SALMON AND STEELHEAD HABITAT LIMITING FACTORS

CHEHALIS BASIN AND NEARBY DRAINAGES
WATER RESOURCE INVENTORY AREAS 22 AND 23

WASHINGTON STATE
CONSERVATION COMMISSION
FINAL REPORT

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Several maps have been included with this report for your reference. The maps are appended to the report, either as a separate electronic file (for the electronic copy of this report) or separate printed section (for hard copy). The maps are included as a separate electronic file to enable the reader to utilize computer multi-tasking capabilities to simultaneously bring up the map and associated text. Below is a list of maps that are included in the WRIAs 22 and 23 map appendix/file:

EXECUTIVE SUMMARY

As directed under Engrossed Substitute House Bill 2496 and Second Engrossed Second Substitute Senate Bill 5595, the habitat conditions of salmonid-producing watersheds within WRIAs 22 and 23 are reviewed and rated. In addition, we prioritized sub-basins based upon greatest benefit to salmonids, and prioritized the actions (restoration, conservation, and assessments) that are needed for restoration of each individual sub-basin. The worst habitat problems are summarized here, but an overview of all the habitat ratings is provided in Table 40 in the Assessment Chapter. The Assessment Chapter also specifies the criteria used to rate habitat conditions. Other components of this report include detailed discussions for each of the habitat conditions, which can be found within the Habitat Limiting Factors Chapter of this report. Also, maps of updated salmon and steelhead trout distribution, large woody debris (LWD) conditions, and riparian conditions are located in a separate electronic file on this disc. This first round report examines salmon and steelhead trout habitat conditions. Later versions will address habitat issues for other salmonids.

The streams addressed in this report include all streams in WRIAs 22 and 23 that have known salmon or steelhead usage. This includes the Grays Harbor estuary, the mainstem Chehalis River, streams that drain into the Chehalis River, and independent streams that drain into Grays Harbor such as the Humptulips River, Hoquiam River, Wishkah River, Elk River, Johns River, and other independent sub-basins. The report begins with the Grays Harbor estuary and continues upstream on a sub-basin by sub-basin approach.

One major impediment to assess the fish distribution and habitat conditions in these two WRIAs is the tremendous lack of detailed field information. While the Chehalis drainage is the second largest in Washington State (second to the Columbia River), only eight watershed analyses have been completed, and of those, two are in areas upstream of most anadromous salmonid production. Assessments regarding sedimentation, off-channel habitat, channel conditions (incision, aggradation, etc), water usage, water quality, salmonid escapement estimates, fish habitat use, stream flow, instream habitat components (pools, LWD, etc), riparian conditions, and landcover are some of the major categories where data are lacking. Also, the Chehalis basin is far behind most other areas in the State regarding assessment and prioritization of fish habitat blockages. Very few surveys of blockages have been conducted that include impacts to salmonids, and the existing information is scattered among various landowners. The potential impact of blockages to fish habitat is considerable because of the high road densities. Using NMFS standards, none of the sub-basins rate “good” for road density and most rate “poor”. Fish distribution data are also generally not as complete as in other areas of Washington State. Several sub-basins are not annually surveyed. Without proper assessment of fish presence and abundance, it will be difficult to accurately use fish data to define impacts and recovery success and to monitor projects and recovery progress.

The Technical Advisory Group (TAG), combined with local citizens, used fish data (number of stocks and number of stream miles with known salmon and steelhead presence) to prioritize sub-basins within these two WRIAs. High priority sub-basins include the: Grays Harbor estuary, mainstem Chehalis River, Humptulips, Hoquiam, Wishkah, Wynoochee, Satsop, Black River, Skookumchuck, Newaukum, and the South Fork Chehalis sub-basins. Medium priority sub-basins are Johns, Elk River, Cloquallum, Delezene, Rock/Williams, Garrard, Scatter, Lincoln, Elk Creek, and the upper Chehalis River and tributaries (upstream of Pe Ell). Low priority sub-basins include Newman, Workman, Porter, Gibson, Cedar, Independence, Stearns, Dillenbaugh, Salzer, Bunker, and Rock Creek (near Crim Creek). Furthermore, action recommendations and data needs are prioritized for each of these sub-basins, and those are detailed in the prioritization section near the end of the report.

No one, single "bottleneck" is currently believed to most impact natural salmonid production in these two WRIAs. In the early 1990s, Schroder and Fresh (1992) documented severe water quality problems in Grays Harbor that resulted in a significant loss of coho smolt production. However, several causes of the water quality problems have been addressed, and the TAG believes that current water quality conditions in the Grays Harbor estuary have improved. One major data need is to better assess current water quality and potential impacts to salmonids in Grays Harbor. The estimated loss of estuarine habitat is 30% and this is believed to be an underestimate. However, compared to estuaries elsewhere in Washington State, this is a low level of loss. Dredging impacts are another concern within Grays Harbor.

The mainstem Chehalis River has severe impacts from channel incision, sedimentation, riparian loss or conversion, water quality problems, and reduction in stream flow, and many of these problems are translated to the mainstem Chehalis River from tributaries. The causes of channel incision are not well defined. In the upper Chehalis, debris torrents have led to incision. Downstream, potential causes of incision include increased sediment transport due to increased sediment loads from tributaries coupled with an extensive loss of LWD. Also, increased peak flows due to urbanization and changes in landcover vegetation is another suspected cause. While local bank erosion is common along the mainstem, large sediment loads enter the mainstem Chehalis from the tributaries. In order of contribution, those that contribute the most sediment are the Satsop, Wynoochee, and three areas in WRIA 23 (the Newaukum, South Fork Chehalis, and upper Chehalis sub-basins). To address sediment problems in the mainstem, actions must occur in those sub-basins. There has also been an extensive loss of riparian vegetation along the mainstem, coupled with conversion of conifer to hardwoods. This contributes to bank erosion, warm water temperatures, and lack of LWD. The causes of riparian loss to the mainstem are mainly agriculture and urbanization.

Water quality problems are well documented in the mainstem Chehalis River upstream of Porter Creek, particularly for warm water temperatures and low dissolved oxygen levels. The temperature problems are likely related to riparian loss, increased sedimentation resulting in channel changes (width –to-depth ratios), and decreased water flows, not only in the mainstem Chehalis, but also in tributaries. The priority mainstem segments for riparian restoration include the Chehalis River mainstem from Porter Creek to the headwaters. The primary causes for low dissolved oxygen levels are livestock waste and urban stormwater. The priority areas to address those problems include Salzer Creek, the mainstem Chehalis River at RM 70.7 and from RM 77.6 to 97.9, Dillenbaugh Creek, the South Fork Chehalis River, Black River, Lincoln Creek, Independence Creek, and Scatter Creek. Warm water temperatures and low dissolved oxygen levels are also documented in many of the tributaries, such as in the Humptulips, Wynoochee, Satsop, Wildcat, Independence, Lincoln, Black, Scatter, Skookumchuck, Salzer, Dillenbaugh, Newaukum, Stearns, Bunker, South Fork Chehalis, and upper Chehalis sub-basins. The known causes of the poor water quality problems in these sub-basins are riparian loss or conversion, livestock waste, sedimentation, decreased flows, industrial inputs, and urban stormwater. It is also likely that the reduction in wetlands has contributed to degraded water quality. Recommended solutions include riparian restoration, sediment load and transport reduction, decreasing livestock waste inputs, decreasing industrial and urban inputs, and increasing stream flows during the summer to early fall.

Low stream flows are an increasing problem in the mainstem Chehalis, and the problem extends throughout many of the tributaries. Since 1953, mainstem flows measured near Porter decreased 19%, while annual precipitation decreased only 6% (Wildrick et al. 1995). Many tributaries to the mainstem Chehalis River from Porter Creek upstream are closed to further water rights allocations, because of concerns that base flows are not being met. The closed streams are Wildcat Creek, Mox Chehalis Creek, Rock Creek, Garrard Creek, Hope Creek, Lincoln Creek, Black River and several tributaries, Scatter Creek, Salzer Creek, Dillenbaugh Creek, Stearns Creek, Bunker Creek, and the South Fork Chehalis River. In addition, base flows are often not met in the Satsop, Wynoochee, Skookumchuck, and Newaukum sub-basins. The primary water users in the WRIA 23 drainage are irrigation (top user), power generation, and domestic water use (Wildrick et al. 1995). Also, groundwater is important to maintain summer flows in WRIA 23, and potential increases in groundwater withdrawals would worsen stream flow conditions in the summer months.

Riparian degradation is extensive throughout the sub-basins, particularly the Wynoochee, Satsop, Cloquallum, Garrard, Lincoln, Skookumchuck, Newaukum, Salzer, Bunker, and the South Fork Chehalis sub-basins. The lower reaches of most of the other sub-basins have “poor” riparian conditions, as well. Instream levels of LWD are generally low, where levels are known.

Excess sediment delivery is a major problem throughout most of the sub-basins. In those with moderate to steep slopes, landslides from roads are one of the greatest problems, and sidecast roads pose a notable risk. Road density is high throughout all the sub-basins, especially in the upper Chehalis (6.4 mi roads/sq mi watershed) and Scatter Creek (5.3 mi/sq mi). Road densities greater than 3 mi/sq mi are found in the Stearns, Skookumchuck, Newman, Mox Chehalis, Delezene, Workman, Bunker, Newaukum, Elk Creek, Rock (near Crim Creek), Black, Lincoln, Independence, Elk River, Johns, Wishkah, and the Hoquiam sub-basins. Bank erosion is common in the agricultural and urban areas, with high levels in the Wynoochee, Satsop, Newman, Porter, Gibson, Black, Skookumchuck, Newaukum, Stearns, South Fork Chehalis, Crim-Rock, upper Chehalis, Elk Creek, Scammon, Lincoln, Rock/Williams, and Workman/Delezene sub-basins. The high levels of sedimentation coupled with the low levels of LWD result in high sediment transport rates. This can increase the impact of scour, channel incision, and width-to-depth ratios, and reduce habitat complexity.

Floodplain impacts are generally not well-documented, and because the Chehalis basin is the third greatest coho salmon smolt producer in Western Washington (Seiler 2000), and coho salmon depend heavily on side-channel and off-channel rearing habitat, floodplain habitat should be a high priority issue. Known "poor" floodplain conditions exist in the lower Skookumchuck and Hanaford sub-basin due to bank protection and channelization. Other floodplain impacts such as channel incision or loss of refuge habitat have been identified in parts of the Newaukum, Satsop, Wynoochee, Wishkah, Hoquiam, Newman, Cloquallum, China, Salzer, and Stearns sub-basins. The causes of floodplain impacts are poorly documented, but suspected causes include increased sediment transport (leading to channel incision), bank hardening, and filling and draining of wetlands by urbanization and agriculture. The loss of LWD has likely contributed to a loss of side-channel habitat. One area of excellent floodplain habitat exists in the lower mainstem Chehalis from RM 1-11, and this area is a high priority conservation need.

The problems within these two WRIAs are numerous and intertwined. Solutions to a given problem might be varied, such as addressing water quality issues by riparian restoration, stream flow increases, or sediment reduction. Reducing livestock access will aid not only water quality conditions, but also bank erosion and riparian development. Recommended efforts should consider the restoration of natural processes, as those will likely be the most successful actions over the long-term. These include reducing human-caused sedimentation, improving riparian conditions, restoration of natural stream flows, and a return to natural floodplain conditions, especially in the high priority sub-basins.

INTRODUCTION

Habitat Limiting Factors Background

The successful recovery of naturally spawning salmon populations depends upon directing actions simultaneously at harvest, hatcheries, habitat and hydro, the 4H's. The 1998 state legislative session produced a number of bills aimed at salmon recovery. Engrossed Substitute House Bill (ESHB) 2496 is a key piece of the 1998 Legislature's salmon recovery effort, with the focus directed at salmon habitat issues.

Engrossed Substitute House Bill (ESHB) 2496 in part:

- directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group;

- directs the technical advisory group to identify limiting factors for salmonids to respond to the limiting factors relating to habitat pursuant to section 8 sub 2 of this act;

- defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon."

- defines salmon as all members of the family salmonidae, which are capable of self-sustaining, natural production.

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmon in the state. In waters shared by salmon, steelhead trout and bull trout we will include all three. Later, we will add bull trout only waters as well as cutthroat trout.

It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydro and harvest segments of identifying limiting factors are being dealt with in other forums.

The Relative Role Of Habitat In Healthy Populations Of Natural Spawning Salmon

During the last 10,000 years, Washington State anadromous salmonid populations have evolved in their specific habitats (Miller 1965). Water chemistry, flow, and the physical stream components unique to each stream have helped shaped the characteristics of every salmon population. These unique physical attributes have resulted in a wide variety of distinct salmon stocks for each salmon species throughout the State. Within a given species, stocks are population units that do not extensively interbreed because returning adults rely on a stream's unique chemical and physical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, thus preserving 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 has been theorized 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 1971). 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 support salmon. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, stream and river physical features, riparian zones, upland terrestrial 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 the amount of available dissolved oxygen, while concentrating toxic materials. Water quality can impact stream conditions through heavy sediment loads, which result in a corresponding increase in channel instability and decrease in spawning success. The riparian zone interacts with the stream environment, providing nutrients and a food web base, woody debris for habitat and flow control (stream features), filtering runoff prior to surface water entry (water quality), and providing shade to aid in water 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 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 adults return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to their natal grounds. They need deep pools with vegetative cover and instream structures such as root wads for resting and shelter from predators. Successful spawning and incubation depend 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. Also, 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 2-3 weeks. Delays can results 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. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities. 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. The natural, healthy river is sinuous and contains large pieces of wood contributed by an intact, mature riparian zone. Both slow the speed of water 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. 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. A stable incubation environment is essential for salmon, but is a complex function of nearly all habitat components contained within that river ecosystem.

Once the young fry emerge from the gravel nests, certain species such as chum, pink, and some chinook salmon quickly migrate downstream to the estuary. Other species, such as coho, steelhead, bull trout, and chinook, will search for suitable rearing habitat within the side sloughs and channels, tributaries, and 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 populations migrate from their gravel nests quickly 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 juvenile salmon (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bull trout, 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 that amount of habitat; hence the number of salmon dependent on adequate summer flows.

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, and remaining chinook parr require habitat to sustain their growth and protect them from predators and winter flows. Wetlands, stream habitat protected from the effects of high flows, and pools with overhead are important habitat components during this time.

Except for bull trout 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 heavily on natural flow patterns.

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 salmon smolts, but 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 and 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 adult pink salmon typically begin to enter the rivers in August and spawn in September and October, although Dungeness summer pink salmon 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 less frequent and shallow pools from 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.

Pink salmon fry emerge from their gravel nests around March 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 return to the rivers only in odd years. The exception is the Snohomish Basin, which supports both even- and odd-year pink salmon stocks.

In Washington, adult chum salmon (3-5 years old) have three major run types. Summer chum adults 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 adults 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 generally in their natal rivers throughout the calendar year. Adults begin river entry as early as February in the Chehalis, 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 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 juveniles that begin to leave the rivers to the estuary throughout spring and into summer (August). Within a given Puget Sound stock, it is not uncommon for other chinook 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 salmon stocks in the Columbia Basin exhibit some distinct juvenile life history characteristics. Generally, these stocks remain in the basin for a full year. However, some stocks migrate downstream from their natal tributaries in the fall and early winter into larger rivers, including the Columbia River, where they are believed to over-winter prior to outmigration the next spring as yearling smolts.

Adult summer chinook begin river entry as early as June in the Columbia, but not until August in Puget Sound. They generally spawn in September and/or October. Fall chinook stocks range in spawn timing from late September through December. All Washington summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March, and outmigration downstream to the estuaries occurs over a broad time period (January through August). A few of these stocks have a component of juveniles that remain 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 sloughs for up to two months. Then, some gradually move into the faster water areas of the stream to rear, while 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 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. They typically enter freshwater from September to early December, but has 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 typically occurs in tributaries and sedimentation in these tributaries can be a problem, suffocating eggs. 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 which 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 the summer after early rearing, low flows can lead to problems such as a physical reduction of available habitat, increased stranding, decreased dissolved oxygen, increased temperature, and increased predation. Juvenile coho are highly territorial and can occupy the same area for a long period of time (Hoar 1958). The abundance of coho can be limited by the number of suitable territories available (Larkin 1977). Streams with more structure (logs, undercut banks, etc.) support more coho (Scrivener and Andersen 1982), not only because they provide more territories (useable habitat), but they also provide more food and cover. There is a positive correlation between their primary diet of insect material in stomachs and the extent 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, 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 which never enter saltwater. Of the populations that migrate to sea, adult freshwater entry varies from spring for the Quinault stock, summer for Ozette, to summer for 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 some types of fry migrate to the sea. Lake rearing ranges from 1-3 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, and weed control.

Steelhead have 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 adults begin river entry in a mature reproductive state in December and generally spawn from February through May. Summer steelhead adults 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. However, the coastal streams support more winter steelhead populations.

Juvenile steelhead can either migrate to sea or remain in freshwater as rainbow or redband trout. In Washington, those that are anadromous usually spend 1-3 years in freshwater, with the greatest proportion spending two years (Busby et al. 1996). Because of this, steelhead rely heavily on the freshwater habitat and are present in streams all year long.

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 stay 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 are generally recognized as a sensitive species by natural resource management 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 (competition). 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 contribute to habitat and to other species.

Introduction to Habitat Impacts

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 wood. 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. Provided first though, is a general description of the current and historic habitat including salmon populations.

CHEHALIS WATERSHED DESCRIPTION AND CONDITION

This report describes and rates habitat conditions within WRIAs 22 and 23 (Map 1). The geographic area includes the entire Chehalis drainage and all tributaries to the Chehalis River. The report also includes the independent watersheds that drain into Grays Harbor, such as the Humptulips River, the Hoquiam River, Johns River, Elk River, and several smaller streams. In total, there are 1,391 streams with 3,353 linear stream miles in these two WRIAs (Phinney and Bucknell 1975). The Chehalis Basin is the second largest basin in Washington State, second only to the Columbia River Basin.

The largest tributaries based upon average annual discharge are the Satsop sub-basin (1968 cfs), the Humptulips sub-basin (1344 cfs), the Wynoochee sub-basin (1316 cfs), the Skookumchuck sub-basin (540 cfs), the Newaukum sub-basin (506 cfs), Cloquallum Creek (375 cfs), and the Black River (330 cfs) (Pickett 1992).

The Mainstem Chehalis River Habitat Description and Salmonid Distribution

The mainstem Chehalis River is formed by the confluence of the East Fork Chehalis River with the West Fork Chehalis River at RM 118.9 (Phinney and Bucknell 1975). The East Fork Chehalis is considered a continuation of the mainstem Chehalis River in the WDFW Stream Catalog. The headwaters for the mainstem Chehalis River are in the eastern Willapa Hills near the town of Pe Ell. However, tributaries to the Chehalis River arise from diverse sources, such as the Olympic Mountains, the Bald Hills, the Willapa Hills, the Black Hills, and a spur of the Cascade Mountain Range.

The upper Chehalis mainstem flows northerly and is unusual in having a confined channel with a moderate to low gradient (Weyerhaeuser 1994a). The landuse in this area is predominately forestry. As the mainstem flows through the areas of Pe Ell and Doty, the direction of flow changes to the east. As the Chehalis River approaches its confluence with the Newaukum River, the floodplain broadens and turns again to flow in a northerly direction. From Pe Ell to the city of Chehalis, the landuse adjacent to the mainstem is dominated by agriculture.

Urban and industrial use predominates as the mainstem flows through the Centralia and Chehalis area. The channel is deeply cut with very little spawning habitat, as the streambed is comprised of sands. A very low gradient of less than 1 foot per mile exists just upstream of the Skookumchuck confluence (ACOE 2000 draft). Downstream of Centralia, the landuse surrounding the Chehalis River mainstem is again dominated by agriculture. Near Scatter Creek, the mainstem flows in a westerly direction through an area of low prairie land that has experienced heavy residential growth.

Near Gibson, Porter, and Cedar Creeks, the mainstem has both spawning and rearing habitat, although the mainstem spawning habitat is used mostly by chinook and historically by chum salmon. Agriculture occurs in the valleys, with timber production on the moderately steep slopes (Phinney and Bucknell 1975). Downstream of Porter, the flow changes to westerly and spawning habitat becomes limited in the mainstem Chehalis

River. In this area, the Satsop River, one of the largest sub-basins in the drainage, enters the mainstem Chehalis River. The current upper extent of most of the chum spawning habitat is in this region, near the mouth of Cloquallum Creek. While some chum spawning occurs farther upstream and in the Black River, it is at a much lower level than historically existed (Phinney and Bucknell 1975). Coho salmon and steelhead trout use the mainstem for transportation to spawning areas, and also rear in the sloughs and off-channel habitat. From Montesano to the mouth, the mainstem Chehalis River is tidally influenced with numerous sloughs and side channels (Ralph et al. 1994). The larger sloughs are Blue, Preachers, Higgins, and Metcalf sloughs, while the larger freshwater tributaries include the Wynoochee and the Wishkah Rivers. The sloughs and side channels provide important rearing habitat for salmonids.

Throughout the Chehalis drainage, land ownership is predominately private, with state holdings in the Capitol Forest and U.S. Forest Service ownership in the upper reaches of tributaries within WRIA 22 (Jennings 1995). Agricultural activities dominate the valleys, while timber management occurs throughout most of the upland areas. Forests encompass a total of about 85% of the entire drainage (Pickett 1992), 66% of those are privately owned (CRC 1992). The lower Chehalis Basin (downstream of Porter) consists of 91% forest, while the upper Chehalis is 77% forest. Agricultural activities account for 10% of the basin's landuse, and the remainder is urban and industrial lands, mostly concentrated in Aberdeen, Hoquiam, Centralia, and Chehalis (Pickett 1992).

The Humptulips River Basin Habitat Description and Salmonid Distribution

The drainage area of the Humptulips sub-basin encompasses 276 square miles, of which 119.6 square miles is upstream of the East and West Forks at river mile 28.1. The upper two thirds of the East and West Fork drainages are in the Olympic National Forest, with the headwaters originating from the southern Olympic Mountains. The vast majority of the lower East and West Fork Humptulips Rivers and the remainder of the drainage consist of private timberlands owned or managed by Rayonier Northwest Forest Resources, Simpson Timber Company, Mason Timber, and Green Crow Timber Company. Annual precipitation at the headwaters is over 220 inches, with 100 inches in the lower basin. Intense, long storms are frequent from October through April.

Soils are derived from marine basalts with some minor inclusions of sedimentary bedrock, both highly prone to erosion (Lewis County Conservation District 1992). Landslides provide most of the erosion and sediment input to the upper watershed, while streambank erosion predominates in the lower basin. The most severe erosion is downstream of the town of Humptulips, where the river forms an alluvial plain. It is estimated that the river actively erodes 20 miles of its banks, washing away nine acres of bottomland, annually (Lewis County Conservation District 1992).

Land within the East and West Fork Humptulips drainages is exclusively commercial timberland or National Forest, and has been highly managed for timber. Within the National Forest, there is still some old growth forest; however, private forest and the small state parcels in the remainder of the drainage have been completely converted to second growth. The regenerated forests have a higher component of hardwoods and Douglas fir than native forests, and riparian hardwood stands are more extensive than in pre-managed forests (Peter 1999).

In the lower drainage, the uplands are almost exclusively private timberlands, while the floodplain of the mainstem Humptulips is mostly rural residential or agricultural land, with only a few active livestock farms remaining. In addition to logging and farming, the basin is used for gravel mining, fishing, and recreation. The Humptulips River still has a rural character, with less than 3,000 people living within the drainage. The largest community is the town of Humptulips located along the mainstem near the vicinity of the Highway 101 bridge crossing (Lewis County Conservation District 1992).

There is a total of 187 miles of known habitat in the Humptulips River sub-basin that supports fall chinook, fall chum, and coho salmon, plus winter and summer steelhead trout (Maps 2a-2d). This includes approximately 8.6 miles of rearing habitat in Burg, Campbell, Jessie and Gillis Sloughs, which enter the tidal zone of the lower river. Chenois and Grass Creeks enter North Bay immediately southeast of the Humptulips River, and they also provide rearing habitat. A majority of the habitat is located in the mainstem, East Fork, and West Fork Humptulips Rivers, as well as in Big and Stevens Creeks. Other tributaries with greater than one mile of accessible habitat are Newbury, O'Brien, Donkey, Brittain, Deep, Fairchild, and Hansen Creeks (Martin and McConnell 1999; WDFW/QIN Escapement Survey Data). Fish passes constructed on O'Brien Creek, Rainbow Creek, and East Fork Humptulips River have extended salmon and steelhead habitat (1.5, 0.7, and 10.5 miles respectively) above natural barrier falls. All other tributaries are steep in gradient with impassible natural barriers near their mouths.

<u>Identification of Historic Patterns of Habitat Alterations</u>

Timber Industry

Logging in the Grays Harbor region began in 1881 when the first steam-driven sawmill opened in Cosmopolis. By 1887, two more mills were operating on Grays Harbor where the cities of Aberdeen and Hoquiam established. McGillicuddy (1976) provides a good summary of early logging in the Humptulips River drainage. In 1882, timber stood to the banks of most rivers and streams in Grays Harbor County. Initial harvesting took place along the banks of the lower seven miles of the Humptulips River within the tidal zone where trees could be felled directly into the river and transported to tidewater on the ebbing tide. Bull team and horse logging, followed by donkey steam engines, allowed timber harvest further from the riverbank. These techniques moved logs to the river on skid trails constructed of logs half buried in the ground.

As timber harvest progressed upriver of the tidal zone, logs were transported to the bay during flood events, and beginning in the early 1900s, by splash dams. Over 30 splash dams were constructed on the Humptulips River and its tributaries between 1900 and 1920, and these dams were in place for an average duration of 20 years (Hiss and Knudsen 1992). Dam heights ranged from 12 to 45 feet in the tributaries and 30 to 48 feet in the East and West Forks (Collins and Dunne 1986). Splash dams stored logs in temporary reservoirs, and when gates were opened, artificial flood flows carried the logs to the next splash dam and eventually to tidewater. Splash dams blocked salmonid migration, degraded habitat below the dams by scouring stream gravels to bedrock, deposited bark on the stream bottom during log storage, and removed large woody debris (LWD) from the frequent high flows (Murphy 1995; Hiss and Knudsen 1992). Frequent high-water events during log drives changed the vegetation diversity of the riparian areas. As the riparian forest regenerated, the intermittent flooding favored the growth of alder (Peter 1999), which reduced the future source of conifer LWD.

Most old growth timber on private lands in the Humptulips sub-basin was harvested between 1930 and 1950, while the majority of harvest in the Olympic National Forest (ONF) occurred from the 1950s to the 1980s (Peter 1999). As timber harvest increased, roads and railroads were constructed to transport timber. Until the 1980s, logging road standards did not protect salmonid habitat. Older logging roads remain problems today, serving as triggers for landslides, increasing fine sediments to streams, and blocking fish access. Also, until the mid-1980s, riparian harvest was unregulated resulting in clearcut harvesting to the edge of streams. Harvest of streamside trees reduced the amount of stream shade and eliminated future sources of LWD. Until the early 1980s, LWD that did enter salmon streams naturally, was often removed along with logging debris.

Beginning in the 1980s, forest practice regulations began to progressively incorporate guidelines aimed at reducing impacts to fish bearing habitat. The Timber, Fish, and Wildlife Agreements in 1987 and 1992 resulted in more restrictive standards for riparian harvest, harvest on unstable slopes, and road construction and maintenance on state and private lands (Murphy 1995). The listing of the Northern Spotted Owl on the Endangered Species List resulted in the 1994 Northwest Forest Plan, which indirectly provided benefits to salmon habitat in the upper East and West Fork Humptulips drainages by eliminating harvest of the remaining old growth forest in the Olympic National Forest. No commercial harvest of timber in the Olympic National Forest within the upper East and West Fork Humptulips has occurred since 1994, but timber harvest of second growth timber has continued to take place on private timberlands lower in the East and West Forks, Stevens Creek, and Big Creek drainages. Continuing declines in salmon stocks in many Washington State watersheds resulted in *The 1999 Forests and Fish Report* (ESB 2091) and the current forest practices rules (June 2000) that provide further protection of salmon habitat from harvest and associated roads on private timberlands.

Gravel Mining

The increased road building for log transportation resulted in an increased demand for gravel. During the early road-building years, stream gravel was used extensively. Beginning in 1945, permits were required, and by 1955 it was prohibitive to mine in a wetted channel (Collins and Dunne 1986). Besides the physical impacts that gravel bar mining caused, juvenile salmon entering pits during high flows were often trapped as flows subsided. Scalping of exposed gravel bars was then permitted with the requirement that gravel bars be graded flat to avoid isolating juvenile salmonids from the river channel. Gravel harvesting occurred on at least 24 gravel bars in the mainstem Humptulips River, resulting in a harvest rate that exceeded the replenishment rate between 1955 and 1985 (Collins and Dunne 1986). This, along with the reduction of LWD in the channel to capture gravel, reduced the availability of spawning gravel in the mainstem Humptulips River. In response to the Collins and Dunne's study, Grays Harbor County established gravel bar harvesting limits for the Humptulips River beginning in 1986. Since 1990, gravel bar harvest cannot exceed 6,500 cubic yards and harvest sites are only permitted where they will reduce stream bank erosion or flood hazards (Grays Harbor County Planning Department 1987a). Harvest in this manner does not directly degrade habitat, but does reduce the amount of gravel available in the system to be redistributed during high flow events.

Rural Development

The Humptulips watershed is rural with only 2,400 residents living in the watershed in 1990. The largest community is Humptulips, located along the Humptulips River between RMs 22 and 24. Projected population in the year 2,010 is only 2,650 (Lewis County Conservation District 1992). Due to the low population density there is little impact to water quality from sewage or stormwater run-off. Paved road densities related to residential areas is very low.

Agricultural

As land was cleared during timber harvest, some land in the floodplain was transformed to farms. Until the 1970s, there were both dairy and livestock farms, but currently there are only livestock operations in the drainage (Dave Peiper, rancher, personal communication). Livestock farms are located in the vicinity of RM 4, 17, 26, and at the confluence of Big and Hansen Creeks (Brian Erickson, Columbia Pacific RC&D, personal communication). During the mid 1990s, there were livestock exclusion projects conducted at all four of these livestock ranches to reduce bank erosion, riparian impacts, and water quality problems. The 1986 Grays Harbor County Comprehensive Plan designates most of the Humptulips floodplain as agricultural, but active agricultural land in the basin is limited to scattered livestock grazing on Dave Peiper's leased lands and the cottonwood ranch located between RM 4 and 5. Just outside of the basin there is a tract of cranberry farms located approximately one mile west of the Humptulips River on North Bay.

Habitat Protection and Rehabilitation Projects Completed

As the degradation of fisheries habitat from land management activities in the Pacific Northwest became more widely acknowledged during the 1980s, habitat restoration projects were planned in the Humptulips sub-basin. In 1990, Trout Unlimited in cooperation with Columbia Pacific RC&D and the Quinault Indian Nation, developed the Loomis Imprinting Ponds by providing access to abandoned gravel ponds. Since 1994, various government and private partners have completed four LWD introduction projects, eight riparian planting and/or livestock exclusion projects, and created off-channel rearing habitat through enhancement of an existing gravel pit (Brian Erickson, Columbia Pacific RC&D; Ron Wisner, Grays Harbor Conservation District; Sally Lewis, Trout Unlimited, personal communication).

Table 1. Completed Humptulips Watershed Restoration Projects (Columbia Pacific RC&D, Grays Harbor County Conservation District).

Location	River Mile	Project Type	Year
Loomis Ponds	24	Gravel Pit – Rearing Ponds	1990
O'Brien Creek	2	Large Woody Debris	1994 - 95
Mainstem	3	Large Woody Debris	1995
Kollman's Pond	21	Gravel Pit – Rearing Pond	1995 - 96
Big Creek	10	Large Woody Debris	1996
Mainstem	3	Riparian Planting	1996
Mainstem / Falls Cr	17	Riparian Fence / Planting	1997
Mainstem & Trib.	4	Riparian Fence	1997
So. Branch Big Cr.	1	Large Woody Debris	1998
Big / Hansen Cr.	3	Riparian Fence	1998
Mainstem	26	Riparian Fence	1998
Big Creek	10	Riparian Planting	1998
Mainstem	26	Riparian Fence	1998
So. Branch Big Cr.	1	Riparian Planting	1998 - 99

Habitat Description and Salmonid Distribution in the Hoquiam, Wishkah, and South Grays Harbor Sub-Basins

The low gradients of the Hoquiam, Wishkah, and South Grays Harbor drainages created a broad tidewater area and floodplain that was very productive for salmon and steelhead. The broad tidewater area also provided ideal conditions for logging along the lower rivers where logs could easily be transported to Grays Harbor during ebb tide flows. As timber was harvested along the streams within the tidal zone, splash dams were constructed to transport logs upstream of the tidal zone. Starting with timber harvesting, and followed by agricultural, commercial, and residential development, the forested river valleys have progressively changed to the current patchwork of landuse and associated vegetation types. There are limited data available on fish habitat conditions within this area for the Limiting Factors Analysis.

Hoquiam River Habitat Description

The Hoquiam River drains a 98 square mile are, and consists of three major forks. The East Fork confluence is at RM 2.5, and the West Fork and Middle Fork confluence is at RM 7.1. The Little Hoquiam River enters the lower mainstem from the west, just upstream of the East Fork, at RM 3.5. The lower five miles of the mainstem Hoquiam flows through the City of Hoquiam where most of the riparian vegetation has been permanently converted into commercial or residential lands. Rural residences are scattered along the remainder of the mainstem and the lower West Fork Hoquiam Rivers. The City of Hoquiam owns 7,500 acres of forested land within the West Fork Hoquiam River drainage that is protected as a municipal watershed and closed to public access. Within the municipal watershed, diversion dams on Davis Creek and the West Fork Hoquiam River provide water storage for the City of Hoquiam.

The Middle Fork Hoquiam drainage is not accessible by public roads, and has been exclusively managed for commercial timber. The East Fork Hoquiam watershed has dense residential development along the lower 0.75 miles, with sparse development further upstream. Most of the Little Hoquiam drainage consists of second growth commercial timber and in the uplands, residential development. There has been no agricultural development in the Hoquiam River drainage due to the poorly drained soils in the floodplain. Outside of the developed floodplain areas and the West Fork municipal watershed, the remainder of the Hoquiam River drainage is managed commercial timberlands of second growth forest.

Habitat Description in Fry Creek

Fry Creek is a 2.5 mile long independent tributary that drains the hills immediately north of Hoquiam and flows near the Hoquiam and Aberdeen boundary before entering Grays Harbor. Fry Creek has been severely degraded by marine industrial development in the estuary. The lower half mile of Fry Creek is channelized with the original channel filled from the marine industrial development. Rootwads have been anchored every 100 meters, but a more natural channel is needed to restore any functioning habitat. In the lower and middle reaches, residential and road development have occurred, while timber harvest and off-road vehicle travel in the hills of the upper drainage (Klatte 1999). Recently, the commercial forestland in the upper drainage is being converted to a new housing and condominium subdivision with paved roads.

The combined impacts of land conversion and timber harvest have extensively degraded the habitat. Recent harvesting left marginal buffers that appear to be less than the current Forest and Fish standards (Mark Wenger, Columbia Pacific RC&D, personal communication). In addition, fine sediments appear to be a major problem. Columbia Pacific RC&D, Grays Harbor College, and Grays Harbor PUD installed three spawning pads in the middle drainage, introduced LWD, and planted riparian vegetation, but fine sediments have already degraded the new substrate. Further restoration of Fry Creek will be difficult due to the heavy development in the lower mile of the drainage coupled with the impacts from land conversion and timber harvest in the uplands.

Habitat Description in the Wishkah River Sub-Basin

The Wishkah River drains a 102 square mile area with the mainstem, East and West Forks originating in the foothills of the southern Olympic Mountains. The Wishkah River enters the Chehalis River at river mile 0 and is tidally influenced in its lower 7 miles. The lower 3 miles of the Wishkah are exclusively commercial or residential lands, with only small areas containing streamside vegetation. From this point upstream to the upper end of tidal influence at RM 8, the river meanders through reforested mature alder and mixed conifer that is currently undeveloped. Upstream of the tidal zone to RM 23, the floodplain consists of agricultural and rural residential development. The floodplain upstream of this point is mostly commercial timberlands. The uplands throughout the drainage have been intensely managed for commercial timber and are a patchwork of clearcuts in various successional stages of reforestation. The Malinowski Dam at RM 32.1 of the upper mainstem created the 2.8 acre Aberdeen Reservoir, which serves as the water supply for the City of Aberdeen.

Habitat Description in the South Grays Harbor Drainages

The South Grays Harbor region includes the two larger drainages of Elk and Johns River and six smaller, independent drainages (O'Leary, Stafford, Indian, Chapin, Newskah, and Charley Creeks) entering Grays Harbor between Johns River and the mouth of the Chehalis River. The Elk and Johns Rivers have extensive estuaries, which support oyster farms. The remainder of the Elk River drainage is managed as commercial timberlands.

The Johns River estuary also has a cranberry processor located at the mouth. The estuary was diked and drained to develop croplands, but a recent project breached the dike in two locations on the eastside of the river, and installed a tidal gate to increase function and access to fish habitat. The Johns River estuary is part of the Johns River State Wildlife Area, which is a popular elk viewing and waterfowl hunting area. Rural residential land is located along Johns River Road between RM 4 and 6 where the road periodically follows the river. The uplands throughout the drainage are managed commercial timberlands.

Newskah Creek is the third largest drainage in the South Grays Harbor region. Its diked estuary was recently breached as part of an off-site mitigation project from construction of the Stafford Creek Correctional Facility. Rural residential development and a large rock quarry are located in the lower Newskah watershed. All other land in the drainage has been managed for commercial timber.

The small independent drainages of O'Leary, Stafford, Indian, Chapin, and Charley Creeks are short basins that have minimal spawning habitat due to sedimentation from legal timber harvesting activities since the 1930s (WDFW and WWTIT 1994). All have good rearing habitat due to the low gradients, good riparian vegetation, and instream woody debris. There is rural residential development along Highway 105, which crosses all of these creeks, but the estuaries and floodplains are mostly undisturbed. The uplands surrounding these creeks are exclusively commercial timberlands. The only other notable development along these creeks is the Stafford Creek Correctional Facility that was completed in 1999.

Salmonid Distribution in the Hoquiam, Wishkah, and South Grays Harbor Sub-Basins

This area supports fall chinook, chum, and coho salmon, and winter steelhead trout (Maps 2a-2d). The only summer steelhead trout are located in the West Fork Hoquiam River (Streamnet 2000). Chum salmon are distributed throughout the floodplain reaches of all rivers in this area, but the distribution limits have not been well documented except for known presence up to the Wishkah River Falls at RM 29.4 (Map 2b) (Raines et al. 1992). The East Fork Hoquiam River and Wishkah River and their tributaries are believed to have the largest chum runs in this area (WDFW and WWTIT 1993). A long time resident knowledgeable with the South Grays Harbor drainages believes that the number of chum salmon in South Grays Harbor drainages has declined significantly over the past 40 years (Floyd Ruggles, South Bay resident, personal communication).

In the Wishkah River, chinook salmon spawning is concentrated in the mainstem (WDFW and WWTIT 1994), with additional distribution into the upper reaches of the West and East Forks (Map 2a) (Streamnet 2000). Fall chinook in the Wishkah watershed are described as "native" (WDFW and WWTIT 1994). Since 1985, the stock has been supplemented by the Long Live the Kings native broodstock hatchery located on the upper mainstem near RM 26 (WDFW and WWTIT 1993).

In the Hoquiam River, fall chinook spawning is primarily concentrated in the East and West Forks, with some spawning in Davis Creek and the Middle Fork (Map 2a). Hoquiam chinook stocks are considered "native", with only one documented fingerling release of 1,600 native-origin brood fall chinook raised at the Stevens Creek Hatchery in 1985 (Stan Hammer, WDFW, personal communication). Fall chinook salmon are also found in the mainstems of Johns River, Elk River (WDFW and WWTIT 1994), and occasionally in the smaller drainages (Floyd Ruggles, personal communication), but

Streamnet (2000) only documents presence to RM 10 of Johns River. Historical records do not mention chinook salmon in South Grays Harbor drainages, and runs may have originated from hatchery plants during the 1950s to 1970s (WDFW and WWTIT 1993).

It is likely that winter steelhead are present in most accessible tributaries where coho spawning has been documented. Wishkah Falls, at RM 29.4, is the upstream barrier for salmon, but steelhead are able to pass the falls at high flows and use the river up to the Malinowski Dam at RM 32.2 (Raines et al. 1992). Steelhead are distributed to the upper reaches of the Newskah, Johns River, and Elk River drainages (Map 2d) (Streamnet 2000).

The streams in South Grays Harbor have low gradient mainstems with abundant wetlands, providing ideal habitat for coho salmon. Coho salmon are known to spawn in all of the South Grays Harbor drainages with Johns River historically supporting the largest coho return in South Grays Harbor, followed by Andrews Creek in the Elk River drainage (Map 2c). The smaller independent tributaries, especially Newskah River and Chapin Creek, in some years support as many, or more coho as the Elk River (WDFW/QIN Escapement Surveys).

