protection areas important for coho, chum, steelhead, and resident trout stocks. Areas of primary habitat importance for coho are typically those with an abundance of spawning habitat, good cover, and abundant wetland rearing habitat. The Griffin Creek watershed and associated rearing areas on the Snoqualmie floodplain are generally recognized as critically important for coho production, which warrant special protection consideration. There are numerous additional watershed areas that remain highly productive for coho, chum, and steelhead that also warrant special consideration for protection, some of which are included in whole or in part in the chinook Focus Areas identified above. In addition to the chinook Focus Areas, habitat areas with high annual spawner presence that are of special protection interest include:

- Remaining high coho production areas in the Quilceda and Allen creek watersheds
- Pilchuck River mainstem to RM 15
- Little Pilchuck Creek watershed
- Dubuque/Panther Creek
- Middle Pilchuck River tributaries (e.g., Purdy, Worthy, Bosworth, Swartz Lake, Coon, Menzel Lake, and Boyd Lake creeks)
- Cherry Creek
- Weiss Creek
- Harris Creek
- Stossel Creek
- Patterson/Canyon/Dry watershed
- Raging River and tributaries
- WF Woods/Carpenter Creek
- Wallace River and tributaries
- Deer Creek
- Miller, Foss, Beckler, and Tye rivers
- Lewis Creek

Coho, chum, and steelhead spawner counts and densities may assist in identifying streams/reaches of key importance, but it is likely also important to look at additional watersheds that may not be adequately represented in the spawner count database. It is also important to consider relative risk to current habitat and the need for acquisition/conservation easement to facilitate habitat protection/restoration efforts.

This list of habitats in need of protection represents those areas where special efforts should be made to ensure that critical ecological functions are protected. However, this is only a partial list of habitats in need of protection; numerous other tributary reaches also warrant special consideration for protection. Opportunities for public acquisition of key habitats should be evaluated and exercised where warranted; public ownership offers greater potential for protection and restoration.

Protecting existing habitat function is far more cost effective and provides greater certainty than attempting to restore lost habitat function. Federal and state forest management regulations are anticipated to reduce past adverse affects to salmonid habitat, and lead to natural restoration of habitat conditions over time. County and local development regulations should be reviewed and modified as necessary to ensure that they adequately protect critical areas and salmonid habitat functions, and implemented to ensure that the desired habitat protection is achieved. All salmonid habitats should be included within local critical areas ordinances, and those ordinances should be reviewed and revised as necessary to ensure no further degradation of salmonid habitat, and to restore habitat function where possible. Perhaps one of the greatest opportunities for habitat protection through acquisition/conservation easement is on existing agricultural lands in WRIA 7. Acquisition/conservation easement on existing agricultural lands would provide opportunity for much needed restoration of off-channel habitat in the lower mainstem and estuarine focus areas, and would provide opportunity to restore specific habitat elements (e.g., riparian function) on agricultural lands that are currently not adequately protected by local land-use regulations.

DATA GAPS

The extent of baseline habitat information and understanding of salmonid utilization linkages varies widely through WRIA 7. Much of the habitat assessment work to date in the watershed has focused on estuarine habitat and key chinook habitats (e.g., City of Everett and Pentec Environmental (2001), SBSRF (2001)).

The Snohomish Basin Research and Monitoring Gap Summary (Hinton 2000) was developed for the WRIA 7 Technical Committee as a starting point for a research program to address the data gaps identified in the Initial Snohomish River Basin Chinook Salmon Conservation/Recovery Technical Work Plan (SBSRTC 1999). The ranked habitat-related elements in the Summary were:

Category 1: Inventory - Assessment of Current or Historical Baseline Conditions

- Develop sediment budgets for all watersheds
- Inventory floodplain wetlands (location, size, functions, and value)
- Assess, characterize, and map riparian forest conditions
- Model hillslope stability; inventory location and magnitude of mass wasting events
- Conduct quantitative habitat limiting factors analysis for each species
- Inventory LWD and develop wood budgets for all watersheds
- Inventory water temperature throughout WRIA 7 during the hottest months of the year
- Assess, characterize, and map instream and channel hydro-modifications
- Inventory off-channel habitat and habitat types
- Identify and map channel migration zones
- Conduct surveys of hydrologic conditions in all watersheds
- Inventory all roads (Open, Closed, and Legacy); discriminate by proximity to riparian zone and susceptibility to failure
- Inventory eelgrass beds
- Utilize geo-morphological analysis to define potential habitat that may currently by underutilized
- Inventory percent impervious surface in each watershed
- Inventory spawning and rearing locations for sand lance, surf smelt, and herring
- Identify key locations of upwelling and down-welling in mainstem and major tributaries

Category 2: Research – Investigating Cause Effect Relationships

- Model changes in peak flow characteristics (e.g., timing, magnitude, frequency, and duration) and evaluate changes attributable to land use practices
- Determine impacts of toxic contaminants in estuary and nearshore environments
- Study and use effects on low flows in lateral tributaries
- Reconstruct historical conditions
- Research role of LWD in estuary and nearshore environments
- Determine habitat types(s) preferred by juvenile salmonids, by species
- Determine effects of scour on egg survival at known spawning locations
- Study how groundwater recharge and peak precipitation storm events combine to affect mass wasting
- Determine water temperature response to land use or recovery activities
- Research juvenile salmonid use of microhabitat in estuary

Category 3: Effectiveness Monitoring

- Monitor water quality for targeted parameters

The Summary was primarily focused at addressing data gaps for chinook salmon in WRIA 7. All of the elements in the Summary are critical to an effective understanding of salmonid habitat utilization relationships, and the effects of land use actions on salmonid habitat conditions. These research needs were also incorporated and updated in the Snohomish River Basin Chinook Salmon Near Term Action Agenda (SBSRF 2001). However, while many of the research needs may be feasible for chinook habitat, due to the limited distribution of chinook in WRIA 7, the complexity of surveys, assessments, and analyses increases dramatically if applied to the smaller tributary species (e.g., coho salmon and cutthroat trout), as well as those with unique spawning and rearing habitat requirements in the upper extent of the watershed (e.g., bull trout/Dolly Varden).