Habitat Description and Salmonid Distribution in the Wynoochee Sub-Basin

The Wynoochee River drains the southwest side of the Olympic Mountains with the uppermost headwaters contained within the Olympic National Park and the upper 17 miles of the mainstem (including 4.4 miles in Wynoochee Lake) within the Olympic National Forest. The total drainage area of the Wynoochee sub-basin is 195 square miles, of which 53.5 square miles are upstream of the National Forest boundary (U.S. Forest Service 1996). The remainder of the drainage is primarily in private ownership. The headwaters of the mainstem and upper tributaries originate at a 3000' elevation, Wynoochee Lake (at RM 50.8) is at 250' elevation.

The lowest mile of the Wynoochee River is tidally influenced. The Wynoochee River enters the Chehalis River at RM 13.0 near the upper end of the tidal influence of Grays Harbor. Annual rainfall in the drainage ranges from 75 inches in the lower river to 220 inches in the headwaters.

Upstream of RM 26, land is almost exclusively commercial forestland (80%) (U.S. Forest Service 1996). Simpson Timber Company owns the timberlands downstream of the U.S. Forest Service property and Weyerhaeuser Company owns timberlands in the lower valley. While the uplands are managed for commercial timber, the floodplain of the lower river has been converted to agricultural land. Currently, the agricultural land is used either for livestock or for crop farms. Dairy farms have not operated since the 1980s (Ron Wisner, Grays Harbor Conservation District, personal communications). Development within the floodplain is limited to residences associated with farms and some residential subdivisions on the terrace lands in the lower two miles of the Wynoochee valley. The only community in the sub-basin is the City of Montesano, located about one mile northeast of the mouth of the Wynoochee River.

Wynoochee Lake was created when a 172-foot high dam was completed at RM 50.8 in 1972. The Wynoochee Dam was constructed to maintain summer flows above critical levels, to control flooding of agricultural and residential land in the lower valley, and to provide recreational opportunities (U.S. Forest Service 1996). Prior to the dam, Wynoochee Falls, at RM 58.1, was the natural barrier to salmon migration and spawning. The upper limit of salmon migration is now at the water supply dam for the fish collection facility at RM 47.8. The natural spawning populations of coho salmon and steelhead have been maintained upstream of the reservoir by transporting fish captured at the fish collection facility. Beginning in 1985, fall chinook salmon captured at the fish collection facility have also been released above the reservoir. Historically, it is thought that spring chinook spawned in the area immediately upstream of the dam (David Hamilton, Regional Enhancement Group, personal communication).

In the early 1990s, the Wynoochee Dam was upgraded with hydroelectric turbines that went on-line in 1994. To mitigate for mortality of outmigrating smolt from turbine entrapment, hydroelectric turbines are not operated during April 15 through June 30 when the majority of smolts leave (U.S. Forest Service 1996). However, smolt mortality rates have ranged from 14% to 42% due to high velocities at the tailrace outlet and from migration delays due to poor attraction to the outlet openings located at four different depths of the dam. To further mitigate smolt mortality, funding has been requested to install an Eicher screen that is expected to improve coho smolt survival to 95% (Shane Scott, Tacoma Power, personal communication). Construction of the dam has not only decreased the distribution of fish and increased salmonid mortality, but also has altered river flows and sediment transport below the dam. In an effort to mitigate the sediment transport balance, Tacoma Power periodically dredges gravel from above the fish collection facility dam, and spreads it on a gravel bar downstream of the dam to be redistributed in the system during high water. Large woody debris that is caught in the log booms above the dam is also transported to the gravel bar below the fish collection dam (Shane Scott, Tacoma Power, personal communication).

Since the 1960s, the City of Aberdeen has had an industrial water withdrawal at RM 8.1 that diverts water to Lake Aberdeen. This has resulted in decreased summer flows and increased water temperatures (greater than 18^{o}C). One of the objectives of the Wynoochee Dam is to provide summer flows downstream of the diversion that support salmonid migration and rearing. At the Wynoochee Dam, minimum flows of 140 cfs are required to be maintained from April through June, with a minimum of 190 cfs the remainder of the year (ACOE 1983).

The Wynoochee River has been extensive mined for road gravels in the past (Collins and Dunn 1986). Gravel mining has occurred throughout the lower river in pits located in the floodplain and through gravel bar scalping operations. Current gravel mining is limited to floodplain pits, with emergency permits for gravel bar scalping to remove excess gravel deposition for the purpose of controlling erosion or flooding, as outlined in the *Grays Harbor County Shorelines Master Program Interim Policies on Extracting Gravel from River Bars* (Grays Harbor County 1986b). Since the dam was completed in 1972, the amount of gravel in the system might not support gravel harvesting because the replenishment rate has been reduced (Collins and Dunn 1986).

Salmonid Distribution in the Wynoochee Sub-Basin

Wynoochee Falls at RM 58.1 was historically the natural upstream barrier to chinook and coho salmon and steelhead trout, prior to construction of the Wynoochee Dam at RM 50.1. In 1994, the use of the Wynoochee Dam was converted from flood control to hydroelectric generation, which eliminated spawning habitat for an estimated 1,500 coho salmon and 570 steelhead trout adults. To mitigate the impacts of the conversion of 4.4 miles of anadromous river into a reservoir, a fish collection facility was constructed at RM 47.8. The 20’ water supply dam for the fish collection facility became the upstream extent of salmon and steelhead migrations, blocking a total of 6.6 miles of spawning habitat, 4.4 miles within the reservoir, and 2.2 miles of habitat between the water supply dam and the Wynoochee Dam. Salmon and steelhead captured at the collection facility are transported 7.5 miles upstream, and released in the river above the reservoir.

Coho are widely distributed in the Wynoochee River drainage with primary spawning in the middle and upper reaches of the mainstem and tributaries of Carter, Schafer, and Big

Creeks (Map 2c). Black, Helm, and Wedekind Creeks support spawning populations in the lower drainage (WDFW and WWTIT 1994). Prior to construction of the Wynoochee Dam, coho salmon utilized habitat up to Wynoochee Falls at RM 58.1, but now the upper limit is RM 47.8 at the fish collection facility. WDFW estimated that 3,460 coho historically spawned upstream of this point (ACOE 1983). Since construction of the dam, coho salmon have been transported upstream of the reservoir to spawn in the 2.5 miles of habitat below the falls. Annual coho transports have ranged from 236 to 5,698 adults, comprising an average of 24% of the total Wynoochee River coho salmon escapement (ACOE 1997). Hatchery releases from several stocks outside of the Wynoochee have been made since the 1950s, resulting in stocks of mixed origin. Annual hatchery plants of coho fry were made through 1991, but no stocking has been done since then (Stan Hammer, WDFW, personal communication).

Fall chinook salmon historically distributed to Wynoochee Falls, but now range to RM 47.8 below the dam. Primary spawning areas are the mainstem upstream of RM 10.5 with key tributary production in Carter, Schafer, Helm, Big, and Anderson Creeks (Map 2a). Since 1952, there have only been three hatchery releases of chinook salmon originating from other drainages.

Winter steelhead trout are native to the basin with their historic spawning distribution extending to Wynoochee Falls (Map 2d). Estimates of habitat indicate an average of 1,500 steelhead historically spawned upstream of the existing Wynoochee Dam.

Typical of chum salmon distributions, their upper range of habitat is lower in the drainage than chinook and coho salmon or steelhead trout. Chum salmon are known to utilize habitat up to RM 39 near the confluence with Save Creek (Map 2b) (U.S. Forest Service 1996). The river above this point enters a confined canyon for over 5 miles where increased water velocities prevent further upstream migration.

<u>Identification of Historic Patterns of Habitat Alterations</u>

Timber Industry

Timber harvest in the Wynoochee sub-basin began in the early 1900s along the tidally influenced lowest mile of the river where logs could be transported to the Chehalis River on the out-going tides. As timber harvesting progressed upstream of the tidal zone, logs were transported to the bay during flood events or by splash dams. Splash dams were used to drive logs in the lower tributaries of the Wynoochee, but there are no records of splash dams being used in the mainstem or any tributaries upstream of RM 9.2. Black Creek had four splash dams, Geisler Creek had two dams, and Sylvia and Wedekind Creeks each had one splash dam (Wendler and Deschamps 1955). Splash dams stored logs in temporary reservoirs and when gates were opened, artificial flood flows carried the logs to the next splash dam and eventually to tidewater. Splash dams blocked upstream migration to spawning and rearing habitat, degraded spawning habitat below the dams by scouring stream gravels to bedrock, deposited bark on the stream bottom during log storage, and removed LWD from the frequent high flows (Murphy 1995; Hiss and Knudsen 1992). Frequent high-water events during log drives also changed the vegetation diversity of the riparian areas. As the forest regenerated, the intermittent flooding favored regeneration by alder (Peter 1999), which reduced the future source of conifer LWD. Beginning in the 1930s, roads and railroads began to replace splash dams for log transportation.

Gravel Mining

As roads replaced river transport of logs, gravel to construct roads was needed. The most easily available source was from the river channels and gravel bars, and gravel mining was a common practice on the Wynoochee River until 1986. Besides the physical impacts that gravel bar mining caused, such as increasing suspended sediment, juvenile salmon entering pits during high flows were often trapped as flows subsided. Beginning in 1955, it was prohibitive to mine in a wetted channel, but mining of exposed gravel bars at low water continued until the mid 1980s. Scalping of exposed gravel bars was then permitted with the requirement that gravel bars be graded flat to avoid isolating juvenile salmonids from the river channel. However, gravel bar mining between RM 2 and RM 11 continued to exceed the natural replenishment rate of gravel from 1966 to 1986 (Collins and Dunne 1986). Current gravel mining is limited to floodplain pits and gravel bar scalping with site specific permits for the purpose of controlling erosion or flooding, as outlined in the *Grays Harbor County Shorelines Master Program Interim Policies on Extracting Gravel from River Bars* (Grays Harbor County 1986b). Harvest in this manner does not directly degrade habitat, but does reduce the amount of gravel available in the system to be redistributed during high flow events.

In recent years, WDFW required that gravel pits be located outside of the active floodplain channel or on bench lands outside the floodplain. WDFW recognized the potential for gravel pits located in the floodplain to provide rearing habitat, requiring egress channels to the river to allow salmon access to abandoned ponds. At RM 16, there is a network of five abandoned gravel pits that were restored in the 1980s and early 1990s into salmon rearing ponds (Weyco-Brisco Ponds), with a common access to the river (Norman 1998). Today, the ponds appear natural with dense alder and willow vegetation along the pond margins and an abundance of submerged debris providing good cover for juvenile salmon.

Residential / Agricultural

The lower 22 miles of the Wynoochee River can be classified as rural with the majority of land being either agricultural or a mix of residential and agricultural landuse. The City of Montesano, with a population of 3,270 (U.S. Census Data 1990), is located approximately one mile upstream of the confluence of the Chehalis and Wynoochee Rivers. Residential lands are being developed on the terrace above the floodplain in the lower two miles on both sides of the river, but there are no large developments in the floodplain.

Habitat Restoration Projects

The U.S. Fish and Wildlife Service habitat inventory on the lower 44 miles of the Wynoochee River identified streambank erosion from livestock as the primary cause for habitat degradation in non-forested areas of the watershed (Hiss and Knudsen 1992; Wampler et al. 1993). Because of these findings, the Grays Harbor Conservation District and Columbia Pacific Resource Conservation and Development, with landowner cooperation, began implementing livestock exclusion fencing projects on agricultural lands. Other restoration projects have included creating off-channel juvenile salmon rearing habitat from decommissioned gravel pits and replacement of a fish passage barrier culvert on Schafer Creek (Table 2).

Table 2. Wynoochee River Watershed Restoration Projects

Location	**RM**	**Project Type**
Sylvia Creek	0.8	Riparian Fence, 2,260’
Sylvia Creek	0.8	Riparian Fence, 7,020’
Spaulding Creek Confluence	1.0	Evasive Plant Removal, Native Planting
Spaulding Creek Confluence	1.0	Riparian Fence, 650’
Wynoochee River	1.0	Gravel Pit Rearing Pond
Wynoochee River	8.5	Riparian Fence, 2,900’
Wynoochee River	9.5	Riparian Fence, 1,550’
Wynoochee River	12.5	Riparian Fence, 1,550’
Wynoochee River	13.0	Riparian Fence, 2,800
Wynoochee River	13.8	Riparian Fence, 3,800’
Wynoochee River	13.8	Riparian Fence, 9,975’
Wynoochee River	13.8	Riparian Planting, Instream Barbs
Wynoochee River	15.0	Riparian Fence, 5,620’
Weyco Brisco Ponds (Mainstem)	16.0	Gravel Pit Rearing Ponds, LWD
Wynoochee River	19.0	Riparian Fence, 3,900’
Wynoochee River	19.0	Riparian Fence, 16.000’
Wynoochee River	20.0	Riparian Fence, 10,120
Schafer Creek		Culvert Replacement

The Satsop River Sub-Basin Habitat Description and Salmon Distribution

The Satsop River sub-basin drains over 300 square miles, and is formed by the confluence of the East, Middle, and West Fork Satsop Rivers (Phinney and Bucknell 1975). The various forks of the Satsop River drain the Olympic Mountains, with the East Fork Satsop considered a continuation of the mainstem. Below the forks, the mainstem Satsop River flows through a broad, flat valley, currently utilized for agriculture and rural residences. Mean annual precipitation ranges from over 160 inches in the headwaters to about 80 inches in the lower reaches (Weyerhaeuser and Simpson Timber Co 1995).

The East Fork Satsop River flows through low hills and flat valleys, and has several major tributaries, such as Decker Creek, Dry Run Creek, and Bingham Creek, each supporting salmon populations (Maps 2a-2e). The upper East Fork is formed by the confluence of Stillwater and Phillips Creeks. Stillwater Creek provides steelhead spawning and rearing habitat for about one mile upstream and downstream of its confluence with Phillips Creek (Jay Hunter, WDFW, personal communication).

Bingham Creek is a major tributary that enters the East Fork Satsop River at RM 17.4. It flows through low hills, and has spawning habitat for coho salmon (up to RM 12), steelhead trout (up to RM 10), and chum salmon (up to RM 5.3) (Streamnet 1999). A small tributary to Bingham Creek, stream number 22.0468, supports coho spawning up to RM 0.3 (Map 2c). Outlet Creek joins Bingham at RM 2.2 and provides spawning habitat for coho up to RM 3.7 (Streamnet 1999) and steelhead up to RM 1.7 (Jay Hunter, WDFW, personal communication). Outlet Creek drains Lake Nahwatzel, and tends to dry up in the summer. In the past, screens were placed in Outlet Creek to keep trout in the lake. These screens also prevented the use of the lake for rearing by coho up until recent years, when the screens were removed. Bingham Creek also is the site for a salmon hatchery, which is located near its mouth.

The lower East Fork Satsop River has a low gradient and joins with the Middle Fork Satsop River at RM 11. Numerous salmonid species utilize this area (Maps 2a-2e). Cook Creek enters the East Fork at RM 10, and provides steelhead trout habitat to RM 0.5, and coho, chum and chinook salmon habitat to RM 1 (Streamnet 1999). The East Fork/mainstem Satsop Rivers support fall chinook spawning from the mouth to RM 17.4 and fall chum spawning from RM 2.5 to 17.4 (Maps 2a and 2b). However, the chum primarily use the side-channels and sloughs (Phinney and Bucknell 1975).

Of special note are summer chinook that spawn in the mainstem Satsop River and East Fork Satsop River up to the confluence of Bingham Creek and the East Fork Satsop River (Map 2e). Summer chinook also spawn in lower Decker Creek (WDFW and WWTIT 1994). Small numbers of riverine sockeye used to spawn in the lower mainstem, but none have been noted in the last 5 years (John Linth, WDFW, personal communication). Coho spawn and rear in the mainstem from RM 3.3 to RM 25 (Streamnet 1999). In the smaller tributaries, coho spawning has been documented up to RM 1.5 in stream 22.0459, up to RM 5.5 in Dry Run Creek, up to RM 1 in Cook Creek, and up to RM 0.5 in stream 22.0408 (Streamnet 1999). Coho have been documented up to RM 1.0 in stream 22.0470

(WDFW Spawning Ground Survey Database). Also in the lower East Fork Satsop River, several side sloughs are utilized by coho and chum salmon, including the Simpson Sloughs #1 and 2, the Simpson Springs Side Channel, and Maple Glen Slough.

Steelhead trout utilize the mainstem from RM 2.5 to about 1 mile into Stillwater Creek (Map 2d). From RM 20 to 25 of the mainstem East Fork Satsop River is a marshy area that doesn't support spawning, but does contribute to rearing and transportation (Jay Hunter, WDFW, personal communication). Dry Run Creek is used by steelhead spawners up to RM 2.9 (Streamnet 1999).

Decker Creek is a major salmon-producing tributary that enters the East Fork Satsop River at RM 12. It flows southerly through prairies and valleys and has a low gradient (Phinney and Bucknell 1975). Steelhead, chum, and chinook spawners have been documented up to RM 11.4 (Streamnet 1999), and coho have been recorded up to RM 15.2 (WDFW Spawning Ground Survey Database). Dry Bed Creek is a major tributary to Decker Creek, joining at about RM 5.8. In Dry Bed Creek, steelhead trout (Jay Hunter, WDFW, personal communication) and coho salmon (WDFW Spawning Ground Database) have been observed spawning up to RM 8.4. Coho also spawn in Dry Creek (up to RM 1) and Peterson Creek (RM 3), both are small tributaries to upper Dry Bed Creek. Chum salmon spawn in Dry Bed Creek up to RM 7.5 as well as in the lower mile of Peterson Creek (Map 2b) (Streamnet 1999).

The Middle Fork Satsop River joins the East Fork Satsop River at RM 11. Its headwaters are located in the foothills of the Olympic Mountains, and it flows southerly through steep valleys and canyons until about RM 23.8 (confluence with Baker Creek). The surrounding land then changes to prairie and valleys. Most of the land has been under forest management. Major tributaries include: Baker Creek (joins at RM 23.8), Walter Creek (joins at RM 30.2), Rabbit Creek (joins at RM 16.6), and Smith Creek (joins at RM 3.3). Winter steelhead trout have an extensive range within the Middle Fork drainages, spawning up to RM 24.5 in the mainstem, up to RM 2 in Rabbit Creek, and up to RM 1.2 in Baker Creek (Map 2d) (Streamnet 1999). Coho have been documented to RM 23.8 in the mainstem, RM 1 in Baker Creek, RM 3 in Rabbit Creek, RM 0.8 in stream 22.0420, and RM 0.7 in Smith Creek (Map 2c) (Streamnet 1999). Chinook salmon spawn in the lower 15.6 miles of the mainstem Middle Fork, while chum salmon have been documented in the lower 9.5 miles. Chum salmon also spawn in the lower mile of Smith Creek and in the lower 2 miles of stream 22.0420 (Streamnet 1999).

Downstream of the confluence of the Middle Fork and the East Fork Satsop, two small tributaries empty into the mainstem Satsop at RM 8.1 (King Creek), and 8.9 (stream 22.0408). Chum salmon spawn in the lower 0.4 miles of King Creek and in the lower 0.6 miles of stream 22.0420 (WDFW Spawning Ground Database).

The West Fork Satsop empties into the mainstem Satsop at RM 6.3, and is a glacial stream with flow patterns and turbidity that differ from the remaining Satsop sub-basin. Its headwaters are in the steep foothills of the Olympic Mountains. The headwaters geology consists of a mix of volcanic rocks, which are stronger and weather more slowly than the rocks in the lower watershed, producing gravel and boulders (Weyerhaeuser and Simpson Timber Co 1995). Coho salmon and steelhead trout spawn in these upper waters to about RM 34.5 (Streamnet 1999) and 33.4 (Jay Hunter,WDFW, personal communication), respectively. A series of falls and cascades occur near RM 35.5, and are natural blocks to anadromous salmon (Phinney and Bucknell 1975). Both coho and steelhead spawn up to RM 0.8 (to the falls) in Little River (Weyerhaeuser 1995), a tributary to the upper West Fork. Chinook salmon also spawn in the mainstem West Fork up to RM 32, and chum salmon spawn up to RM 21.8 (Streamnet 1999).

In the middle West Fork, the landform changes to moderate and low relief with short, steep tributaries. The geology changes to materials that break down quickly to gravels, sands, silts and clays. Canyon River is a major tributary that joins at RM 20. It supports steelhead trout spawners up to a falls at RM 10.3 (Jay Hunter, WDFW, personal communication), and coho and chinook salmon up to RM 8 (Streamnet 1999).

Black Creek joins the West Fork at about RM 18.2, and its lower 0.9 miles support chinook, coho, and steelhead (WDFW Spawning Ground Database). The lower West Fork Satsop is surrounded by rolling hills with a sandstone geology. Singer Creek joins at RM 14.9 and provides spawning habitat for chinook salmon up to RM 0.8 and coho salmon up to RM 0.5 (WDFW Spawning Ground Database). Stream number 22.0372 joins the West Fork at RM 7.1, with chinook salmon spawning in its lower 0.8 miles, and coho salmon in the lower 1.1 miles. Still Creek enters the West Fork at RM 3. Chinook and chum salmon spawn up to RM 2.5, while coho salmon spawn up to RM 4.5 (WDFW Spawning Ground Database).

Historic Land Use in the Satsop Sub-Basin

Hartman and Scrivener (1990) have described the common features of temperate rainforest watersheds of western Vancouver Island, and these watersheds are similar to those in western Washington. The watersheds have abundant rainfall in the winter that could result in hydrologic stress, especially in a disturbed condition. The natural, pre-disturbed conditions have mild winter and summer stream temperatures. Coniferous forests in the late seral stage surrounded the streams. This resulted in abundant LWD and clean well-sorted gravels. Deep pools were numerous due to the abundant LWD, which also moderated gradient by forming step-pool profiles. The forests consisted primarily of large (200' tall) western hemlock, Sitka spruce, western red cedar, and Douglas fir. The canopy was relatively open due to low densities of the massive trees. Deciduous trees were much less numerous (ratio of deciduous to conifer 1:1,000) and when present, consisted mostly of red alder and bigleaf maple (Kuchler 1964).

The Satsop River Basin began to change significantly in the early 1900s with the onset of active timber harvest. Early logging techniques were very damaging to rivers, while the Satsop River itself was used for log transportation in those early years. Later, railroads were constructed near the river which resulted in numerous cuts and fills, contributing to sedimentation. By 1945, the lower watershed had been fully logged, and the U.S. Forest Service began partial-cut harvest in the upper watershed (Weyerhaeuser and Simpson

Timber Co 1995), almost completely changing the vegetation in the watershed. The early logging in the lower two thirds of the watershed removed the old-growth forest, including the riparian areas, and burned the land without replanting, converting the riparian from old-growth fir to alder (Weyerhaeuser and Simpson Timber Co 1995). In the 1940s, log trucks began transporting logs, but rail is still used to some degree. The use of log trucks led to a proliferation of logging roads within the basin, and some of these early roads are still major contributors to sediment in the streams. Wildfires were common in the West Fork basin, especially after timber harvest due to high fuel loads. Much of the middle and southern basin were cable logged to stream channels, which resulted in large inputs of sediment and debris.

Splash dams were constructed in the Satsop sub-basin, and were especially harmful to salmon populations (Weyerhaeuser and Simpson Timber Co 1995). Impact from these dams include a total blockage of habitat to anadromous salmon, scour of spawning gravels (and eggs within) downstream of the dam, increased channel instability and sometimes channel incision (which increases scour risk and cuts off the river from the floodplain, reducing salmon rearing habitat). The locations of these dams were:

Canyon Creek (T16, R4, S18)
Decker Creek (T20, R7, S24, 25)
Middle Fork Satsop (T20, R7, S22)
Satsop River (T18, R7, S25)
Smith Creek (T19, R7, S10, 23, 24)
Still Creek (T18, R7, S10)
Robertson Creek (T21, R7, S10).

By the 1960s, stream cleaning began and continued throughout the 1970s, which resulted in the removal of large woody debris (LWD), now recognized as important for salmon habitat. In the late 1960s or early 1970s, the U.S. Forest Service also began clear-cutting the upper watershed and burning the slash (Weyerhaeuser and Simpson Timber Co 1995). These actions in the headwaters have resulted in the inability to reforest the land. The thin soils and steep slopes were unsuitable for clear cut timber harvest, and new growth is slow to achieve hydrologic maturity (Weyerhaeuser and Simpson Timber Co 1995).

Currently, the lower reaches flow mainly through agricultural land, and the middle and upper watersheds are still predominantly managed for timber harvest with improved forest practices. The land surrounding the West Fork Satsop River is primarily owned by Simpson Timber Company (39%), the U.S. Forest Service (33%), and Weyerhaeuser (22%) (Weyerhaeuser and Simpson Timber Co 1995).

Habitat Description and Salmonid Distribution in Newman, Workman, Delezene, Cloquallum and Mox Chehalis Sub-Basins

Newman Creek is located slightly east of the Satsop River, and heads in low hills to join the Chehalis River at RM 20.8 (Phinney and Bucknell 1975). Its largest tributary is Vance Creek, which joins lower Newman Creek at RM 0.4. Agriculture and residential development heavily impact the lower reaches of Newman and Vance Creeks. There has been extensive riparian removal and channelization.

Cloquallum Creek drains 70 square miles of low hills east of the Satsop River near the town of Elma. The entire 20.2 mile length of the mainstem is low gradient and accessible to salmon. Key tributaries making up the 21 square mile watershed are Wildcat Creek entering the lower Cloquallum and Rock Creek, which enters the middle reaches of the mainstem. Landuse in the watershed is rural residential in the lower floodplain, with a scattering of small livestock pastures. The confluence of Cloquallum Creek and the Chehalis River has a high density of agricultural land. McCleary is located at RM 5.1 on Wildcat Creek. Land use in the uplands is private timberland management of second growth forest. The riparian areas are predominantly alder regrowth with sparse distribution of conifers because there were no forest practice guidelines for streamside buffers until the 1980s.

Mox Chehalis Creek is a low gradient stream that drains the lowlands northeast of the Capital State Forest. The floodplain has scattered rural residential and livestock grazing lands, while the low hills are in commercial timber production. Sand Creek is the main tributary entering the north bank at RM 7. It originates in a large wetland pond immediately south of Highway 8 near McCleary, and flows through a low wetland for over 5 miles. Mox Chehalis Creek enters the Chehalis at river mile 25 through an old oxbow channel. The historic lower mile of Mox Chehalis has been filled for croplands, and the stream has been re-routed.

Delezene and Workman Creeks are left bank tributaries to the Chehalis River. Their lower reaches have some agricultural or residential development, while the middle and upper reaches of Delezene Creek have been managed for timber production with increasing conversion to residences. Of the two streams, Delezene Creek is considered the more important for salmon production because Workman Creek has very limited spawning habitat (Phinney and Bucknell 1975).

The low gradients of most rivers and creeks in this area make them ideal habitat for coho salmon. Coho salmon are known to use all the major streams in this area, such as Cloquallum Creek and its tributaries, Wildcat, Bush, Power, and Rock Creeks, Newman Creek, Vance Creek, Mox Chehalis Creek, Sand Creek, and Delezene Creek (Map 2c). Coho salmon likely use most of the other smaller streams in this area as well, but documentation was not found to list other streams as "known habitat". Fall chinook salmon and winter steelhead trout are also located in Cloquallum, Wildcat, Rock, Mox Chehalis, and Delezene Creeks (Maps 2a and 2d) (WDFW Spawning Ground Survey Database). Chum salmon have been documented in Cloquallum Creek and its tributaries, Rock Creek and Wildcat Creek, as well as in Delezene Creek (WDFW Spawning Ground Survey Database; Streamnet 2000). The WDFW Stream Catalog states that small numbers of chum used Mox Chehalis Creek and Newman Creek, but specific, recent documentation was not found to verify that chum still use these areas (Phinney and Bucknell 1975).

Habitat Description and Salmon and Steelhead Distribution in Gaddis, Rock, Garrard, Independence, and Lincoln Creeks

These small to medium sized tributaries head in the Willapa Hills. The upper reaches are generally confined, while the lower reaches flow through broad valleys (Phinney and Bucknell 1975). The landuse surrounding each is a mix of timber use, agriculture, and rural residences. All of these streams support coho salmon production, with very limited steelhead use. Fall chinook salmon have been documented in only one of the streams, Rock Creek (Map 3a). In the past, chum salmon have used these areas, but are now uncommon. It is assumed that coho salmon use all accessible areas for rearing, but many of these areas have not been specifically mapped or documented. In general, salmon and steelhead distribution and production data are very limited in this region.

Rock Creek joins the Chehalis River at RM 39.3, and its largest tributary Williams Creek also provides important coho habitat (Map 3b). The Rock Creek drainage has 32.2 miles of stream (Phinney and Bucknell 1975). Garrard Creek is another medium sized drainage with 45.5 miles of stream length. It joins the Chehalis River at RM 45. Its larger tributaries include Kellogg Creek, the South Fork Garrard Creek, and Bloomquist Creek, all of which support coho salmon.

Independence Creek enters the Chehalis River at RM 51.5 and has several unnamed tributaries that likely provide coho salmon habitat in addition to habitat in the mainstem. The lower reaches of the mainstem consist of a sand and silt bottom. Coho salmon spawning habitat is more common upstream of RM 4.0, where gravel is found (John Linth, WDFW, personal communication). Upstream of RM 6.0, the gradient steepens and salmon use is questionable. However, fish distribution data are especially lacking in this watershed, and other than personal communications with local fish biologists, no documentation of known salmonid presence was found for the entire watershed.

Lincoln Creek joins the Chehalis River at RM 61.9 near the city of Centralia. Several tributaries provide habitat for coho salmon including Eagle Creek, Sponenberg Creek, Wildcat Creek, and the North and South Fork Lincoln Creeks (Phinney and Bucknell 1975).

Habitat Description and Salmonid Distribution in the Porter Creek, Cedar Creek, and Gibson Creek Sub-Basins

Cedar Creek drains the Capital Forest flowing about 10 miles west before entering the Chehalis River at river mile 38.5. Shelton, Sherman, Monroe, and Falls Creek are the major tributaries of Cedar Creek. Gibson Creek has less than 10 miles of drainage in its watershed and enters the Chehalis at river mile 37.1.

Porter Creek enters the Chehalis River at river mile 33.5, and has been the location of habitat restoration monitoring studies evaluating the effectiveness of LWD introductions. Porter Creek and other creeks originating in the Capital Forest were cleaned of LWD during timber harvests until the 1970s when stream cleaning was documented as a habitat impact (Cederholm et al. 1997). The stream forks at river mile three and again at river mile five, forming the West and South Forks, with the mainstem continuing as the North Fork. The lower floodplain consists of residential and agricultural land, with timber management activities in the upslope areas.

Coho salmon spawning has been documented in the Cedar Creek mainstem upstream to RM 10.8 and in all accessible tributaries (Map 3b). Shelton, Sherman, Monroe and Fall Creeks are tributaries that also contribute to coho salmon production (WDFW & Tribal Co-Management Escapement Data, 1984 to 1999). Chinook salmon spawning and rearing has been documented in the Cedar Creek mainstem upstream to the Sherman Creek confluence (RM 7.5), the lower 1.3 miles of Sherman Creek, and the lower 0.3-mile of Lost Valley Creek (Map 3a) (Streamnet 2000). Winter steelhead trout presence has been documented in the Cedar Creek mainstem upstream to RM 8.0, in Sherman Creek to RM 4.0, and in the lower 0.1 mile of Fall Creek (Map 3c). Chum salmon may spawn in Cedar and Gibson Creek, but the extent of spawning is not known (Phinney and Bucknell 1975). The only salmon spawning that has been documented in Gibson Creek drainage has been coho salmon upstream to RM 2.1 in the mainstem and in the lower mile of an unnamed tributary (WDFW & Tribal Co-Management Escapement Data, 1984 to 1999).

Coho salmon spawning and rearing habitat is distributed throughout the Porter Creek drainage, except for the West Fork where there has been no documented presence of salmon (Map 3b). Coho use the entire mainstem, into the upper reaches of the North Fork and the lower four miles of the South Fork (WDFW & Tribal Co-Management Escapement Data, 1984 to 1999). Fall chinook salmon spawning and rearing has only been documented in Porter Creek upstream to the West Fork confluence at RM 4.1 (Map 3a) (Streamnet 2000). Winter steelhead trout spawning and rearing presence occurs in the entire length of the mainstem, in the North Fork to RM 8.0, and in the South Fork to RM 2.6 (Streamnet 2000). A large run of chum salmon historically spawned in the lower 4 miles of the mainstem, but only small returns were present by the mid 1970s (Phinney and Bucknell 1975). Chum salmon typically spawn in river margin spring upwellings. Increased fine sediments may have degraded this type of spawning habitat.

Black River Habitat Description and Salmonid Distribution

Black River drains an area of 144 square miles, with 25 miles of mainstem and 84 tributary miles (Lewis County Conservation District 1992). It is probably the most studied river for water quality in the Chehalis River Basin. The Black River is an extremely low gradient river that historically drained Black Lake, flowing southwest for 14 miles through wetlands and bogs, then forming alternating riffles and long pools in the lower nine miles, and entering the Chehalis River at RM 47. The drainage has an elevation of 144 feet above sea level at Black Lake and 125 feet at the Chehalis River. The major tributaries of Black River are Mima and Waddell Creeks that originate in the Capital Forest, and Salmon and Beaver Creek that enter from the east.

Landuse in the drainage ranges from suburban residential development around Black Lake, wetland and marsh in the floodplain for six miles below the lake and for eight miles below the community of Littlerock, downstream to the agricultural land in the lower nine miles of floodplain. The uplands above the wetland habitat downstream of Black Lake are rapidly developing, with the remainder of uplands west of the river managed for commercial timber. The lowlands east of the upper river are primarily agricultural or rural residential property.

In 1922, a flood control ditch was excavated from the north end of Black Lake, into Percival Creek, which then drains into Puget Sound near Olympia. Deepening of the ditch in 1952 and 1976, along with progressive down-cutting, have resulted in the Black Lake Ditch becoming the primary outlet of the lake. In the 1960s, a gas pipeline was excavated across the Black River, 1.5 miles downstream of the lake. The excavation left spoils in the stream, which resulted in vegetation growth along with beaver dam debris accumulation. This created a blockage for fish access upstream of this point, as well as contributed to the reversal of flow in the wetlands of the upper Black River to flow into Black Lake (J. Roach, personal communication). Over the past 20 years, the outlet at the south end of the lake (Black River) has surface flows only during high water periods, and during lower flows, the wetlands in the upper Black River flow into Black Lake (Christensen 1993).

The community of Littlerock is located adjacent to RM 17.5 to 19.0 of the mainstem and the lower reaches of Waddell and Beaver Creeks. There is high-density residential development surrounding Black Lake, which has been expanding south along the uplands of the upper river. The increased pressure for additional residential and commercial development in the upper river initiated the U.S. Fish Wildlife Service and The Nature Conservancy to jointly acquire private property in the floodplain and adjacent uplands as a 3,610-acre unit of the Nisqually National Wildlife Refuge. Funding recently approved by the Salmon Recovery Funding Board will protect 1,200 acres of wetland and riparian habitat and 2,410 acres of uplands zoned for residential and commercial development. Public access for recreation use in the refuge unit will be provided (U.S. Fish Wildlife Service 1996). Other protected public lands in the Black River drainage are the 1,100 acre Thurston County Natural Area Park, the 80 acre WDFW Black River Habitat

Management Area, and the Nature Conservancy's 40 acre Black River Reserve (U.S. Fish Wildlife Service 1996).

Salmon and steelhead spawning habitat in the Black River drainage is primarily in tributaries because the majority of the mainstem has a mud or fine sediment bottom due to the extremely low gradients. Mainstem spawning in the Black River is limited to the lower 9 miles and from RM 16 to 17.3, where riffle reaches between long pools have suitable spawning gravels. The low gradient reaches through the wetlands upstream of RM 9 provide ideal physical rearing conditions for coho juveniles, but high temperatures and low dissolved oxygen from reduced summer flows limit available rearing habitat. Coho salmon spawning is widely distributed in Black River tributaries (Map 3b), with the most productive spawning habitat located in Waddell, Mima, and Allen Creeks (WDFW Escapement Data). Chinook salmon spawning has been documented in the lower mile of Waddell Creek and throughout the Black River mainstem (Map 3a) (Streamnet 2000), with the most productive mainstem reach from RM 16 to 17.3 (Phinney and Bucknell 1975). Winter steelhead trout spawning has been documented in the lower seven miles of the mainstem and in Blooms Ditch, Dempsey, Salmon, Beaver, Waddell, and Mima Creeks (Map 3c). Chum salmon were once very abundant in the Black River, but in the 1970s the run size dropped considerably with no known reasons (Phinney and Bucknell 1975). Chum salmon presence has been documented in the mainstem upstream to about RM 10 (Map 3d) (WDFW and WWTIT 1993).

Historically chinook, coho, and chum salmon, as well as steelhead trout, migrated into Black Lake from Black River, using tributaries of the lake to spawn (Hawkins 2000). Construction of a flood control ditch (Black River Ditch) in 1922 allowed Black Lake to drain into Percival Creek during high flows. Deepening of the ditch in 1952 and 1976, further increased the flows draining Black Lake into the Black River Ditch. Since the early 1990s, it has been documented that the upper mile of Black River is fed by ground water sources, with no surface water connection to Black Lake (Pickett 1994a and 1994b; Christensen 1993). The reduced flows at the historic Black River outlet allowed a series of beaver dams to completely block the outlet (Thurston County 1992 and 1999), which has eliminated native salmon and steelhead access to Black Lake. Chinook and coho salmon spawning in tributaries of the lake in recent years are from Puget Sound hatchery stocks.

Scatter Creek and Prairie Creek Habitat Description and Salmon and Steelhead Distribution

Scatter Creek enters the Chehalis River from the right bank at RM 55.2. It drains 43 square miles and has a relatively low gradient (Thurston Conservation District 1999). It is located within Thurston County, and agriculture and rural residences surround the lower reaches, with timber production in the upper reaches. Much of the lower watershed is prairie land with gentle hills. Coho salmon are the primary salmonid stock within Scatter Creek, spawning and rearing throughout the watershed (Map 3b). Steelhead use the lower portions of Scatter Creek (Map 3c), and chum salmon use has been reported in the past. It is not known if chum salmon currently spawn in the Scatter Creek drainage.

Prairie Creek joins the Chehalis River at RM 58.4. It often dries up in the summer months, but it does provide some rearing habitat for coho salmon (Pat Hanratty, WDFW, personal communication). No known spawning of salmon or steelhead has been documented in Prairie Creek, and salmonid surveys are rare in this stream.

The Skookumchuck River and China Creek Basin Habitat Description and Salmon Distribution

The Skookumchuck River is a major tributary to the upper Chehalis River. It originates in the Mt. Baker-Snoqualmie National Forest, and flows northwesterly to the town of Bucoda, draining into the Chehalis River at Centralia (CRC 1992). Elevations range from over 3,000 feet in the headwaters to 150 feet at the mouth (Lewis County 1999). Upstream of the Skookumchuck Dam (RM 21.9), the mainstem Skookumchuck has a steep to moderately steep gradient that is often confined, except in the 10 mile reach just upstream of the reservoir. The gradient falls an average of 19 feet per mile from the headwaters to Bucoda (Lewis County 1999). Near Bucoda, the slope changes to about five feet per mile. The sub-basin drains 181 square miles with an estimated average annual discharge of 540 cfs (CRC 1992). Annual mean precipitation ranges from 40 to 80 inches (CRC 2000). The annual runoff from the Skookumchuck has been estimated to be 1.2 times that from the Newaukum River (CRC 2000).

The largest tributary to the Skookumchuck River is Hanaford Creek, which drains 58 square miles and has an average annual flow of 85 cfs. Other larger tributaries in the lower Skookumchuck include Salmon Creek, Thompson Creek, and Johnson Creek. Larger tributaries in the upper Skookumchuck include Pheeny, Fall, Laramie, and Eleven Creeks.

Overall, current landuse patterns in the sub-basin are shown in Figure 1. Most of the Skookumchuck sub-basin consists of coniferous forest, but the lower reaches also support agriculture. Two population centers exist in the sub-basin. Bucoda lies near RM 11, and Centralia spans from the mouth to RM 3. The Skookumchuck Dam is located at RM 21.9, and this structure has greatly altered salmon distribution and habitat features. The dam was built in 1970 and stores water for the Centralia Steam-Electric Power Plant, provides some flood control, and furnishes hydroelectric power. The storage capacity is 34,800 acre-feet with a surface area of 550 acres when full (Phinney and Bucknell 1975).

The dam currently blocks passage to all anadromous fish, but steelhead trout are trucked to stream reaches upstream of the dam. It is estimated that 3.6 miles of spring and fall chinook mainstem habitat were lost when the dam was constructed, and 8 miles of coho salmon distribution were lost (Weyerhaeuser 1997). Chinook and coho distribution extend to the dam in the mainstem Skookumchuck, and coho salmon are found in all Type 1-3 streams below the dam (Maps 3a, 3b, and 3e). These streams include Bloody Run Creek, Johnson Creek, Salmon Creek, Thompson Creek, the Hanaford watershed, and several unnamed streams (TAG personal communication). Downstream of the dam, steelhead are assumed to have the same distribution as coho salmon. Upstream of the dam, steelhead are found up to a falls in the headwaters at RM 38, as well as in tributaries such as Three Fork Creek, Bigwater Creek, Drop Creek, Range Creek, Twelve Creek, Eleven Creek, Hospital Creek, Laramie Creek, Pheeny Creek, Baumgard Creek, and a few other unnamed streams (Map 3c) (Weyerhaeuser 1997).

Timber harvest has also greatly altered habitat in the Skookumchuck sub-basin. Logging began in the early 1900s, and in the 1910s, railroad track was installed to transport logs (Weyerhaeuser 1997). In the 1920s, three logging splash dams were constructed on the Skookumchuck River, with locations at RMs 3.7, 11.5, and 23.8 (Wendler and Deschamps 1955; Phinney and Bucknell 1975). These blocked the passage of salmon to a varying degree, with estimates of 50% to 95% blockage (Wendler and Deschamps 1955). The dams remained in place for many years, with the last one removed as late as 1969 (Weyerhaeuser 1997). Splash dams not only blocked fish passage, but also created several major habitat degradations, many of these problems remain for decades. The problems include washing out spawning gravel and LWD, which often results in incised channels that have greatly reduced off-channel habitat, a lack of spawning gravel, and a lack of stream complexity (Weyerhaeuser 1994a). Natural barriers include a low flow blockage for chinook salmon near RM 25.5, and a falls at RM 28.9, which blocks coho salmon (Phinney and Bucknell 1975). Steelhead trout are found upstream of the falls.

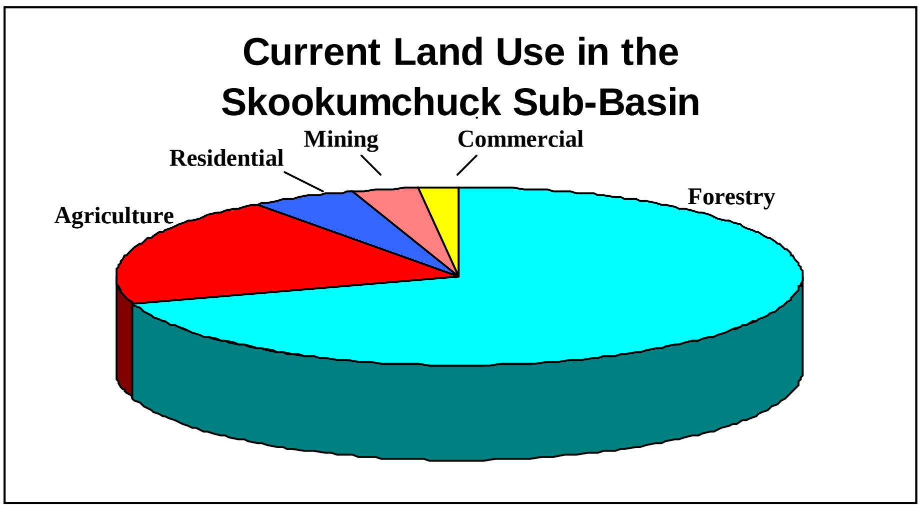
By the 1930s, much of the timber up to the Twelve Creek had been logged. Log trucks replaced trains in the 1940s, and this extended logging to the upper slopes of the lower and middle reaches. The old railroad grades were rebuilt as logging roads, particularly Roads 2000, 2125, 2126, and 2090. In the mid-1970s, timber harvest extended to the upper basin (Drop Creek and higher) (Weyerhaeuser 1997).

Rural residences and farms are located along the lower nine miles of Hanaford Creek and along the lower reaches of the Skookumchuck River. This has resulted in bank erosion, loss of riparian vegetation, and reduced water quality due to chemicals and animal waste. The Centralia Steam-Electric Power Plant is located near Hanaford Creek, and uses coal that is mined nearby. It pumps water from the Skookumchuck River near RM 7.2, contributing to lower summer water flows (Phinney and Bucknell 1975).

The City of Centralia is located near the mouth of the Skookumchuck River. The human population in the Skookumchuck sub-basin was estimated at 22,000 using 1990 census numbers (CRC 2000). A major problem in this region is development in the floodplain and subsequent flood-control activities to protect development.

China Creek is a short, small watershed that runs through Centralia and empties into the Chehalis River just upstream of the Skookumchuck River at RM 67.3. The lower two miles of China Creek consists mostly of long culverts and concrete and rock-lined channels. Its surrounding floodplain is heavily urbanized (SCS 1977).

Figure 1. Land use in the Skookumchuck Sub-Basin (data from CRC 2000)



Newaukum River, Dillenbaugh Creek, and Salzer Creek Sub-Basin Salmon Habitat and Salmonid Distribution

The Newaukum sub-basin is one of the larger sub-basins within WRIA 23, draining 158 square miles with an average annual discharge of 1,600 cfs (CRC 1992). The mainstem Newaukum River enters the Chehalis River near RM 75.2, just south of the City of Chehalis. It has a low gradient, and runs through farmland (Phinney and Bucknell 1975). Spring and fall chinook salmon spawn, rear, and transport in the mainstem (Maps 3a and 3e), while coho salmon and steelhead trout use the mainstem for rearing and transportation (Phinney and Bucknell 1975). Two small tributaries, Allen and Taylor Creeks, provide habitat for coho salmon and steelhead trout. The mainstem Newaukum River is formed by two major forks, the North Fork Newaukum River and the South Fork Newaukum River, which join at RM 10.8.

The North Fork Newaukum River heads in steep hills then flows into a broad valley in its lower reaches (Phinney and Bucknell 1975). The upper North Fork watershed has a steep gradient, while the lower ten miles consists of a moderate gradient. Private timber management dominates the middle and upper watershed, while agriculture occurs in the lower ten miles of the North Fork Newaukum River. Spring and fall chinook spawn up to RM 12.5, and coho and steelhead have been documented to RM 18.5 (Maps 3a, 3b, 3c, 3e) (Weyerhaeuser 1998). The larger tributaries to the North Fork Newaukum River include the Middle Fork Newaukum River, and Lucas, Bear, Mitchell, and Johns Fork Creeks. Coho salmon and steelhead trout have been documented in each of these streams (Maps 3b and 3c).

The South Fork Newaukum River is about 26.5 miles long. The upper watershed is in steep terrain of the Cascade Mountain Range, and the upper stream reaches have steep gradients. The river heads in Newaukum Lake and near RM 30, the terrain begins to broaden and the gradient moderates (Phinney and Bucknell 1975). The upper reaches are under private timber management, while farmland, rural residences, and small towns surround the lower reaches. Spring and fall chinook salmon spawn up to RM 31, and coho salmon and steelhead trout have been documented to RM 32.2 (Weyerhaeuser 1998). In the upper South Fork watershed, Bernier, Beaver, Frase, and Kearney Creeks provide habitat for coho salmon and steelhead trout (Weyerhaeuser 1998). In the lower reaches, the coho and steelhead producing tributaries include Gheer and Lost Creeks.

Dillenbaugh and Salzer Creeks are independent streams that join the Chehalis River at RMs 74.7 and 69.4, respectively (Phinney and Bucknell 1975). The lower reaches flow through urbanized areas, while residences and farmland surround the upper reaches. Coho salmon have been documented to RM 10 in Salzer Creek, as well as up to RM 7 in Dillenbaugh Creek (Map 3b) (Streamnet 1999). Berwick Creek, a tributary to Dillenbaugh Creek, also provides habitat for coho salmon.

Throughout the Newaukum sub-basin (including Dillenbaugh and Salzer Creeks), private land ownership comprise more than 95% of the ownership type (Lunetta et al. 1997). Another major landuse issue is a dam constructed on the North Fork Newaukum to allow water to be diverted for the Cities of Centralia and Chehalis. This dam blocked passage to all salmon until passage was provided in 1970 (Phinney and Bucknell 1975). Presently, the City of Chehalis continues to use this facility as part of their water supply.

Salmon Habitat Distribution in Stearns, Scammon, Mill, Bunker, Deep, and Van Ornum Creeks

These small to medium sized streams provide valuable habitat for coho salmon, and in the past, also supported small runs of chum salmon (Phinney and Bucknell 1975). However, accurate information regarding fish distribution is scant in some cases and non-existent in others. Estimates of escapement are also non-existent and specific stock status cannot be determined in these streams. Known distribution is presented here, but it likely underestimates actual distribution. Salmon and steelhead distribution, escapement, and juvenile use are a data need.

Scammon Creek is a left bank tributary that joins the Chehalis River at RM 65.9. The lower reaches lie within the City of Centralia, while rural residences and agriculture surround the upper reaches. The stream bottom of Scammon Creek consists of sand with very little spawning gravels. No known salmon use has been documented in this creek, but it is very likely that coho salmon use the stream for rearing. Coal Creek enters the Chehalis River at RM 71.8 and, like Scammon Creek, is probably used for coho rearing. No documentation of salmon or steelhead use has been found for Coal Creek.

Mill Creek enters the left bank of the Chehalis River at RM 77.85, and has a low gradient with a sand and gravel stream bottom (Phinney and Bucknell 1975). Mill Creek has rarely been surveyed for fish presence, and no documentation was found to determine salmon and steelhead distribution in this stream. It is mentioned as a "major coho spawning area" by Phinney and Bucknell (1975), and probably provides rearing habitat too. Access to the creek is problematic in low flow conditions (John Linth, WDFW, personal communication). Most of the surrounding land is used for agriculture and rural residences.

Stearns Creek is a right bank tributary to the Chehalis River, joining at RM 78.1. Its lower reaches consist of a channelized ditch with little to no riparian trees. It is predominately a low gradient stream, except in the upper reaches. Coho salmon and winter steelhead trout are documented within Stearns Creek and several of its upper tributaries (Maps 3b and 3c). The middle to lower reaches are surrounded by land used for agriculture and rural residences, with some forested lands in the upper reaches.

Bunker Creek and its largest tributary, Deep Creek, provide habitat for both coho salmon and steelhead trout (Maps 3b and 3c) (Streamnet 1999). Bunker Creek joins the Chehalis River at RM 84.8 from the left bank, and has a low gradient. The entire watershed lies within farmland and rural residences. Little is known about fish habitat and distribution in Van Ornum Creek, which enters the Chehalis River at RM 84.

South Fork Chehalis Salmon Habitat and Salmonid Distribution

The South Fork Chehalis sub-basin enters the mainstem Chehalis River at RM 88.3, and includes major tributaries such as Lake Creek and Stillman Creek. Stillman Creek is discussed in greater detail below. Other important salmonid-producing tributaries include Lentz, Beaver, Hanlan, Black, and Cedar Creeks (Phinney and Bucknell 1975). The lower mainstem South Fork Chehalis ranges from one to two miles wide and is surrounded by agricultural lands. The small towns of Curtis and Boistfort are located in the South Fork Chehalis Valley. The mainstem South Fork Chehalis River has a low gradient from the mouth to about RM 16.8 (the confluence with Black Creek), then narrows to average widths of 4 to 15 yards (Phinney and Bucknell 1975). While Black Creek has a low gradient throughout its length, other tributaries in the upper South Fork Chehalis drainage have limited low gradient habitat in their lower reaches, with steeper gradients upstream. This limits the available habitat for salmonids. The South Fork Chehalis River mainstem provides habitat for fall chinook, spring chinook, and coho salmon, in addition to steelhead trout (Maps 3a, 3b, 3c, and 3e). Steelhead trout and coho salmon also spawn and rear in several of the tributaries (Maps 3b and 3c).

Lake Creek is a low gradient stream also surrounded by farmlands (Phinney and Bucknell 1975). Coho salmon have been observed up to RM 7.7 (Map 3b) (Bruce Baxter, WDFW, personal communication).

<u>Stillman Creek Salmon Habitat and Salmonid Distribution</u>

The climate of the Stillman Creek basin is coastal marine with a mean annual precipitation of 110 inches in the upper watershed to 60 inches in the lower reaches. About one third of the basin is in a rain-on-snow zone, a third in a rain-dominated zone, and a third in a lowland zone. The elevation ranges from 300 to 3,100 feet.

Stillman Creek is located in Lewis County as a tributary to the South Fork Chehalis River, joining the South Fork at RM 5.1. The creek contains 14.9 miles of mainstem and 55 miles of tributaries (Phinney and Bucknell 1975), and its headwaters drain the high hills that separate the South Fork Chehalis River from the upper mainstem Chehalis River. The upper watershed consists of narrow valleys and steep hills, and the stream reaches in this area have moderate to steep gradients (Phinney and Bucknell 1975). Salmon-producing tributaries in the upper watershed include unnamed streams 23.1026 and 23.1034, and Halfway Creek. Halfway Creek has a low gradient, and provides significant habitat for salmon. Its salmon producing tributaries include Keller Creek and Slide Creek, both moderate gradient streams in their lower reaches, with steep gradients in their upper reaches. Little Mill Creek is another major tributary to Stillman Creek, but a falls near its mouth prevents anadromous salmon passage (Phinney and Bucknell 1975).

Lower Stillman Creek (downstream of Halfway Creek) runs through broad valleys that are now agricultural and rural residence land (Phinney and Bucknell 1975). Lost Creek is a major tributary to lower Stillman Creek.

Coho spawners have been documented throughout the mainstem up to RM 12, up to RM 2 in stream 23.01026, RM 4.5 in Halfway Creek, RM 1.5 in Slide Creek, and RM 2 in Keller Creek (Map 3b) (Weyerhaeuser 1994b). Winter steelhead spawners use the mainstem up to RM 11.5, and up to RM 1 in stream 23.1034, RM 2 in stream 23.1026, RM 4 in Halfway Creek, RM 1 in Keller Creek, and RM 1.5 in Slide Creek (Map 3c) (Streamnet 1999). Stocks of spring and fall chinook spawn and rear in the mainstem from the mouth to RM 4.4 (Maps 3a and 3e) (WDFW Spawning Ground Database).

Historic Habitat and Current Land Use in the Stillman and South Fork Chehalis Sub-Basins

Hartman and Scrivener (1990) have described the common features of temperate rainforest watersheds of western Vancouver Island. These watersheds are similar to those in western Washington. The watersheds have abundant rainfall in the winter that could result in hydrologic stress, especially in a disturbed condition. The natural, pre-disturbed conditions have mild winter and summer stream temperatures. Coniferous forests surrounded the streams in the late seral stage. This resulted in abundant LWD and clean well-sorted gravels. Deep pools were numerous due to the abundant LWD, which also moderated gradient by forming step-pool profiles. The forests consisted primarily of large (200' tall) western hemlock, Sitka spruce, western red cedar, and Douglas fir. The canopy was relatively open due to low densities of the massive trees. Deciduous trees were much less numerous (ratio of deciduous to conifer 1:1,000) and consisted mostly of red alder and bigleaf maple (Kuchler 1964).

In the Stillman drainage, a large fire completely burned the forest around 1800. This resulted in a natural change of the forest composition to a current forest of almost pure Douglas fir. Timber harvest began in the basin in the 1940s, when the forest was found to be uniform composition of Douglas fir that was about 150 years old.

Timber harvest began in the basin in the 1940s using railroads. One sawmill was located on upper Little Mill Creek and another mill located near the confluence of Halfway Creek and the mainstem Stillman. A splash dam was built in the mainstem, just downstream of Little Mill Creek, which blocked anadromous salmon passage and impacted the riverbed near this area. Also in the 1940s, a reoccurring fire burned timber stands in the basin, which resulted in soil disturbance, especially along the southern slopes. By 1959, nearly the entire Stillman Creek watershed was harvested (Weyerhaeuser 1994b).

Second growth timber was logged in the 1970s and 1980s near Keller Creek, Slide Creek, and Lost Valley. Road building increased in the late 1980s to prepare for higher levels of timber harvest in the mid 1990s. Commercial forestry still dominates the land use in the Stillman Creek watershed. Weyerhaeuser owns most of the land, followed by International Paper, miscellaneous private owners, and Simpson Timber Company. In the lower reaches, agriculture and rural residences can be found.

Salmon Habitat and Salmonid Distribution in the Upper Chehalis Sub-Basin

This sub-basin includes all of the Chehalis River drainage upstream of the confluence with the South Fork Chehalis River. Major tributary systems include: Elk, Rock, Crim, Big, Thrash, and Cinnabar Creeks, in addition to the West Fork Chehalis River. The upper mainstem Chehalis River continues as the East Fork Chehalis River.

In the lower portion of this sub-basin, salmon or steelhead use has been documented in Nicholson, Garret, Hope, Dell, Marcuson, Dunn, and Absher Creeks (Maps 3b and 3c) (Streamnet 1999). Further upstream, the Elk Creek watershed covers 58 square miles (Phinney and Bucknell 1975). Small salmonid-producing tributaries within the Elk Creek watershed include Eight, Seven, Nine, Ludwig, Swem, and Smith Creeks. The northern end of the watershed consists of high hills, while the southern portion lies in lower hills. Farmlands can be found in the lower reaches of Elk Creek, but most of the watershed is used for timber production. A 12 foot high falls exists at RM 1.5, but a fishway was built in 1972 to allow upstream passage of salmon. Presently, spring and fall chinook salmon are known to spawn in the lower two miles of Elk Creek, while steelhead trout and coho salmon extend several more miles upstream including smaller tributaries (Maps 3a, 3b, 3c, and 3e).

The mainstem Chehalis River upstream of the confluence with Elk Creek flows through steep-sided valleys. Upstream of the town of Pe Ell, the watershed is entirely in timber production (Phinney and Bucknell 1975). Most of the small tributaries are moderately steep and many have cascades near their mouths, which limits salmon production. The larger tributaries have moderate gradients (Phinney and Bucknell 1975), and the upper mainstem Chehalis River is unique in having a confined channel combined with a low gradient (Weyerhaeuser 1994a). While the mainstem is important for spring chinook, fall chinook, and coho salmon, as well as for steelhead trout, coho salmon and steelhead trout also use the following tributaries: Lester, Hull, Browns, Crim, Big, Alder, Thrash, Roger, Mack, Sage, Cinnabar, and George Creeks. The West and East Forks of the Chehalis River provide habitat for spring chinook, fall chinook, and coho salmon, and steelhead trout (Maps 3a, 3b, 3c, and 3e) (Weyerhaeuser 1994a).

Historic Land Use in the Upper Chehalis Sub-Basin

Timber harvest dominates the landuse in the upper Chehalis sub-basin. In the area upstream of Pe Ell, railroad logging first occurred in the northern region several decades ago, and now that area contains mature second growth, some of which has recently been harvested (Weyerhaeuser 1994a). Beginning in the 1960s, log trucks replaced rail, facilitating logging activity in the remainder of the sub-basin. Extensive road networks were constructed. These early roads were built before forest practice regulations, and are currently major sources of sedimentation as well as triggers for debris torrents.

Two splash dams were built in the Upper Chehalis sub-basin. One was located above Fisk Falls and the other below Crim Creek. Splash dams have extreme deleterious effects on salmonid habitat, and often their impact continues for many decades. In the areas near and downstream of the splash dams, channels are usually incised and scoured, with a lack of spawning gravel and LWD. Active removal of LWD from many tributaries in the upper Chehalis sub-basin occurred in the 1970s, and has worsened stream channel and streambed conditions (see Streambed/Sediment Chapter).

Downstream of Pe Ell, timber harvest remains a dominant feature, but agriculture and rural residences are scattered near the lower reaches of many tributaries. Many of these areas have experienced a complete loss of trees, particularly of conifer, in the riparian zone (see the Riparian section in the Habitat Limiting Factors chapter).

DISTRIBUTION AND CONDITION OF SALMONID STOCKS IN THE CHEHALIS BASIN

General Notes on Chehalis Basin Salmonid Population Status and Distribution

Many of the salmon and steelhead stocks in the Chehalis drainage and nearby independent watersheds are defined over a broad geographic range, which includes several sub-basins. Because of this, an overview of the stocks present in the two WRIAs is provided first, followed by a more detailed discussion on stock status for each major sub-basin. In general, stock status and distribution data are limited, and often, data from index areas are expanded to include streams that are not regularly surveyed. Many of the small to medium sized watersheds are rarely surveyed.

Within WRIAs 22 and 23, there are seven fall chinook stocks, one summer chinook stock, and one spring chinook stock identified in the SASSI report (WDFW and WWTIT 1994). The spring chinook stock is managed for wild production, and it spawns in the larger streams in WRIA 23, the upper Chehalis drainage. The summer chinook stock is primarily noted in the Satsop sub-basin, but some observations suggest that summer chinook could also be present in the upper Chehalis region (David Hamilton, Regional Enhancement Group, personal communication). The fall chinook stocks are designated as separate stocks based upon geography, and those stocks are: Humptulips, Hoquiam, Wishkah, Wynoochee, Satsop, Johns/Elk/South Bay Tributaries, and Chehalis fall chinook (WDFW and WWTIT 1994). The Chehalis stock includes all fall chinook upstream of the confluence of the Satsop River. Considerable hatchery releases, including non-native stocks, of fall chinook have occurred in the Humptulips, Satsop, Wynoochee, Johns/Elk/South Bay, and Chehalis fall chinook areas. The remaining fall chinook stocks (Hoquiam, Wishkah, and Wynoochee stocks) are considered to be wild, native fall chinook stocks, with very minimal hatchery influence.

Two stocks of fall chum are identified in these WRIAs: Humptulips and Chehalis (WDFW and WWTIT 1994). Both are listed in the 1992 SASSI report as "wild" and "native" (WDFW and WWTIT 1994), but considerable hatchery influence has been noted for the Wishkah and Satsop chum populations (David Hamilton, Regional Enhancement Group, personal communication). Chehalis chum include all chum spawning in WRIA 22 and 23 streams, outside of the Humptulips sub-basin. This includes the Hoquiam, Wishkah, Wynoochee, Satsop, Cloquallum, and Black River, as well as some smaller streams. The status of Chehalis chum is "healthy" and escapement estimates for the entire Chehalis population is shown in Figure 2. It is noteworthy that the distribution of chum has decreased over time (Phinney and Bucknell 1975).

The Chehalis and nearby drainages produce more coho smolts (575,000 in 1999) than any other system along the Washington Coast, and in 1999 was the third largest producer of wild coho smolts in Washington State (Seiler 2000). Seven stocks of coho salmon are listed in the SASSI report, using the same geographic categories as fall chinook: Humptulips, Hoquiam, Wishkah, Wynoochee, Satsop, Johns/Elk/South Bay Tributaries, and Chehalis coho (all coho spawners upstream of the confluence of the Satsop River with the Chehalis River) (WDFW and WWTIT 1994). All of these stocks are considered composites of hatchery and wild fish, with significant hatchery influence.

While the coho stocks are defined based upon geographic separation (WDFW and WWTIT 1994), there are also two run timings, but these run timings were not used to define stocks in the SASSI report. "Normal" coho are the most numerous and spawn in December throughout the basin (Hiss and Knudsen 1992). "Late" coho salmon spawn from January through February and have been noted in Bingham Creek, Wishkah River, and the upper Wynoochee River. Hiss and Knudsen (1992) suggested that the late run consists of wild fish, and the normal run has more hatchery influence.

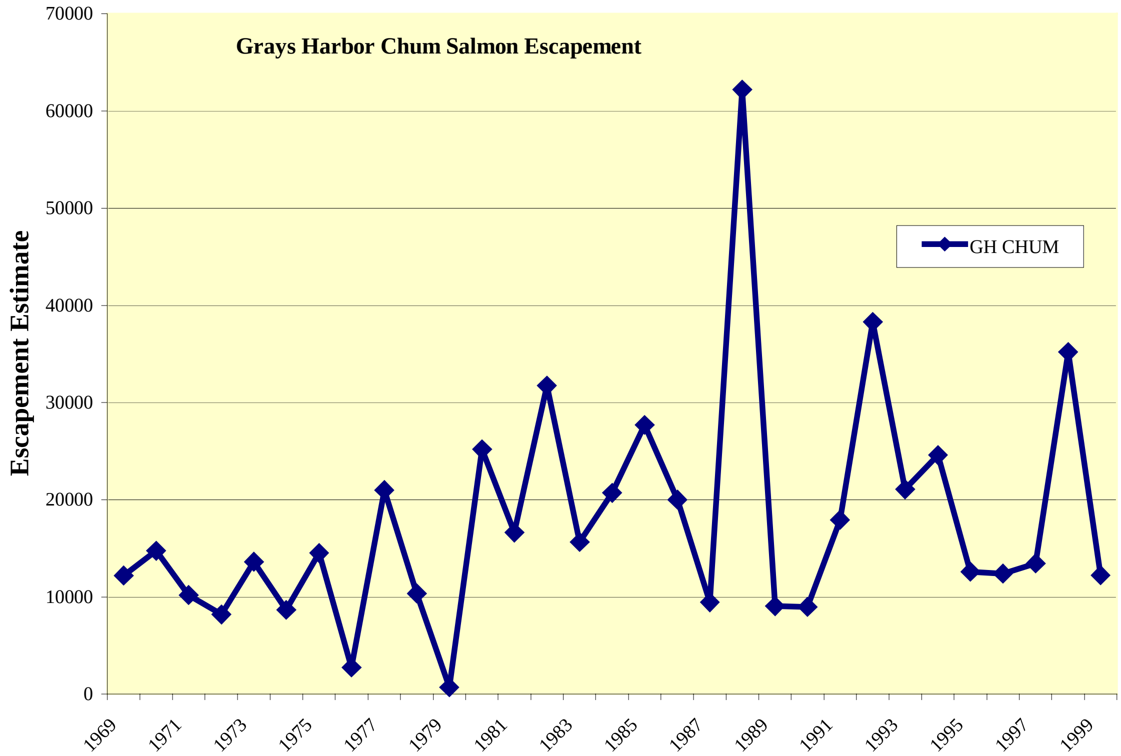
Two summer steelhead trout stocks are identified in SASSI, one in the Humptulips, and the other in the remaining areas of the Chehalis drainage, including the independent drainages, such as the Hoquiam and Wishkah Rivers (WDFW and WWTIT 1994). While the Humptulips summer steelhead stock is native, the origin of summer steelhead elsewhere is uncertain because of hatchery plants. The precise location of summer steelhead is also uncertain.

Eight stocks of winter steelhead trout are listed in the SASSI report, with separate stocks in the Humptulips, Hoquiam, Wishkah, Wynoochee, Satsop, Johns/Elk/South Bay Tributaries, Skookumchuck/Newaukum and Chehalis (all spawners upstream of the confluence of the Satsop River except in the Skookumchuck and Newaukum Rivers) (WDFW and WWTIT 1994). Most of the winter steelhead stocks are native, but the Skookumchuck/Newaukum stock is considered a composite of hatchery and wild returns, and the Wynoochee stock is mixed origin, with hatchery production. Also, there are questions about the origin of the early portion of Satsop winter steelhead; those are discussed in more detail in the Satsop section below.

While WDFW lists a bull trout/Dolly Varden stock in the Chehalis drainage (WDFW 1998), documentation regarding the presence of the stock is scant. Six records document the presence of low numbers of bull trout within the Grays Harbor estuary (Jackson 2000), and it is possible that these fish temporarily dipped into the estuary or are strays from the more robust stocks located north of Grays Harbor. Recent evidence of bull trout presence outside of tidally-influenced areas is lacking. In the eleven years that WDFW has operated the juvenile smolt trap in the Chehalis River, no native char have been reported (Jackson 2000). Also, smaller scale smolt trapping has occurred in various tributaries to the Chehalis River, with no records of bull trout presence. Records for adult returns to a trap in the Wynoochee River since 1968 were examined, and no evidence of char were found (Jackson 2000). The low gradients in the Chehalis drainage are not considered to be ideal habitat for bull trout, and while historically, bull trout might have inhabited limited areas of the Chehalis drainage, their current existence within this region is questionable.

For all salmonid populations addressed in this report, insufficient data exist to estimate historic stock data. The data within the SASSI report are used to assess stock status, but these can only be considered recent.

Figure 2. Chehalis Drainage Chum Salmon Escapement Estimates (data from John Linth, WDFW).



Status of Salmonid Populations in the Humptulips Sub-Basin

Historic Salmonid Population Condition

Wendler and Deschamps (1955) provide an early account of commercial fisheries landings in Grays Harbor and the Chehalis River. However, there are no historical data specific to the Humptulips sub-basin. WDFW and the Quinault Indian Nation have conducted spawning escapement surveys dating back to the 1950s. Beginning in 1984, they developed formal escapement estimates for chinook and coho salmon and for winter steelhead trout in the Humptulips River drainage, using redd counts per mile at index reaches on most anadromous tributaries. Since 1969, WDFW and the Quinault Indian Nation have tracked chum salmon escapements in Stevens Creek using spawners per mile. Escapement estimates are discussed in the current population conditions section below. Hatchery plants of coho and chinook salmon and steelhead trout have occurred regularly in the Humptulips sub-basin since the 1970s. Most releases have occurred in Stevens Creek.

Chinook and coho salmon return rates to the Humptulips have been consistently greater than to the Chehalis River. Based on watershed area, the Humptulips would be expected to contribute approximately 10% of chinook and coho salmon returns to Grays Harbor (Seiler 1989). However, Seiler (1989), citing Deschamps and Johnson (1957), showed that 40% of chinook and 28% of coho salmon harvests in Grays Harbor originated from the Humptulips River. He also reviewed WDFW unpublished data from 1972 through 1988, and estimated that the Humptulips River contributed an average of 33.6% of Grays Harbor chinook salmon returns. Higher adult return rates to the Humptulips River were due to better survival of smolts as they outmigrated through the undeveloped lower Humptulips and estuary of North Bay. In contrast, smolts leaving the Chehalis outmigrated through the more developed lower Chehalis and inner Grays Harbor where water quality was impaired (Seiler 1989). The disparity in coho smolt survival between the Chehalis and Humptulips may be improving. One year of data collected since one mill closed and the remaining mill made improvements to effluent treatments to inner Grays Harbor, showed that Chehalis coho had survival rates similar to the Humptulips (Dave Seiler, WDFW, personal communication).

The fish distributions shown on Maps 2a-2d are known distributions confirmed during WDFW and Quinault Indian Nation fish escapement surveys. This is a conservative presentation of the actual distributions. For example, known distributions on Big Creek (mile 13) and Stevens Creek (mile 11) reflect the amount of stream that is surveyed for fish. However, because there are no known barriers in these streams, the actual distribution is most likely to the headwaters (Rick Brix and John Linth, WDFW, personal communication). Additional surveys are needed to confirm any presumed distribution.

There is a lack of historic run size estimates for Humptulips salmonids except for reference reaches in escapement surveys since 1984. The early escapement surveys done by the Quinault Indian Nation and WDF need to be summarized along with commercial fishery catch estimates. The best assessment (and most costly) is to monitor smolt outmigrations at the Forks and Big Creek. This would give a good estimate of annual outmigration and a means of estimating adult returns when coupled with escapement estimates.

Current Salmonid Population Condition

The Steelhead and Salmon Stock Inventory (WDFW and WWTIT 1994) and WDFW and Quinault Indian Nation salmon spawning escapement inventories provide salmon and steelhead escapement estimates for the Humptulips River since 1984 for coho and chinook salmon, 1979 for winter steelhead trout, and 1969 for chum salmon (Figures 2 and 3). SASSI (WDFW and WWTIT 1994) designates all salmon and steelhead stocks in the Humptulips River as "healthy" (Table 3), however, recent declines in coho and chum salmon returns may indicate that these stocks are "depressed" (Rick Brix, WDFW, personal communication). Quinault Indian Nation fisheries biologist Scott Chitwood (personal communication) also stated that coho and chum returns are declining and that beginning in 1997, the wild winter steelhead run has not been able to support any sport, commercial, or treaty fishery.

Table 3. Humptulips River Stock Assessment of Salmon and Steelhead (WDFW and WWTIT 1994).

*Recent conditions based on an overall trend of decreased escapements since 1992 (R. Brix, WDFW, personal communication).

Stock	Origin	Production Type	1992 Status (SASSI)	Recent Condition *	Source
Coho	Mixed	Composite	Healthy	Depressed	R. Brix
Chinook	Mixed	Wild	Healthy	Healthy	SASSI
Chum	Native	Wild	Healthy	Declining	R. Brix
Steelhead Summer Run	Native	Wild	Unknown	Unknown	SASSI
Steelhead Winter Run	Native	Wild	Healthy	Declining	R. Brix

Sockeye salmon presence in the drainage has been confirmed, but is believed these are strays rather than a distinct stock (Martin and McConnell 1999; Scott Potter, Quinault Indian Nation, personal communication). There was also documentation of pink salmon caught by sport fishermen in the lower Humptulips River (Jon Gow, personal communication), but there is no reference to pink salmon in the watershed analysis or in WDFW escapement survey data.

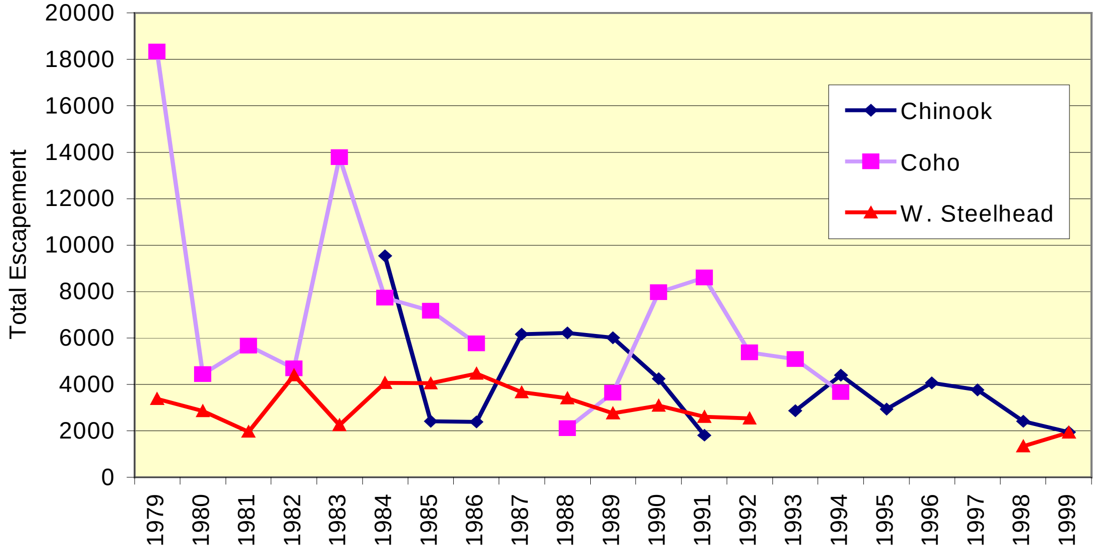
Chinook begin entering the river in September and continue into November. Spawning begins in October, peaks in late October to early November and typically ends in early December. Chinook salmon from non-native stocks have been released into the Humptulips River since the early 1950s, resulting in probable genetic mixing of hatchery and wild fish. Mean estimated escapement since 1984 has been 4,083, ranging from 1,821 in 1991 to 9,542 in 1984 (Figure 3) (WDFW and WWTIT 1994; WDFW/QIN escapement data 2000).

Coho spawning distributions in the Humptulips River are the most wide-ranging stock in the basin. They have been documented in almost all accessible streams of the drainage (Map 2c). Since there are no migration barriers in Big and Stevens Creek, the spawning distributions in these systems are believed to extend upstream of the distributions documented from annual escapement surveys (John Linth, WDFW, personal communication). Coho return to the Humptulips River in October and spawn between November and February in all accessible waters of the drainage. Coho releases from other drainages have occurred since the 1950s, potentially resulting in stocks of mixed origin. Natural Resources Consultants conducted a study of coho salmon stock assessments in Grays Harbor drainages and showed that hatchery strays may contribute

80% of the natural spawning population in the Humptulips sub-basin (Rick Brix and John Linth, WDFW, personal communication; Ruggerone 1997). Since 1984, mean estimated escapement has been 6,936, with a high of 18,334 in 1984 to a low of 2,114 in 1993 (Figure 3) (WDFW and WWTIT 1994; WDFW/QIN Escapement Data 2000). Currently, the Humptulips coho salmon population is considered to be depressed (Table 3).

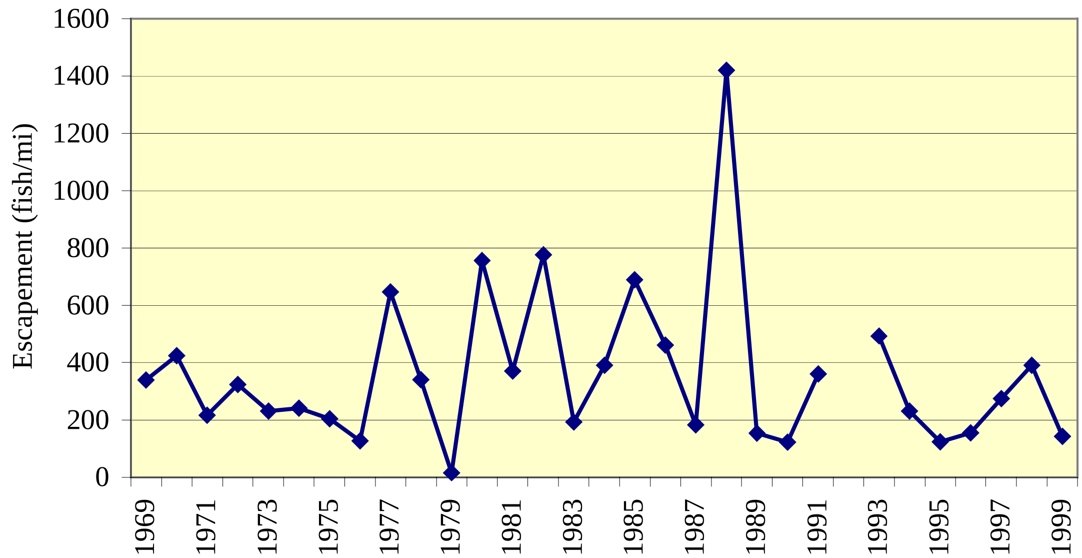
The Humptulips sub-basin has both summer and winter runs of steelhead, but the run size and stock status of the summer run is unknown due to the lack of escapement data (WDFW and WWTIT 1994). The summer run steelhead return in 2000 is expected to provide good sport fishing. Winter run steelhead distributions extend slightly further than salmon in the East and West Fork Humptulips Rivers, but known distributions in smaller tributaries are similar to those of coho. Winter run escapements from 1979 to 1999 have averaged 3,453, ranging from 4,470 in 1986, to 1,181 in 1997 (Figure 3) (WDFW and WWTIT 1994; WDFW/QIN escapement data 2000). Currently, the Humptulips winter steelhead population is considered to be declining (Table 3).

Figure 3. Escapement Estimates of Chinook, Coho and Winter Steelhead in the Humptulips River (WDFW and WWTIT 1994; WDFW/QIN Escapement Survey Data 2000)



Chum salmon enter the Humptulips in early October with the run peaking in early November. Spawning takes place in October through early December. A hatchery program on the Humptulips in the mid-1980s was abandoned due to poor returns. It is felt that some mixing of hatchery fish with wild spawners occurred, especially in Brittain Creek (Rick Brix, WDFW, personal communication); however, the stock origin is considered wild (WDFW and WWTIT 1994). Peak annual counts per mile of chum salmon in Stevens Creek have been used since 1969 to assess escapement to the Humptulips River (Figure 4). Peak adult chum counts per mile between 1969 and 1991 averaged 391, since 1992 chum counts per mile have averaged 321 (WDFW and WWTIT 1994). Currently, the Humptulips chum salmon population is considered to be declining (Table 3).

Figure 4. Escapement Estimates of Chum Salmon in Stevens Creek (WDFW and WWTIT 1994; WDFW/QIN Escapement Survey Data 2000).



Status of Salmonid Populations in the Hoquiam, Wishkah, and South Grays Harbor Sub-Basins

Stocks present in this area are fall chinook, chum, and coho salmon, and winter steelhead trout. The only summer steelhead trout are located in the West Fork Hoquiam River (Streamnet 2000). Salmon and steelhead stocks in the three major drainage basins (Hoquiam, Wishkah and South Grays Harbor) are all rated as "healthy" (WDFW and WWTIT 1994).

Chum salmon are distributed throughout the floodplain reaches of all the larger streams in this area, but the distribution limits have not been well documented, except for known presence up to Wishkah River Falls at RM 29.4 (Raines et al. 1992). Chehalis River chum salmon are managed as a single stock, so there are no escapement estimates specific to the Wishkah, Hoquiam or South Grays Harbor systems. The 1992 SASSI review labels the chum stock as "native" and "healthy", but David Hamilton (Regional Enhancement Group, personal communication) reports that Wishkah chum are a composite of the Bitter Creek (North River, WRIA 24) and Hood Canal stocks. A substantial number of off-site incubators were utilized by WDFW to rebuild the runs. Chum salmon escapement estimates for the Chehalis River are based on annual spawner per mile counts in several sloughs and side channels of the Satsop River. The East Fork Hoquiam River and the Wishkah River and its tributaries are believed to have the largest runs in this area (WDFW and WWTIT 1994). A long time resident knowledgeable with the South Grays Harbor drainages feels that the number of chum salmon in South Grays Harbor drainages has declined significantly over the past 40 years (Floyd Ruggles, South Bay resident, personal communication).

In the Wishkah and Hoquiam Rivers, fall chinook counts are available from 1985. The chinook run in the Wishkah declined in the late 1980s, but the runs have been relatively stable since. The mean run between 1985 and 1992 was 1,080 compared to 756 from 1992 to 1999. Chinook spawning primarily takes place in the mainstem of the Wishkah River (WDFW and WWTIT 1994), but spawning is also distributed into the upper reaches of the West and East Fork Wishkah Rivers (Streamnet 2000). Fall chinook in the Wishkah are native, with natural spawning supplemented since 1985 by the Long Live the Kings native broodstock hatchery located on the upper mainstem near RM 26 (WDFW and WWTIT 1994).