There are several potentially even more basic data gaps that are apparent as a result of the Salmonid Habitat Limiting Factors Analysis effort. The apparent key data gaps resulting from this effort are as follows:

Incomplete Knowledge of Salmonid Species Distribution in WRIA 7

The species distribution maps (in separate Map files included with this report) and supporting salmonid distribution data support table (Appendix A) represent the best available knowledge of anadromous salmonid and bull trout/Dolly Varden distribution in WRIA 7. These data represent a substantial increase in known and presumed anadromous salmonid distribution compared to either Streamnet (WDFW) or the 1995 Snohomish River Basin Mapping Effort (Snohomish County SWM). However, despite this increased knowledge base, the salmonid distribution knowledge base for many watersheds is limited to spawner index surveys or one time site-only observations, which may not be indicative of uppermost distribution extent.

Some fish passage barriers have been corrected, but the maps and tables in this report may not include any distribution observations upstream of the corrected barriers. In addition, most salmonid distribution information is based on observations of adult spawners, and do not include resulting juvenile distribution into non-spawning areas and smaller tributary habitats that are only capable of supporting rearing juvenile salmonids. Represented distribution is likely much more complete for those species that are more mainstem spawners and which migrate out of the watershed as 0+ age smolts (0+chinook, chum, pink); data is likely more incomplete for those species that spawn in smaller tributaries and higher in the watershed, or that migrate out as yearling or older smolts (yearling chinook, coho, steelhead, bull trout/Dolly Varden).

Limited knowledge of salmonid distribution limits the ability to determine habitat protection and restoration needs, and to protect habitat under land use regulations. This report is a good example of the potential adverse effects of limited fish distribution knowledge; habitat conditions were assessed only for those watershed areas known or presumed to have anadromous salmonid or bull trout/Dolly Varden utilization. Habitats supporting only resident salmonids and whitefish are not included in this assessment, except for a few creeks. Ideally, comprehensive adult salmonid spawner distribution inventories would be most effective in years with high adult abundance and wet conditions that would allow spawning adults to access further upstream, including upstream of partial barriers. For example, the coho and pink spawner escapements to WRIA 7 in 2001 were the largest on record and were coincident with relatively wet conditions; numerous calls were received from watershed residents reporting spawning coho and pink salmon presence in many streams where they had never been seen before. The greatest extent of juvenile rearing distribution would likely be encountered following a year of high spawner abundance, in a year with relatively wet conditions (Kraemer). If adults are able to get there, juveniles will also be there. Identification of over-wintering areas should be done in late fall/early winter in off-channel ponds, etc. Care should be taken to avoid electrofishing while eggs are incubating in the gravel. Where areas are found to "hold" adult or juvenile salmonids in low flow conditions, fish would likely be expected to be found further upstream of those areas in wetter years. Unfortunately, the difficulty of predicting when the ideal suite of environmental conditions is likely to occur compromises the ability to plan an effective inventory in advance.

Lack of Availability of Consistent Habitat Baseline Data Across Watersheds in WRIA 7

Quantitative habitat assessment data have been collected for many of the larger mainstem habitats in WRIA 7 (e.g., Snohomish River, Snoqualmie River, Sultan River, Tolt River, lower and middle Pilchuck River), providing sufficient information to rate the condition of most habitat elements for these watershed areas in the Assessment of Habitat Conditions chapter. A combination of quantitative data and qualitative professional knowledge provided sufficient information to rate the condition of most habitat elements for some of the other watersheds in WRIA 7. However, the lack of available watershed information severely compromised the ability to rate habitat conditions in many of the smaller watersheds in WRIA 7. Consequently, it is difficult to develop a comprehensive WRIA 7 wide habitat restoration strategy when we are unable to identify potential habitat problems in such a large portion of the watershed. The limited habitat knowledge has a much greater effect on those species that are dependent on smaller tributary habitats (coho, chum, cutthroat, steelhead, bull trout/Dolly Varden) than on those that utilize larger mainstem habitats (chinook, pink).

The ~130 watershed assessment units in the LFA, combined with the 10 habitat assessment elements in the Assessment table (Table 19, excluding Estuarine), yield an approximate total of 1,300 cells with potential habitat ratings. There was insufficient data (quantitative or qualitative) for ~61% of the ~1,300 cells to make a rating other than Data Gap. Even for those habitat elements with the greatest occurrence of habitat condition ratings (Fish Access, Floodplain Modifications, and Riparian Condition), only ~65% of the watersheds had sufficient information to allow a rating other than Data Gap. Channel condition ratings (LWD, Pools, and Substrate Condition) were only available for ~37% of the watersheds. Water quantity and water quality habitat condition ratings were only available for ~21% of the watersheds. Lack of sufficient habitat knowledge resulted in habitat ratings of Data Gap for ~21% of the watershed analysis units (this was particularly apparent for the upper Pilchuck River tributaries). In addition, habitat information for many of the smaller watersheds comes from the coincidental experience of biologists conducting spawner index or Hydraulic Project Approval (HPA) surveys, which often only cover selected sites or reaches within a watershed, and may not be representative of broader watershed-wide conditions. Efforts to develop a multi-species habitat restoration strategy in WRIA 7 will require a more comprehensive assessment of habitat conditions in the smaller watersheds, in order to develop informed and reasoned habitat restoration recommendations.

Lack of Information and Understanding of Juvenile Salmonid Utilization of Mainstem River Habitats

Although information is available on the importance of mainstem spawning habitats, and the importance of mainstem habitats as adult and juvenile migration corridors, little is known on the role and utilization of mainstem habitats (including the tidal portions of the lower mainstem and distributary channels) for juvenile salmonid rearing. In addition, there is a lack of information on how and to what extent the identified modifications to mainstem habitat (loss of natural floodplain function, impaired riparian function, lack of LWD, altered hydrology and water quality, etc.) impair overall productivity for each of the salmonid species in WRIA 7. There is also information suggesting that mainstem (or other) habitats may provide important rearing habitat for juvenile coho and other species that are displaced from tributary streams due to low or non-existent summer flows (e.g., Stevens/Catherine/Little Pilchuck creeks).

There is information indicating the important role of certain mainstem associated floodplain sloughs and wetlands to coho productivity (e.g., wetlands at the mouth of Griffin Creek), but a general dearth of information on utilization of floodplain sloughs and wetlands that are not directly associated with primary salmonid spawning and production areas.

Limited Understanding of Habitat Condition/Salmonid Productivity Relationships

The collective body of salmonid habitat-related science indicates general relationships between healthy habitat conditions and resulting salmonid utilization and abundance. These relationships are the foundation for the Salmonid Habitat Rating Standards identified in Appendix B, and as applied in the Assessment of Limiting Factors chapter. However, most of the collective scientific habitat data are from watersheds other than WRIA 7. There is general technical confidence in concluding that for similar tributaries, ones with higher rated habitat functions are likely to be more productive for salmonids than ones having poorer habitat conditions. Unfortunately, there are continual demands to estimate precise numbers of salmon produced by specific habitat restoration projects. This type of assessment may be practicable for some project types, such as correction of a fish passage barrier that provides access to a known amount of upstream habitat. However, there is typically insufficient information to estimate anticipated production increases associated with a project such as restoration of riparian habitat along a selected reach, where the restored riparian function takes decades to mature and may only represent a small percentage of the overall watershed. Research designed to improve the understanding of habitat condition/salmonid productivity relationships (freshwater, estuarine, and marine nearshore) specific to WRIA 7 will improve our ability over time to more accurately estimate benefits of specific habitat restoration efforts. "We [WRIA 7] are fortunate to have healthy and abundant coho populations remaining; it is important for us to understand why, before we lose these fish" (comment made at a WRIA 7 Technical Committee meeting).

Need to Complete Comprehensive Inventory of Culverts/Fish Passage Barriers

Significant efforts by counties, cities, Washington Trout, Adopt-A-Stream, forest landowners, and others have substantially improved the barrier culvert inventory in WRIA 7. Unfortunately, it was only possible to conclude for a few subwatersheds in this report whether the available inventory data represent a comprehensive inventory. There is record of the culverts that have been inventoried, but there is only limited record of other streams/reaches that were surveyed where no culverts or barriers were found, and most surveys were limited to those culvert/barrier sites that were in public ownership or private sites for which landowner permission was granted to survey the site. Unfortunately, there is limited information on presence of known culvert/barrier sites for which access permission was not obtained. Information may be available for inventoried sites to assist in prioritization of barrier correction; however, the data is insufficient in many drainages to conclude whether there may be other non-inventoried barriers that would impair/preclude the benefits of correction of inventoried sites.

The Snohomish Basin Salmonid Recovery Technical Committee is currently in the process of developing an Ecological Analysis Workplan for WRIA 7. One of the key components of the workplan will be development of a Research and Monitoring Strategy that will build on prior efforts to identify and prioritize actions to fill identified data gaps in WRIA 7.

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APPENDICES

APPENDIX A -

SNOHOMISH RIVER WATERSHED (WRIA 7) SALMONID DISTRIBUTION

The following streams in the Snohomish River watershed (WRIA 7) are identified as having anadromous salmonid (cutthroat and other resident salmonids not mapped) and/or bull trout presence. Distribution for anadromous salmonids and bull trout/Dolly Varden represents review and reconciliation of differences between products from the 1995 Snohomish Basin Fish Distribution Mapping Workshop, Streamnet (WDFW), and Conservation Reserve Enhancement Program (CREP) mapping, with additions and modifications based on surveys in the WDFW Spawner Survey Database, additional input and observations of Technical Advisory Group (TAG) participants, and other sources. Bull trout presence includes spawning areas identified in Streamnet, with presumed rearing presence throughout the watershed mirroring identified coho distribution (known and presumed). Bull trout are known to be opportunistic feeders; it is possible that they may forage to the extent of coho distribution, although the likelihood of sampling a bull trout, particularly in the upper extent of coho distribution in smaller tributaries, on any given day is minimal due to low bull trout abundance and their nomadic foraging behavior traits (Knudsen).

Known distribution (code=1 in species column) in these streams represents current knowledge, which is limited to those streams/locations where observations of adult or juvenile salmonids have been made. Known distribution may be significantly different than historic distribution, with current distribution likely being more limited. Reasons for more restricted current distribution include habitat conditions that no longer support salmonids; presence of barriers that preclude salmonid access to productive habitats; and reduced spawner populations that tend to narrow the distribution extent, limit the ability of the fish to maintain suitable substrate conditions, and limit the return of marine nutrients from carcass decomposition that support the instream food web for subsequent juvenile salmonid production. Actual distribution may be greater than represented, as known distribution only includes areas where observations of fish have been made, and there are numerous tributaries in the watershed where comprehensive assessment of salmonid presence has not been conducted.