Except for fall chinook estimates of over 1,000 returning to the Hoquiam in 1988, 1989 and 1997, runs have ranged from 300 to 850. The mean fall chinook return on the Hoquiam was 741 from 1985 to 1992, and 663 from 1993 to 1999. Hoquiam chinook stocks are considered native, with only one documented fingerling release of 1,600 native brood fall chinook raised at the Stevens Creek Hatchery in 1985 (Stan Hammer, WDFW, Hatchery Program).

Historical records make no mention of chinook salmon in South Grays Harbor drainages, and runs may have originated from hatchery plants in the 1950s to 1970s (WDFW and WWTIT 1994). There are no escapement estimates available for chinook in South Grays Harbor drainages.

Table 4. Summary of Fall Chinook and Winter Steelhead Escapement Estimates in the Wishkah and Hoquiam Rivers (WDFW and WWTIT 1994 and WDFW/QIN Escapement Surveys).

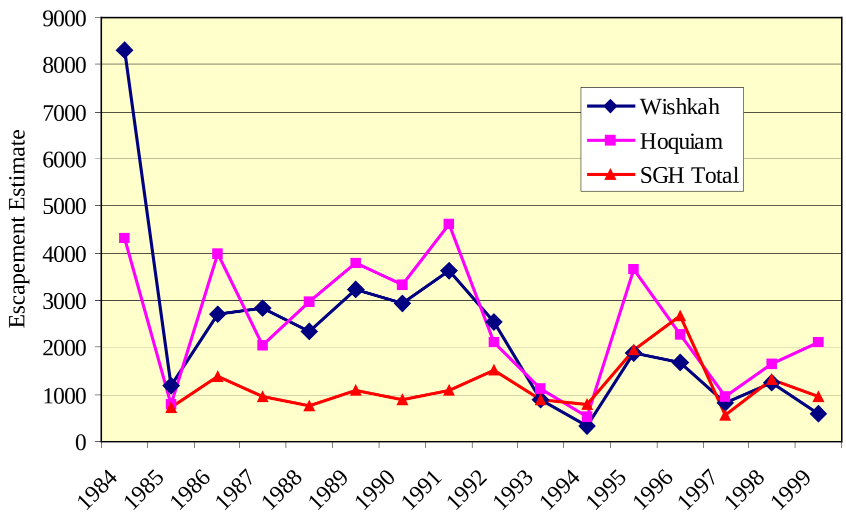
	Fall Run Chinook		Winter Run Steelhead	
Year	**Wishkah**	**Hoquiam**	**Wishkah**	**Hoquiam**
1999	606	519		
1998	755	361		
1997	1270	1152		
1996	785	845		
1995	343	840		
1994	756	527		
1993	780	397		
1993-1999 Mean	756	663	NA	NA
1992	863	494	846	533
1991	732	749	624	822
1990	970	148	752	487
1989	719	1285	472	675
1988	1367	1355	860	525
1987	1473	690	998	700
1986	1320	712	1534	862
1985	1194	644	1182	730
1984			1016	766
1984-1992 Mean	1080	741	920	678

Winter steelhead estimates are available from 1984 to 1992 for the Wishkah and Hoquiam Rivers. A mean of 920 winter steelhead returned to the Wishkah and 678 returned to the Hoquiam. There are no escapement numbers for steelhead in South Grays Harbor drainages (WDFW and WWTIT 1994).

Escapement data are available for coho salmon in the South Grays Harbor Rivers and in the Wishkah and Hoquiam Rivers. The low gradient mainstems with abundant wetlands make all these drainages ideal habitat for coho salmon. Due to this, coho are widely distributed in accessible tributaries throughout most of these drainages. The three forks of the Wishkah each contribute similar returns to the total Wishkah River escapement, which averaged 3,300 from 1985 to 1992, and has declined to a mean of 1,085 since 1993. Hoquiam River coho salmon returns have also declined in recent years from a mean of 3,109 between 1985 and 1992, and 1,749 since 1993 (Figure 5).

Coho salmon are known to spawn in all of the South Grays Harbor drainages with Johns River historically supporting the largest coho return, followed by Andrews Creek in the Elk River drainage. The smaller independent tributaries, especially from Newskah River and Chapin Creek, in some years support as many, or more coho as Elk River (WDFW/QIN Escapement Surveys). South Grays Harbor drainages have contributed 13% to 48% of the coho run of the three major drainages in this area (Figure 5). Coho are of mixed origin in the South Grays Harbor drainages, with hatchery releases of Humptulips River origin coho occurring from the 1950s until 1980. Beginning in 1980 the Grays Harbor Gillnetters Association sponsored a number of small fry plants in the Elk and Johns Rivers, and occasionally in the small independent drainages (WDFW and WWTIT 1994 and Floyd Ruggles, personal communication). The WDFW/Tribal Wild Salmonid Policy resulted in discontinued fry plants in South Grays Harbor drainages beginning in the mid-1990s (Floyd Ruggles, personal communication).

Figure 5. Comparison of Coho Salmon Escapements in the Wishkah, Hoquiam and South Grays Harbor Drainages.



Status of Salmonid Populations in the Wynoochee Sub-Basin

Escapement data on salmon and steelhead in the Wynoochee River are available from 1984 to 1999. Prior to that, WDFW and Quinault Indian Nation conducted spawning surveys, but the survey methods do not allow comparison of data with more recent spawning redds per mile surveys. The Wynoochee River historically had runs of fall chinook salmon, a small run of spring chinook, coho salmon, fall chum salmon, and winter steelhead trout. Summer steelhead trout were initially stocked in the Wynoochee sub-basin, and have established a self-sustaining population that has not been supplemented for over 20 years (Randy Aho, Aberdeen Lake Hatchery, personal communication). Table 5 summarizes the SASSI 1992 salmon and steelhead stock status in the Wynoochee River sub-basin. All of the stocks with status data are considered "healthy" except for spring chinook stock, whose status is disputed (WDFW and WWTIT 1994).

Table 5. Stock Status of Salmon and Steelhead in the Wynoochee River Sub-Basin (WDFW and WWTIT 1994).

Stock	Origin	Production	1991 Status
Coho	Mixed	Composite	Healthy
Fall Chinook	Native	Wild	Healthy
Spring Chinook	Mixed	Unknown	Disputed
Fall Chum	Native	Wild	Healthy
Winter Steelhead	Mixed	Composite	Healthy

Wynoochee Falls at RM 58.1 was historically the natural upstream barrier to chinook, coho, and steelhead spawning habitat, prior to construction of the Wynoochee Dam at RM 50.1. In 1994, the Wynoochee Dam was converted from a flood control dam to a hydroelectric dam. This eliminated spawning habitat for an estimated 1,500 adult coho salmon and 570 adult steelhead per year. To mitigate the impacts of the conversion of 4.4 miles of anadromous river into a reservoir, a fish collection facility was constructed at RM 47.8. The 20-foot dam for the fish collection facility became the upstream extent of salmon and steelhead migrations, blocking a total of 6.6 miles of spawning habitat, 4.4 miles within the reservoir, and 2.2 miles of habitat between the water supply dam and the Wynoochee Dam. Salmon and steelhead captured at the collection facility are transported 7.5 miles upstream, and released in the river above the reservoir. Table 6 summarizes the numbers of coho, chinook, and steelhead that have been captured at the fish collection facility and transported above the dam (Royce 1985 and ACOE 1997). The Aberdeen Hatchery uses the fish collection facility to collect steelhead broodstock for production.

Table 6. Summary of Fish Transfer Facility Transport of Salmon and Steelhead.

	Coho Salmon	Winter Run Steelhead	Fall Chinook
Year	1971 - 1998	1971 - 1998	1985 - 1998
Range	236-5698	42-1765	9-147
Mean	1423	463	70

Prior to construction of the Wynoochee Dam, coho salmon utilized habitat up to Wynoochee Falls at RM 58.1, but now the upper limit is RM 47.8 at the fish collection facility. WDFW estimated that 3,460 coho historically spawned upstream of this point (ACOE 1983). Since construction of the dam, coho salmon have been transported upstream of the reservoir to spawn in the 2.5 miles of habitat below the falls. Annual coho transports have ranged from 236 to 5,698 comprising an average of 24% of the total Wynoochee River escapement (ACOE 1997).

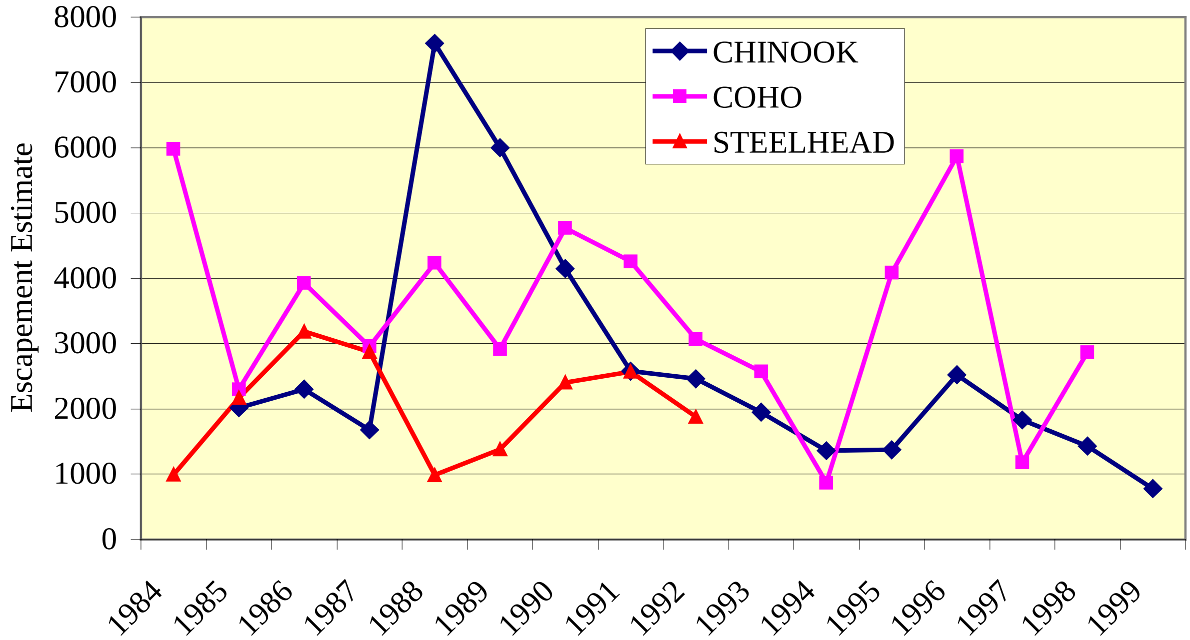
Hatchery releases from several stocks outside of the Wynoochee have been made since the 1950s, resulting in stocks of mixed origin. Annual hatchery plants of coho fry were made through 1991, but no stocking has been done since (Stan Hammer, WDFW personal communication). Coho begin entering the Wynoochee River in late September with spawning from November to as late as February. Coho escapement estimates since 1984 have averaged 3,458, ranging from a high of 5,979 in 1984 and a low of 872 in 1994 (Figure 6) (WDFW/QIN Escapement Data 2000; WDFW and WWTIT 1994).

Since 1952, there have only been three hatchery releases of chinook salmon originating from other drainages. Because the numbers of these hatchery releases were low (8,000 to 20,000), it is assumed that the current fall chinook stock is native (WDFW and WWTIT 1994). Fall chinook escapements since 1985, have averaged 2,671 with a high of 7,601 in 1988 and a low of 782 in 1999 (Figure 6) (WDFW/QIN Escapement Data 2000). Since 1985, an average of 51 fall chinook, or approximately 2% of the total basin escapement spawned upstream of the reservoir (ACOE 1997).

Sports fishers, WDFW, and the Quinault Indian Nation have long disputed the presence of spring chinook in the drainage. A small number of sports fishermen reported catching spring chinook during the summer run steelhead season, but none of these has been verified (Brian Erickson, Columbia Pacific RC&D and Curt Holt, QIN, personal communication). WDFW's only documentation of spring chinook in the Wynoochee drainage is from hatchery plants of Cowlitz River spring chinook in 1975 and 1976. (WDFW and WWTIT 1994). Quinault Indian Nation escapement surveys in 1987 identified five spring chinook redds on October 21 between RM 32.6 and 35.3, based on the old condition of gravel disturbance. In an October 4, 1996 survey, five spring chinook redds were identified between RM 46.0 and 47.8, based on October 15th being the break off point for "spring" versus "fall" chinook for most Olympic Peninsula watersheds. The debate is that observations of "spring" chinook in October surveys may actually be early spawning "fall" chinook (John Linth, WDFW, and Curt Holt, QIN, personal communication). Catch records from the ACOE fish collection facility recorded a total of 7 to 8 wild spring chinook captured and transported above the reservoir in 1971, 1980, 1981, and 1983 (Royce 1985). The only other documented identification of spring chinook was in spring 1988 when QIN captured two spring chinook at the fish collection facility while conducting a steelhead project (Curt Holt, QIN, personal communication).

Winter run steelhead are native to the basin with their historic spawning distribution extending to Wynoochee Falls. Estimates of habitat indicate an average of 1,500 steelhead historically spawned upstream of the existing Wynoochee Dam. Hatchery smolt plants originating from native brood stock captured at the fish collection facility have been common, resulting in interbreeding with true wild fish. Therefore, the stock is considered mixed origin, and has been sustained by both natural and artificial production. Winter steelheads enter the river from December through May, with spawning taking place during mid February through June. From 1984 to 1992 escapement estimates downstream of the fish collection facility have averaged 2,052, ranging from 988 to 3,190, with the escapement goal of 1,260 steelhead exceeded in 7 of the 9 years (WDFW and WWTIT 1994). Since the fish collection facility began operations in 1971, an average of 450, or about 20% of the total winter run steelhead, were transported above the reservoir to spawn. Annual captures at the trap ranged from 42 in 1979 to 1,134 in 1999 (ACOE 1997 and Brett DeMond, WDFW, personal communication).

Figure 6. Escapement Estimates of Salmon and Steelhead in the Wynoochee River Sub-Basin.



There are no escapement estimates for chum salmon specific to the Wynoochee River. Escapement estimates for the Chehalis River Basin are based on annual spawner per mile counts of chum salmon on the Satsop River. Fall chum enter the Wynoochee in October and spawn during late October to early November (WDFW and WWTIT 1994). Without available escapement surveys, the known spawning distribution is primarily in the mainstem, but it is likely spawning occurs in most accessible tributaries below river mile 39.

Status of Salmonid Populations in the Satsop Sub-Basin

Five stocks of salmon and steelhead are known to use to Satsop sub-basin. These include summer chinook, fall chinook, coho, and chum salmon as well as winter steelhead trout.

Satsop summer chinook salmon is an early-timed chinook stock found in the Satsop drainage. They spawn in the month of September and the stock was listed as "depressed" in the 1992 SASSI report (WDFW and WWTIT 1994). The earliest escapement data are from 1982 with an escapement of about 750 adults. By 1991, the number of spawners decreased to less than 100 per year. Since then, the stock has likely decreased further in numbers (Rick Brix, WDFW, personal communication). Observations by David Hamilton (Regional Enhancement Group, personal communication) note that the summer chinook have a different spawn timing than the Satsop fall chinook stock. Recent dry years resulted in the summer chinook spawning downstream or near Schafer Park, rather than distributing more broadly. Some observations suggest that summer chinook are also present in the upper Chehalis Basin (David Hamilton, Regional Enhancement Group, personal communication), and that those fish are counted as part of the fall chinook stock.

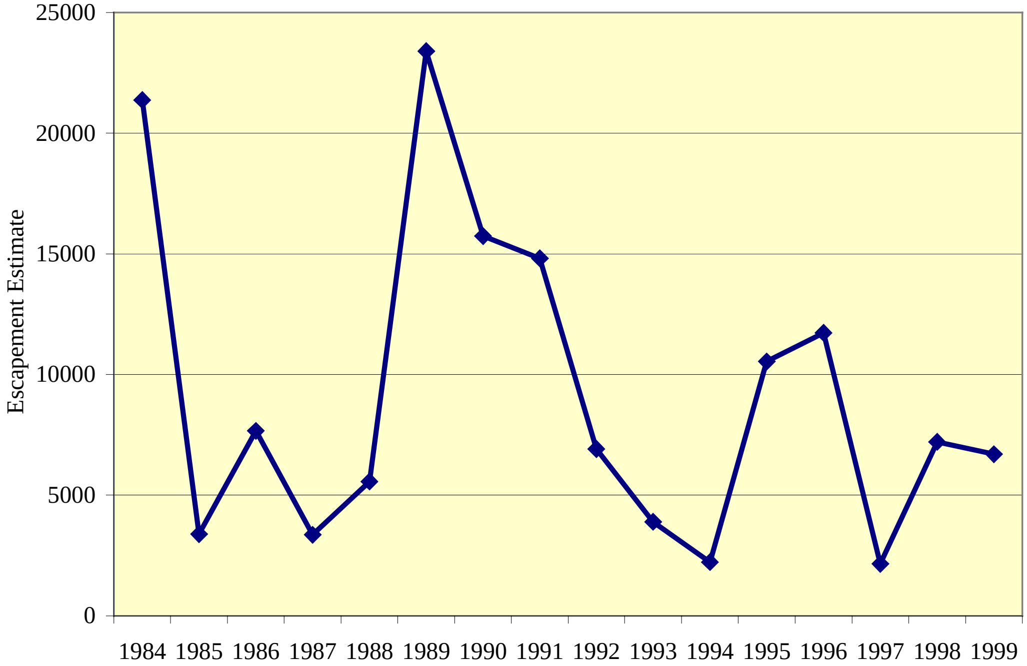
Fall chinook salmon comprise a single chinook stock in the Satsop, and are believed to be a hybridized stock with many of the hatchery plants from other basins. David Hamilton (Regional Enhancement Group, personal communication) notes that the Satsop fall chinook were nearly wiped out when large numbers were transferred to the upper Chehalis from the former Schafer Park Hatchery. Years later, WDFW released yearling chinook comprised of primarily Humptulips stock with a mix of Willapa stock. This is likely the primary origin of the current fall chinook stock in the Satsop. Past introductions of stocks from Puget Sound and the Columbia River have also occurred (WDFW and WWTIT 1994). The Satsop fall chinook salmon stock was described as “healthy” in the 1992 SASSI report, but those numbers included spawners from hatchery origin. Fall chinook enter the Satsop from mid-September through mid-November, and spawn from October through mid-December (WDFW and WWTIT 1994).

Fall chum salmon spawn in the Satsop basin, but these are considered part of a larger Chehalis Basin stock that also spawns in the Wynoochee River, Wishkah River, Hoquiam River, Cloquallum Creek, Black River, and the mainstem Chehalis River. The 1992 SASSI review labels the chum stock as "native" and “healthy”, but David Hamilton (Regional Enhancement Group, personal communication) reports that Satsop chum are a composite of the Bitter Creek (North River, WRIA 24) and Hood Canal stocks. A substantial number of off-site incubators were utilized by WDFW to rebuild the runs. Fall chum enter the Satsop from October through mid-November, and spawn from November through mid-December (WDFW and WWTIT 1994).

Coho salmon within the Satsop are considered a single stock, entering in late September or October and spawning from November to January or February (WDFW and WWTIT 1994). The coho salmon stock is believed to be of mixed origin due to plants of Puget Sound, Soleduck, and Willapa coho in the basin. Satsop coho were described as “healthy” in the 1992 SASSI report, but hatchery fish may have contributed to those numbers. Escapement estimates for coho salmon are shown in Figure 7 and are highly variable from year to year.

Satsop winter steelhead is reported as a native, "depressed" stock in the SASSI report (WDFW and WWTIT 1994). However, David Hamilton (Regional Enhancement Group, personal communication) states there are two components of this stock, an early non-native component and a later native component. He notes an early-timed coastal stock comprised of Quinault, Bog, and Chambers Creek (Puget Sound) stocks was planted throughout the Chehalis for many years to support fisheries. The fisheries that targeted this planted stock could have also decimated the native early component of the winter steelhead stock. He believes that the later component (entering from February on) is native. Adults enter the Satsop from December though May and spawn from mid-February through June (WDFW and WWTIT 1994).

Figure 7. Satsop River Coho Salmon Escapement

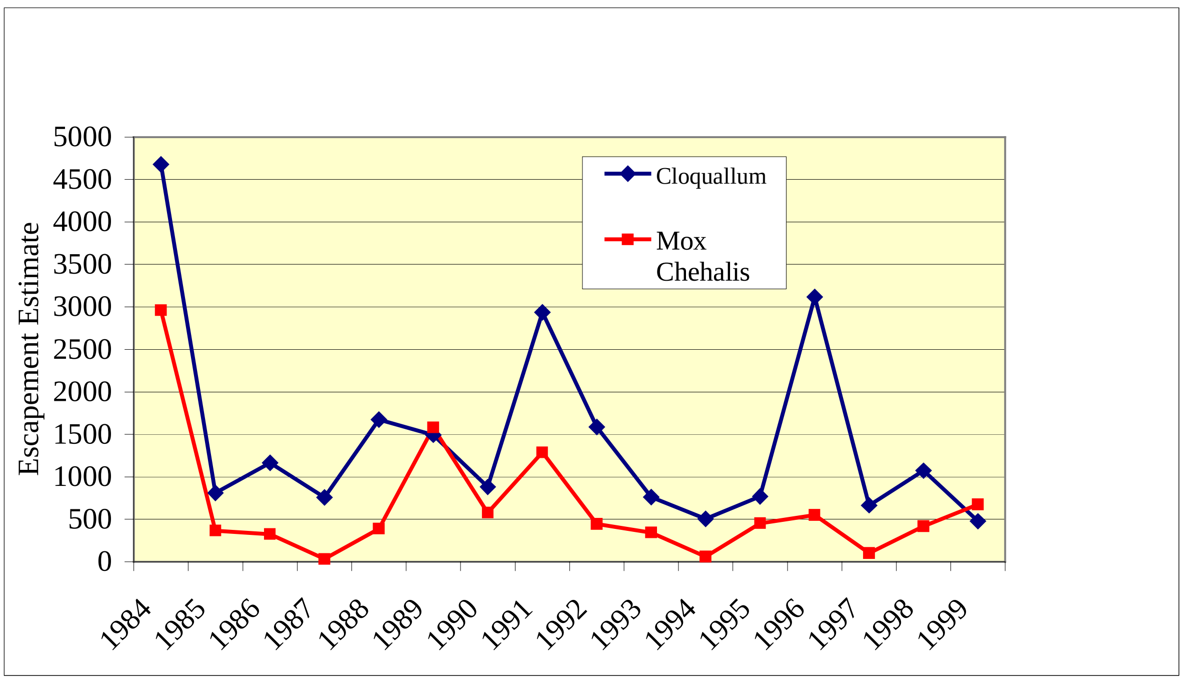


Salmon and Steelhead Stocks in the Newman, Delezene, Cloquallum, and Mox Chehalis Sub-Basins

Coho, fall chinook, and chum salmon as well as winter-run steelhead are present in this area. There are no specific estimates of adult escapement specific to these streams because these stocks are managed as an aggregate with populations in several other sub-basins within the Chehalis Basin (WDFW and WWTIT 1994). The chum salmon are managed as one stock throughout their distribution range in the Chehalis Basin. Fall chinook, coho, and winter steelhead are managed in conjunction with all other populations that spawn upstream of the confluence of the Satsop River with the exception of winter steelhead in the Skookumchuck and Newaukum Rivers.

The low gradients of most rivers and creeks in the analysis area make them ideal habitat for coho salmon. Coho are distributed throughout Cloquallum and Mox Chehalis Creeks, and have also been documented in Delezene and Newman Creeks (Map 2c). It is likely that coho salmon use some of the other streams as well, but this information remains a data need. Coho escapement for Cloquallum Creek is shown in Figure 8 (data from John Linth, WDFW). The aggregate coho population upstream of the Satsop confluence is considered "healthy" (WDFW and WWTIT 1994). Fall chinook salmon and chum salmon are also listed as "healthy" in the SASSI report, even though the distribution of chum salmon is greatly reduced from historic levels (Phinney and Bucknell 1975). The Chehalis winter steelhead stock was classified as native and "healthy" in SASSI (WDFW and WWTIT 1994).

Figure 8. Coho Salmon Spawning Escapement in Cloquallum and Mox Chehalis Creeks (data from WDFW/Tribal escapement surveys).



Status of Salmon and Steelhead in Gaddis, Rock, Garrard, Independence, and Lincoln Creeks

Coho salmon are the most numerous salmon and steelhead species in these small to medium sized streams. The coho stock spawning in these areas is classified as part of a much larger population of coho found throughout the Chehalis Basin upstream of the Satsop River (WDFW and WWTIT 1994). They spawn from November through January and sometimes into February, and are classified as "healthy" with a mixed origin (WDFW and WWTIT 1994). The escapement averaged 18,510 from 1984 to1991, when the SASSI classification was made. From 1992 to 1998, the coho escapement dropped to a mean of 14,625 adults/year (data from John Linth, WDFW). Coho likely spawn in all accessible areas containing adequate flows and spawning gravel within these creeks and rear in all accessible areas. However, specific information about the status of coho to these streams is lacking, and distribution information is scant.

Winter steelhead have been noted in Rock Creek, Williams Creek, and Lincoln Creek, and these populations are part of a much larger stock that includes spawners in the South Fork Chehalis River and the upper Chehalis River (WDFW and WWTIT 1994). This stock was classified as "healthy" in the 1992 SASSI report.

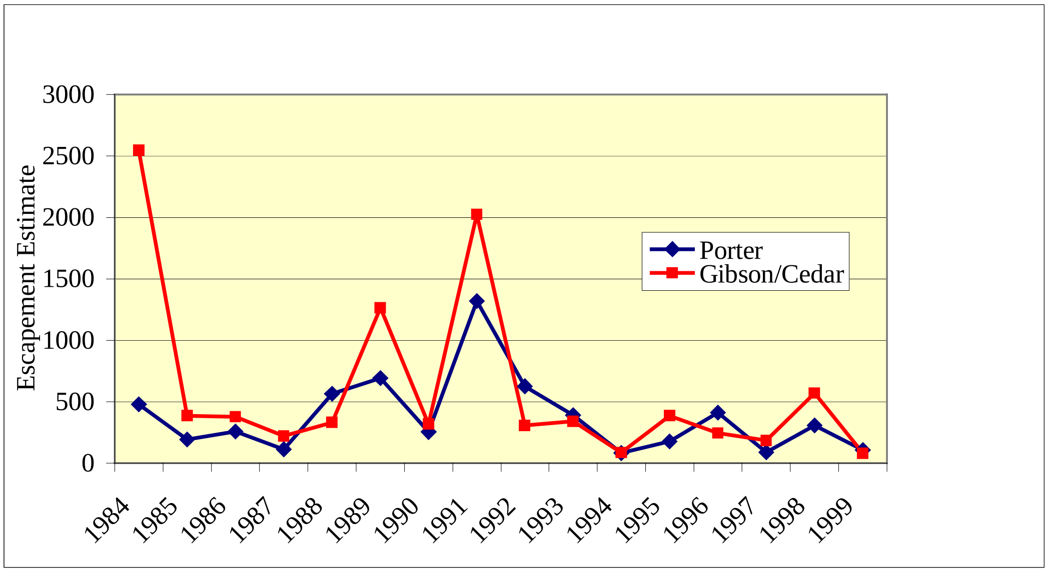
Fall chinook salmon have been recorded in Rock Creek, and are part of a much larger population of chinook that includes all fall chinook upstream of the Satsop River (WDFW and WWTIT 1994). Spawning occurs from October through November. The stock is classified as "healthy" with a mixed origin (WDFW and WWTIT 1994). Recent escapement estimates indicate that the escapement has been stable and at similar levels to those used in the SASSI classification.

Historically, chum salmon likely used these streams as well, and a small run of chum salmon was documented in Lincoln and Independence Creeks (Phinney and Bucknell 1975). Currently, there are no specific stocks of chum known in these areas, although small numbers may be seen occasionally (John Linth, WDFW, personal communication).

Status of Salmon and Steelhead in the Porter, Gibson, and Cedar Creek Sub-Basins

Coho and fall chinook salmon and winter steelhead trout are documented in the Porter and Cedar Creek sub-basins, and coho salmon are present in the Gibson Creek watershed. The salmon and steelhead stocks that spawn in these streams are all part of larger stocks that includes fish that spawn in the Chehalis River Basin upstream of the mouth of the Satsop River (WDFW and WWTIT 1994). All of those stocks are listed as "healthy" in the SASSI report. Since 1984, WDFW, the Quinault Indian Nation and the Chehalis Tribe have cooperatively conducted spawning escapement surveys for coho, fall chinook, and winter steelhead in Gibson Creek, Cedar Creek, and Porter Creek. Escapement summaries for coho salmon are presented in Figure 9. The estimates indicate that recent escapement levels are not as high as estimates from the late 1980s to early 1990s. Escapement estimates for fall chinook and winter run steelhead were not summarized for this analysis, but raw annual escapement data are available at the WDFW in Montesano.

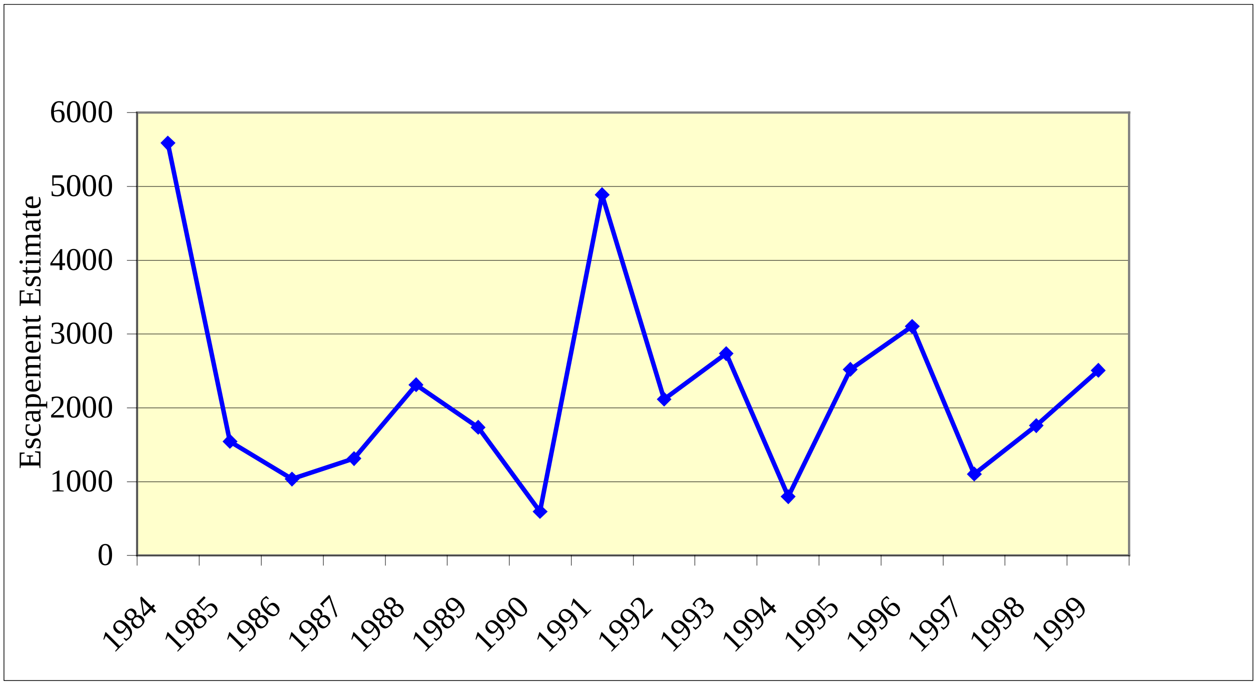
Figure 9. Coho Salmon Spawning Escapement in Porter, Gibson and Cedar Creeks (data from WDFW/Tribal escapement surveys).



Status of Salmon and Steelhead in the Black River Sub-Basin

Coho, fall chinook, and chum salmon, as well as winter steelhead trout, are present in the Black River sub-basin. The salmon and steelhead stocks that spawn in these streams are all part of larger stocks that includes fish that spawn in the Chehalis River Basin upstream of the mouth of the Satsop River (WDFW and WWTIT 1994). All of these stocks are listed as "healthy" in the SASSI report. Since 1984, WDFW, the Quinault Indian Nation, and the Chehalis Tribe have cooperatively conducted spawning escapement surveys for coho, fall chinook, and winter steelhead in Gibson Creek, Cedar Creek, and Porter Creek, and escapement summaries for coho salmon are presented in Figure 10. Escapement estimates for fall chinook and winter run steelhead were not summarized for this analysis, but raw annual escapement data are available at the WDFW in Montesano.

Figure 10. Coho Salmon Spawning Escapement in the Black River (data from WDFW/Tribal escapement surveys).



Scatter Creek Salmon and Steelhead Population Status

Coho are the most numerous salmon species in Scatter Creek, using almost all of the watershed (WDFW Spawner Survey Database; Thurston Conservation District 1999). Coho salmon rearing has also been documented in Prairie Creek (Pat Hanratty, WDFW, personal communication). The coho stock spawning in these areas is classified as part of a much larger population of coho found throughout the Chehalis Basin upstream of the Satsop River (WDFW and WWTIT 1994). They spawn from November through January and sometimes into February, and were classified as "healthy" with a mixed origin in the early 1990s (WDFW and WWTIT 1994). The escapement for the total population averaged 18,510 from 1984 to 1991, when the SASSI classification was made. From 1992 to 1998, the coho escapement dropped to a mean of 14,625 adults/year (data from John Linth, WDFW).

Winter steelhead have been noted in the lower reaches of Scatter Creek (Streamnet 1999), but this population was not specifically mentioned in SASSI (WDFW and WWTIT 1994). Stock status is unknown.

Chum salmon are thought to utilize Scatter Creek (Thurston Conservation District 1999), but specific distribution has not been documented (Streamnet 1999), nor were they mentioned in the SASSI report (WDFW and WWTIT 1994).

Skookumchuck Sub-Basin Salmon Population Status

There are four stocks of salmon and steelhead in the Skookumchuck sub-basin: spring chinook, fall chinook, and coho salmon, as well as winter steelhead trout (WDFW and WWTIT 1994). Winter steelhead in the Skookumchuck sub-basin are considered to be part of a larger population that includes Newaukum winter steelhead. Skookumchuck/Newaukum winter steelhead were classified as “depressed” in the 1992 SASSI report, and current escapement estimates remain well below escapement goals. From 1996 to 1999, the wild steelhead escapement in the Skookumchuck River ranged from 193-473 with a total wild escapement goal of 766 (450 upstream of dam plus 316 downstream of dam) (John Linth, WDFW, personal communication). Skookumchuck winter steelhead were also described as a mixed-origin stock, and are partially sustained by hatchery production from dam mitigation.

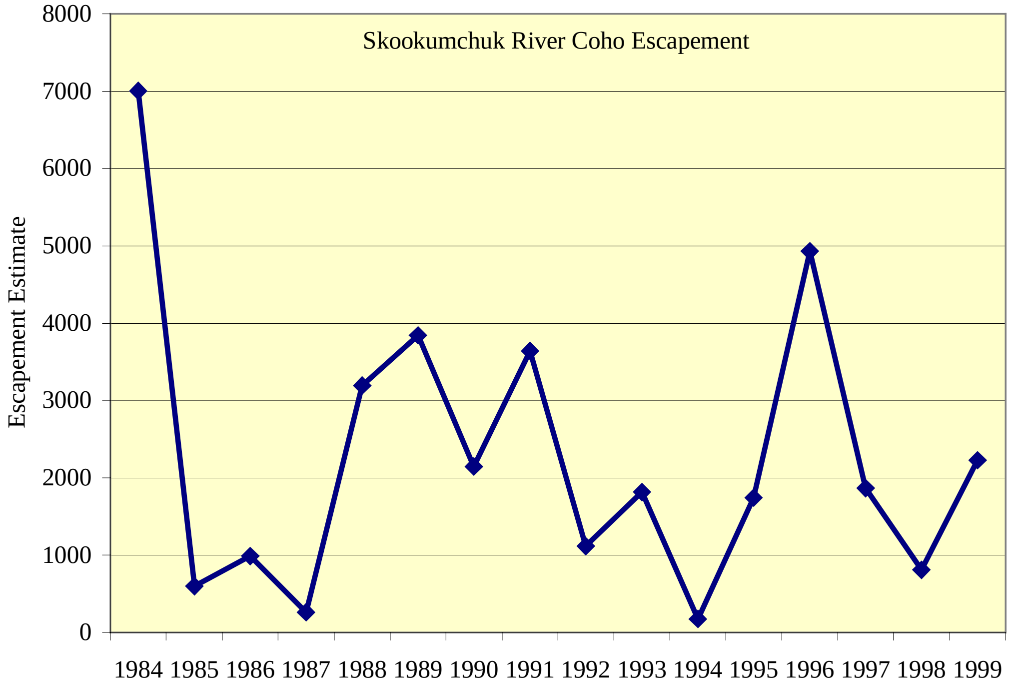
The coho stock spawning in these areas is also classified as part of a much larger population of coho found throughout the Chehalis Basin upstream of the Satsop River (WDFW and WWTIT 1994). They spawn from November through January and sometimes into February, and were classified as "healthy" with a mixed origin in the early 1990s (WDFW and WWTIT 1994). The escapement for the total population averaged 18,510 from 1984 to 1991, when the SASSI classification was made. From 1992 to 1998, the mean coho escapement throughout the upper Chehalis dropped to 14,625 adults per year (data from John Linth, WDFW). Coho salmon returning to the Skookumchuck River show a decrease in adult escapement from 1992 to 1994, but more recent returns have increased to levels that are similar to returns in years between 1988 and 1991 (Figure 11).

The Skookumchuck Dam has reduced coho habitat by an estimated 8 miles which has likely decreased coho production from the Skookumchuck River (Weyerhaeuser 1997). A rearing pond on Bloody Run Creek has been used to rear Minter Creek (Puget Sound) coho salmon for release in Puget Sound. However, recently the stock has been changed to Bingham Creek coho (Satsop Hatchery, a mixed origin stock). While most are still released into Puget Sound, 100,000 are released into the Skookumchuck River as part of the dam mitigation (John Linth, WDFW, personal communication).

Fall chinook salmon in the Skookumchuck sub-basin are also part of a much larger Chehalis basin stock, which includes all fall chinook upstream of the Satsop River (WDFW and WWTIT 1994). Spawning occurs from October through November. The stock was classified as "healthy" with a mixed origin in the early 1990s (WDFW and WWTIT 1994). Recent escapement estimates indicate that the escapement has been stable and at similar levels to those used in the SASSI classification.

Spring chinook salmon in the Skookumchuck sub-basin are a component of the Chehalis spring chinook stock identified in SASSI (WDFW and WWTIT 1994). Over 90% of this stock spawns in the Skookumchuck, Newaukum, and upper mainstem Chehalis Rivers. The remaining 10% spawn in the North Fork Newaukum, Elk Creek, the Chehalis mainstem downstream of RM 88, and in Stillman Creek (WDFW and WWTIT 1994). The stock spawns from early September through mid-October, and is considered to be native and "healthy" in the 1992 SASSI report (WDFW and WWTIT 1994). Escapement estimates since the SASSI classification show that average escapement has increased. Escapement averaged 1,490 prior to SASSI publication, but has averaged 2,379 since 1991. However, even though both spring and fall chinook stocks were classified as “healthy”, the Skookumchuck component of these stocks has very likely been reduced due to the presence of the dam. The dam has decreased mainstem habitat for both chinook salmon stocks by 3.6 miles for each chinook salmon stock (Weyerhaeuser 1997).

Figure 11. Coho salmon spawning escapement in the Skookumchuck River (data from WDFW/Tribal escapement surveys)..



Newaukum Sub-Basin Salmon Population Status

There are four stocks of salmon and steelhead in the Newaukum sub-basin; spring chinook, fall chinook, and coho salmon, as well as winter steelhead trout (WDFW and WWTIT 1994). Winter steelhead in the Newaukum sub-basin are considered to be part of a larger population that includes Skookumchuck winter steelhead. The stock was classified as “depressed” in the 1992 SASSI report, and current escapement estimates remain well below escapement goals (John Linth, WDFW, personal communication). Skookumchuck/Newaukum winter steelhead were also described as a mixed-origin stock, and is partially sustained by hatchery production in the Skookumchuck River from dam mitigation.