Presumed species distribution (code=2 in species column) is also identified for a number of streams and species. Presumed distribution typically represents streams/reaches with known distribution downstream and sufficient knowledge of habitat conditions to estimate that distribution of the species likely extends upstream through suitable habitat to an identified migration barrier (natural or anthropogenic). Bull trout distribution is presumed to the extent of known/presumed coho distribution, except where known bull trout distribution is identified in Streamnet. There are several streams with more extensive anadromous salmonid distribution than for coho, where presumed bull trout is not identified. Potential/historic distribution (code=3 in species column) is identified where historic distribution is known/presumed to have been more extensive based on watershed literature, personal knowledge, or presence of suitable salmonid habitat upstream of anthropogenic fish passage barriers. Potential/historic salmonid distribution is also likely greater than represented.

Artificial distribution (not represented in table or distribution maps) represents areas above natural barriers that were not historically accessible to anadromous salmonids, but which are now accessible due to fishways or trap and haul operations. Anadromous salmonid and bull trout presence in the SF Skykomish and tributaries upstream of Sunset Falls is artificial, and only possible due to the trap and haul operation , initiated in 1958, that bypasses Sunset Falls, Canyon Falls, and Eagle Falls.

See Snohomish River watershed species distribution maps for a visual representation of the data in Table 20. Stream index numbering and river mile designations are based on that presented in the WDF Stream Catalog – Puget Sound Volume 1 (Williams et al. 1975).

Sources Referenced in Snohomish Salmonid Distribution Table (Table 20**)**

1 WDFW Spawner Survey Database
2 Anne Savery, Tulalip Tribes
3 Curt Kraemer, WDFW
4 Pete Castle - 1995 Fish Distribution Workshop
5 Don Hendrick, WDFW
6 Rich Johnson, WDFW
7 Mike Chamblin, WDFW
8 Kurt Beardslee, Washington Trout
9 Kurt Nelson, Tulalip Tribes
10 Bob Heirman - 1995 Fish Distribution Workshop
11 Chuck Baranski, WDFW
12 Dave Ward, Snohomish County SWM
13 Randy Middaugh, Snohomish County
14 Streamnet, WDFW
15 CREP Mapping - Nelson/Kraemer
16 1995 Fish Distribution Workshop, specific source undetermined
17 Jamie Glasgow, Washington Trout
18 Frank Staller, Washington Trout
19 Susan Cierebeij, WDFW
20 Chris Dietrick, WDFW
21 Mike Nelson, Snohomish County Planning and Development Services
22 Tony Opperman, WDFW
23 Andy Haas, Snohomish County SWM
24 Hans Berge, King County DNRP
25 Kirk Anderson, King County DNRP
26 Mike Ackley, WDFW

Table 20: Salmonid support data for WRIA 7 salmonid species distribution maps

Please click on this line to access Table 20

APPENDIX B

SALMONID HABITAT CONDITION RATING STANDARDS FOR IDENTIFYING LIMITING FACTORS

Under the Salmon Recovery Act (passed by the legislature as House Bill 2496, and later revised by Senate Bill 5595), the Washington Conservation Commission (WCC) is charged with identifying the habitat factors limiting the production of salmonids throughout most of the state. This information should guide lead entity groups and the Salmon Recovery Funding Board in prioritizing salmonid habitat restoration and protection projects seeking state and federal funds. Identifying habitat limiting factors requires a set of standards that can be used to compare the significance of different factors and consistently evaluate habitat conditions in each WRIA throughout the state.

In order to develop a set of standards to rate salmonid habitat conditions, several tribal, state, and federal documents that use some type of habitat rating system (Table 1) were reviewed. The goal was to identify appropriate rating standards for as many types of habitat limiting factors as possible, with an emphasis on those that could be applied to readily available data. Based on the review, it was decided to rate habitat conditions into three categories: Good, Fair, and Poor. For habitat factors that had wide agreement on how to rate habitat condition, the accepted standard was adopted by the WCC. For factors that had a range of standards, one or more of them were adopted. Where no standard could be found, a default rating standard was developed, with the expectation that it will be modified or replaced as better data become available.

Table 1 - Source documents

Code	Document	Organization
Hood Canal	Hood Canal/Eastern Strait of Juan de Fuca Summer Chum Habitat Recovery Plan, Final Draft (1999)	Point No Point Treaty Council, Skokomish Tribe, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Washington Department of Fish and Wildlife
ManTech	An Ecosystem Approach to Salmonid Conservation, vol. 1 (1995)	ManTech Environmental Research Services for the National Marine Fisheries Service, the US Environmental Protection Agency, and the US Fish and Wildlife Service
NMFS	Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast (1996)	National Marine Fisheries Service
PHS	Priority Habitat Management Recommendations: Riparian (1995)	Washington Department of Fish and Wildlife
Skagit	Skagit Watershed Council Habitat Protection and Restoration Strategy (1998)	Skagit Watershed Council
WSA	Watershed Analysis Manual, v4.0 (1997)	Washington Forest Practices Board
WSP	Wild Salmonid Policy (1997)	Washington Department of Fish and Wildlife

The ratings adopted by the WCC are presented in Table 2. These ratings are not intended to be used as thresholds for regulatory purposes, but as a coarse screen to identify the most significant habitat limiting factors in a WRIA. They also will hopefully provide a level of consistency between WRIAs that allows habitat conditions to be compared across the state. However, for many habitat factors, there may not be sufficient data available to use a rating standard or there may be data on habitat parameters where no rating standard is provided. For these factors, the professional judgment of the TAG should be used to assign the appropriate ratings. A set of narrative standards will be developed in the near future to provide guidance in this situation.

In some cases there may be local conditions that warrant deviation from the rating standards presented here. This is acceptable as long as the justification and a description of the procedures that were followed are clearly documented in the limiting factors report. Habitat condition ratings specific to streams draining east of the Cascade crest were included where they could be found, but for many parameters they were not. Additional rating standards will be included as they become available. In the meantime, TAGs in these areas will need to work with the standards presented here or develop alternatives based on local conditions. Again, if deviating from these standards, the procedures followed should be clearly documented in the limiting factors report.

Table 2 - WCC salmonid habitat condition ratings

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Access and Passage						
Artificial Barriers	% known/potential habitat blocked by artificial barriers	All	>20%	10-20%	<10%	WCC
Floodplains						
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	<1% gradient	>50%	10-50%	<10%	WCC
Loss of Floodplain Habitat	Lost wetted area	<1% gradient	>66%	33-66%	<33%	WCC
Channel Conditions						
Fine Sediment	Fines < 0.85 mm in spawning gravel	All – Westside	>17%	11-17%	≤11%	WSP/WSA/NMFS/Hood Canal
	Fines < 0.85 mm in spawning gravel	All – Eastside	>20%	11-20%	≤11%	NMFS
Large Woody Debris	pieces/m channel length	≤4% gradient, <15 m wide (Westside only)	<0.2	0.2-0.4	>0.4	Hood Canal/Skagit
	or use Watershed Analysis piece and key piece standards listed below when data are available					
	pieces/channel width	<20 m wide	<1	1-2	2-4	WSP/WSA

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
	key pieces/channel width*	<10 m wide (Westside only)	<0.15	0.15-0.30	>0.30	WSP/WSA
	key pieces/channel width*	10-20 m wide (Westside only)	<0.20	0.20-0.50	>0.50	WSP/WSA
	* Minimum size to qualify as a key piece:	BFW (m) 0-5 6-10 11-15 16-20	Diameter (m) 0.4 0.55 0.65 0.7	Length (m) 8 10 18 24		
Percent Pool	% pool, by surface area	<2% gradient, <15 m wide	<40%	40-55%	>55%	WSP/WSA
	% pool, by surface area	2-5% gradient, <15 m wide	<30%	30-40%	>40%	WSP/WSA
	% pool, by surface area	>5% gradient, <15 m wide	<20%	20-30%	>30%	WSP/WSA
	% pool, by surface area	>15 m	<35%	35-50%	>50%	Hood Canal
Pool Frequency	Channel widths per pool	<15 m	>4	2-4	<2	WSP/WSA
	Channel widths per pool	>15 m	-	-	chann width / pools/mile / cw/pool 50' 26 4.1 75' 23 3.1 100' 18 2.9	NMFS
Pool Quality	pools >1 m deep with good cover and cool water	All	No deep pools and inadequate cover or temperature, major reduction of pool volume by sediment	Few deep pools or inadequate cover or temperature, moderate reduction of pool volume by sediment	Sufficient deep pools	NMFS/WSP /WSA
Streambank Stability	% of banks not actively eroding	All	<80% stable	80-90% stable	>90% stable	NMFS/WSP

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Sediment Input						
Sediment Supply	$m^3/km^2/yr$	All	> 100 or exceeds natural rate*	-	< 100 or does not exceed natural rate*	Skagit
	* Note: this rate is highly variable in natural conditions					
Mass Wasting		All	Significant increase over natural levels for mass wasting events that deliver to stream	-	No increase over natural levels for mass wasting events that deliver to stream	WSA
Road Density	mi/mi^2	All	>3 with many valley bottom roads	2-3 with some valley bottom roads	<2 with no valley bottom roads	NMFS
	or use results from Watershed Analysis where available					
Riparian Zones						
Riparian Condition	riparian buffer width (measured out horizontally from the channel migration zone on each side of the stream) riparian composition	Type 1-3 and untyped salmonid streams >5' wide	<75' or <50% of site potential tree height (whichever is greater) OR Dominated by hardwoods, shrubs, or non-native species (<30% conifer) unless these species were dominant historically.	75'-150' or 50-100% of site potential tree height (whichever is greater) AND Dominated by conifers or a mix of conifers and hardwoods (≥30% conifer) of any age unless hardwoods were dominant historically.	>150' or site potential tree height (whichever is greater) AND Dominated by mature conifers (≥70% conifer) unless hardwoods were dominant historically	WCC/WSP
	buffer width riparian composition	Type 4 and untyped perennial streams <5' wide	<50' with same composition as above	50'-100' with same composition as above	>100' with same composition as above	WCC/WSP

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
	buffer width riparian composition	Type 5 and all other untyped streams	<25' with same composition as above	25'-50' with same composition as above	>50' with same composition as above	WCC/WSP
Water Quality						
Temperature	degrees Celsius	All	>15.6° C (spawning) >17.8° C (migration and rearing)	14-15.6° C (spawning) 14-17.8° C (migration and rearing)	10-14° C	NMFS
Dissolved Oxygen	mg/L	All	<6	6-8	>8	ManTech
Hydrology						
Flow	hydrologic maturity	All	<60% of watershed with forest stands aged 25 years or more	-	>60% of watershed with forest stands aged 25 years or more	WSP/Hood Canal
		or use results from Watershed Analysis where available				
	% impervious surface	Lowland basins	>10%	3-10%	≤3%	Skagit
Biological Processes						
Nutrients (Carcasses)	Number of stocks meeting escapement goals	All Anadromous	Most stocks do not reach escapement goals each year	Approximately half the stocks reach escapement goals each year	Most stocks reach escapement goals each year	WCC

APPENDIX C

WATERSHED ANALYSIS UNIT BOUNDARY COMPARISON

Salmonid habitat assessment reports for the Snohomish River watershed have utilized varying subwatershed analysis unit boundary designations. The Snohomish Basin Salmonid Recovery Technical Committee recently completed the Snohomish River Basin Salmonid Habitat Conditions Review report (SBSRTC 2002). The Technical Committee expressed a desire that the Limiting Factors Analysis report utilize the subwatershed boundaries in the Habitat Conditions Review for consistency. However, due to concerns regarding disassociation of watershed process considerations for the Snohomish, Snoqualmie, Skykomish, Sultan, and Tolt mainstems, and concerns related to the lack of identification of habitat conditions and processes in tributaries, this report utilizes different subwatershed analysis units than those in the Habitat Conditions Review (SBSRTC 2002). At the request of the Snohomish Basin Salmonid Recovery Technical Committee, following is a list of the subwatershed analysis units in this report, and corresponding subwatershed analysis units in the Habitat Conditions Review (SBSRTC 2002) report (Table 21).