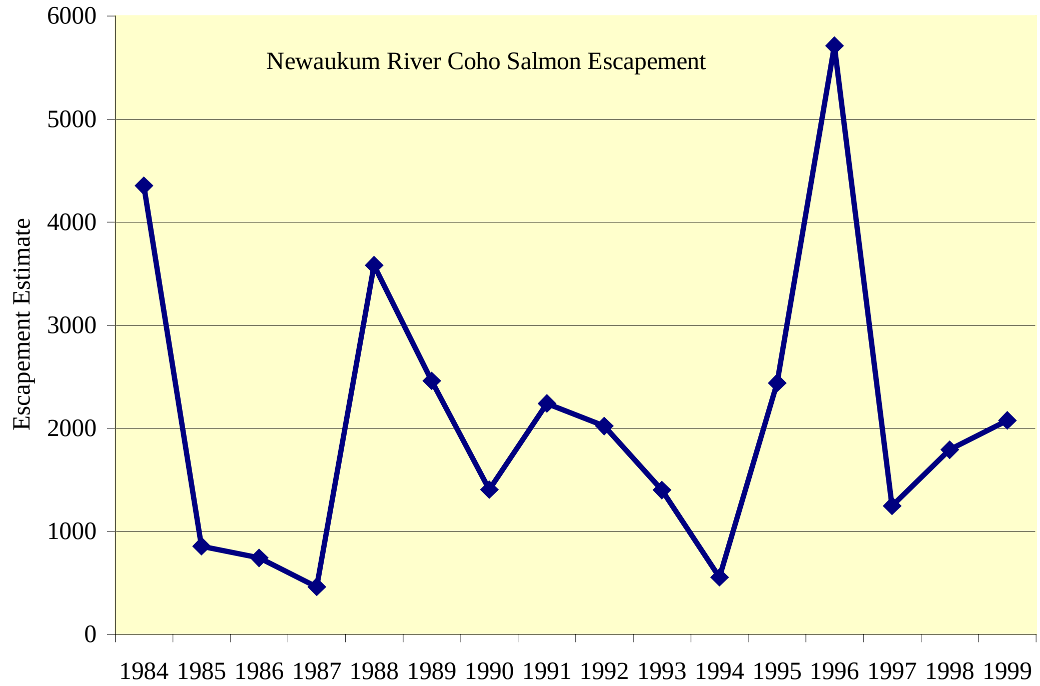
The coho stock spawning in these areas is classified as part of a much larger population of coho found throughout the Chehalis basin upstream of the Satsop River (WDFW and WWTIT 1994). They spawn from November through January and sometimes into February, and were classified as "healthy" with a mixed origin in the early 1990s (WDFW and WWTIT 1994). Coho salmon escapement estimates to the Newaukum sub-basin are shown in Figure 12. While coho spawn in all accessible areas within the

Newaukum sub-basin, Lucas Creek and lower Mitchell Creek are considered major coho producing streams (Map 3b) (Weyerhaeuser 1998).

Fall chinook salmon in the Newaukum sub-basin are also part of a much larger Chehalis basin stock, which includes all fall chinook upstream of the Satsop River (WDFW and WWTIT 1994). The Newaukum sub-basin contributes an estimated 6% of the total spawning population of Chehalis fall chinook (Weyerhaeuser 1998). Spawning occurs from October through November. The stock was classified as "healthy" with a mixed origin in the early 1990s (WDFW and WWTIT 1994). Recent escapement estimates indicate that the escapement has been stable and at similar levels to those used in the SASSI classification.

Spring chinook salmon in the Newaukum sub-basin are a component of the Chehalis spring chinook stock identified in SASSI (WDFW and WWTIT 1994). About 34% of spring chinook spawning occurs in the Newaukum sub-basin (Weyerhaeuser 1998). The stock spawns from early September through mid-October, and is considered to be native and "healthy" in the 1992 SASSI report (WDFW and WWTIT 1994). Escapement estimates since the SASSI classification show that the average escapement has increased. Escapement averaged 1,490 prior to SASSI publication, but has averaged 2,379 since 1991.

Figure 12. Coho Salmon Spawning Escapement in the Newaukum River (data from WDFW/Tribal escapement surveys).



Salmon and Steelhead Populations in Stearns, Mill, Bunker, and Deep Creeks

Coho are the most numerous species in these small to medium sized streams. The coho stock spawning in these areas is classified as part of a much larger population of coho found throughout the Chehalis basin upstream of the Satsop River (WDFW and WWTIT 1994). They spawn from November through January and sometimes into February, and were classified as "healthy" with a mixed origin in the early 1990s (WDFW and WWTIT 1994). The escapement for the total population averaged 18,510 from 1984 to 1991, when the SASSI classification was made. From 1992 to 1998, the mean coho escapement has dropped to 14,625 adults/year (data from John Linth, WDFW). Coho likely spawn in all accessible areas containing adequate flows and spawning gravel within these creeks and rear in all accessible areas. However, specific information about the status of coho to these streams is lacking, and distribution information is scant.

Winter steelhead have been noted in Stearns Creek, Bunker Creek, and Deep Creek, but these populations were not specifically mapped in the SASSI report (WDFW and WWTIT 1994). The stock spawning nearby in the South Fork Chehalis River and upper Chehalis River was classified as "healthy" in the 1992 SASSI report (John Linth, WDFW, personal communication). No other species of salmon or steelhead has been documented in these creeks.

South Fork and Upper Chehalis Sub-Basin Salmon Population Status

Coho salmon are the most abundant salmonid in the South Fork Chehalis and Upper Chehalis sub-basins (Hadley 1994; WDFW and WWTIT 1994). The coho stock spawning in these areas was classified as part of a much larger population of coho found throughout the Chehalis basin upstream of the Satsop River (WDFW and WWTIT 1994). They spawn from November through January and sometimes into February, and were classified as "healthy" with a mixed origin (WDFW and WWTIT 1994).

In the SASSI report (WDFW and WWTIT 1994), winter steelhead trout in the South Fork Chehalis and Upper Chehalis sub-basins were also considered part of a larger population found throughout the Chehalis upstream of the Satsop River confluence, and is referred to as "Chehalis winter steelhead". This stock does not include spawners in the Skookumchuck and Newaukum sub-basins. The Chehalis winter steelhead stock was classified as native and "healthy", even though the escapement trend is downward. Low numbers of summer steelhead trout are thought to use the Stillman Creek watershed for spawning (Hadley 1994).

Spring chinook salmon in the South Fork Chehalis and Upper Chehalis sub-basins are a component of the Chehalis spring chinook stock identified in SASSI (WDFW and WWTIT 1994). Over 90% of this stock spawns in the Skookumchuck, Newaukum, and upper mainstem Chehalis Rivers. The remaining 10% spawn in the North Fork Newaukum, Elk Creek, the Chehalis mainstem downstream of RM 88, and in Stillman Creek (WDFW and WWTIT 1994). The stock spawns from early September through mid-October, and is considered to be native and "healthy" in the 1992 SASSI report (WDFW and WWTIT 1994).

Fall chinook salmon in the South Fork Chehalis and Upper Chehalis sub-basins are also part of a much larger Chehalis basin stock, which includes all fall chinook upstream of the Satsop River (WDFW and WWTIT 1994). Spawning occurs from October through November. The stock was classified as "healthy" with a mixed origin (WDFW and WWTIT 1994).

HABITAT LIMITING FACTORS IN THE CHEHALIS DRAINAGE BY SUB-BASIN

Categories of Habitat Limiting Factors used by the Washington State Conservation Commission

The following is a list and description of the major habitat limiting factor categories that are used to organize the Limiting Factors Reports. Although these categories overlap with each other, such that one habitat problem could impact more than one habitat limiting factor category, they provide a reasonable structure to assess habitat conditions within a basin or sub-basin. Within each category are one or more data types that provide a means to assess each category.

Loss of Access to Spawning and Rearing Habitat

This category includes culverts, tide gates, levees, dams, and other artificial structures that restrict access to spawning habitat for adult salmonids or rearing habitat for juveniles. Additional factors considered are low stream flow or temperature conditions that function as barriers during certain times of the year.

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. Impacts in this category includes direct loss of aquatic habitat from human activities in floodplains (such as filling), disconnection of main channels from floodplains with dikes, levees, revetments, and riparian roads, and impeding the lateral movement of flood flows with dikes, riparian roads, levees, and revetments. Disconnection can also result from channel incision caused by changes in hydrology or sediment inputs.

Streambed Sediment Conditions

Changes in the inputs 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 and reduce the frequency and volume of pools, while decreases can limit the availability of spawning gravel. Decreased channel stability is often noted by analyzing aerial photographs for widespread channel changes or by measuring scour. Increases in fine sediment can fill in pools, decrease the survival rate of eggs deposited in the gravel (through suffocation), and lower the production of benthic invertebrates. As part of this analysis, increased sediment input from landslides, roads, agricultural practices, construction activities is examined as well as decreased gravel availability caused by dams and floodplain constrictions. This category also assesses instream habitat characteristics that are related to sedimentation and sediment transport, such as bank stability and erosion and large woody debris (LWD).

Riparian Conditions

Riparian areas include the land adjacent to streams, rivers, and nearshore environments that interacts with the aquatic environment. This category addresses factors that limit the ability of native riparian vegetation to provide shade, nutrients, bank stability, and large woody debris. Riparian impacts include timber harvest, clearing for agriculture or development, and direct access of livestock to stream channels. This section also examines future LWD recruitment, where data are available, and the abundance and depth of pool habitat.

Water Quality

Water quality factors addressed by this category include stream temperature, dissolved oxygen, and toxics that directly affect salmonid production. Turbidity is also included, although the sources of sediment problems are addressed in the streambed sediment category. In some cases, fecal coliform problems are identified because they may serve as indicators of other impacts 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. All types of hydrologic changes can alter channel and floodplain complexity. This category addresses 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, and changes in hydrological maturity (vegetation age).

Estuarine and Nearshore Habitat

This category addresses habitat impacts 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 on fresh water. These areas provide especially important rearing habitat and an opportunity for transition between fresh and salt water. Impacts include loss of habitat complexity due to filling, dikes, and channelization; and loss of tidal connectivity caused by tidegates. Nearshore habitat includes intertidal and shallow subtidal saltwater areas adjacent to land that provide transportation and rearing habitat for adult and juvenile fish. Important features of these areas include eelgrass, kelp beds, cover, large woody debris, and the availability of prey species. Impacts include bulkheads, overwater structures, filling, dredging, and alteration of sediment processes. Water quality issues of the estuarine or nearshore environment, such as toxics, dissolved oxygen, and water temperatures are included in this section, as well as the presence of significant baitfish spawning sites. Also included are habitat changes that have promoted the increase in opportunistic predators on salmon, such as marine mammals and birds. The introduction of non-native species specific to the estuary, such as *Spartina*, is included in this section.

Lake Habitat

Lakes can provide important spawning and rearing for salmonids. This category includes impacts that are unique to lake environments, such as the construction of docks and piers, increases in aquatic vegetation, the application of herbicides to control plant growth and changes in lakeshore vegetation. Also included are habitat changes that have promoted the increase in opportunistic predators on salmon, such as squawfish (northern pike minnow).

Biological Processes

This category addresses 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. It also includes impacts from increased predation or competition and loss of food-web function due to habitat changes.

Rating Habitat Conditions

The major goal of this project is to identify the habitat conditions that should be restored or conserved for the best benefit of salmonid production. Often, numerous habitat degradations can be found within a watershed, and some have a greater impact on salmonids than others. To help identify the most significant habitat limiting factors, the Conservation Commission developed a system to rate the above-described habitat limiting factor categories as “good”, “fair”, or “poor”. This is useful to allow comparisons of limiting factors within a watershed, as well as provide the same general standards to rate conditions across the state for this project. These ratings are not intended to be used as thresholds for regulatory purposes. The details and data sources for the standards are described in the Assessment Chapter.

Habitat Limiting Factors in the Grays Harbor Estuary and along the Near Shore

Introduction

Grays Harbor is about 12 miles wide at the widest point, and at high tide covers about 97 square miles. A two-mile wide channel connects Grays Harbor to the Pacific Ocean. Two major river basins drain into Grays Harbor. The Chehalis River drains 2,200 square miles into the inner harbor, while the Humptulips Basin drains 245 square miles into North Bay. Several smaller drainages also empty into Grays Harbor and include the Hoquiam River, Elk River, Johns River, Newskah Creek, and Charlie Creek. North Bay is relatively undeveloped, while the inner harbor is heavily industrialized. Pulp mills, landfills, sewage treatment plants, and log storage facilities are all located within the inner harbor. In addition, the inner harbor is regularly dredged.

Grays Harbor provides vital feeding and transitional habitat for salmonids, both when juveniles leave the rivers to enter saltwater, and when adults return to the rivers to spawn.

The larval northern anchovy is found in deeper waters of Grays Harbor and serves as food for chinook and chum salmon (Simenstad and Eggers 1981). These authors also suggest that open-water zooplankton levels limit the population of juvenile salmonids in Grays Harbor. Areas that are especially important for zooplankton production include Moon Island, Cow Point, and the marine waters east to Stearns Bluff. Herring spawning beds have been recently located in and around the Elk River estuary, and sand lance spawning was documented in South Arbor (Bob Burkle, WDFW, personal communication). Both of these species are important food items for salmonids.

Large woody debris (LWD) in the estuary was common prior to logging and settlements, but is now believed by the TAG to be very low. Estuarine LWD serves as cover for juvenile salmonids (Martin and Dieu 1997). The wood also creates firm substrates in a fine sediment environment, and is used as nurse logs by spruce and cedar.

Water Quality

In the past, water quality problems have been significant in Grays Harbor and were thought to contribute to a bottleneck for salmon production from the Chehalis River, particularly for wild coho production (Schroder and Fresh 1992). Most of the Grays Harbor water quality problems for salmonids have been chemicals; specifically those discharged from the Weyerhaeuser and ITT-Rayonier pulp mills. Water quality problems in Grays Harbor occurred as early as 1928 when Grays Harbor Pulp and Paper Co (later became ITT-Rayonier) began to release acid waste that killed large numbers of fish and shellfish (Wendler and Deschamps 1955; Hiss and Knudsen 1992). In 1957, another pulp mill was constructed. This one was located in Cosmopolis and owned by Weyerhaeuser Company. It discharged through a series of ponds into the Harbor near south Aberdeen. In the late 1980s, the mills' discharges were also toxic for oyster larvae and rainbow trout as shown in bioassays (Schroder and Fresh 1992).

A parasite seemed to worsen the impact from the inner harbor water quality problems. Schroder and Fresh (1992) demonstrated that wild coho traveling through the inner harbor had higher counts of a fluke, *Nanophyetus salmincola*, compared to wild salmon from the Humptulips drainage. Also, fish held in live boxes in the lower Chehalis River, acquired high levels of this parasite. The habitat in this area is ideal for the intermediate host (freshwater snail) of this parasite. The authors believe that the higher levels of parasites stressed coho salmon and made them more vulnerable to other problems such as poor water quality (Schroder and Fresh 1992). However, the fluke is common in low-gradient streams and does not impact salmon in the absence of water quality degradations (Dave Seiler, WDFW, personal communication).

Beginning in 1990, the Weyerhaeuser mill greatly changed operations to reduce the discharge of chemicals into the harbor, and since then, the ITT-Rayonier mill has ceased operations. It is very likely these actions improved water quality within Grays Harbor, but data showing recent conditions are sparse. One year’s worth of data was collected on the brood of coho juveniles that traveled through the inner harbor after the mill improvements. This brood of Chehalis coho salmon survived as well as Humptulips coho salmon (Dave Seiler, WDFW, personal communication). However, further tagging and monitoring of subsequent broods has not occurred due to cessation of tagging, onset of selective fishing, and poor marine survival. Also, in the late 1990s "no chronic toxicity was detected" in the mill effluents (DOE 1999). This suggests that Grays Harbor water quality may no longer be the most single largest bottleneck for salmon production from the Chehalis River, but further testing of discharges and their effects on salmonids remains an important data need.

Dioxin has been found in the sediments below both mill outfalls (Schroder and Fresh 1992). It binds to sediments and debris, and accumulates in invertebrates to become part of the food web. It has been suggested that dioxin-contaminated amphipods may increase salmon smolt mortality (Hiss and Knudsen 1992). Dioxin is still a concern in inner Grays Harbor based upon samples of flounder tissue (EPA 1999). A Total Maximum Daily Load (TMDL) has been approved, and is in progress to determine the extent of the problem.

In 1998, Grays Harbor sediment sampling showed low sediment chemical concentrations, with a few localized problems (Norton 1999). Of greatest concern was the Grays Harbor Paper Mill, which exceeded standards with significant levels of 4-methylphenol. Westhaven Cove was noted as having high enough concentrations of bis (2-ethyl hexyl) phthalate to elicit concern. These chemicals are believed to impact invertebrates that comprise part of the salmonid food web. The Little Hoquiam Boatyard was sampled, and did not have any chemical violations (Norton 1999). Of 15 other sampled sites, 6 violated standards.

In 1994 and 1995, high levels of pesticides were documented in an unnamed stream that empties into South Bay near Bay City, and this ditch is on the 1998 303(d) List for various pesticide chemicals. The stream drains cranberry bogs, and contains diazinon, chlorpyrifos (Dursban), and azinphos-methyl (Guthion) (Jennings 1995). These chemicals are toxic to invertebrates that can serve as food for salmonids.

Sevin (carbaryl) has been used to treat oyster beds in Grays Harbor for ghost and mud shrimp (Jennings 1995). About 200 acres of tidelands are treated and its effect upon salmonids and their food sources is unknown and is a data need.

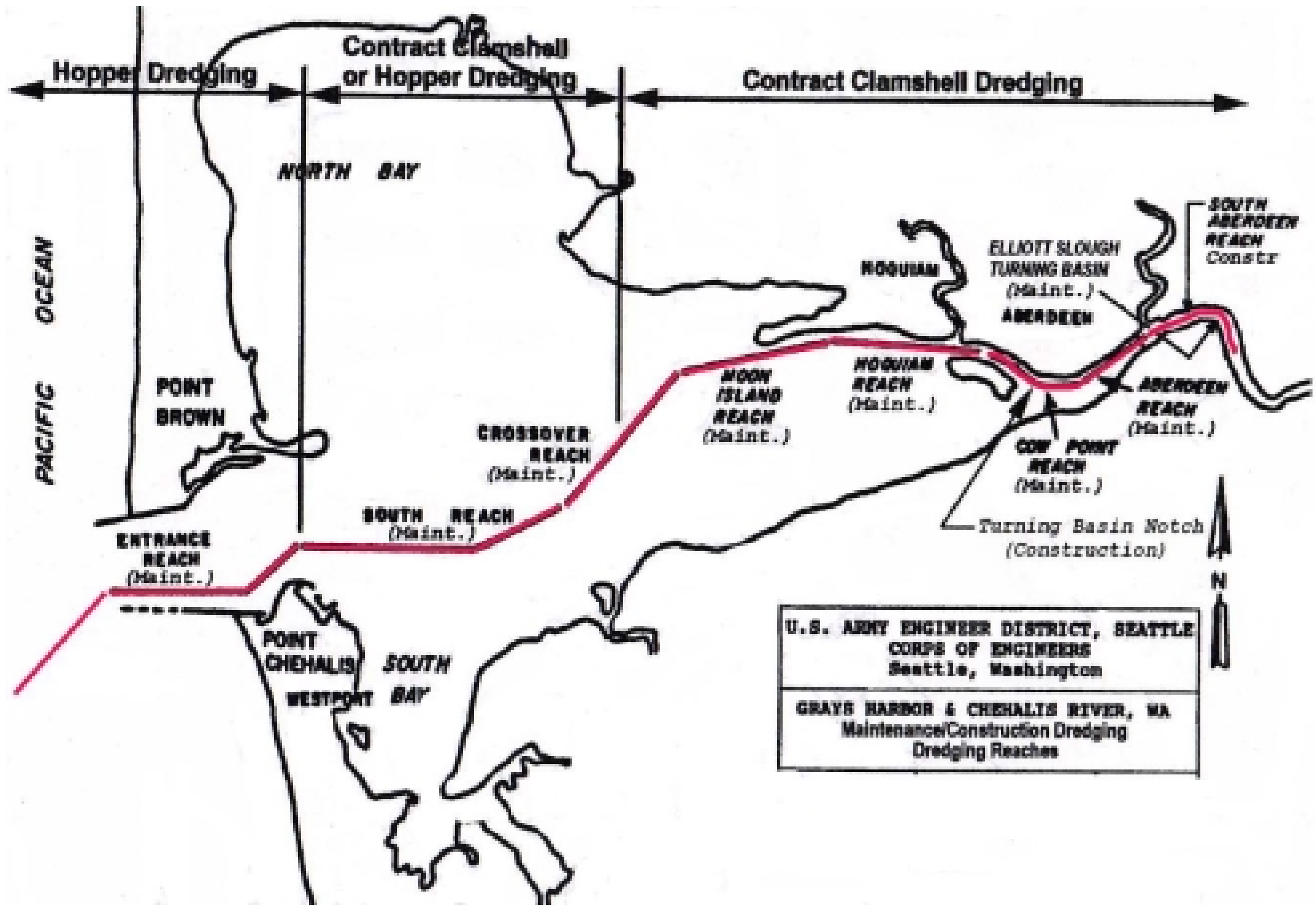
The U.S. Environmental Protection Agency has rated Grays Harbor as having "serious problems with low vulnerability" (EPA 1999). This rating means that there are serious water quality problems, but they are unlikely to worsen in the near future. Both the inner and outer Grays Harbor sections are on the 303(d) List for fecal coliform, but much of the source of fecal coliform comes from upstream. In addition, numerous sites in all sampled areas of Grays Harbor have violated water temperature, dissolved oxygen, or pH standards. However, these current exceedances are believed to be the result of natural conditions, such as ocean upwelling bringing in water low in oxygen or solar heating of shallow water (DOE 1999). The EPA rating together with the recent sediment chemical violations, results in a water quality rating as "poor" for the Grays Harbor estuary (see Assessment Chapter). However, it is important to note that improvements have been made and current impacts to salmonids are unknown and are a high priority data need.

Dredging

The water quality problems have been worsened by the inner harbor dredging. Dredging likely holds together wastewater and fish for longer periods of time (Dave Seiler, WDFW, personal communication) and increases side slope instability and turbidity (Bob Burkle, WDFW, personal communication). An additional concern is that dredging re-suspends some of the contaminants contained within the sediments. The increased turbidity may reduce eelgrass habitat, which is important for copepod production, a major food of juvenile salmonids (Bob Burkle, WDFW, personal communication). However, trends in eelgrass habitat have not been monitored within Grays Harbor and remains a data need.

One improvement is that the Army Corps of Engineers has agreed not to dredge during the coho salmon outmigration period (Schroder and Fresh 1992). Dredging is still extensive throughout the outer and inner channel, and the outmigration of salmonid juveniles can occur throughout the year. The dredged area is shown in Figure 13. Maintenance dredging of 2,700,000 cubic yards of sediment occurs annually, with most of the dredged spoils deposited near the South Jetty or Point Chehalis (ACOE 1998). An additional 60,000 cubic yards are dredged biennially in Elliot Slough, and new dredging is scheduled for the years 1999 to 2000 to remove 55,000 cubic yards near South Aberdeen and 1,000 cubic years near the Cow Point Turning Basin Notch (ACOE 1998). Up to a two-year total of 600,000 cubic yards of materials are deposited at Half Moon Bay and another 400,000 cubic yards at South Beach to function as erosion control.

Figure 13. Dredging sites in Grays Harbor (ACOE 1998).



Loss of Estuarine Habitat in Grays Harbor

There have been varying estimates of estuarine habitat loss for Grays Harbor. In 1996, NRC estimated that about 30% of historic estuary has been lost, and this is probably the best estimate to-date. This amounts to 14,579 acres lost, and includes all types of estuarine habitat. The specific known areas of loss include wetlands near Cow Point and tidelands that were filled to build the cities of Aberdeen and Hoquiam (Hiss and Knudsen 1992). Significant diking exists in the lower Wishkah and Hoquiam Rivers and near Montesano, with minimal diking near Humptulips (Burrows Road) (Bob Burkle, WDFW, personal communication). Additional impacts include a rail line along the Johns River estuary (Bob Burkle, WDFW, personal communication). A different estimate examined marsh habitat. Seliskar and Gallaghar (1983) estimated that 3,840 acres of marsh habitat has been lost, but this analysis did not include other types of estuarine wetlands. Using the rating system for this project and the NRC estimates (see Assessment Chapter), the Grays Harbor estuary would rate “fair” for habitat loss.

Lower River Off-Channel Habitat

Between RM 1 (east of Aberdeen) and RM 11 (just west of the Wynoochee River), the lower Chehalis River comprises a large, fairly undeveloped floodplain complex with numerous sloughs and canals (Ralph et al. 1994). These are under strong tidal influence with nearby vegetation that is dominated by older conifers and hardwoods (Ralph et al. 1994). Juvenile coho salmon have been documented in several of these sites (Moser et al. 1991; Simenstad et al. 1992), and it is likely that other species of salmonids are using this habitat as well. This large, undeveloped estuarine floodplain habitat should be preserved, as it is one of the few areas within the basin that is in a relatively natural state.

Between RM 13-20 of the lower Chehalis River, 23 freshwater off-channel sites have been identified as potential coho over-wintering habitat (Ralph et al. 1994). These areas are wetlands that are no longer connected to the main channel or need additional work such as vegetation and exclusion of cattle. The sites are shown in Figure 14. Table 7 lists each site and the type of work necessary to convert it to productive salmon habitat.

Figure 14. Potential Off-Channel Coho Rearing Sites in the Lower Chehalis River (Ralph et al. 1994).

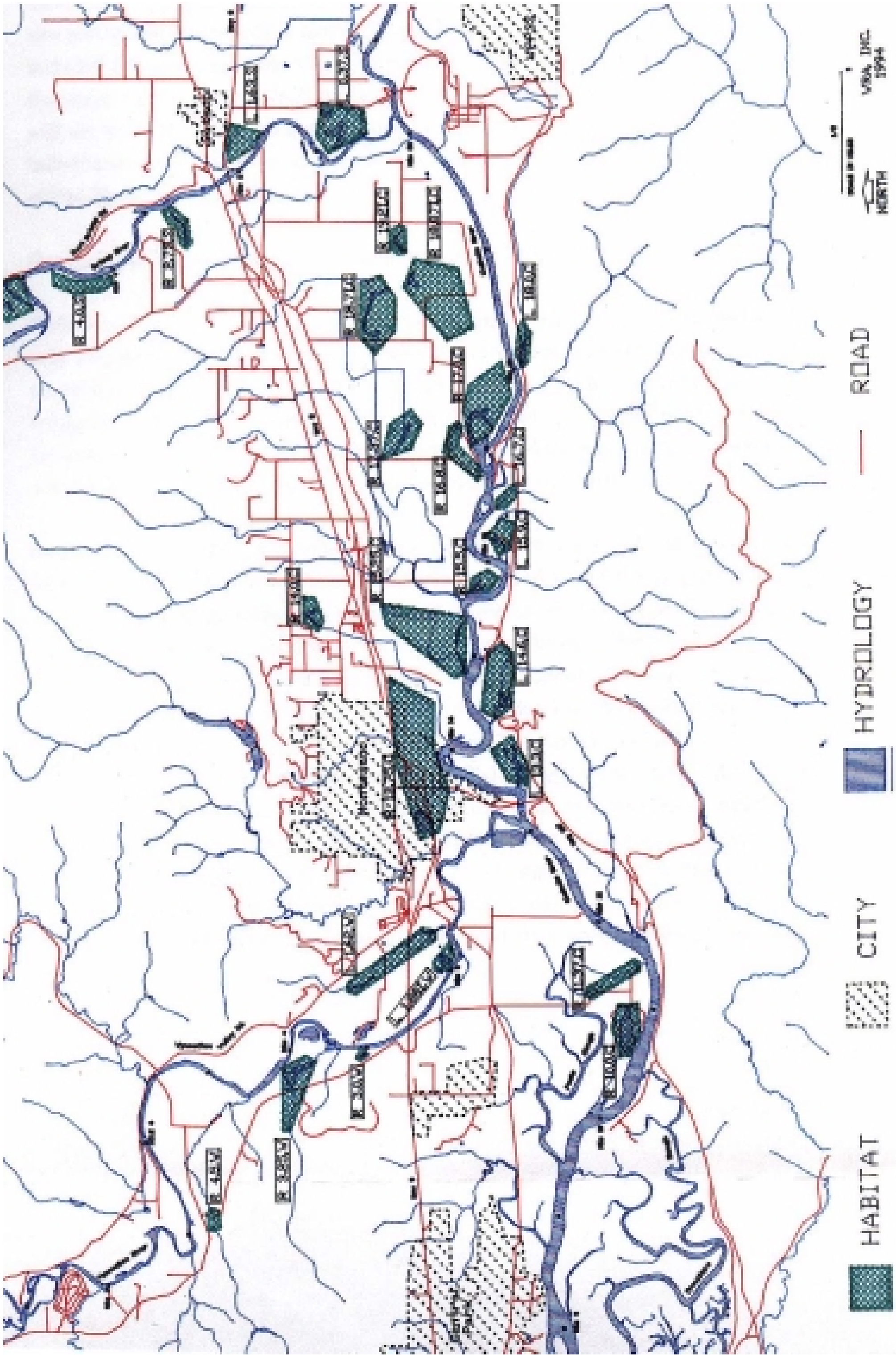


Table 7. Potential Off-Channel Coho Salmon Habitat Sites in the Lower Chehalis River (Ralph et al. 1994).

RIVER	Site No.	Sub-Area	River Mile	Quad Map Name	Air Photo Number		Restoration potential
CHEHALIS	R 10.0 Che		10	Central Park	54	224	Re-vegetate banks/clear 2nd egress channel
	R 11.37 Che		11.37	Central Park	54	224	Clear lower outlet channel
	L 13.3 Che		13.3	Montesano	57	78	Prevent cattle access
	R 13.75 A1,2 Che	1&2	13.75	Montesano	57	78	Re-excavate & re-vegetate outlet channels
	R 13.75 A3 Che	3	13.75	Montesano	57	78	Improve connectivity with area 4
	R 13.75 A4 Che	4	13.75	Montesano	57	78	Create connectivity with area 5
	R 13.75 A5 Che	5	13.75	Montesano	57	78	Create connectivity with neighboring sites
	R 13.75 A6 Che	6	13.75	Montesano	57	173	Clear culverts/prevent cattle access
	R 13.75 A7 Che	7	13.75	Montesano	55	173	Clear culverts of debris and vegetation
	R 13.75 A8 Che	8	13.75	Montesano	55	173	Excavate new egress channel to Sylvia Creek
	R 14.0 Che		14	Montesano	57	78	Re-excavate & re-vegetate outlet channel
	L 14.6 Che		14.6	Montesano	57	78	Create connectivity between areas 1-4
	R 15.25 Che		15.25	Montesano	58	35	Prevent cattle access/re-vegetate oulet channel
	R 15.5 Che		15.5	Montesano	58	35	Prevent cattle access
	L 15.9 Che		15.9	Montesano	58	35	Install culvert/prevent cattle access
	L 16.7 Che		16.7	Montesano	59	252	Clear egress channel
	R 16.8 Che		16.8	Montesano	59	252	Install culvert under access road
	R 17.0 Che		17	Montesano	59	252	Create connectivity with neighboring sites
	R 17.37 Che		17.37	Montesano	60	210	Culvert replacement/re-excavate inlet channel
	L 18.0 Che		18	Montesano	60	210	Clear and modify culverts/modify earthen dam
	R 18.7 I Che		18.7	Montesano	60	210	Create connectivity/re-vegetate inlet channel
	R 18.87 I Che		18.87	Montesano	60	210	Create connectivity with neighboring sites
	R 19.2 I Che		19.2	Montesano	61	45	Create connectivity/prevent cattle access
SATSOP R.	L 0.37 Sat		0.37	South Elma	62	27	Excavate new egress channel to area 1
	L 1.63 Sat		1.63	South Elma/Elma	61	48	Prevent cattle access
	R 2.75 Sat		2.75	Prices Peak/Elma	61	48	Re-excavate outlet channel/prevent cattle access
	R 4.0 Sat		4	Prices Peak	60	216	Clear outlet channel/excavate additional ponds
	L 5.0 A1 Sat	1	5	Prices Peak	60	216	Clear outlet channel
	L 5.0 A2 Sat	2	5	Prices Peak	60	216	Prevent cattle access
WYNOOCHEE	L 1.62 Wyn		1.62	Central Prk./Mont.	55	173	Clear and modify culverts/prevent cattle access
	L 1.88 I Wyn		1.88	Central Park	55	173	Excavate egress channel/add debris matrices
	R 3.0 Wyn		3	Central Park	54	229	Clear outlet channel/modify earthen dam
	R 3.25 Wyn		3.25	Central Park	54	229	Replace culvert/prevent cattle access
	R 4.5 Wyn		4.5	Wyn. Vall. S.W./C.P.	53	13	Re-vegetate outlet channel/prevent cattle access

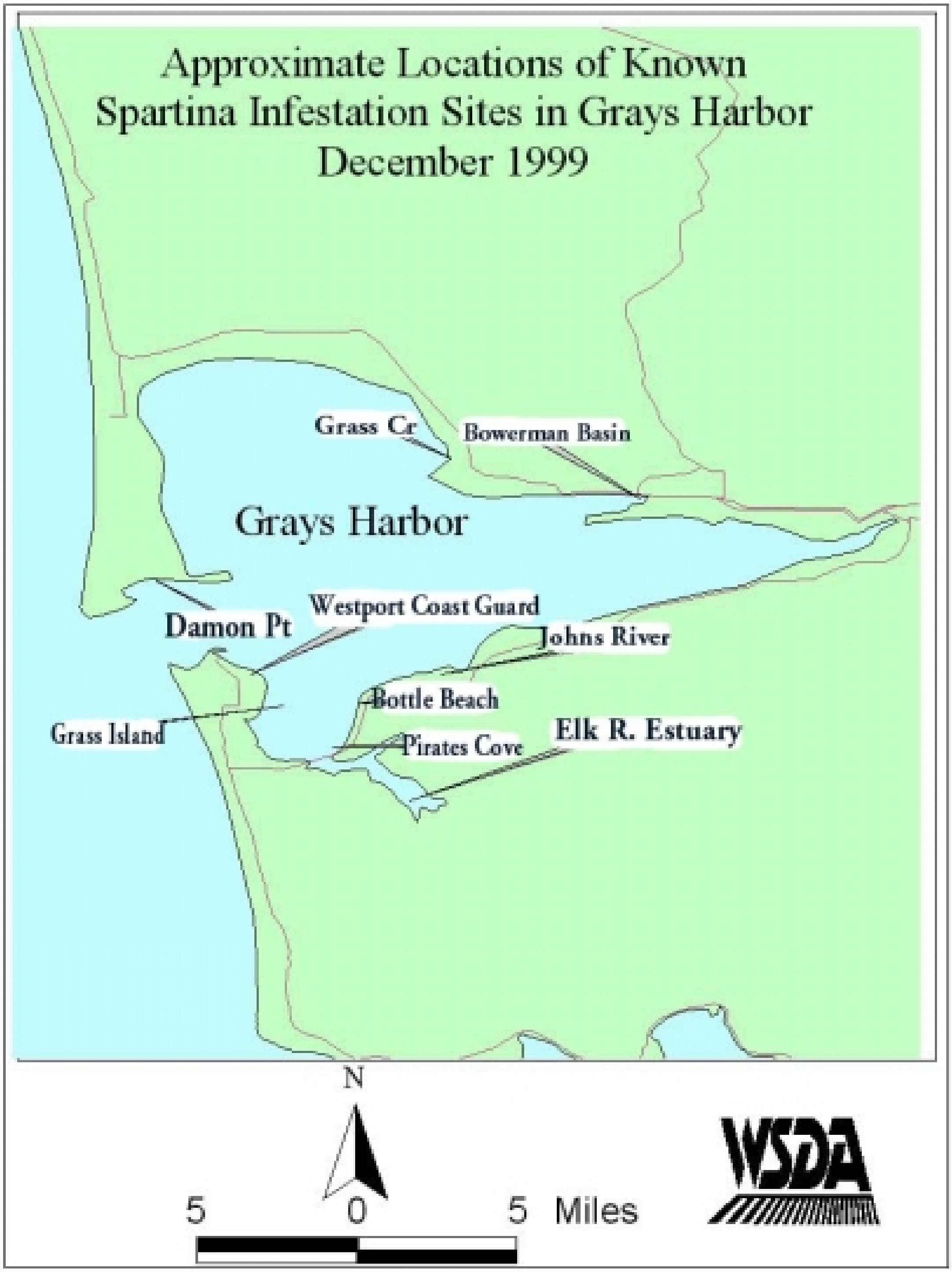
Invasive Species

Spartina is a major invasive species threat in Willapa Bay, and there is great effort to prevent its spread to Grays Harbor. *Spartina* forms thick clones that trap sediments, turning tideflats into meadows. Tideflats contain microalgae that support the foodweb salmon depend upon in estuary habitats. *Spartina* invasion also reduces nutrient cycling, displaces eelgrass, and converts open habitat into an impenetrable area.

Spartina's impact on juvenile salmon rearing habitat, as well as the ecosystem upon which the young salmon depend, is unknown, but the displacement of native eelgrass is a great concern. Eelgrass provides important nursery habitat for juvenile salmonids. Juvenile salmon use the eelgrass to hide from predators, as well as feed on copepods that are living on the bacteria from decaying eelgrass (Levings 1985; Webb 1991).

Although *Spartina* was introduced to Willapa Bay from the East Coast about 100 years ago, it was not documented in Grays Harbor until 1992 (Blain Reeves, personal communication, Washington State Department of Agriculture). Since then, small quantities of Spartina have been documented and eradicated in several sites within Grays Harbor (Figure 15). Those sites include: Grass Creek, Bowerman Basin, Johns River, near the Westport Coast Guard Station, Damon Point, Grass Island, Bottle Beach, Pirates Cove, and the Elk River Estuary (Blain Reeves, personal communication, Washington State Department of Agriculture). The TAG recommends continued eradication of Spartina within Grays Harbor.

Figure 15. Spartina Infestation Sites within Grays Harbor (Blain Reeves, Washington State Department of Agriculture).



Predation

The most likely predators impacting salmonid survival in Grays Harbor are marine mammals (e.g. harbor seals), squawfish (*Ptychocheilus oregonensis*), and birds (e.g. the common merganser). These are documented predators on juvenile salmonids that can consume large numbers of fish in certain circumstances (Foerster and Ricker 1941; Fiscus 1980; Mace 1983; Rieman and Beamesderfer 1988), and all of these predators are found in Grays Harbor.

The most abundant marine mammal in Grays Harbor is the harbor seal, and haul-outs for seals are mostly located in North Bay and the outer Grays Harbor estuary (Schroder and Fresh 1992). Although harbor seals can be found throughout the year, seals in Grays Harbor generally pup and breed in Grays Harbor in the summer, and feed in the Columbia River in the fall through spring months (Beach et al. 1985; Brown et al. 1995). In Washington State, the numbers of harbor seals have increased by 7.7% annually between 1978 and 1993, with an estimated population of 5,422 seals along the Washington Coast in 1993 (NMFS 1997). Beach et al. (1985) analyzed the diet of these predators in Grays Harbor and the Columbia River, and provided evidence that adult salmon, but not juveniles, were consumed. Adult salmon made up a small percentage of the diet of harbor seals. In Grays Harbor, the most frequent food items for harbor seals are northern anchovy, flat fish, crustaceans, smelt, and sculpin (Beach et al. 1985). Another study found evidence that harbor seals ate both adults and juvenile salmonids (Brown et al. 1995).

Early studies (prior to 1980) used otoliths as markers for salmon in seal scat samples, but this is unreliable because otoliths are bones found in the heads, and sometimes seals do not consume fish heads. When these early studies were re-analyzed using other bones as markers for salmon presence, the percent of samples containing salmonid remains increased from 4% to10% in Grays Harbor (Riemer and Brown 1996). Most documented impacts are relatively small; however, much larger impacts have been recorded when harbor seals are incidentally caught in Grays Harbor gillnet fisheries. These seals had the largest percentage (50%) of salmonid remains (Brown et al. 1995). This discrepancy could be the result of a biased sample (sampling individual seals that feed heavily on salmonids) or the result of seals taking advantage of fish that are unable to escape predation.

Impacts of marine mammal predation on salmonids do not appear to be a major problem except when the following conditions are met: high local abundance of marine mammals coincident with salmonid migrations, restricted passage (such as the Ballard Locks), and depressed salmonid populations (NMFS 1995). In Grays Harbor, two of these conditions exist. The population of marine mammals has been increasing, and there are at least two salmonid stocks that are considered depressed: Satsop summer chinook and Chehalis winter steelhead (NMFS 1997). To prevent marine mammal predation from worsening, maintaining unrestricted passage for salmonid migration is essential. Activities that slow the migration of either juveniles or adults can create habitat conditions that encourage increased marine mammal predation. Dredging is one example that can potentially create still-water areas that slow the outmigration of juveniles.

California sea lions are infrequently seen in Grays Harbor, but have been observed far upriver in the Chehalis mainstem (NMFS 1997). They generally migrate to Washington waters from September to May, and their population has increased by 5% annually (NMFS 1997). Their impact on salmonids in the Chehalis Basin has not been studied, but maintaining flows and unrestricted passage for salmonids remains the best recommendation.

Large numbers of migratory and resident birds use Grays Harbor (Herman and Bulger 1981). Predation from birds is evident, and Schroder and Fresh (1992) suggested that poor environmental conditions in the inner harbor could increase salmonid susceptibility to predators. In other studies that documented bird predation on salmonids, predation is highest when the fish were sick (Mace 1983; Ruggerone 1986; Wood 1987a,b). The high levels of parasitism from the lower Chehalis River could be a factor that would likely stress wild salmonids. Another potential bird predation problem on salmonids is the environment near the jetty. Rockfish and lingcod near the jetty likely force juvenile salmonids to the narrow channel of open water, which makes them more susceptible to bird predation (Bob Burkle, WDFW, personal communication). All of these possible bird predation scenarios have not been supported by studies specific to this region. Without objective information, potential predation of salmonids by birds remains a data gap.

Northern pike minnow (squawfish) are abundant in the Chehalis River, but were not found to account for unusually high levels of salmonid mortality (Schroder and Fresh 1992). After sampling squawfish stomachs, salmon smolts were found in only 3.5% of the stomachs. Most predation occurred in the lower Chehalis River, and most were found after the release of hatchery fish.