Table 21: Comparison of subwatershed analysis unit boundaries in this report with those in the Habitat Conditions Review (SBSRTC 2002)

Salmonid Habitat Limiting Factors Watershed Analysis Unit Designation	**Snohomish River Basin Salmonid Habitat Conditions Review (SBSRTC 2002) Watershed Designation**
Tulalip Creek 07.0001	Part of Tulalip watershed
Battle (Mission) Creek 07.0005	Part of Tulalip watershed
Snohomish River 07.0012	Included as part of Quilceda, Allen, Snohomish Estuary, Sunnyside, Fobes Hill, French Creek, Marshland, and Cathcart watersheds
Deadwater Slough 07.0024, EF Deadwater Slough 07.0028, and tributaries	Part of Snohomish Estuary watershed
Bigelow Creek/Wetlands 07.0035?	Part of Everett Drainages watershed
Quilceda Creek 07.0044, Unnamed 07.0045, Sturgeon Creek 07.0046, Unnamed 07.0048, WF Quilceda 07.0049, MF Quilceda 07.0058, and tributaries	Part of Quilceda Creek watershed
Allen Creek 07.0068, Unnamed 07.0068A, Unnamed 07.0068X, Sunnyside Creek 07.0070, Munson Creek 07.0073, Unnamed 07.0074, Unnamed 07.0078, Ross Creek 07.0079, Unnamed 07.0081, and tributaries	Part of Allen Creek watershed
Sunnyside Creek 07.0083, Hulbert Creek 07.0086, Weiser Creek 07.0090, and Burri Creek 07.0091	Part of Sunnyside watershed
Unnamed 07.0096	Unclear whether part of Sunnyside or Fobes Hill watershed
Moshers Creek 07.0098	Part of Fobes Hill watershed
Swan Trail Slough 07.0103	Part of Fobes Hill watershed
Marshland Drainages, Wood Creek 07.0036,	Part of Marshland watershed

Salmonid Habitat Limiting Factors Watershed Analysis Unit Designation	Snohomish River Basin Salmonid Habitat Conditions Review (SBSRTC 2002) Watershed Designation
Larimer Creek 07.0107, Thomas Creek 07.0108, Batt Slough, Hanson Slough	
Cemetery Creek 07.0117 and tributaries	Part of Fobes Hill watershed
Swifty Creek 07.0124	Part of Fobes Hill watershed
Pilchuck River Mainstem 07.0125	Part of Lower Pilchuck, Middle Pilchuck, and Upper Pilchuck watersheds
Sexton Creek 07.0126 and tributaries	Part of Lower Pilchuck watershed
Bunk Foss Creek 07.0130, Collins Creek 07.0132, and Fields Fork Creek 07.0133	Part of Lower Pilchuck watershed
Scott Creek 07.0134	Part of Lower Pilchuck watershed
Kuhlman's Creek 07.0135	Part of Lower Pilchuck watershed
Williams Creek 07.0137	Part of Lower Pilchuck watershed
Dubuque Creek 07.0139, Panther Creek 07.0140, and tributaries	Dubuque Creek watershed
Little Pilchuck Creek 07.0146 and tributaries (excluding Stevens/Catherine Creek watershed)	Little Pilchuck watershed
Stevens Creek 07.0147, Catherine Creek 07.0148, and tributaries	Lake Stevens watershed
Connor Creek 07.0158	Part of Middle Pilchuck watershed
Unnamed 07.0159	Part of Middle Pilchuck watershed
Unnamed 07.0161 and tributaries	Part of Middle Pilchuck watershed
Black Creek 07.0161B and Coon Creek 07.0161A	Part of Middle Pilchuck watershed
Swartz Lake Creek 07.0162	Part of Middle Pilchuck watershed
Bosworth Creek 07.0163	Part of Middle Pilchuck watershed
Boyd Lake Creek 07.0164	Part of Middle Pilchuck watershed
Menzel Lake Creek 07.0164A	Part of Middle Pilchuck watershed
Purdy Creek 07.0165	Part of Middle Pilchuck watershed
Worthy Creek 07.0166 and tributaries	Part of Upper Pilchuck watershed
Kelly Creek 07.0170 and tributaries	Part of Upper Pilchuck watershed
Unnamed 07.0173?	Part of Upper Pilchuck watershed
Ross Creek 07.0175	Part of Upper Pilchuck watershed
Wilson Creek 07.0176	Part of Upper Pilchuck watershed
Miller Creek 07.0180	Part of Upper Pilchuck watershed
Unnamed 07.0181	Part of Upper Pilchuck watershed
French Creek 07.0184 and tributaries	Part of French Creek watershed
Unnamed 07.0206?	Part of Cathcart Drainages watershed
Lake Beecher Creek 07.0207, Unnamed Side-Channel 07.0209, Evans Creek 07.0210, Anderson Creek 07.0212, and Elliott Creek 07.0214, and tributaries	Part of Cathcart Drainages watershed
Ricci Creek 07.0220	Part of Snoqualmie Mouth watershed
Unnamed 07.0217	Part of Cathcart Drainages watershed
Snoqualmie River Mainstem 07.0219	Part of Snoqualmie Mouth, Mid-Mainstem Snoqualmie, Upper Mainstem Snoqualmie, and Coal Creek Lower watersheds