Nearshore Conditions

The nearshore environment associated with the Chehalis and nearby drainages is characterized by long stretches of fine-sand beaches with low-lying dunes (Strickland and Chasan 1989). Foredunes, closest to the ocean, help protect against storms, while the area between the dunes and foredunes contains groundwater reserves that extend 35 to 70m deep (Strickland and Chasen 1989). No kelp beds have been found in the nearshore stretch from Kalaloch to the Columbia River (Van Wagenen 1998).

Until recently, the Pacific shoreline has been growing due to the addition of sand from the former Columbia River delta (DNR 1999), and this “new land” has been under intense development near beaches. However, with the construction of numerous dams in the Snake and Columbia River Basins in the last several decades, the sediment supply has decreased by 24 to 50% of the quantity in the pre-development era. Now the coastal shorelines are eroding instead of growing. The erosion is worsened by the loss of vegetation near and on the dune habitat as a result of development (DNR 1999). Vegetative cover on dunes helps prevent erosion by wind and water.

In Ocean Shores, a seawall was constructed in 1996 in response to the erosion, but these seawalls typically accelerate the beach loss. An increase in erosion has been noted both north and south of the Ocean Shores seawall (DNR 1999).

Rating of Grays Harbor Estuary Conditions

Several aspects of the Grays Harbor estuary were assessed. There has been a loss of at least 30% of historic estuary, which is relatively low compared to other losses in Washington State, and this results in a "fair" rating. The level of *Spartina* invasion has been kept to a minimum, resulting in a "good" rating for biological processes. Predation has not been documented as excessive, and this also contributes to the "good" rating for biological processes. However, chemical input and fecal coliform problems persist, resulting in a "poor" rating for water quality. The lack of LWD in the estuary has resulted in a "poor" rating for this category. Lastly, the nearshore environment was rated "fair" because of the loss of gravel recruitment from the Columbia River. There is also concern about seawall impacts leading to greater erosion, but this is a highly localized problem and is not widespread. Additional estuarine ratings and discussions are included in the Humptulips, Hoquiam, Wishkah, and South Grays Harbor sections.

Habitat Limiting Factors in the Mainstem Chehalis River

<u>Loss of Fish Access in the Mainstem Chehalis River</u>

Currently, there are no dams or other human-made structures that block the upstream or downstream movement of salmonids in the mainstem Chehalis River. In the past, seven splash dams were built in the mainstem Chehalis, all located upstream of the confluence with Bunker Creek (Wendler and Deschamps 1955). While most of these dams existed for less than 10 years, the longest lasting dam was built prior to 1920, laddered in 1936, and finally removed in 1944 (Wendler and Deschamps 1955). The dams were listed as partial blockages to salmon, without specific information regarding the extent of impact. Other habitat problems are associated with splash dams, and are discussed in the Streambed/Sediment and Floodplain sections. Current fish access conditions are rated "good" for the mainstem Chehalis River.

<u>Floodplain Conditions in the Mainstem Chehalis River</u>

Specific surveys of floodplain impacts are lacking for the entire Chehalis River mainstem, particularly for wetlands, off-channel habitat, and impacts such as channel incision. There has been an off-channel inventory for the lower mainstem (Ralph et al. 1994) and an examination of the floodplain near Centralia (ACOE 2000 draft), and those results are discussed below. There has also been a habitat survey of bank structures along the entire mainstem Chehalis River, but off-channel habitat condition was not part of that study (Wampler et al. 1993).

The habitat survey noted that bank structures, such as rip-rap or dumping, comprised 8.1 total miles of stream length along the mainstem Chehalis River, which has a total length of 118.9 river miles (Wampler et al. 1993). Most of the sites were located near the Skookumchuck River, Newaukum River, Salzer Creek, and the South Fork Chehalis

River. A few scattered sites were mapped along the lower Chehalis mainstem (WRIA 22). Overall, this is a low level of impact, but the more concentrated areas of rip-rap (near the Skookumchuck, Newaukum, Salzer, and the South Fork Chehalis River) are rated "poor".

The lower mainstem Chehalis River is discussed in the Estuary Section. Briefly, the area between RM 1 to 11 consists of a natural floodplain in "good" condition. The reaches between RM 13-20 have shown some off-channel habitat loss, with 23 sites identified as having future restoration potential (Ralph et al. 1994). From the confluence of the Satsop River (RM 20) to Grand Mound (RM 57), the mainstem channel has areas of incision that can result in juvenile salmonid stranding (Mike McGinnis, Chehalis Tribe, personal communication). Although this area is impacted, it appears to function better than the remaining upstream reaches.

From river mile 57 to 79 (Grand Mound to upstream of Stearns Creek), the mainstem channel appears to have incised along a greater portion of its length (ACOE 2000 draft; Mike McGinnis, Chehalis Tribe, personal communication). This observation is based upon a low width to depth ratio with high banks coupled with steepened profiles of the mouths of the Skookumchuck and Newaukum Rivers just before they join the mainstem Chehalis River (ACOE 2000 draft). The channel incision has likely reduced off-channel habitat and connection with wetlands. This is the same reach that experiences very low dissolved oxygen in the summer months due to deep, slow-moving water coupled with algal blooms. Channel incision would increase the risk of water quality problems by disconnecting wetlands as well as forming the low width to depth ratio. The TAG expressed concern that the mainstem channel incision is extensive, with "poor" reaches extending from the East Fork/West Fork confluence downstream to Grand Mound (Mike McGinnis, Chehalis Tribe, personal communication).

Areas of channel incision have been documented in the mainstem Chehalis River upstream of Pe Ell (Weyerhaeuser 1994a). Channel incision is also a concern in the mainstem reaches between Pe Ell and Bunker Creek because of past splash dams. Splash dams typically result in extensive loss of gravel and large woody debris (LWD) in the reaches immediately downstream of the dam. This leads to channel incision, where the channel cuts downward and disconnects the stream from its floodplain, reducing side channel habitat access. Splash dams were built in seven areas of the mainstem Chehalis, all located upstream of the confluence with Bunker Creek in the upper mainstem (Wendler and Deschamps 1955). In this reach, there are areas of natural confinement mixed in with channel incision (Mike McGinnis, Chehalis Tribe, personal communication).

In addition to channel incision, drainage and filling of wetlands is another floodplain impact. It is known that considerable filling has occurred, but the extent of wetland loss has not been quantified. Maps comparing historic versus current wetlands are a data need.

Based upon the channel incision impacts, floodplain ratings for the mainstem Chehalis River are "good" from RM 1 to 11, "unknown" from RM 12 to 20, "fair" from RM 20 to

57, and "poor" from RM 57 to 118.9. Investigations are needed to more clearly define the channel incision from RM 57 to 79. This should be a high priority data need because the area is also an extremely degraded water quality reach, as well as a high flood potential area. Another data need is wetland mapping and an examination of lost wetland habitat. Efforts to restore off-channel habitat should also be a high priority throughout the mainstem Chehalis as well as in the lower reaches of tributaries to the Chehalis mainstem, to provide important refuge habitat.

Streambed and Sediment Conditions in the Mainstem Chehalis River

Increased sediment transport appears to be a major problem in the mainstem Chehalis River with two primary causes: excess sediment loading from certain tributaries and the loss of large woody debris (LWD) throughout the drainage. This results in a "poor" rating for sediment quantity. The USGS estimated sediment loading in the lower Chehalis mainstem River from 1962 to 1965, and attributed 43.8% of the sediment load to the Satsop sub-basin, 30.6% to the Wynoochee sub-basin, and about 25% as originating from the reaches upstream of Porter (CRC 1992). The main sources of sediment upstream of Porter include the mainstem Chehalis River above Doty, the South Fork Chehalis River, and Newaukum River. The Skookumchuck and Black Rivers contribute relatively low levels of sediment to the mainstem Chehalis (CRC 1992).

The mass wasting (landslide) potential map developed by DNR also indicates that the area along the mainstem Chehalis River from RM 11.5 to 21 on the left bank side (looking downstream) is another site of moderate to high mass wasting potential (Figure 16). Also, high potential soil erosion exists along the mainstem Chehalis River from RM 11.5 to 18 on the left bank side (Figure 17). This indicates that sediment issues should be prioritized in the Satsop, Wynoochee, upper Chehalis, South Fork Chehalis, and Newaukum Rivers, as well as along the mainstem Chehalis River from RM 11.5 to 21.

The causes of excess sediment are landslides due to roads and clearcuts on steep slopes (Weyerhaeuser 1994a, 1994b, 1997, 1998; Weyerhaeuser and Simpson Timber Co 1995). Shallow, rapid landslides appear to be the most frequent type of mass wasting (Mike McGinnis, Chehalis Tribe, personal communication). The worst road problems are sidecast roads, which were constructed decades ago and remain a landslide threat today (Weyerhaeuser 1994a, Weyerhaeuser 1994b; Weyerhaeuser and Simpson Timber Co 1995). Sidecast roads are no longer built. A full discussion of these is in each of the Streambed/Sediment sections for the tributaries.

Splash dams were built in seven areas of the mainstem Chehalis, all located upstream of the confluence with Bunker Creek in the upper mainstem (Wendler and Deschamps 1955). Most dams were present for less than 10 years, although one existed for about 24 years (Wendler and Deschamps 1955). Splash dams result in extensive loss of gravel and large woody debris (LWD) in the reaches just downstream of the dam.

Bank erosion was noted for about 24 miles of the Chehalis River mainstem, and other sources of sediment were documented for 7.4 miles (compared to a total of 118.9 miles of mainstem habitat) (Wampler et al. 1993). Erosion was common in the upper Chehalis near the East Fork Chehalis River, from the confluence of Elk Creek to the South Fork Chehalis River, from near the mouth of Bunker Creek to the Skookumchuck River, near Scatter Creek and Garrard Creek, and from Porter to the Satsop River confluence (Wampler et al. 1993). The ACOE (draft 2000 report) indicated that bank erosion along RM 57 to 79 is likely due to a lack of riparian vegetation coupled with landuse practices (agriculture and urbanization), and is not a result of flood flows. However, the sediment from bank erosion is likely not a large sediment problem compared to landslides and roads in some of the tributaries, especially in the steep-sloped areas of the Satsop and Wynoochee Rivers.

Livestock access can be a contributor to fine sediment inputs and riparian degradation. In an older survey, about 7.7 miles of the mainstem Chehalis River have been documented for livestock access (Wampler et al. 1993). Most of the sites are located near Salzer Creek, downstream of the confluence with the Newaukum River, and near the mouths of Scatter, Independence, Cedar, Porter, and Garret Creeks. In WRIA 22, livestock access problems were noted near the mouths of Mox Chehalis Creek, Cloquallum Creek, and Workman Creek. However, many improvements have been made since this survey. Because of this, sediment ratings will not be based upon livestock access until the data have been updated. Specific measurements of gravel quality, such as percent fine sediments or embeddedness have not been done for the mainstem Chehalis River.

The mainstem Chehalis reach from RM 54 to 79 (Grand Mound to upstream of Stearns Creek) has been studied for flood control measures by the ACOE (draft 2000 report). They state that the channel has remained stable in this area without significant lateral movement. However, the area appears to be incised, which is a significant degradation. The cause of incision in this reach is not yet known. The upper Chehalis mainstem (upstream of Pe Ell) was studied as part of a watershed analysis, which indicated that the scour potential in this area is high due to the confined channel and lack of LWD. Areas of channel incision have been documented in the upper Chehalis mainstem as well, and are attributed to debris torrents. Channel conditions in other areas of the mainstem Chehalis have not been documented.

Measurements of large woody debris levels have not been made within most of the mainstem Chehalis River, but TAG members have indicated that levels appear to be low, resulting in a "poor" rating, as well as a data need. Some instream wood is located in the mainstem Chehalis River near Porter, but the large log jams that historically existed are no longer found (Margaret Rader, Chehalis Basin Partnership, personal communication; Mike McGinnis, Chehalis Tribe, personal communication). Low levels are likely due to active removal of LWD and the severe degradation of the riparian vegetation, which is no longer able to supply adequate wood to the mainstem (see the Riparian section). However, addition of large wood to the mainstem will likely present difficulties due to the channel size, increased peak flows, and channel incision. Instead, recommended restoration activities include reconnection of the floodplain to off-channel habitat, restoration of riparian vegetation with a significant conifer component, and reduction of sediment inputs from high priority areas.

Figure 16. Mass Wasting Potential in the Lower Chehalis River (DNR data 1992). Darker red shading equals a greater mass wasting potential.

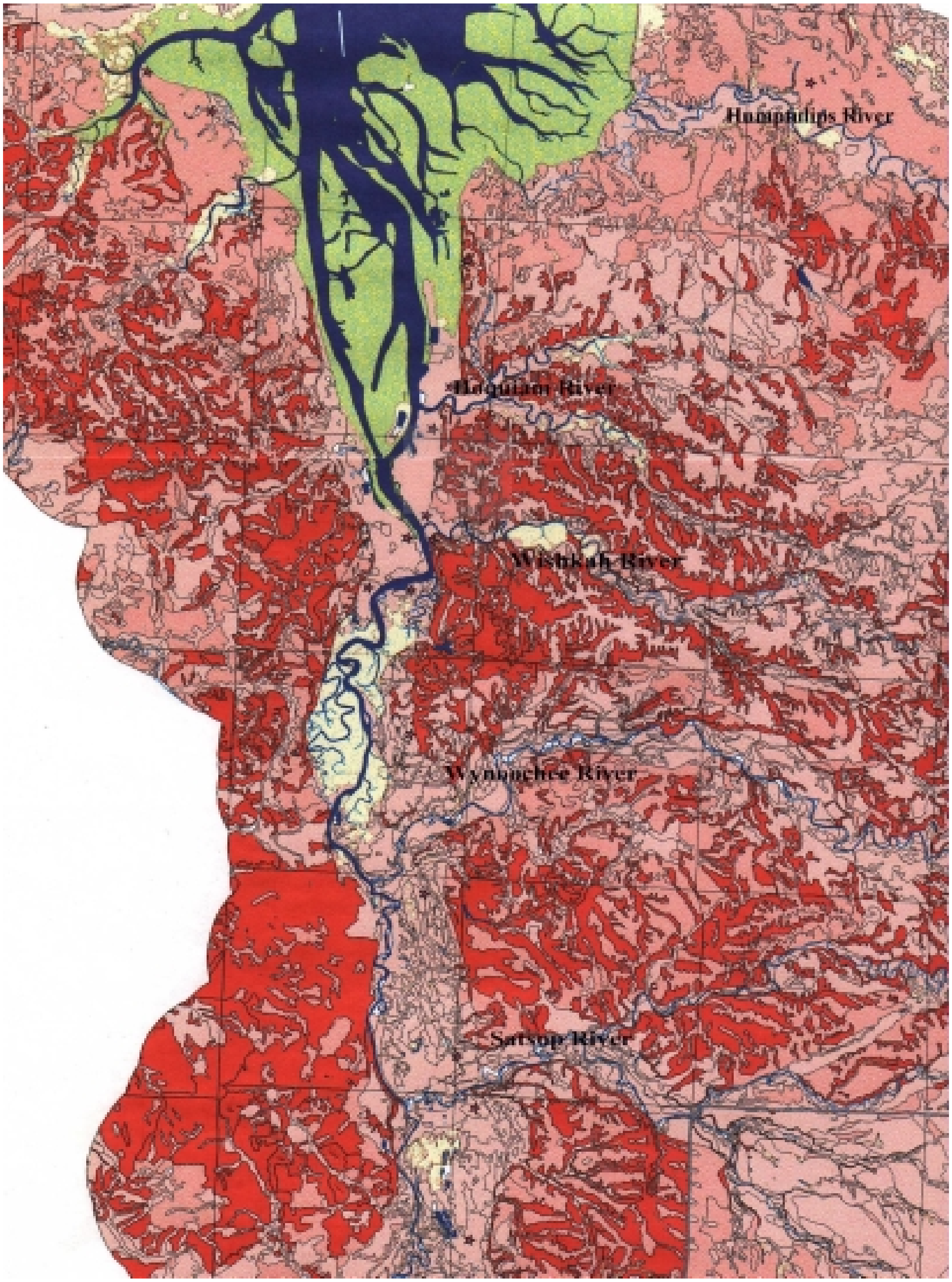
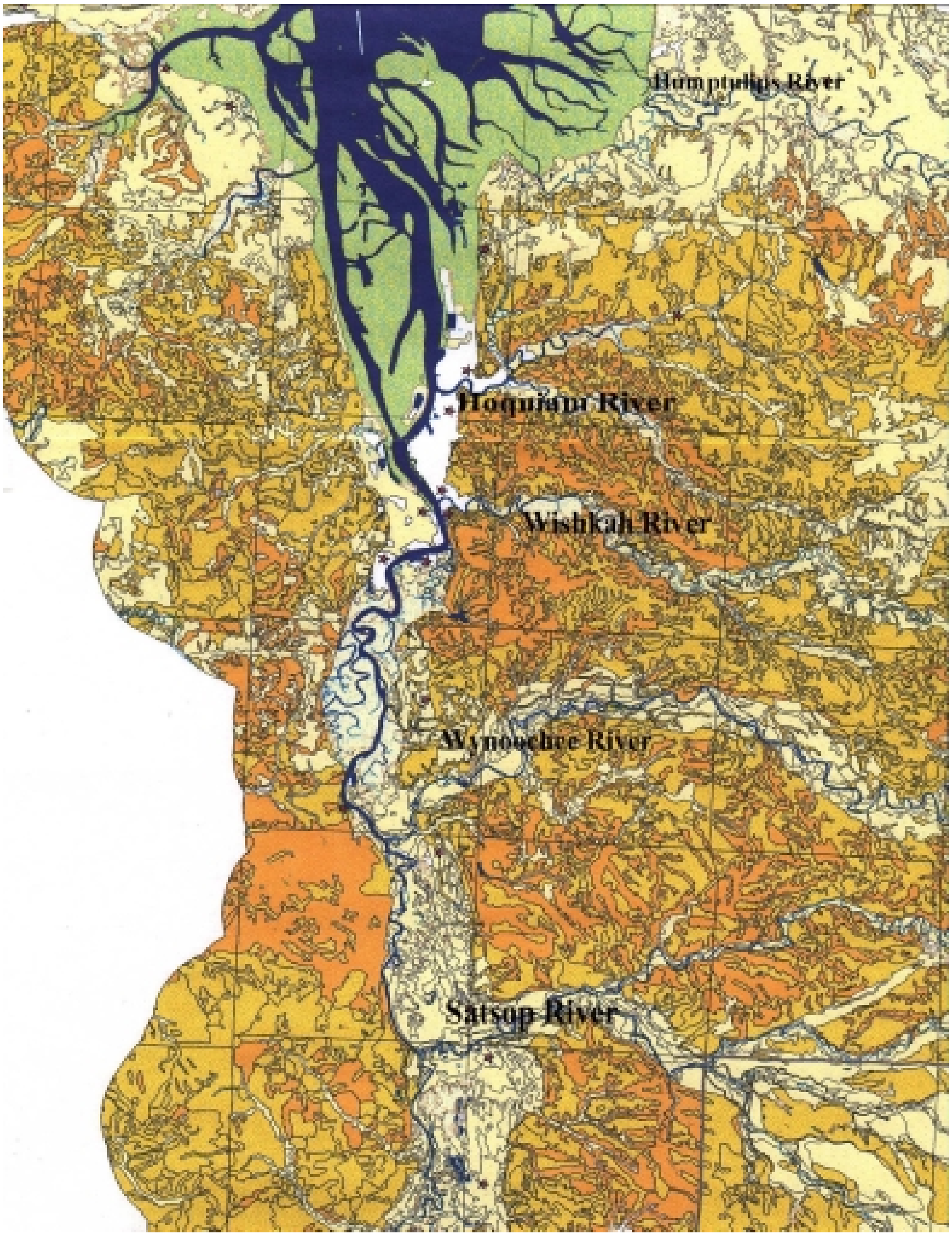


Figure 17. Erosion Potential in the Lower Chehalis Basin (DNR data 1992). The darker colors equal greater erosion potential.



Riparian Conditions along the Mainstem Chehalis River

"Poor" riparian conditions exist throughout much of the mainstem Chehalis River (Map 4a), and "tree canopy loss" is listed as the most extensive mainstem habitat degradation in Wampler et al. (1993). About 105 miles of the mainstem Chehalis River have reduced shade canopy and 23 miles have degraded bank vegetation (many of the bank vegetation degradation miles overlap with loss of shade canopy sections) (Wampler et al. 1993). This compares to 118.9 miles of mainstem Chehalis River, resulting in a "poor" rating for the mainstem Chehalis River. Urbanization is the cause of degraded riparian sections from the mouth of the Chehalis River to its confluence with the Wynoochee River and near Centralia and Chehalis (Wampler et al. 1993). In most other areas, agricultural activities have been identified as the cause for "poor" riparian reaches.

As detailed in the Water Quality section of this report, the riparian conditions along the mainstem have been greatly altered, and contribute considerably to the poor water quality, particularly in WRIA 23. The extensively degraded riparian conditions also result in bank erosion and the lack of large instream wood.

One significant "good" riparian reach is located between Preachers Slough and Cosmopolis (Map 4a). This area also has important off-channel and slough habitat that should be a priority for protection from future degradations.

Water Quality Conditions in the Mainstem Chehalis River

Water quality has been monitored regularly at nine water quality monitoring stations within the lower Chehalis (WRIA 22) and 12 in the upper Chehalis (WRIA 23) (Jennings 1995). From this monitoring, several severe water quality problems have been identified and have led to further investigation. Many reaches of the mainstem Chehalis River are on the 303(d) List for temperature, dissolved oxygen, and fecal coliform levels, which are further discussed below. In addition, the U.S. Environmental Protection Agency ranked 2,110 watersheds (2,110 indicating the highest impact) throughout the country with data regarding agricultural runoff (EPA 1999). The upper Chehalis River ranked 1,057 on this list with the two greatest concerns being nitrogen and sediment inputs.

Warm water temperatures are a major problem throughout the upper mainstem Chehalis River, with 10 segments on the 1998 303(d) List (Butkis 1999). The 10 upper mainstem listed segments are located near RMs 33.8, 44.0, 59.9, 66.3, 67.5, 69.1, 70.7, 73.6, 74.6, and 101.7, which include the mainstem Chehalis River from Porter to a couple miles upstream of Doty. One segment from the lower Chehalis (near RM 13, Wynoochee) is also on the 303(d) List for water temperature. Using a model to evaluate estimated existing shade compared to natural conditions, the most degraded sites are in this priority order:

1) the mainstem between Newaukum River and the Skookumchuck River (168% change between current and natural shade);

2) the mainstem between the Skookumchuck River and Scatter Creek (144% shade change); and,

3) the mainstem between Scatter Creek and Porter (137% shade change) (Butkis 1999).

In addition, the mainstem from Elk Creek to Newaukum River had an estimated 89% shade change and the headwaters to Elk Creek had a modeled 30% shade change.

The model was also used to predict water temperatures if established base flows were met or if the width-to-depth ratio met a standard of 10. If base flows were met, one mainstem reach (Scatter Creek to Porter), as well as the South Fork Chehalis River and the Black River, would meet water quality standards (Butkis 1999). Other reaches have a significant reduction in needed shade (Table 8). If the width to depth ratio met 10, nearly all 303(d) listed reaches within WRIA 23 would meet water quality standards, according to the model (Butkis 1999). Width-to-depth changes are a function of sedimentation. Within WRIA 23, excess sedimentation has been documented in the Upper Chehalis and Newaukum sub-basins (see sedimentation chapters for those areas). This suggests that temperature problems within the mainstem Chehalis River could be addressed by several restoration activities that result in a more naturally functioning channel. These include reduction of water withdrawals from both surface and ground sources (see Water Quantity section), riparian restoration (see prioritized sites below), and reduction of sediment transport (sites are prioritized in the mainstem Streambed/Sediment section).

The upper reaches of the mainstem Chehalis River attain maximum temperatures one month earlier than lower reaches within WRIA 23 (Jennings 1995). This is likely due to lower flow volumes in the upper reaches. The lower sections begin a cooling trend a month later than in the upper reaches (Jennings 1995).

Low dissolved oxygen levels are also a major problem throughout the mainstem in WRIA 23, as well as in the mainstem Chehalis River near Montesano and the mouth of the Satsop River (Jennings and Pickett 2000). The reaches from Porter to the confluence of the East Fork/West Fork Chehalis Rivers are on the 303(d) List for low levels of dissolved oxygen (RMs 33.3 to 106.7). Causes for low dissolved oxygen levels vary from reach to reach. From Porter to Scammon Creek, the primary cause is livestock waste. From Scammon Creek to Newaukum River, causes include urban stormwater, food processing plants, and in the upstream section, dairies (Jennings and Pickett 2000). From the Newaukum River to Rock Creek, the primary cause is livestock waste (dairies). In the reach from Rock Creek to the East and West Fork confluence, causes include livestock waste and sewage discharge from Pe Ell (Jennings and Pickett 2000). The TMDL states that the highest priority in restoring dissolved oxygen levels is to eliminate pollution from large-scale commercial livestock operations.

The mainstem Chehalis River stream section between the Newaukum and Skookumchuck Rivers is commonly called the “Centralia Reach”. This section is deep, slow moving, and in the summer, it is stratified with the water near the stream bottom nearly devoid of dissolved oxygen. This condition is natural to some degree, but has been worsened by other inputs. The surface levels have algal blooms resulting from high levels of nitrogen that have been caused by the Chehalis waste treatment plant and upstream non-point sources (Pickett 1992). High levels of algal decay stimulate bacterial growth, which consumes oxygen. In the summer months, dissolved oxygen levels have been as low as

0-0.5 mg/l (CRC 1992). Improvements in wastewater treatments are under development, but other impacts such as riparian loss, increased sediment transport, livestock waste input, and stormwater input need to also be addressed.

At least part of the source for low dissolved oxygen and warm water temperatures in the mainstem is the result of impaired tributaries. Most of the tributaries to the Chehalis River have highly degraded riparian conditions, excess sedimentation, and high BOD (biological oxygen demand) loads. The BOD levels are mostly a result of livestock waste (Jennings and Pickett 2000). Priority segments for dissolved oxygen impacts are listed below, from highest to lowest: Salzer Creek, the Chehalis mainstem at RM 70.7, Dillenbaugh Creek, the Chehalis mainstem between RM 77.6-97.9, the South Fork Chehalis River, Black River, Lincoln Creek, Independence Creek, and Scatter Creek.

In low rainfall months, the stream flows within the Chehalis Basin receive significant inputs from groundwater contribution, especially to the downstream areas near Centralia (Larson 1994). The East Chehalis Surficial Aquifer underlies much of WRIA 23, while the West Chehalis Aquifer extends from Grand Mound to the mouth of the Chehalis River (Larson 1994). The geology in this region consists of impermeable bedrock that results in these aquifers being close to the surface and vulnerable to contamination that is then easily transferred to the Chehalis River surface waters. The aquifer near the cities of Centralia and Chehalis is perched (very close to the surface), which not only results in an increased contamination risk, but also increased flooding.

While the surface water within the Chehalis River mainstem is highly degraded, the groundwater quality is generally good, with a few noted areas of contamination (Jennings 1995). Water quality risks have been documented at more than 50 industrial sites near Aberdeen and Hoquiam and at 30 similar sites near Centralia and Chehalis. These sites include leaking underground storage tanks, waste disposal, or releases of solvents and metals. In addition, failing septic systems and contaminants from agricultural activities have also contributed to elevated nitrates, especially near the cities of Chehalis, Montesano, and Elma, and the Chehalis Reservation, and Dillenbaugh-Berwick Creek (Jennings 1995). Also, low levels of DDT and PCBs have been detected in whitefish and suckers from the Chehalis Basin, with PCB levels in whitefish exceeding standards (Jennings 1995).

Water quality problems also result from alterations to the alluvial aquifers (Poole and Berman in prep). It has been shown in other basins that up to 90% of the watershed's productivity is derived from alluvial aquifers, which support rich populations of invertebrates, such as stoneflies, as well as vertebrates. As runoff and nutrients distribute from the steep upland slopes to the low gradient floodplain, the groundwater and surface waters mix to form areas of high productivity. This occurs particularly in the summer low flows when warm surface waters mix with nutrient-rich cool water. Alluvial aquifers contribute not only to productivity, but also cool water temperatures in the summer and slightly warm surface water in the winter (Poole and Berman in prep.). Removal of upland vegetation decreases the infiltration of groundwater on hillslopes, reducing baseflows in streams and therefore, reducing productivity and water temperature buffering. Excessive sedimentation (see the Streambed Sediment section) can also degrade the floodplain complex (Poole and Berman in prep).

Other water quality concerns within the Chehalis Basin include the potential impacts of wastewater storage sites on groundwater quality, particularly from fish farms, poultry farms, dairies, turf farms, and food processing plants (Jennings 1995). Also, low but detectable levels of 4 pesticides (atrazine, simazine, diuron, and dichlobenil) were measured in the East Chehalis Surficial Aquifer, which underlies WRIA 23 and contributes to surface water flows (Larson 1994). And, although exceedances are rare, pH levels have been moderately high in the summer due to algal blooms and low in the winter as a result of nonpoint organics (Pickett 1992). Lastly, fecal coliform levels are a major problem, especially near Montesano and Centralia, and likely a result of contaminated storm water (Pickett 1992). This report does not focus on fecal contamination. Instead, it emphasizes other water quality factors that more directly impact salmonids.

The water quality rating for the mainstem Chehalis River is "poor" based upon the extensive 303(d) listing of mainstem reaches for warm water temperatures and low dissolved oxygen. Recommended restoration activities for water quality are listed below.

1) Reduce water withdrawals from both surface and ground sources (see Water Quantity section).

2) Restore riparian vegetation in tributaries (prioritize tributaries with warm water problems) and along the mainstem Chehalis River, particularly between Porter and Newaukum Creeks.

3) Reduce sediment transport by addressing excess sediment inputs at their sources (sites are prioritized in the mainstem Streambed/Sediment section). Activities that promote the maintenance and increase of instream LWD would also help address this problem, particularly in the high priority tributaries (Satsop, Wynoochee, upper Chehalis, and Newaukum).

4) Address dissolved oxygen levels by reducing livestock and urban waste inputs into Salzer Creek, the Chehalis mainstem near RM 70.7, Dillenbaugh Creek, the Chehalis mainstem between RM 77.6-97.9, the South Fork Chehalis River, Black River, Lincoln Creek, Independence Creek, and Scatter Creek.

5) Increase activities that lead to natural recharges in the aquifers. In WRIA 23, both flow and water quality are highly dependent on adequate summer flows. These flows are supplied by groundwater. Loss of wetlands, artificial diversion of floodwaters through ditching, and groundwater withdrawals all contribute to a loss of water quality and summer flows in the Chehalis Basin.

Table 8. Estimated Changes in Riparian Shade Needed to bring Water Temperatures to Standards (Butkis 1999)

Stream or Reach	Percent Riparian Shade from Current to Natural	Percent Riparian Change Needed if Base Flows Met	Percent Riparian Change Needed if Width/Depth = 10
Mainstem: Headwaters-Elk	30	24	0
Mainstem: Elk-Newaukum	89	18	0
Mainstem: Newaukum-Skookumchuck	168	95	0
Mainstem: Skookumchuck-Scatter	144	88	0
Mainstem: Scatter-Porter	137	0	0
South Fork Chehalis	44	0	0
Newaukum River	74	17	0
Dillenbaugh Creek	25	25	0
Salzer Creek	10	10	0.8
Skookumchuck River	20	16	0
Lincoln Creek	24	19	2.2
Scatter Creek	10	9	0.5
Black River	73	0	0

Water Quantity Conditions in the Mainstem Chehalis River

Within the Chehalis Basin, snowmelt influence is minimal and stream flows depend mostly upon precipitation (Pickett 1992). Rainfall varies greatly throughout the basin. It is highest in the Satsop and Wynoochee headwaters at greater than 150" per year, to greater than 100" per year in the headwaters of the mainstem Chehalis River, more than 80" per year in the Newaukum and Skookumchuck headwaters, and 45 to 50" of annual rainfall in the central portion of the basin (Pickett 1992). Most of the rainfall occurs from November through March, and the lowest levels from July through August. Some snowmelt contributes to flows in the Skookumchuck and Newaukum watersheds.

The Chehalis drainage is an important coho salmon producer. Estimates for the 1999 smolt production listed the Chehalis drainage as the third highest coho smolt producer in Washington State (Seiler 2000). However, flows are one of the greatest determinants in coho production, and major flow problems exist in the Chehalis sub-basin. Flows during spawning season are a particularly important factor for coho smolt production because low flows during spawning season prevent coho from spawning in the upper reaches of streams, reducing available rearing habitat as fry distribute downstream of spawning areas (Seiler 2000).

During the summer, existing water rights exceed natural stream flows in many of the streams within WRIA 23. Of the 25 Chehalis Basin streams closed to further water appropriations, all but three are in WRIA 23 (Wildrick et al. 1995). Base flows have not been met 77 days/year, as measured at the Porter gage, and 68 days/year at the Grand Mound gage. Since 1953, flows at Porter have decreased 19%, and decreased 10% at Grand Mound (Wildrick et al. 1995). During the same time period, annual precipitation has decreased 6% and 1%, respectively. Total water rights amount to 1,201 cfs, but the seven consecutive day low flow at the Porter gage averaged 308 cfs, which indicates that allocated water is greater than the seven day low flow by about 400% (Wildrick et al. 1995).

Water rights have been issued for the following activities, which are listed from highest to lowest use: irrigation, power, domestic use, fish propagation, commercial use, municipal use, and frost protection. Very low consumption occurs for stock watering and recreation (Wildrick et al. 1995). In the Wampler et al. (1993) inventory, greater than 33 water withdrawal pumps were documented in the upper mainstem Chehalis River from the Skookumchuck confluence to Elk Creek.

During the summer months, stream flows in the Chehalis drainage are maintained by groundwater discharge. Pickett (1994c) measured gains of an average 3 cfs per river mile along the Chehalis mainstem. The area is underlain by bedrock, over which a large aquifer exists and supplies water to streams (Wildrick et al. 1995). This raises concern about well water withdrawals as well as ground water contamination (see Water Quality section).

Adequate flows in the summer months are a vital component of salmonid production within the Chehalis drainage. Low flows appear to have a direct link to coho salmon production during the spawning season, and according to modeling estimates, if all base flows were met, many of the severe water quality degradations would be greatly improved (see Water Quality section). Because of the low flow problems in WRIA 23 (the upper Chehalis drainage); this area of the mainstem Chehalis River is rated "poor" for water quantity.

Less information exists about the potential impacts of high flows on salmonid production within the mainstem Chehalis River. There has been a documented increase in peak flow and volume in the lower Newaukum River that is likely due to urbanization within the lower Newaukum and Skookumchuck Rivers and nearby Chehalis River mainstem (Clark 1999). However, the extent of scour that exists in the mainstem Chehalis River is not known. Activities that would improve both low and high flow conditions for salmon include wetland and off-channel habitat restoration. Projects that increase dikes or manipulate the landscape for rapid water discharge contribute to further impacts in flow, which is already one of the major habitat problems in WRIA 23. Recommended restoration activities for water quantity conditions are listed below.

1) Reduce water withdrawals from both surface and ground sources (see Water Quantity section).

2) Increase activities that lead to natural recharges in the aquifers. Both flow and water quality in WRIA 23 are highly dependent on maintaining adequate summer flows, which are supplied by groundwater. Loss of wetlands, artificial diversion of floodwaters through ditching, and ground water withdrawals all contribute to a loss of water quality and summer flows in the Chehalis Basin.

3) Restore wetlands and off-channel habitat along the mainstem Chehalis River, as well as in the lower reaches of tributaries to the Chehalis mainstem.

Habitat Limiting Factors in the Humptulips Sub-Basin

<u>Loss of Access for Anadromous Salmonids in the Humptulips River Sub-Basin</u>

Blockages to Spawning and Rearing Habitats

There are a total of 837 miles of roads in the Humptulips sub-basin distributed as follows: 212 miles on National Forest lands and 177 miles on non-Forest lands in the East and West Fork Humptulips (Wood 1999); 104 miles on non-Forest lands in Stevens Creek; and 344 miles of non-Forest roads downstream of the forks, including the Big Creek drainage (Lunetta et al. 1997). Only a small portion of these roads have been inventoried to identify culverts that are barriers to salmon accessing juvenile rearing or adult spawning habitat. Columbia Pacific RC&D inventoried culverts on some National Forest Roads crossing Type 3 tributaries in the East and West Forks of the Humptulips, identifying 32 culverts as barriers to juvenile salmon migrations. During low flows some of these culverts may also be blockages to adult spawning. The Salmon Screening, Habitat Enhancement, and Restoration Division (SSHEAR 1998) database identified nine culverts that are barriers, and the East and West Fork Humptulips Watershed Analysis

(1999) identified one culvert on Newberry Creek as a barrier to juvenile salmon. An additional culvert at the mouth of Damon Creek was identified as a partial barrier during low flows (Jon Gow, City of Ocean Shores; Brian Erickson, Columbia Pacific RC&D, personal communication) (Table 9). The amount of habitat upstream of the barrier culverts was not quantified in the surveys, but was estimated from the anadromous distribution map for culverts identified in the SSHEAR database and the Damon Creek culvert. Olympic Resource Management (ORM) has inventoried some roads, but has not made this information available. Green Crow Timber Company now manages the lands previously managed by ORM.

Table 9. Salmonid Blockages in the Humptulips River Sub-Basin.

Road Name	Road Mile	Township	Range	Section	Stream Name	Quantity Habitat Blocked	Data Source
2220	1.49	21N	09W	06NE	WF Trib	NA	CPRC&D
2220	2.73	21N	09W	04NW	WF Trib	NA	CPRC&D
2220	5.02	22N	09W	28NE	WF Trib	NA	CPRC&D
2220	6.46	22N	09W	22NW	WF Trib	NA	CPRC&D
2204	3.46	22N	09W	23SW	WF Trib	NA	CPRC&D
2206	0.44	21N	08W	05SE	EF Trib	NA	CPRC&D
2206	1.65	22N	08W	32SE	EF Trib	NA	CPRC&D
2206	4.76	22N	08W	17SE	EF Trib	NA	CPRC&D
2281	0.45	22N	08W	33SW	EF Trib	NA	CPRC&D
2281	0.75	22N	08W	33NE	EF Trib	NA	CPRC&D
2281	1.46	22N	08W	28SW	EF Trib	NA	CPRC&D
2281	3.69	22N	08W	21NE	EF Trib	NA	CPRC&D
2281	7.21	22N	08W	11SW	EF Trib	NA	CPRC&D
2281480	1.11	22N	08W	10NW	EF Trib	NA	CPRC&D
2220	2.33	21N	09W	05NE	WF Trib	NA	CPRC&D
2220	2.8	21N	09W	06NE	Newberry Cr	NA	WA
2220	4.44	22N	09W	28SE	WF Trib	NA	CPRC&D
2220	5.87	22N	09W	22SE	WF Trib	NA	CPRC&D
2204	7.46	22N	09W	01SW	WF Trib	NA	CPRC&D

Road Name	Road Mile	Township	Range	Section	Stream Name	Quantity Habitat Blocked	Data Source
2208	0.36	22N	09W	26NE	WF Trib	NA	CPRC&D
2208	0.64	22N	09W	24SW	WF Trib	NA	CPRC&D
2208	1.66	22N	09W	13SE	WF Trib	NA	CPRC&D
2208	2.16	22N	09W	13SE	WF Trib	NA	CPRC&D
2208	2.81	22N	09W	12SE	WF Trib	NA	CPRC&D
2208	3.96	22N	08W	07NW	WF Trib	NA	CPRC&D
2208	4.6	22N	08W	06SE	WF Trib	NA	CPRC&D
2206	5.33	22N	08W	17SE	EF Trib	NA	CPRC&D
2206	5.68	22N	08W	16SE	EF Trib	NA	CPRC&D
2206	5.74	22N	08W	16SE	EF Trib	NA	CPRC&D
2281	3.04	22N	08W	21SW	EF Trib	NA	CPRC&D
2281	4.38	22N	08W	16SE	EF Trib	NA	CPRC&D
2281	4.68	22N	08W	16SE	EF Trib	NA	CPRC&D
2281480	0.34	22N	08W	15NW	EF Trib	NA	CPRC&D
HWY 101	111.3	21N	10W	35SW	Stevens Cr	9.4	SSHEAR
RR Grade	South 110.85	20N	10W	04SW	Stevens Cr	8.0	SSHEAR
HWY 101	105.6	20N	10W	28SW	Fairchild Cr	2.0	SSHEAR
HWY 101	104.9	20N	10W	28SE	Trib 0052	1.1	SSHEAR
HWY 101	103.65	20N	10W	35W	Trib 0057	NA	SSHEAR
HWY 101	101.9	19N	10W	02NE	Trib 0059	1.2	SSHEAR

Road Name	Road Mile	Township	Range	Section	Stream Name	Quantity Habitat Blocked	Data Source
HWY 101	101.7	19N	10W	02NE	Trib 0059	1.0	SSHEAR
HWY 101	101.1	19N	10W	02SE	Trib 0059	0.5	SSHEAR
Polson Camp	0.5	20N	10W	36SW	SB Big Cr	1.5	SSHEAR
Kirkpatrick	2.1	19N	11W	21SW	Damon Cr	1.6	John Gow, Ocean Shores

Martin and McConnell (1999) state there are no known culverts blocking adult spawning habitat in the East and West Fork Humptulips drainages, but there might be culverts that block upstream movements of juvenile salmonids. Because of this, it is likely that the culverts identified in Table 9 only block juvenile migrations. However, these blockages are important due to the limited availability of critical tributary habitat used by juvenile salmon seeking refuge from high flows.