Salmonid Habitat Limiting Factors Watershed Analysis Unit Designation	**Snohomish River Basin Salmonid Habitat Conditions Review (SBSRTC 2002) Watershed Designation**
Unnamed 07.0224, Crescent Lake	Part of Snoqualmie Mouth watershed
Unnamed 07.0226	Part of Snoqualmie Mouth watershed
Unnamed 07.0227	Part of Snoqualmie Mouth watershed
Pearson Eddy Creek 07.0229	Part of Snoqualmie Mouth watershed
Peoples Creek 07.0236	Part of Snoqualmie Mouth watershed
Duvall Creek 07.0238	Part of Snoqualmie Mouth watershed
Cherry Creek 07.0240, Unnamed 07.0240A, NF Cherry 07.0243, Unnamed 07.0245, Unnamed 07.0247, Margaret Creek 07.0248, Hannon Creek 07.0257, and tributaries	Cherry Creek watershed
Tuck Creek 07.0267 and tributaries	Part of Mid-Mainstem Snoqualmie watershed
Duvall Area Independent Creeks (Coe Clemens Creek 07.0267X, Thayer Creek 07.0267Y, and Unnamed 07.0267Z)	Part of Mid-Mainstem Snoqualmie watershed
Adair Creek 07.0275	Part of Mid-Mainstem Snoqualmie watershed
Deer Creek 07.0275X	Part of Mid-Mainstem Snoqualmie watershed
Unnamed 07.0276 (Wallace Creek) and tributaries	Part of Mid-Mainstem Snoqualmie watershed
Ames Creek 07.0278 and tributaries	Ames Creek watershed
Weiss Creek 07.0281 and tributary	Part of Mid-Mainstem Snoqualmie watershed
Harris Creek 07.0283, Stillwater Creek 07.0284, Unnamed 07.0285B, Unnamed 07.0285C, Unnamed 07.0285D, Unnamed 07.0286, Unnamed 07.0286A, and Unnamed 07.0289	Harris creek watershed
Unnamed LB tributaries to Snoqualmie River between Harris Creek and the Tolt River	Part of Mid-Mainstem Snoqualmie watershed
East Horseshoe Lake 07.0290 and tributaries	Part of Mid-Mainstem Snoqualmie watershed
Tolt/NF Tolt River 07.0291, Unnamed 07.0293, Unnamed 07.0294, Unnamed 07.0294X, Moss Lake Creek 07.0298, Stossel Creek 07.0300, North Fork Creek 07.0329, SF Tolt River 07.0302, and tributaries	Lower Tolt River, North Fork Tolt River, South Fork Tolt River, and South Fork Tolt River AD watersheds
Langlois Creek 07.0292 and tributaries	Part of Upper Mainstem Snoqualmie watershed
Griffin Creek 07.0364 and tributaries	Griffin Creek watershed
Patterson Creek 07.0376, Unnamed 07.0377, Canyon Creek 07.0382, Unnamed 07.0383, Dry Creek 07.0383A, and tributaries	Patterson Creek watershed
Raging River 07.0384, Unnamed 07.0384X, Unnamed 07.0389, Soderman Creek 07.0390, Unnamed 07.0391, Unnamed 07.0391A, Unnamed 07.0392, Lake Creek 07.0393, Unnamed 07.0394, Deep Creek 07.0396, Unnamed 07.0422, and tributaries	Raging River watershed
Unnamed 07.0427	Part of Upper Mainstem Snoqualmie watershed
Rutherford Slough Tributary 07.0428	Part of Upper Mainstem Snoqualmie watershed
Unnamed 07.0429	Part of Coal Creek Lower watershed

Salmonid Habitat Limiting Factors Watershed Analysis Unit Designation	Snohomish River Basin Salmonid Habitat Conditions Review (SBSRTC 2002) Watershed Designation
Unnamed 07.0430	Part of Coal Creek Lower watershed
Unnamed 07.0431, Unnamed 07.0432, Unnamed 07.0433, Unnamed 07.0437, Unnamed 07.0439, and Unnamed 07.0452	Part of Coal Creek Lower watershed
Skunk Creek 07.0434 and Mud Creek 07.0435	Part of Coal Creek Lower watershed
Tokul Creek 07.0440	Tokul Creek watershed
Snoqualmie River upstream of Snoqualmie Falls, including SF Snoqualmie, MF Snoqualmie, and NF Snoqualmie	Coal Creek Upper, Tate Creek, Lower South Fork Snoqualmie, Upper South Fork Snoqualmie, Lower Middle Fork Snoqualmie, Upper Middle Fork Snoqualmie, Pratt River, Lower North Fork Snoqualmie, Upper North Fork Snoqualmie, and Taylor River watersheds
Skykomish River Mainstem 07.0012 (upstream continuation of Snohomish River)	Part of Lower Mainstem Skykomish and Upper Mainstem Skykomish watersheds
Unnamed 07.0814 and tributaries	Part of Lower Mainstem Skykomish watershed
Riley Slough 07.0818, Foye Creek 07.0819, High Rock Creek 07.0820, Unnamed 07.0821, Unnamed 07.0822, Unnamed 07.0823	Part of Lower Mainstem Skykomish watershed
Haskel Slough 07.0825	Part of Lower Mainstem Skykomish watershed
Woods/EF Woods Creek 07.0826, Richardson Creek 07.0828, WF Woods Creek 07.0831,Carpenter Creek 07.0836, Unnamed 07.0841, and tributaries	Lower Woods Creek, Woods Creek, and West Fork Woods Creek watersheds
Unnamed 07.0857	Part of Lower Mainstem Skykomish watershed
Barr Creek 07.0858 and Kissee Creek 07.0859	Part of Lower Mainstem Skykomish watershed
Eagle Creek 07.0862	Part of Lower Mainstem Skykomish watershed
Unnamed 07.0863 and Unnamed to east	Part of Lower Mainstem Skykomish watershed
Unnamed 07.0864	Part of Lower Mainstem Skykomish watershed
Groeneveld Creek 07.0864B	Part of Lower Mainstem Skykomish watershed
Unnamed 07.0864A (Groeneveld Slough)	Part of Lower Mainstem Skykomish watershed
Elwell Creek 07.0865, Unnamed 07.0866, and Youngs Creek 07.0870	Part of Lower Mainstem Skykomish watershed
McCoy Creek 07.0876, Tychman Slough 07.0877, and tributaries	Part of Lower Mainstem Skykomish watershed
Yonkers Slough 07.0877A	Part of Lower Mainstem Skykomish watershed
Sultan River 07.0881, Trout Farm Creek 07.0881A, Winters Creek 07.0882, Ames Creek 07.0883	Lower Sultan and Upper Sultan watersheds
Wagleys Creek 07.0939 and tributaries	Part of Lower Mainstem Skykomish watershed
Wallace River 07.0940 and Unnamed 07.0940A, Unnamed 07.0940B, Unnamed 07.0940C, Unnamed 07.0940D, NF Wallace River 07.0951, Bear Creek 07.0942, May Creek 07.0943 and tributaries, Olney Creek 07.0946	May Creek, Bear Creek, Olney Creek, and Upper Wallace River watersheds
Sky Slough 07.0961 and tributaries	Part of Upper Mainstem Skykomish watershed
Berry Farm Slough 07.0961X	Part of Upper Mainstem Skykomish watershed
Unnamed 07.0961Y	Part of Upper Mainstem Skykomish watershed

Salmonid Habitat Limiting Factors Watershed Analysis Unit Designation	Snohomish River Basin Salmonid Habitat Conditions Review (SBSRTC 2002) Watershed Designation
Unnamed 07.0962X, Unnamed 07.0963, and Unnamed 07.0963A	Part of Upper Mainstem Skykomish watershed
Duffey Creek 07.0965	Part of Upper Mainstem Skykomish watershed
Game Trail Slough 07.0965A	Part of Upper Mainstem Skykomish watershed
Proctor Creek 07.0970 and tributary	Part of Upper Mainstem Skykomish watershed
Hogarty Creek 07.0972	Part of Upper Mainstem Skykomish watershed
Anderson Creek 07.0975	Part of Upper Mainstem Skykomish watershed
Deer Creek 07.0979, Son of Deer 07.0979A, Unnamed 07.0979B	Part of Upper Mainstem Skykomish watershed
NF Skykomish River Mainstem 07.0982	Part of Lower North Fork Skykomish and Upper North Fork Skykomish watersheds
Lewis Creek 07.0983, Son of Lewis 07.0983A, Unnamed 07.0983B	Part of Lower North Fork Skykomish watershed
Bitter Creek 07.0985	Part of Lower North Fork Skykomish watershed
Snowslide Creek 07.0994	Part of Lower North Fork Skykomish watershed
Excelsior Creek 07.0995	Part of Lower North Fork Skykomish watershed
Trout Creek 07.0997 and tributary	Part of Lower North Fork Skykomish watershed
Unnamed 07.1030	Part of Lower North Fork Skykomish watershed
Salmon Creek 07.1031	Part of Lower North Fork Skykomish watershed
Lost Creek 07.0141	Part of Lower North Fork Skykomish watershed
Howard Creek 07.0142	Part of Lower North Fork Skykomish watershed
Silver Creek 07.1053	Part of Upper North Skykomish watershed
Troublesome Creek 07.1085	Part of Upper North Skykomish watershed
Bear Creek 07.1120	Part of Upper North Skykomish watershed
West Cady Creek 07.1142	Part of Upper North Skykomish watershed
Goblin Creek 07.1182	Part of Upper North Skykomish watershed
SF Skykomish River 07.0012	Part of Lower South Fork Skykomish, South Fork Skykomish, and Upper South Fork Skykomish watersheds
Bridal Veil Creek 07.1248, Payton Creek 07.1248A	Part of Lower South Fork Skykomish watershed
Barclay Creek 07.1252	Part of Lower South Fork Skykomish watershed
Unnamed 07.1252A	Part of Lower South Fork Skykomish watershed
Baring Creek 07.1252X, Unnamed 07.1263, Unnamed 07.1280, Unnamed 07.1280X, Unnamed 07.1285, Unnamed 07.1296, Unnamed 07.1298, Unnamed 07.1326	Part of South Fork Skykomish watershed
Unnamed 07.1263X	Part of South Fork Skykomish watershed
Index Creek 07.1264	Part of South Fork Skykomish watershed
Unnamed 07.1294	Part of South Fork Skykomish watershed
Money Creek 07.1300 and tributaries	Part of South Fork Skykomish watershed
Miller River 07.1329 and tributaries	Part of South Fork Skykomish watershed
Maloney Creek 07.1407	Part of Upper South Fork Skykomish watershed
Beckler River 07.1413, Eagle Creek 07.1416, Harlan Creek 07.1436, Bullbucker Creek 07.1540, and Rapid River 07.1461	Beckler and Rapid River watersheds

Salmonid Habitat Limiting Factors Watershed Analysis Unit Designation	**Snohomish River Basin Salmonid Habitat Conditions Review (SBSRTC 2002) Watershed Designation**
Anthracite Creek 07.1561	Part of Upper South Fork Skykomish watershed
Foss River 07.1562, WF Foss 07.1573, Burn Creek 07.1596, and tributaries	Foss River watershed
Tye River 07.0012 (cont. from SF Skykomish), Profits Pond Creek 07.1621, Alpine Creek 07.1622, Unnamed 07.1626, Unnamed 07.1627	Tye River watershed
Everett Independent Drainages	Part of Everett Drainages watershed