Land managers have recognized the need for more complete assessment of culverts in the basin, with one assessment currently underway by CPRC&D, and two additional assessments being planned by the Olympic National Forest and Rayonier. Columbia Pacific RC & D is currently conducting a culvert assessment in the Stevens Creek drainage at Forest Service, county, and Rayonier road crossings. This assessment will quantify salmon habitat isolated by any barrier culverts identified. In addition to the Stevens Creek assessment, road inventories will be conducted in timberlands throughout the next 5 years to develop road maintenance plans as required in the Washington Forest Practices Emergency Rule WAC 222-24-050. (Kandice Kahill and Julie Dieu, Rayonier Timber, personal communication). The Olympic National Forest is also planning to conduct culvert assessments in the East and West Fork Humptulips watersheds beginning in summer 2000.

Fish Passage Rating in the Humptulips River Sub-Basin

Because most roads and culverts in the Humptulips sub-basin have not been inventoried, fish passage conditions in the drainage cannot be rated. Field experience by TAG members indicates that the list of barriers underestimates the fish access problem. The current culvert assessment on Stevens Creek, and the planned assessments by the Olympic National Forest and large landowners of timberlands will provide a more complete assessment of the amount of habitat isolated by culverts, but an assessment is needed for all streams in the sub-basin. Also, the information that is collected needs to be shared with the Lead Entity for placement in a central database, rather than scattered between landowners.

Conditions of Floodplains in the Humptulips River Sub-Basin

Floodplain Problems in the Humptulips River Sub-Basin

Like most low-gradient rivers, much of the floodplain has been transformed into farms and rural development. However, the use of dikes and bank hardening to protect property from flooding has been minimal relative to the size of the basin. The Humptulips Valley Dike Road is located just east of the Ocean Beach Road Bridge at RM 6.9 of the mainstem Humptulips River. The total length of the dike is 0.95 miles, extending from the WDFW boat launch 0.25 miles downstream of the bridge, to 0.7 miles upstream of the bridge. The dike was constructed to prevent damage to residences and farmlands, but restricts natural channel migration into the floodplain. A flood in December 1999 breached the upper end of the dike, requiring residents along the eastside of the Humptulips Valley Dike Road to be evacuated. The dike was repaired when floodwaters subsided. The dike does not appear to have cutoff any historic side-channels or sloughs, but has prevented natural channel migration from creating a side-channel or margin habitat in this reach.

There are three sections of rip-rap along the mainstem Humptulips River, which were placed to reduce bank erosion during high flows (John Gow, City of Ocean Shores, personal communication). Approximately 500 feet of rock rip-rap is located at RM 5.5, another 300 feet immediately downstream of the Highway 101 Bridge at RM 23.8, and approximately 300 feet of cabled tire revetment are located at RM 23.5. There are also short reaches of rock rip-rap associated with boat launches at RMs 1.3 and 5.2 and near the highway bridge crossings at RM 6.9. The rip-rap prevents channel migration, the formation of off-channel habitat, and increases the risk of scour.

With the exception of the Dike Road, the only other stream adjacent road that confines the river from entering the floodplain is Ocean Beach Road, which impacts approximately 0.4 tenths mile near RM 6. Overall, the dike and rip-rap impacts described above are limited, resulting in a "good" floodplain rating for this parameter.

The extensive use of splash dams in the Humptulips River sub-basin between the late 1890s and the early 1930s may have had a greater impact on the natural function of floodplains than more recent impacts, but it is difficult to quantify those effects. The Humptulips sub-basin had the most extensive system of splash dams in the Grays Harbor region. Ellison Logging Company compiled written records and interviewed loggers working during the log-drive era to document the legal description of 39 splash dams in the Humptulips sub-basin (Ellison and Fairbain 1982). Splash dams were distributed in tidal sloughs (3) and mainstem tributaries (7), the Big Creek (11), the Stevens Creek (2), the West Fork (10), and the East Fork (6) drainages. The absence of side-channels in the floodplains of confined, low gradient reaches within the East and West Forks indicates a long-term effect of splash dam operations (Martin and McConnell 1999). Research on the impacts of splash dam operations in California rivers showed that channel alterations, and simplification of habitat have persisted since turn of the century logging (Napolitano 1998).

There has been no study on the effect splash dams had on channel morphology in the Humptulips sub-basin, but some basic assumptions of the impacts can be made. The frequent release of high flows during log drives removed natural large woody debris and accelerated channel incision in these main channels and tributaries. Because side-channels were blocked off to prevent logs from being stranded outside the main channels, down-cutting in the side channels would not have occurred at the same rate, resulting in eventual isolation from the main channel. The reduction of large woody debris and side channels has reduced the amount of juvenile rearing habitat.

Until the 1980s, riparian harvesting and stream cleaning have reduced the recruitment of large woody debris to channels, preventing the formation of debris jams that create new side-channels. A natural floodplain allows water to move laterally out of the main channel where wetlands, sloughs and side-channels can disperse high flows over a larger area. These dispersed flows provide refuge habitat for juvenile salmon.

Floodplain Rating in the Humptulips Sub-Basin

It is difficult to rate the condition of the floodplains in portions of the drainage impacted by over 30 years of splash dam operations because there are no specific records on incision impacts in the Humptulips sub-basin. However, it can be assumed there were historically more side-channels, and that the lateral overflow into the floodplains of the main channels and tributaries has been affected by splash dam operations through channel incision. Based on this assumption, the floodplain function in low gradient reaches of the East and West Forks, Lower Big Creek and tributaries that had splash dam operations is considered "poor". The floodplain rating of the remainder of the sub-basin is considered "good" due to a relatively small amount of bank hardening and stream adjacent roads and no other known floodplain problems. It should also be noted that the lower 6 miles of mainstem Humptulips floodplain are in "good" condition due to the relatively undisturbed tidally influenced sloughs.

Streambed and Sediment Conditions in the Humptulips River Sub-Basin

Streambed and Sediment Problems in the Humptulips River Sub-Basin

Timber management, gravel bar mining, and splash dams have modified sediment delivery and substrate composition in the Humptulips drainage. These activities have affected the natural process of bedload movement and increased fine sediment and reduced the amount of spawning gravel in the system. Splash dam log transport and timber harvesting have also reduced the amount of instream large woody debris (LWD) and the ability of the system to store and retain spawning gravel and fine sediment. The frequent release of high water during log drives accelerated channel scouring and stream bank erosion because stream banks were unstable following riparian harvests.

Watershed Analysis identified 55 channel segments with increased fine sediment delivery. In the East Fork Humptulips River, six impacted segments are in the upper watershed, three in the middle watershed, and three in the lower river. There are also three in the West Fork Humptulips River upstream of Chester Creek, six in the Chester Creek watershed, four in the West Fork Humptulips River upstream of Donkey Creek, six in Donkey Creek, and 24 in the lower West Fork Humptulips River. Increased sediment delivery to all stream segments was road-related. In addition to high levels of fine sediments, substrate embeddedness is high in O'Brien Creek and the West Fork Humptulips River. All of these reaches are rated "poor" for sediment quality.

The East and West Fork Humptulips Watershed Analysis inventoried 286 landslides and 99 surface erosion events. Landslides cause the majority of sedimentation input to streams in the drainage, while surface erosion from streambank terrace under-cutting and timber roads deliver much less sediment. Hillslope surface erosion not associated with landslide events is not a significant process in the East and West Fork Humptulips Watershed (Dieu and Shelmerdine 1999). The density of landslide events increases as hillslope gradient increases. The East and West Fork Humptulips watershed was stratified into three sub-basin groups based on the densities of landslides.

Group 1 – This group has a low level of landslide densities (less than 1 event per square mile). A total of 15 landslide events were located in the lower East Fork Humptulips River, lower West Fork Humptulips River, Donkey Creek, and the West Fork Humptulips upstream of Donkey Creek. This area is rated "good" for sediment quantity, using the mass wasting criteria in the Assessment Chapter.

Group 2 – A total of 55 landslide events were located in the middle East Fork Humptulips River and in the West Fork Humptulips River upstream of Chester Creek, where landslide densities were 2-3 events per square mile. This area is rated "fair" for sediment quantity.

Group 3 – A total of 216 landslide events were located in the upper East Fork and West Fork Humptulips Rivers and near Chester Creek, where landslide densities were 4-6 landslides per square mile. This area is rated "poor" for sediment quantity.

The triggering mechanism of 277 landslide events was identified with 48 (17.3%) caused by timber harvest, 130 (46.9%) caused by roads, and 99 (35.7%) from natural events (Dieu and Shelmerdine 1999). There is a total of 389 miles of roads in the East and West Fork Humptulips watersheds: 212 miles in the National Forest and 177 miles on other lands. The Forest Service roads were assigned aquatic impact ratings based on landslide hazards to streams, road location relative to riparian areas, and the number of stream crossings. Sixty-three miles were rated as having a high aquatic impact rating and ninety miles with a moderate aquatic impact rating. Of 14 bridges in the East and West Fork Humptulips watersheds, 8 bridges pose a high vulnerability to mass wasting (Wood and Hocking 1999).

The majority of surface erosion events occurred in the southern sub-basins where hill slope gradients were less, but soil depths were deeper than the upper sub-basins. Of the 99 surface erosion events inventoried in watershed analysis, 57 delivered sediment to streams. The majority of these surface erosion events (68.4%) were caused by natural events of streambank undercutting during peak flows or along inner gorges. Harvest activities (5.3%) and road construction (26.3%) caused the remaining 19. Table 10 summarizes the road erosion in nine sub-basins of the East and West Fork Humptulips watersheds, compares erosion with road densities, and assigns ratings based upon road densities. In five sub-basins with road densities between 3.0 and 5.4, road erosion delivered 95% to 237% of natural background erosion. These sub-basins are rated "poor" and include the West Fork Humptulips River upstream of Chester Creek and the area upstream of Donkey Creek, the lower West Fork Humptulips River, Donkey Creek, and the lower East Fork Humptulips River. In addition, Chester Creek, the middle East Fork Humptulips, and the lower Humptulips WAU rated "poor" for road density. The only area within the entire sub-basin that rated "good" for road density and mass wasting is the upper East Fork Humptulips watershed (based upon data in Dieu and Shelmerdine 1999). An additional 42 surface erosion events were identified, but these did not deliver sediment to a stream. These events were triggered by road construction (37) and timber harvest activities (5) (Dieu and Shelmerdine 1999).

Table 10. Summary of Road Densities and Erosion in the Humptulips Sub-Basin (E/W Humptulips Watershed Analysis 1999 and Lunetta et al. 1997*)

Sub-Basin	Road Density (miles/sq. mi.)	Road Erosion (tons/year)	% of Natural Background	Condition Rating
E. Fork Upper	1.62	308	42	Good
W. Fork Upper	1.28	538	58	Good
Chester Creek	3.17	483	64	Poor
E. Fork Middle	3.19	830	75	Poor
W. Fork above Donkey Creek	3.02	780	95	Poor
W. Fork above Chester Creek	3.01	428	124	Poor
W. Fork Lower	5.05	889	132	Poor
E. Fork Lower	5.38	1308	153	Poor
Donkey Creek	5.23	792	237	Poor
Stevens Creek *	2.50	NA	NA	Fair
Mid Humptulips *	2.70	NA	NA	Fair
Lower Humptulips *	3.50	NA	NA	Poor

Riparian areas in the lower 28 miles of the river consist mostly of farmland interspersed with hardwood stands. In the Humptulips downstream of the forks, sediment delivery to the streams is predominantly from streambank erosion, with the most severe erosion occurring downstream of the town of Humptulips where the river forms an alluvial plain. Most of the heavily eroded sites are at natural meanders or channel migration zones. At this time, tt is estimated that the river is actively eroding 20 miles of its banks, washing away 9 acres of bottomland annually (CRC 1992).

The most recent information on streambank erosion is a 1974 study conducted by Norman Associates for the Grays Harbor Regional Planning Commission. This study examined the mainstem Humptulips River downstream of the Forks and identified four sites with critical erosion and nine sites with severe erosion based on risk of property damage. Many “undocumented” streambank stabilization projects have been conducted which have included rock rip-rap, cabled trees, tire binwalls or even car bodies. However, further assessment is needed to examine the causes and extent of bank erosion in the lower Humptulips sub-basin

Existing large woody debris densities were surveyed in 31% of the 320 total miles of streams in the East and West Fork Humptulips River (Martin and McConnell 1999). LWD densities were ″poor″ in 29.6 miles, "fair" in 6.9 miles, and "good" in 24.9 miles. All reaches with ″good″ LWD ratings were in either the East or West Fork mainstems. All surveyed tributary reaches had ″poor″ LWD densities, except for Rainbow Creek and an unnamed tributary to the West Fork Humptulips River.

Rating for Streambed and Sediment Problems in the Humptulips River Sub-Basin

Sediment input into the drainage resulting from splash dam log drives was probably considerable, but there are no historical baseline data to quantify the problem. More recent timber management practices have continued to significantly increase the input of sediment to the East and West Fork Humptulips Rivers. Landslide densities are high in the upper reaches of both the East and West Fork Humptulips Rivers, while high road densities impact the lower reaches. For these reasons, the East and West Fork Humptulips Rivers are rated "poor" for sediment quantity. In addition, increased levels of fine sediments and embeddedness have been documented in both forks, resulted in "poor" ratings for sediment quality.

Although there is a naturally high rate of surface erosion in the floodplain of the mainstem Humptulips River resulting in considerable channel migration zones, high road densities exist in the lower Humptulips WAU, leading to a "poor" rating for sediment quantity.

Large woody debris is rated as "good" in the mainstems of the East and West Fork Humptulips Rivers and "poor" in tributaries to these forks (except Rainbow Creek). The mainstem Humptulips River and tributaries are not rated, and remain a data need.

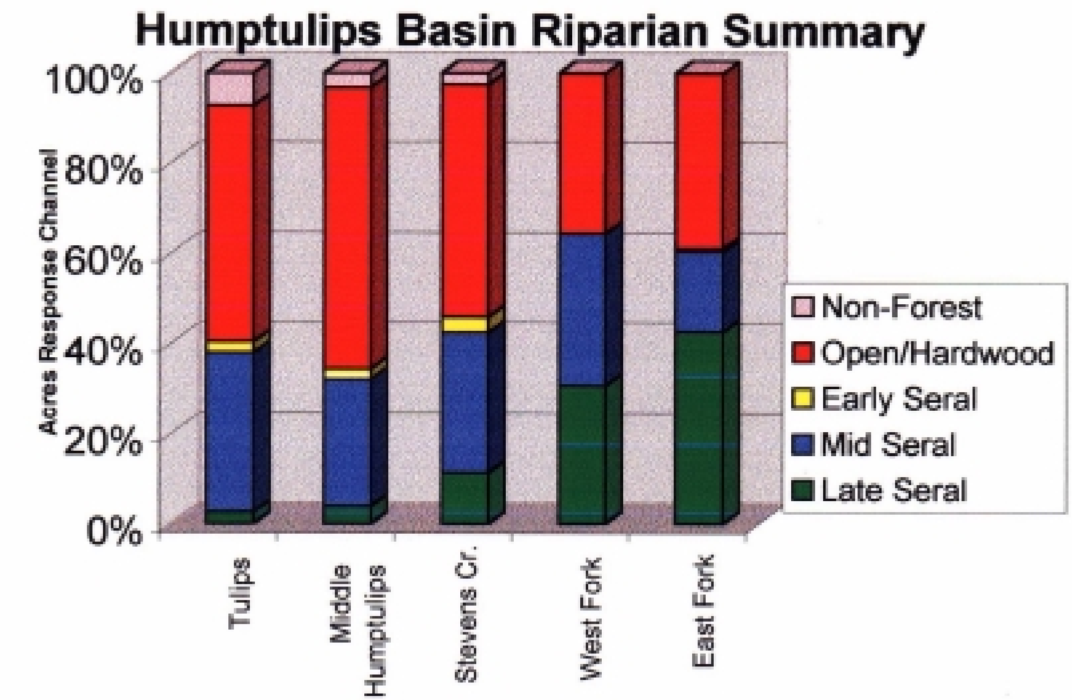
<u>Riparian Conditions in the Humptulips River Sub-Basin</u>

Riparian Conditions in the Humptulips River Sub-Basin

Riparian vegetation in the Humptulips River has been impacted by timber management activities since the late 1800s. Except for fragmented areas of old-growth remaining in the upper reaches of the watershed within the National Forest, the watershed consists primarily of second-growth timber (Peter 1999). Prior to 1930, timber harvesting was concentrated near the mainstem Humptulips River, the East and West Fork Humptulips Rivers, and larger tributaries because the only method of log transport was by splash dams. Early logging practices did not protect riparian habitat and by 1960, the majority of private forestland had been harvested including the majority of timber in riparian areas. The regenerated riparian areas have a greater component of red alder than in pre-harvest conditions. Natural channel migration zones frequently disturbed during high flow have created a considerable number of reaches dominated by alder, and riparian harvests of conifers in areas outside of channel migration zones have further decreased the conifer component (Bretherton and Matye 1999).

Overall the majority of the riparian zones downstream of the confluence with the East and West Fork Humptulips Rivers are "poor" because they consist of either no vegetation or are dominated by hardwoods (Figure 18) (data from Lunetta et al. 1997). The Tulips WAU (lower Humptulips watershed) riparian has 52% open or hardwood riparian lengths and 35% mid-seral stage conifer riparian (Lunetta et al. 1997). The middle Humptulips WAU consists of 62% open or hardwood riparian and 28% mid-seral stage conifer. The Stevens Creek WAU riparian includes 51% open or hardwood trees, 31% mid-seral conifer, and 11% late seral stage conifer (Lunetta et al. 1997). These riparian conditions are worse than those in the East and West Fork Humptulips Rivers, which have a significant component of late seral conifer and less open or hardwood riparian (Figure 18). Specific reach data for riparian conditions downstream of the Forks are not available, and this is a data need.

Figure 18. Overall Riparian Vegetation Type by WAU in the Humptulips Sub-Basin (data from Lunetta et al. 1997).

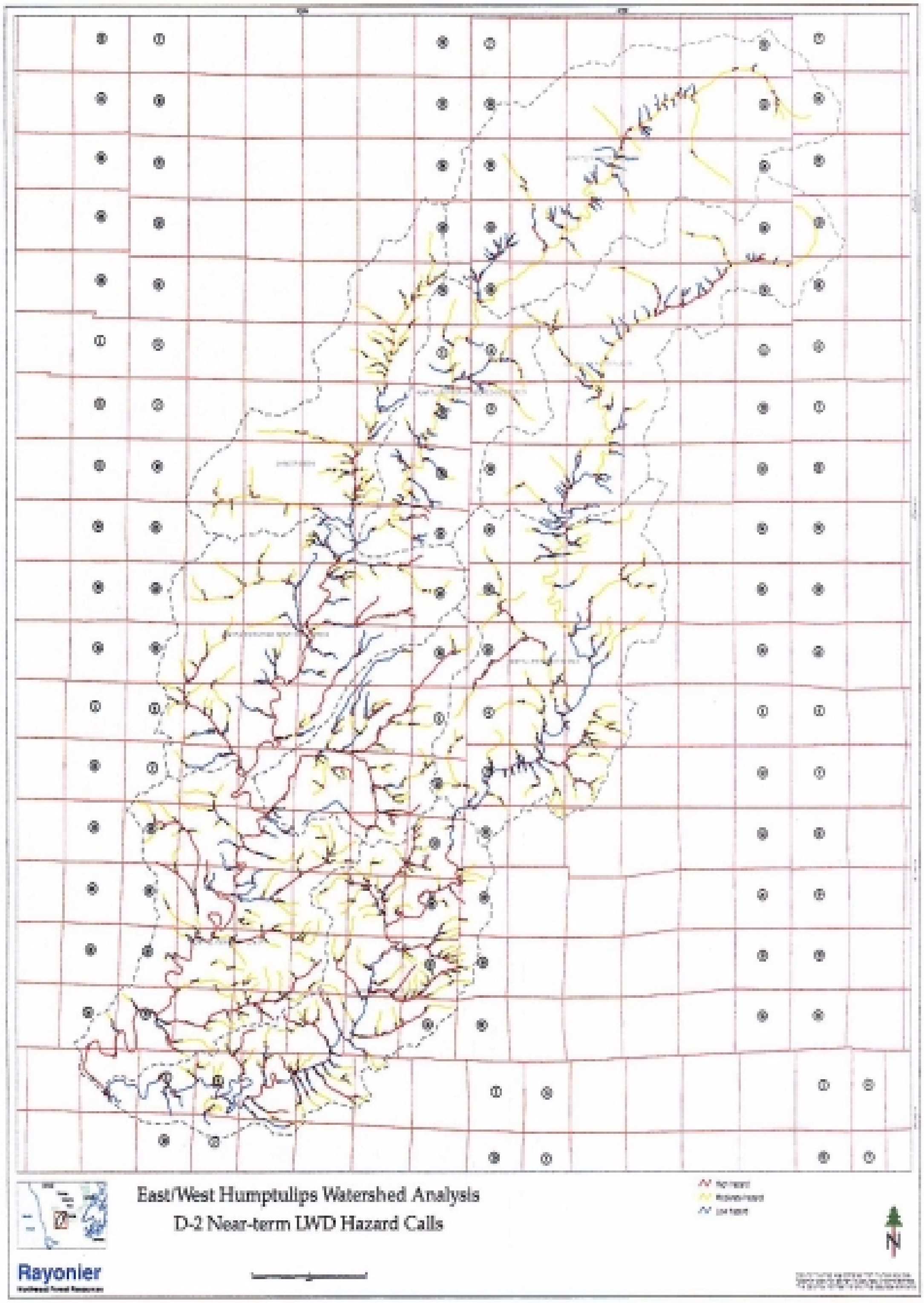


Riparian conditions of the lower West Fork Humptulips mainstem consist of either alder or mixed conifer/hardwood stands due to frequent natural channel meandering. Large woody debris recruitment and riparian canopy is low in this reach. Riparian stands in the upper West Fork Humptulips mainstem have medium to large conifers, which provide a good source of large woody debris and riparian shade. The lower East Fork Humptulips mainstem is more confined, but past riparian harvests have created poor large woody debris recruitment and riparian shade. The lower reaches of tributary channels to the East and West Fork Humptulips Rivers have poor LWD recruitment and riparian shade. The upper tributaries within the National Forest are mostly unmanaged, where LWD recruitment and riparian shade are "good" (Bretherton and Matye 1999).

Near-term future LWD recruitment potential is worse in areas of the West Fork Humptulips River compared to the East Fork (Figure 19). Near-term LWD recruitment potential is "poor" in the lower West Fork Humptulips mainstem, O' Brien Creek, Newbury Creek, Rainbow Creek, Elk Creek, and Donkey Creek (Bretherton and Matye 1999). In the East Fork Humptulips watershed, Rock Creek and Webfoot Creek rated "poor" for near-term LWD recruitment potential (Bretherton and Matye 1999). Near-term future LWD recruitment is more of an indicator of current riparian health. Restoration projects can do little to alter near-term recruitment, but can improve long-term LWD recruitment potential through the addition of conifers within certain areas of riparian zones.

The long-term LWD recruitment potential for the majority of the drainage has improved since riparian buffer protection increased on all lands in the mid-1980s, and became even more restrictive with the recent Forest Practices addressing listed salmon species (WFP 2000). The potential size of future large woody debris will be controlled by the degree of riparian protection implemented during more frequent harvest cycles of current timber processing.

Figure 19. Near-Term LWD Recruitment Potential in the West and East Fork Humptulips Rivers (Bretherton and Matye 1999).



Rating of Riparian Conditions in the Humptulips River Sub-Basin

The upper reaches of the East and West Fork Humptulips Rivers within the National Forest currently have "good" riparian conditions. Downstream of the National Forest, the current riparian conditions are "poor" where riparian harvests occurred. Harvested riparian stands have a higher hardwood component that will provide a future source of shade, but not a long-term source of large woody debris. Inadequate buffer widths in the lower West Fork Humptulips drainage have been vulnerable to blow-down, resulting in “poor” riparian conditions. The mainstem Humptulips River and tributaries including Stevens Creek are rated "poor" for riparian conditions based upon overall WAU data. Specific riparian information is lacking in the mainstem Humptulips and associated tributaries, and projects to improve riparian conditions need to be field verified.

Water Quality Conditions in the Humptulips River Sub-Basin

Water Quality Problems in the Humptulips River Sub-Basin

The mainstem Humptulips River is on the 303(d) List for warm water temperatures (DOE 1998). This results in a "poor" water quality rating for this stream. In the East and West Fork Humptulips Rivers, warm water temperature problems have also been documented. In the upper reaches, temperature monitoring was conducted at 28 different sites in the National Forest between 1992 and 1998, and at 12 sites downstream of the Forest boundary during 1998 (Martin and McConnell 1999). Within the National Forest, mean stream temperatures from July through September exceeded 15.6^{o}C at 2 of 28 sites and exceeded 14^{o}C at 8 of 28 sites. The two sites that exceeded 15.6 ^{o}C are rated "poor" for water quality. They are located in the West Fork Humptulips near the confluence with Rainbow Creek and the confluence with Elk Creek.

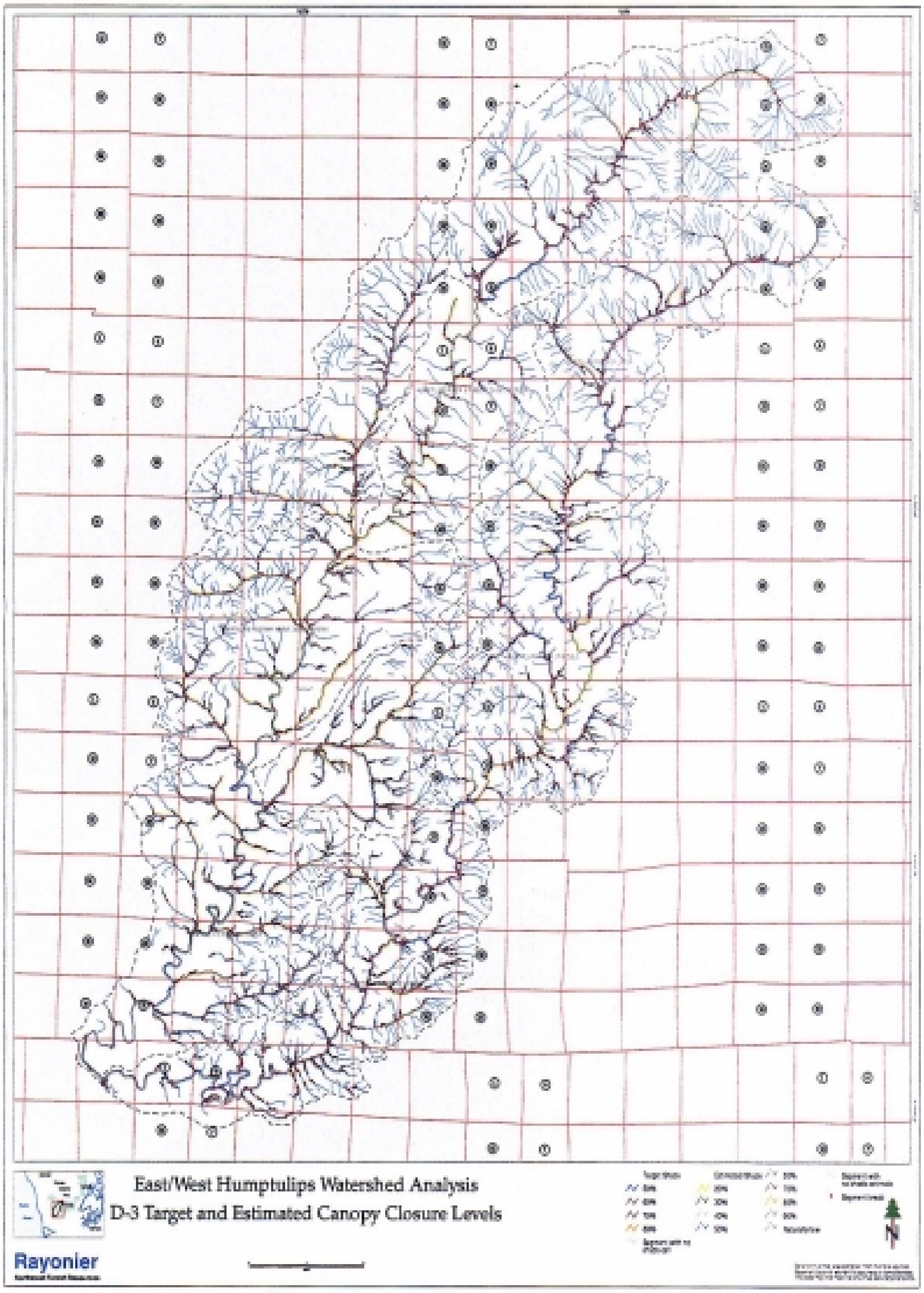
Downstream of the Forest boundary, mean temperatures exceeded 15.6 ^{o}C ("poor" rating) at 4 of 12 sites and exceeded 14 ^{o}C ("fair" rating) at 7 of 12 sites (Martin and McConnell 1999). The "poor" rated sites are located in the lower West Fork and East Fork Humptulips mainstems near their confluence with each other and in two different tributaries to Donkey Creek. The greater frequency of high temperatures in the lower reaches of the drainage are associated with increased riparian harvests and degraded riparian vegetation conditions (Martin and McConnell 1999).

Other areas that exceeded 15 ^{o}C include lower Furlough and Chester Creeks, two tributaries to the middle reaches of the East Fork Humptulips River, and near the East Fork Humptulips confluence with Flatbottom Creek (Martin and McConnell 1999). These areas are also rated "poor" for water quality. Riparian shade conditions were estimated for the West and East Fork Humptulips watersheds and are shown in Figure 20.

Temperature has also been monitored at the WDOE water quality monitoring site at RM 23.6 of the mainstem Humptulips River. At the mainstem Humptulips site, mean monthly temperatures frequently exceeded 15.6 ^{o}C in the summer months. For this reason, the mainstem Humptulips is rated "poor" for water quality. Mean monthly dissolved oxygen levels at the mainstem Humptulips site are "good", never falling below 9.0 mg/l and well above the preferred level for incubating eggs and juvenile rearing.

The recently completed TMDL study of fecal coliform in the Chehalis Basin states that the Humptulips sub-basin produces 13% of fecal coliform delivered to Grays Harbor (Dave Rountry, DOE, personal communication). That seems like a high contribution from a sparsely populated basin with minimal agricultural lands actively farmed. DOE did not identify nonpoint sources of fecal coliform, but potential sources include failed septic systems, livestock waste, and wild game waste.

Figure 20. Riparian Shade Conditions in the West Fork and East Fork Humptulips Rivers (Bretherton and Matye 1999).



Ratings for Water Quality Conditions in the Humptulips River Sub-Basin

Overall water quality in the Humptulips River is "poor" due to warm water temperatures.

Water Quantity in the Humptulips River Sub-Basin

Water Quantity Problems in the Humptulips River Sub-Basin

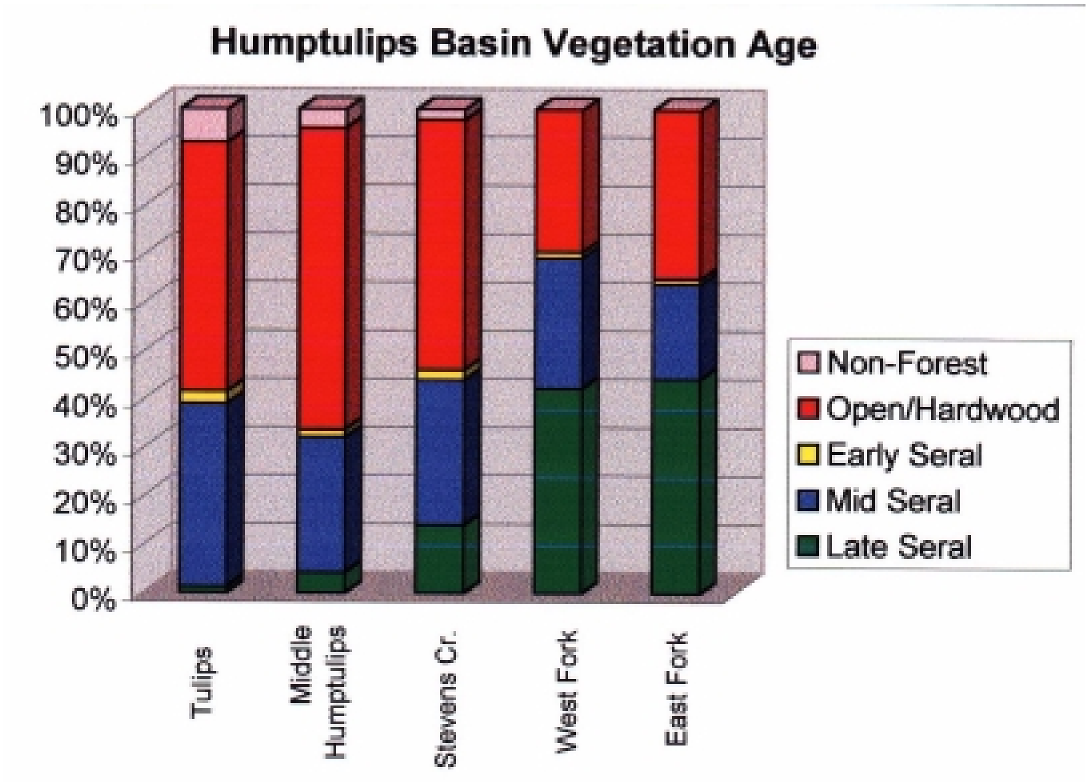
Potential flow impacts on salmonid habitat include human activities that change the natural flow pattern of a stream, as well as activities that either increase peak flows or worsen low flows. Direct measurements of streamflow in the Humptulips sub-basin ceased in 1979, and because of that, flow trends or comparison of current flows to established base flows is not possible. However, some information regarding impacts to flows can be derived indirectly. The extensive removal of trees or change in age and type of trees can increase the magnitude of high flow events and route water more rapidly to channels. An increase in impermeable surfaces results in even greater impacts. In the Humptulips sub-basin, there has not been significant development that would increase impermeable surfaces. However, timber harvest and conversion of land to agriculture has changed the landscape.

While historically the Humptulips sub-basin consisted mostly of mature conifer, the current types of land cover vegetation is shown in Figure 21. The middle Humptulips WAU rated "poor" for hydrologic maturity with about 63% of the land consisting of hardwoods or lacking trees (data from Lunetta et al. 1997). While the lower (Tulips) Humptulips WAU and Stevens Creek WAU also had a significant loss of mature conifer, the estimates were just under the threshold of labeling them "poor". However, compared to the East Fork and West Fork Humptulips River, the lower Humptulips and Stevens Creek WAUs are more impacted for land cover vegetation age and type.

A relatively undisturbed watershed will have a hydrograph that rises and falls slowly during a flood event cycle, because a natural floodplain allows water to move laterally out of the main channel. This also helps supply water to wetlands, sloughs and side channels, providing critical refuge habitat from high velocity flows for juvenile salmon. However, the Humptulips River hydrograph rapidly increases during heavy rainfall then quickly returns to the seasonal flow. This suggests impacts to the hydrology and/or the floodplain habitat. The increased magnitude of peak flows can impact salmon by

increasing the amount of bank erosion and associated input of fine sediments to the channel. Increased fines in spawning gravels can also reduce the survival rate of salmon eggs during incubation. More frequent high flows also increase channel scour and the potential of uncovering and displacement of developing eggs and embryos from salmon redds (Murphy 1995).

Figure 21. Land cover Vegetation Age and Type in the Humptulips Sub-Basin by WAU (data from Lunetta et al. 1997).



Ratings for Water Quantity Conditions in the Humptulips River Sub-Basin

The middle Humptulips WAU is rated "poor" for water quantity because of the current low quantity of mature conifer as a land cover vegetation. The other areas are rated "good", although the lower Humptulips and Stevens Creek WAUs barely missed the "poor" rating threshold for land cover vegetation. Additional timber harvest or land conversion from timber to other uses will reduce the "good" ratings for these two WAUs to "poor". The West Fork Humptulips WAU and the East Fork Humptulips WAU are both rated "good" for water quantity. However, these ratings are based solely on coarse land cover data, and recent timber harvest in the East Fork Humptulips watershed might have decreased hydrologic maturity. Direct measurements of flow over long time periods are important data needs in the Humptulips sub-basin.

Estuarine Habitat Conditions in the Humptulips River Sub-Basin

The Humptulips estuary and tidally-influenced lower seven miles of the river are relatively undisturbed and functioning naturally. The Grays Harbor Estuary Management Plan (1986) designates the Humptulips River Estuary as “ RL/N – Rural Low Intensity/Natural” supporting oyster farms, fish rearing, water fowl and shore bird staging and nesting habitat. Over eight miles of off-channel slough habitat provide excellent rearing habitat for juvenile coho and chinook salmon, and important transitional habitat for all salmonid species during smolt outmigration. Just south of the mouth, Chenois and Grass Creek sloughs enter the same tidal flats and also provide transitional habitat for

Humptulips salmonids. The relatively natural conditions of the estuary and lower river are believed to be responsible for the better survival of outmigrating coho and chinook salmon smolt compared to production in the Chehalis River (Seiler 1989). The only potential hazard to the estuary is upland residential development. There is one large tract used for livestock grazing within the tidally-influenced lower river, but riparian fencing has decreased the potential of stream bank degradation.

Ratings for Estuarine Habitat in the Humptulips River Sub-Basin

The natural character of the lower Humptulips River and estuary at North Bay provides "good" estuary conditions.

Condition of Lake Habitat in the Humptulips Sub-Basin

There are two lakes in the Humptulips River watershed, Damon Lake and Failor Lake. Failor Lake was created when Deep Creek was dammed. At the location of the dam, Deep Creek was never accessible to salmon and steelhead due to a natural falls at river mile 6.5. Failor Lake was created to provide recreation opportunities, and is stocked annually with 7,000 to 8,000 rainbow trout that support a popular sports fishery. Both lakes have historically supported wild stocks of resident cutthroat trout. Damon Lake was historically accessible to coho salmon, but recently the culvert at the Kirkpatrick Road crossing of Damon Creek has been identified as a fish passage barrier during low flows. Damon Lake has not been stocked, but in the early 1990s there were net pens in the lake to condition smolts before outmigration. That program was discontinued in 1995 (Randy Aho, Aberdeen Hatchery, personal communication).

Both Failor and Damon Lake are in "good" condition for providing native cutthroat trout habitat. Failor Lake was created in a location that did not effect anadromous distribution in Deep Creek, and is providing a good hatchery-supported sport fishery. However, until the fish passage barrier in Damon Creek is repaired, Damon Lake is rated as "poor" for providing habitat for anadromous species.

Biological Processes in the Humptulips River Sub-Basin

Nutrient cycling is assessed for this report by the attainment of escapement goals, and a detailed discussion of stock health is in the "Distribution and Condition of Stock" section. To briefly summarize, only one salmon or steelhead stock (fall chinook salmon) within the Humptulips sub-basin is currently described as "healthy". The coho salmon population is depressed, while chum salmon and winter steelhead trout are declining (R. Brix, WDFW, personal communication). The status of the summer steelhead trout stock is unknown. Because more than half of the stocks in the sub-basin are not healthy, nutrient levels are likely lower than historical levels. For this reason, the category of biological processes is rated "poor" for the Humptulips sub-basin.

Habitat Limiting Factors in the Wishkah, Hoquiam, and South Grays Harbor Sub-Basins

Loss of Access for Anadromous Salmonids in the Wishkah, Hoquiam, and South Grays Harbor Sub-Basins

The only documented information available on fish passage barriers for this area is the WDFW SSHEAR database, which lists three culverts in the West Fork Hoquiam drainage and four culverts in the South Grays Harbor drainages (Table 11). High road densities suggest that blockages by culverts might be a considerable problem in this area, and an assessment and prioritization of blockages is greatly needed for all types of roads in this region. The new Forest and Fish agreement should result in culvert assessment and repair for forestland roads. This information should be made available to the Lead Entity to include in a central database for technical assessments and projects. Salmon habitat blockages also need to be addressed for lands outside of timber production, and this remains a high priority data need.

The low gradients of the rivers and tributaries of the floodplains in this analysis area are ideal conditions for establishment of beaver habitat. Combined high densities of beavers and roads with undersized culverts in this region sometimes create debris blockages at culverts that cause flooding of roads and might create fish barriers. Although occasionally beaver dam debris is known to occasionally block access for juvenile and adult salmonids, these blockages are usually temporary, and are not generally believed by fish biologists to pose a significant problem. The wetland habitat that beavers create provides excellent rearing and high water refuge habitat for juvenile salmon. Instead of beaver dams, roads located near streams (susceptible to flooding) and undersized culverts are the actual habitat problems for anadromous salmonids.

Loss of Access in the Hoquiam River Sub-Basin

Two Highway 101 culverts on non-cataloged tributaries in the West Fork Hoquiam drainage are identified in the WDFW SSHEAR database as fish passage barriers. Another culvert on a private road crossing an unnamed tributary to Davis Creek (22.0181) is also listed as a fish passage barrier (SSHEAR 1998). The Grays Harbor Road Maintenance Division (Randy Beuner, Copalis, personal communication) periodically cleans a culvert blocked with beaver debris when it causes flooding on the Panhandle Road. This culvert is located at the outlet of a beaver associated wetland 0.4 miles west of the East Fork Hoquiam River at RM 0.7, and is likely undersized. The existing outlet channel below the culvert appears to be a man-made ditch that is accessible to juvenile salmon from the river during high tide.

Loss of Access in the Wishkah River Sub-Basin

No information regarding salmonid habitat access conditions was found for the Wishkah River sub-basin. County employees have reported the existence of undersized culverts. These need further evaluation; however, the specific location of these culverts has not been provided.

Loss of Access in the South Grays Harbor Drainages

Complete barrier information is needed for road crossings on managed forestlands. In the SSHEAR database, four culverts at Westport Highway 105 crossings of south Grays Harbor drainages have been identified as fish passage barriers. Heading west from Aberdeen, they are located at Chapin Creek, O'Leary Creek, an unnamed tributary to Johns River, and an unnamed tributary (22.1321) to South Bay about one mile east of Elk River. The Highway 105 crossings at Chapin and O'Leary Creeks are currently bridges that are no longer barriers to fish habitat. The culverts at the other two crossings are located in tidally influenced waters, but it is unknown if these culverts are complete barriers, or if they only block fish access during low tide.

A culvert located on the E-Line Road crossing of East Branch Elk River is believed to be undersized. Also, the Grays Harbor County Road Division has identified three culverts on the Johns River Road. Two of the culverts block access to wetland networks on Gold Creek and Atwood Creek, and the other culvert blocks access to Ballon Creek near the confluence with Johns River. Rock weirs have been installed at the inlet and outlet of the Ballon Creek culvert, but it appears this culvert may still be a velocity barrier to juvenile salmon during high flows. The Gold Creek and Atwood Creek culverts are likely undersized. Two culverts on Fry Creek, ¼ mile upstream of the Grays Harbor PUD Compound, have been reported and are also likely undersized. The pumping station just inside of the tidegate to Fry Creek is unscreened, and needs correction.

Table 11. Known and potentially blocking culverts in the Hoquiam River, Wishkah River and South Grays Harbor Sub-Basins**.**

Road Name	Road Mile	Township, Range, Section	Watershed	Stream Name	RM	Barrier	Data Source
Hwy 101	93.8	18N, 10W	WF Hoquiam	Unnamed		Yes	SSHEAR
Hwy 101	96.9	19N, 10W, 34	WF Hoquiam	Unnamed		Yes	SSHEAR
Private	NA	18N, 10W, 4	WF Hoquiam	Davis Cr	0.1	Yes	SSHEAR
Hwy 105	38.1	17N, 10W, 36SE	Johns River	Unnamed		Partial	SSHEAR
Hwy 105	31.6	16N, 11W, 16NE	S. Grays Harbor	22.1321	0.1	Partial	SSHEAR

Fish Passage Rating in the Wishkah/Hoquiam/South Grays Harbor Sub-Basin

Comprehensive assessments of barriers to salmonid habitat are needed throughout the Wishkah sub-basin, Hoquiam sub-basin, Johns River, Elk River, and other nearby watersheds. Without this information, fish passage conditions cannot be rated and are listed as a data gap. The high road densities in the area suggest that road-related problems, such as blockages, might pose a considerable impact, and because of this, the barrier assessment should be a high priority data need.

Floodplain Conditions in the Hoquiam, Wishkah, and South Grays Harbor Drainages

The low gradients of the Hoquiam, Wishkah, and South Grays Harbor drainages created a broad tidewater area for early logging along the lower rivers where logs could easily be transported to Grays Harbor during ebb tide flows. As timber was harvested along the streams within the tidal zone, splash dams were constructed to transport logs upstream of the tidal zone. The Wishkah River had 34 splash dams, the Hoquiam sub-basin had 21 dams, and all of the South Grays Harbor drainages combined had 17 dams (Ellison Timber 1982). Although the impacts of splash dams were not documented specifically in these streams, it is well known that splash dams severely degrade stream habitat. Impacts include: accelerated incision of the channel bed (often to bedrock); removal of large woody debris to clear barriers for log transport; and blocking access to off-channel juvenile salmon rearing habitat to prevent logs from leaving the channel (Wendler and Deschamps 1955; Hiss and Knudsen 1992). It has been documented that these impacts often take over a century to fully recover (Napolitano 1998). Spawning gravel will eventually replenish itself as large woody debris reestablishes through improved riparian conditions from the new forest practices combined with restoration efforts.

In addition to the effects of splash dams, development has considerably changed the floodplains from historic conditions. The lower three miles of the Wishkah River, the lower five miles of the Hoquiam River, and the lower one mile of the East Hoquiam River are confined by commercial development, roads, or residential areas. The floodplain of the Wishkah River from the tidal zone (RM 8) upstream to RM 23 is impacted by agricultural and rural residences, which limits off-channel habitat. Incised channels can be found throughout the mainstem Wishkah River at sporadic locations (Lonnie Crumley, LWC Consulting, personal communication). In the lower Hoquiam River, the tidally influenced reaches have been developed, but upstream of the commercial and residential lands in the lower drainage, development is less extensive than along the Wishkah River. Upstream of RM 7 along the Hoquiam River, there are scattered rural residences in the floodplain to RM 15 on the East Fork and to RM 10 on the West Fork Hoquiam River. The West Fork Hoquiam River floodplain is currently protected within the City of Hoquiam's Municipal Watershed from RM 10 to RM 14. The entire Little Hoquiam River, Middle Fork Hoquiam River, and the upper reaches of the East and West Fork Hoquiam Rivers are managed for commercial timber, where the riparian areas of the floodplains are regenerating from past forest practices.

There are several county and state roads in the floodplains of the Hoquiam and Wishkah River drainages. The Wishkah Road periodically enters the floodplain in the lower 23 miles of the Wishkah River, as does Highway 101 along the mainstem Hoquiam River and West Fork Hoquiam River sporadically for 16 miles. None of the roads are influencing channel migration for long reaches, but there are some localized areas where the rivers are confined by roads.

The floodplains in the South Grays Harbor drainages have not been developed as much as the Wishkah and Hoquiam floodplains. There is currently no agricultural development, with only scattered rural residences along two miles of Johns River and Newskah Creek. There is no development in the floodplains of the Elk River or along O'Leary, Indian, Stafford, Chapin, and Charley Creeks. There is considerable beaver activity in the floodplains upstream of tidal influence on Elk and Johns River. The wetlands maintained by beaver dams retain water in the floodplains, and provide important rearing habitat for juvenile salmonids.

The Newskah River Road closely parallels the Newskah River for three miles preventing the river from natural channel migration to the east, and there are several bank stabilization sites that are visible along the road. Johns River Road follows the floodplain wetland terrace, and about four miles upstream from the Grays Harbor estuary, the road parallels the river for short reaches, but there is little channel confinement.

Tidal land along the lower ¾ mile of Newskah Creek, ½ mile along Charley Creek, and about 1 mile within the tidal zone of Johns River have been historically disconnected by dikes, but since 1999, two of these dikes were breached to provide fish habitat. On the east bank of Newskah Creek immediately downstream of Highway 105, an estuary dike was breached at two locations. A tidal channel was created between the breach points, and native vegetation was transplanted along the tidal channel. This project was implemented as off-site mitigation of tidal wetlands impacted from the utility corridor for the Stafford Creek Correctional Facility (Brian Blake, Environmental Coordinator, SCCC, personal communication).

Dikes in the estuary floodplain are located along both sides of the Johns River. The west bank dike extends 3/4 miles from the WDFW boat launch upstream to RM 1 and is the site of a wildlife viewing trail. A tidal gate was recently installed to control tidal flow to the adjacent estuary. The east bank dike extends from RM 1 to RM 2. In July 2000, a Ducks Unlimited project breached the dike at two locations to reestablish tidal flows into estuarine habitat (Randy Van Hoy, Ducks Unlimited, personal communication).

Table 12. Floodplain Condition Rating for the Wishkah, Hoquiam, Elk and Johns Rivers and Independent South Grays Harbor Drainages.

Watershed	Lower Watershed	Upper Watershed
Elk River	Good	Good
Johns River	Good	Good
Newskah/Charley Rivers	Fair	Good
Other S. Grays Harbor Streams	Good	Good
Wishkah/Hoquiam Rivers	Poor	Fair-Good

<u>Streambed and Sediment Conditions in the Hoquiam, Wishkah, and South Grays Harbor Drainages</u>

Only the extreme upper reaches of the mainstem Wishkah River (upstream of RM 28.5) were included in the sedimentation module of the watershed analysis contracted by Rayonier Northwest Timber Resources. No other assessment quantifying streambed sediment conditions or sources of sediment delivery was found for the remainder of the sub-basin. The only existing information available to assess sediment delivery conditions in this sub-basin was to evaluate road densities from Lunetta et al. (1997) and the surface erosion and mass wasting potential GIS databases in the WRIA 22, Salmon Recovery Data Viewer (WDNR 2000). The Wishkah, Hoquiam and South Grays Harbor drainages were not included in the USFWS habitat inventory that quantified streambank erosion degradation sources (Wampler et al. 1993). Quantification of sedimentation impacts is an important data need for the area.

In the upper Wishkah River watershed analysis area, the mass wasting density for the 42 years of photo records was less than 2 events/square mile, with a total of 31 total events. The majority of the landslides appeared in the 1950 and 1960 photos following heavy clear cutting, but events were usually associated with road sidecast or fill failures (Table 13) (Raines et al. 1992). Numerous landslide problems are believed to exist (TAG, personal communication), and coupled with the evidence of landslides caused by human activities; sediment quantity is rated "poor".

Table 13. Summary of Non-Natural Landslide Events in the Upper Wishkah River Watershed Analysis (Raines et al. 1992).

Management Activity	Shallow-Rapid Landslides	Debris Flows	Deep-Seated Landslides
Road Fill Failures	14	2	
Road Stream Crossings		2	
Clear Cut Yarding	8		
Unknown	5		2

Small tributary streams in the upper Wishkah watershed analysis area had good habitat complexity and spawning gravel due to a significant amount of instream large woody debris (LWD). However, the LWD in the small tributaries was in an advanced state of decay, and there was a poor source of future LWD because of a hardwood-dominated riparian. There was minimal LWD in the mainstem Wishkah River upstream of the reservoir due to past salvage of large trees in the channel, and current smaller diameter wood entering the channel is not stable during winter high flows (Raines et al. 1992).

Road densities in the Wishkah sub-basin are “poor” (greater than 3 miles/sq. mile watershed) in all Watershed Administrative Units (WAUs), except the Upper Wishkah River WAU and the East Fork Hoquiam River WAU where road densities are rated as "fair" (Lunetta et al. 1997) (Table 14). Areas with high road densities (>3 miles/sq. mile) are more prone to deliver fine sediments to streams. Fine sediment can originate from erosion of the road surface itself, and roads serve as pathways for sediment coming from exposed cut slopes adjacent to roads (Chamberlin et al. 1991). Water generated on roads appears to be a sediment delivery problem for unpaved logging roads in the Wishkah sub-basin (TAG, personal communication).

Table 14. Road Mileage and Density for the Wishkah, Hoquiam and South Grays Harbor Drainages (Lunetta et al. 1997).

WAU	Road Mileage	Road Density (mi/sq. mi)	Habitat Rating
Upper Wishkah River	89	2.4	Fair
Lower Wishkah River	155	4.9	Poor
East Fork Hoquiam River	114	2.9	Fair
Middle/W Fork Hoquiam R	212	4.3	Poor
Johns River	240	3.9	Poor
Elk River	190	3.5	Poor

The Salmon Recovery Data Viewer database classifies soil types to show surface erosion potential, and landslide potential on a broad scale (WDNR 2000). The lower Wishkah River drainage, the lower East Fork Hoquiam River, and the extreme upper East Fork Hoquiam River have high surface erosion potential. The remainder of the Wishkah and Hoquiam drainages has medium erosion potential. There are large areas of high landslide potential throughout the Wishkah drainage and in the lower and upper Hoquiam drainage. The remainder of the Hoquiam and Wishkah drainages is classified as having low landslide potential. The medium to high risk areas indicate areas where there is a higher risk of sediment problems associated with development and management activities.

When the West Fork Hoquiam River and Davis Creek water supply reservoirs are flushed, released sediment degrades spawning habitat downstream of the reservoirs (Phinney and Bucknell 1975). This problem was further documented in July 1987, when draining and dredging of sediment caused a fish kill from high turbidity and low dissolved oxygen levels (LCCD 1992). Fine sediments entered the reservoirs from road surfaces, road cut slopes, and road ditches draining directly to streams (Columbia Pacific RC&D 1995). To reduce fine sediment delivery to the Davis Creek reservoir, large woody debris was installed in streams, sediment collection structures were installed at cross drain culverts, and cut slopes were stabilized and planted (Columbia Pacific RC&D 1995).

In the South Grays Harbor watershed, the lower reaches of drainages between O'Leary Creek and the Elk River have low surface erosion potential. However, surface erosion potential is high in the upper Johns and Elk Rivers. The remaining areas in the South Grays Harbor watersheds have a medium erosion potential. High landslide potential exists throughout the South Grays Harbor analysis area, consisting of approximately 60% of the total area. The remainder of the area is classified as having low landslide hazards.

The smaller independent drainages of South Grays Harbor are extremely silty, partially due to natural soil types and deposition in the low gradient floodplains. However, intensive timber management in the upper drainages has increased the amount of fine sediments delivered to streams (WDFW and WWTIT 1993 and Phinney 1975). Elk River, Johns River and Newskah Creek have areas with suitable spawning gravels, but sediment delivery to streams from timber management is believed to have degraded spawning conditions (Phinney 1975). Coho salmon spawning escapement surveys indicate that the most suitable spawning locations are in Johns River (RM 4 – 7.5), North Fork Johns River (RM 7.5 – 12.5), West Branch Elk River (RM 0.4 – 4.0), Andrews Creek (RM 1.3 – 3.3), and Newskah Creek (RM 3 – 7).

In recent years there have been introductions of spawning gravel in the Elk River and Stafford Creek drainages to temporarily improve spawning conditions and increase coho salmon production. In 1997, spawning pads were installed in a 0.2-mile reach of West Branch Elk River, a 0.1-mile reach of Andrews Creek, and a 0.1-mile reach of an unnamed tributary to Andrews Creek (Floyd Ruggles, personal communication). Escapement surveys estimated that 202 coho used the spawning pads in 1999 and 61 in 2000. In 2000, a mitigation project for construction activity of the prison introduced spawning gravel in Stafford Creek near the upper limit of known coho salmon spawning distributions. The SCCC Environmental Program will monitor this project in the future. While these types of projects address a short-term need, their use should be combined with long-range activities to resolve the sedimentation problem. For example, three spawning pads were installed in Fry Creek to increase spawning habitat, but recent forest practices and residential development have greatly increased the amount of fine sediment entering the creek. The rock weirs that stored the spawning gravels are still visible, but the majority of the gravels are covered with a layer of fine silt from land management in the upper drainage.

Because there have been no assessments of stream substrate or sediment delivery sources in the Wishkah, Hoquiam, or South Grays Harbor drainages, many sedimentation parameters could not be rated based on documented studies. The Salmon Recovery Data Viewer does not provide enough detail to indicate the magnitude of landslide or surface erosion that has the potential for sediment delivery to streams. Based on road densities (Lunetta et al. 1997), the only WAUs that rated "fair" for sediment delivery potential are the Upper Wishkah River (2.4 mi./sq. mi) and the East Fork Hoquiam River (2.9 mi./sq. mi). The remainder of the Wishkah and Hoquiam drainages, and the entire South Grays Harbor drainage area, rate "poor" for sediment delivery due to road densities greater than 3 mi./sq. mi.

Riparian Vegetation Conditions in the Hoquiam, Wishkah, and South Grays Harbor Drainages

Wishkah Sub-Basin

Based on the broad scale classification of riparian vegetation cover in response channel buffers, riparian conditions in the Lower Wishkah and West Fork Wishkah WAUs are mostly "poor", with the majority of native conifer converted to non-forest or hardwoods (Figure 22). The Upper Wishkah WAU has "poor" conditions in about half its buffers, with the other half "good", consisting of conifer or mixed conifer in mid- to late seral stages (Figure 22) (Lunetta et al. 1997).

The Upper Wishkah Watershed Analysis conducted a riparian assessment and identified riparian areas into conifer, mixed, or hardwood, as well as density and age class (Table 15). Mature-dense-hardwoods were the dominant riparian type, followed by mature-dense-mixed stands. Reach breaks of the riparian conditions were not mapped in that analysis. Based on the WCC rating criteria, overall riparian conditions upstream of RM 29.5 were rated as "fair", since over 30% of riparian cover was conifer or mixed over story in mature and old age classes. The data suggest that the riparian shade is "good" based on over 70% being mature or old trees, but "fair" based on a future source of large woody debris from riparian stands dominated by red alder (Raines et al. 1992).

Table 15. Summary of riparian vegetation types in the Upper Wishkah River Watershed Analysis Area, upstream of RM 29.5 (data from Raines et al. 1992).

Vegetation Type	% Sparse Young	% Dense Young	% Sparse Mature	% Dense Mature	% Sparse Old	% Dense Old
Conifer	2.0	0	7.0	8.1	0	1.7
Mixed	1.7	2.3	5.8	22.7	2.9	.8
Hardwood	1.3	4.8	0	38.6	0	0

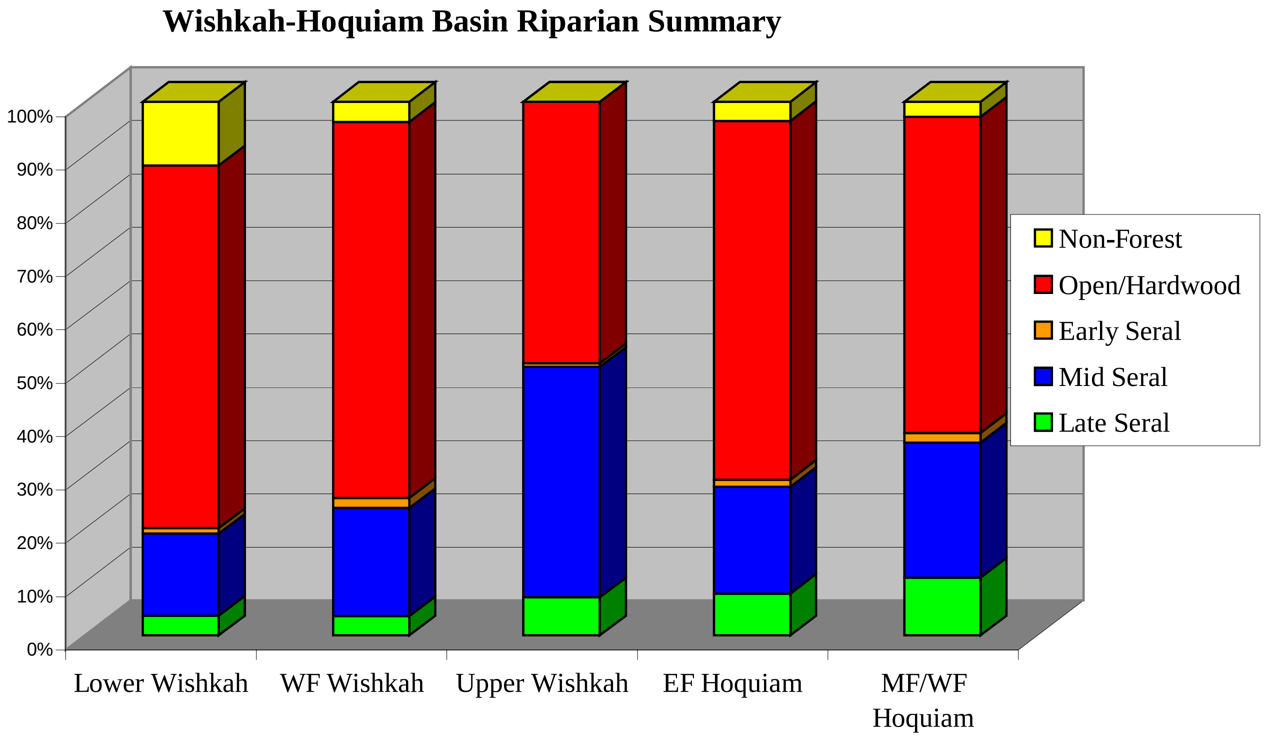
To map general riparian conditions for the Wishkah, Hoquiam, and South Grays Harbor drainages, ortho-photography on the DNR Salmon Recovery Data Viewer was reviewed to identify riparian conditions as "good", "fair", or "poor" in addition to some field visits (Map 4a). The lower three miles of the Wishkah are exclusively industrial or residential lands, with only small areas of riparian vegetation ("poor"). From this point upstream to RM 7.5 near the upper limit of tidal influence, there is dense riparian vegetation of alder with a few reaches of stands dominated by mature conifer. Within this reach, the Wishkah Road closely parallels the river at four locations, resulting in the overall riparian condition being a mix of "poor" with some reaches of "good" riparian in this upper tidal zone. From the upper tidal zone upstream to RM 20 in the mainstem and the lower mile of the East Fork Wishkah, riparian conditions are "poor" due to narrow buffers associated with past timber harvests and agriculture development. The remainders of the mainstem Wishkah and East Fork Wishkah Rivers and the entire West Fork Wishkah River have riparian conditions alternating from "fair" to "good" depending on the width of buffers left from past forest management. Riparian conditions in the upper drainages will improve over time as wider riparian buffer requirements are implemented under the year 2000 state forest practices rules.

Hoquiam River Sub-Basin

Based on the broad scale classification of riparian vegetation cover in “response” channel buffers, riparian conditions in the East Fork Hoquiam WAU are "poor" with over 70% of the riparian area consisting of hardwood or non-forested use. The Middle and West Fork Hoquiam WAU has mostly "poor" conditions, with 62% as non-forested, open, or hardwood and 36% of riparian cover classified as conifer or mixed conifer in mid- to late seral stages (Figure 22) (data from Lunetta et al. 1997).

In the lower 5.2 miles of the mainstem Hoquiam River and the lowest mile of the East Fork Hoquiam River, most of the riparian vegetation has been converted into commercial or residential lands, and is rated "poor". Upstream of this dense residential area, the remainder of the drainage has “fair” and “poor” riparian conditions, consisting of a mixed conifer and alder riparian interspersed with areas lacking adequate vegetation. The Little Hoquiam and North Fork Little Hoquiam Rivers are undeveloped, but riparian zones are mostly "fair", as they recover from riparian harvests.

Figure 22. General Riparian Conditions in the Wishkah and Hoquiam Sub-Basins.



South Grays Harbor Drainages

Riparian vegetation in the estuaries of Elk River, Beardslee Slough, and Andrews Creek are native and in "good" condition. The remainder of the Elk River is also in "good" condition, except for a 1.2 mile reach of West Branch Elk River, and 1.5 miles of Beardslee Slough that have inadequate buffers from past timber harvests and are rated as "poor". The majority of Andrews Creek upstream of the estuary is in "fair" condition recovering from past timber harvests of the riparian zone (Map 4a).

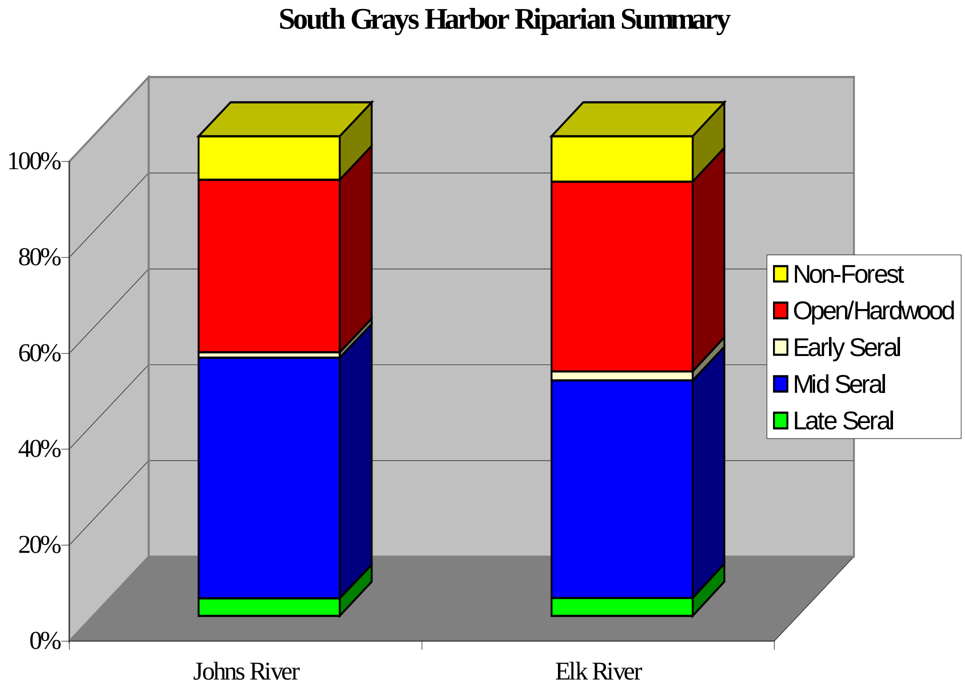
Good riparian conditions on Johns River extend upstream to RM 3.8, then changes to "fair" conditions to RM 6. Upstream of RM 6, including the lower two miles of South Fork Johns River, riparian conditions are "poor" due to inadequate buffers from past timber harvests. The upper 2.5 miles of South Fork Johns River are "fair" (~1 mile) to "good" (~1.5 miles). The North Fork Johns River, Florence Creek, and the lower 2 miles of Hall Creek have "fair" riparian conditions, while the upper 1.5 miles of Hall Creek are in "poor" condition from past timber harvests (Map 4a).

The majority of riparian areas adjacent to the seven smaller independent drainages in South Grays Harbor have "fair" riparian conditions. However, "poor" riparian conditions exist in the lower mile of O'Leary Creek, 0.5 mile of Stafford Creek, and 2.2 miles of Newskah Creek, and "good" riparian conditions are found throughout the Indian Creek drainage and upstream of RM 3.5 on Charley Creek (Map 4a).

General riparian conditions of response channels in the Elk River WAU and Johns River WAU (includes the smaller independent South Grays Harbor drainages) are 49% and 45% "poor", respectively, with close to 50% of riparian cover consisting of conifer or mixed conifer in mid to late seral stages (Figure 23) (Lunetta et al. 1997).

No information on pool habitat was found for the Hoquiam, Wishkah, or South Grays Harbor drainages. This is a data need, along with better delineation of riparian conditions throughout each of these watersheds.

Figure 23. General Riparian Conditions in the South Grays Harbor Sub-Basins (Lunetta et al. 1997)



Water Quality Conditions in the Hoquiam, Wishkah, and South Grays Harbor Drainages

There are no reaches in this analysis area on the Department of Ecology 303(d) List of Impaired Waters. The lower Wishkah and Hoquiam Rivers are classified as Class B waters, while the remainder of the area is classified as Class A. Water quality data available for this analysis area was minimal. One year of data from the West Fork Hoquiam River from October 1993 through September 1994 recorded a high mean monthly temperature of 15^{o}C during July. This is within the "fair" rating standard for juvenile salmon rearing (14 – 15.6^{o}C) set by the Washington Conservation Commission. Dissolved oxygen was near saturation for the year of record. Periodic temperature measured as part of the Upper Wishkah River Watershed Analysis did not exceed 10^{o}C, but the dates of measurements were not provided. The only other water temperature data is from the Aberdeen water supply intake at the Malinowski Dam, where temperatures range from 6^{o}C to 12^{o}C throughout the year. (Raines et al. 1992).

The Grays Harbor Fecal Coliform TMDL Study concluded that 96% of fecal coliform is coming from non-point sources entering tributaries to the Chehalis River and Grays Harbor (Pelletier and Seiders 2000). Fecal coliform bacteria does not directly affect fish, but high concentrations during low water periods may contribute to reductions in dissolved oxygen. The percentage contribution of fecal coliform to Grays Harbor from drainages in the analysis area were: 6.3% from the Wishkah River, 5.4% from the Hoquiam River, 2.8% from the Elk River, and 2.4% from the Johns River. The Elk River contribution is from natural sources because there is no agricultural or residential development in the drainage, although it is responsible for oyster bed closures following rainfalls greater than 1 inch over a 24 hour period (Brady Engvall, Brady's Oysters, personal communication; Pelletier and Seiders 2000). A public working group has been developed by the Washington Department of Ecology to develop alternatives for reducing the fecal coliform counts in each basin (Dave Rountry, WDOE).

Another water quality issue with greater potential impact to salmonids is the cedar waste sites (spaults) in the Newskah River. Leachates from the cedar waste sites that deliver to streams may contaminate water by reducing dissolved oxygen, while the contaminants themselves kill juvenile salmon. Wood waste in the stream may also cause a physical degradation by smothering spawning gravels. Two cedar waste sites near the Newskah River were identified as potential sources of degrading water quality (Terry Filah, Newskah R. resident), but no monitoring data of these sites was available. Both sites are on private property, one near RM 5.5 and the other near RM 1 just upstream of Highway 105.

Water Quantity Conditions in the Hoquiam, Wishkah, and South Grays Harbor Drainages

There are no recent records of flows from USGS gaging stations in the analysis area. There was a gage at Charley Creek from 1947 through 1949 that recorded a peak flow of 290 cfs in February 1947 and a low of 2 cfs in August 1949. Flows were also recorded on the West Fork Hoquiam and the mainstem Wishkah Rivers from July through October in 1942 and 1943. The West Fork Hoquiam mean monthly flows for a 16 sq. mi. drainage area ranged from 8 cfs to 427 cfs. The Wishkah River mean monthly flows for a 58 sq. mi. drainage area ranged from 44.1 cfs to 120 cfs.

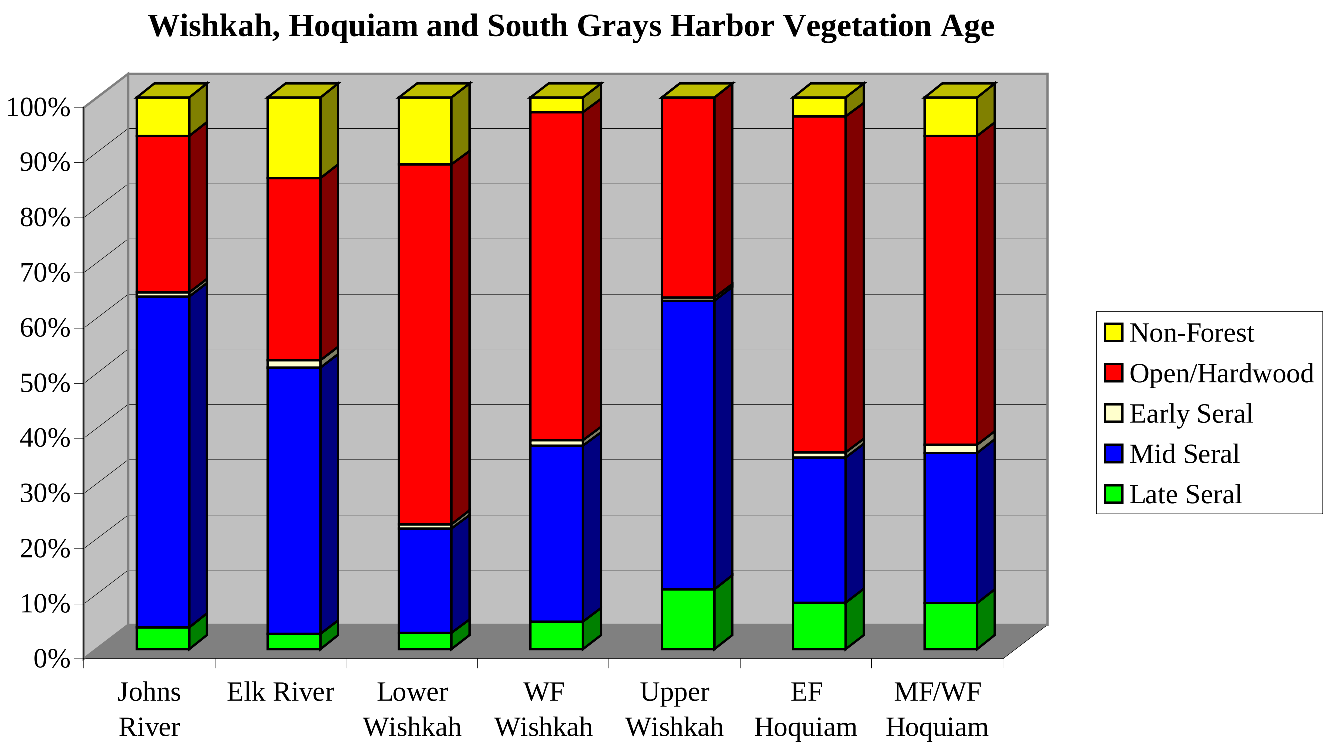
The upper Wishkah River has been the source of the City of Aberdeen's water supply since 1923. In 1963, the concrete Malinowski Dam was constructed at RM 29.4, creating the 2.8-acre Aberdeen Reservoir, replacing three wooden water supply dams in the same area (Pat Dier, City of Aberdeen, Water Department). Since 1923, the city has had a water right of 55 cfs to provide a residential water supply (DOE Water Right Claim 1979). Minimum flow requirements for the dam were not available.

The City of Hoquiam owns 7,500 acres of municipal watershed with small diversion dams for water withdrawals on Davis Creek and the West Fork Hoquiam River. The City of Hoquiam has water rights for the diversions, but the Public Works Department did not make this information available for this analysis (letter from County Commissioner requested by Dean Parsons, PWD).

Relatively natural drainage areas that have over 60% of land cover in mature forest stages (>25 years) slow the delivery of run-off to streams and rivers following heavy rains. These areas are considered hydrologically mature. As mature forested land is converted to agricultural, commercial, residential, or immature forest use, run-off to streams and rivers occurs more rapidly and can increase the magnitude of peak flow events (flooding).

A summary of land cover conditions in this area reflects how development in the lower Hoquiam and Wishkah Rivers and intensive forest management in the uplands has changed the forested landscape (Figure 24). The land cover vegetation conditions in the Lower Wishkah, West Fork Wishkah, East Fork Hoquiam, and Middle/West Fork Hoquiam WAUs have only 21% to 37% of total land cover in mid- to late seral stages, and are hydrologically immature, with a "poor" rating for water quantity. The upper Wishkah River WAU has 63% of land cover in mid- to late seral stages and rates "good" for water quantity. Elk River has 51% of its land cover in mid- to late seral stages and has a "poor" rating for water quantity. The Johns River WAU, including the smaller independent drainages to South Grays Harbor, has 63% of land cover in mid- to late seral stage and is rated as "good" for water quantity.

Figure 24. Land cover Conditions in the Wishkah, Hoquiam, and South Grays Harbor Drainages (data from Lunetta et al. 1997).



<u>Estuary (tidally influenced floodplain) Conditions in the Hoquiam, Wishkah, and South Grays Harbor Drainages</u>

In this analysis, estuary habitat includes the tidally influenced lower floodplains of the rivers and streams flowing into Grays Harbor. Estuaries and tidally influenced lower rivers provide important transitional habitat for salmon and steelhead smolt as they outmigrate from rivers to the marine environment. Intertidal areas also provide habitat for salmon fry that have not yet undergone smolt transformation (Simenstad and Eggers 1981; Tschaplinski 1988).

The lower floodplains of the all the streams in this region that drain directly into Grays Harbor are tidally influenced, with estuary conditions ranging from mostly pristine in the Elk River, to highly degraded in Fry Creek and the lower Wishkah and Hoquiam Rivers. Degradation and habitat loss have resulted from commercial and residential development. The approximate five miles of estuary shoreline extending from one mile west of the Hoquiam River to east of the Wishkah River have also been highly degraded from commercial development in the Cities of Hoquiam, Aberdeen, and the Port of Grays Harbor. Impacts have resulted from filling or draining of estuarine wetlands, permanent conversion of tidal zone riparian vegetation to impervious surfaces, and a decrease in the amount of large woody debris in shallow shoreline areas of the estuary and lower rivers. The Grays Harbor Estuary section in this report discusses degradation in more detail.

The South Grays Harbor estuaries have relatively little development compared with the Hoquiam and Wishkah Rivers. Residential development in South Grays Harbor is sparse, and commercial development is limited to oyster growers in the Elk River estuary and a cranberry processor at the mouth of Johns River. Until 2000, there were dikes along 0.75 miles of the eastside of lower Newskah Creek and 1.75 miles of Johns River. Restoration projects recently breached these dikes to reestablish estuarine habitat that had been cut-off from tidal flows. In November 2000, the Stafford Creek Correction Center completed the estuary restoration project at the mouth of Newskah River as mitigation for prison construction activities. The project included breaching the dike in two places, excavating a meandering channel connecting the breaches, introducing large woody debris, and transplanting native plants along the excavated channel (Brian Blake, SCCC, personal communication). A breaching project was conducted by Ducks Unlimited on Johns River, where the dike was breached in two locations allowing tidal water into the adjacent wetland east of the river (Randy Van Hoy, Ducks Unlimited, personal communication).

Lower Charley Creek is diked along 0.5 miles of the west bank. Also, a 0.2 mile dike contains an auto salvage yard on the east bank immediately downstream of the Highway 105 crossing. A dike along Grays Harbor connects the dikes along Newskah and Charley Creeks. Prior to the Newskah Creek dike breach, the 0.5 square mile of estuary between Newskah and Charley Creek was completely contained by a dike between the creeks along Grays Harbor.

The Elk River and Johns River estuaries have relatively natural conditions and are rated as "good". Breaching of the dike on the eastside of the Johns River will improve conditions further by increasing the availability of estuary refuge habitat for juvenile salmon. O'Leary, Stafford, Indian, Campbell, and Chaplin Creeks are in "fair" condition, with impacts due to Highway 105 crossings. The Newskah Creek estuary had "poor" conditions prior to breaching of the dike that reconnected the creek to the adjacent estuary. Conditions currently are "fair", but will improve as the estuary habitat establishes over time. The Charley Creek estuary is "poor" due to a dike protecting an auto salvage yard along the east bank. The Wishkah and Hoquiam estuaries and approximately five miles of estuary between the rivers are "poor" due commercial and residential development.

Habitat Limiting Factors in the Wynoochee River Sub-Basin

Loss of Access for Anadromous Salmonids in the Wynoochee River Sub-Basin

There are a total of 667 miles of roads in the Wynoochee River sub-basin distributed as follows: 214 miles on National Forest lands, 50.5 miles on non-Forest lands in the upper Wynoochee drainage (upstream of Save Creek) (USFS 1996), and 402 miles of county and private roads in the lower basin (Lunetta et al. 1997). Only a small portion of these roads have been inventoried to identify culverts that are barriers to salmon accessing juvenile rearing or adult spawning habitat. Columbia Pacific RC&D has inventoried 196 culverts on 25 miles of county roads in the lower basin, identifying 35 culverts as fish passage barriers (Brian Erickson, Columbia Pacific RC&D, personal communication). The amount of habitat blocked upstream of barrier culverts was not quantified. The Salmon Screening, Habitat Enhancement, and Restoration Division (SSHEAR 1998) culvert database identifies no fish passage barrier culverts in the Wynoochee River, but this is due to the lack of an inventory.

The recent Forest and Fish Agreement requires that timber companies inventory all roads and develop road maintenance and decommissioning plans within the next five years as described in the Washington Forest Practices Emergency Rule WAC 222-24-050. (Phil Peterson, Simpson Timber, personal communication). The Olympic National Forest is also conducting an inventory of National Forest roads that will identify fish passage barriers and erosion hazards (Larry Ogg, Hoodsport Ranger District, personal communication).

In addition to documented blockages, there are believed to be other culvert barriers based on professional judgment. For example, Lonnie Crumley, LWC Consulting, has walked the road on the west side of the Wynoochee River upstream of Schafer Creek, and observed many blocking culverts in tributaries to the Wynoochee River. Dave Kloempken, WDFW, Region 6 Habitat Division, noted two fish passage barrier culverts in Helm Creek. Documented barriers to salmon habitat in the Wynoochee sub-basin are listed in Table 16, but this list is incomplete.

Table 16. Salmonid Blockages in the Lower Wynoochee River Sub Basin (data from Columbia Pacific RC&D).

Road Name	Road Mile	Stream Name	Township	Range	Section	Quantity Habitat Blocked
Aldergrove	0.75	Unnamed	17N	08W	11	NA
West Wynoochee	0.20	Unnamed	17N	08W	11	NA
West Wynoochee	0.27	Unnamed	17N	08W	11	NA
West Wynoochee	0.35	Unnamed	17N	08W	02	NA
West Wynoochee	0.50	Unnamed	17N	08W	02	NA
West Wynoochee	0.85	Unnamed	17N	08W	02	NA
West Wynoochee	0.87	Unnamed	17N	08W	02	NA
West Wynoochee	1.10	Unnamed	17N	08W	02	NA
West Wynoochee	1.29	Unnamed	18N	08W	34	NA
West Wynoochee	1.60	Unnamed	18N	08W	34	NA
West Wynoochee	2.20	Unnamed Creek	18N	08W	34	NA
West Wynoochee	2.31	Geisler Creek	18N	08W	34	NA
Geisler Road	1.75	Mooney Creek	18N	08W	33	NA
Geisler Road	3.22	Unnamed Creek	18N	08w	29	NA
Geisler Road	3.60	Unnamed Creek	18N	08w	20	NA
Geisler Road	3.80	Unnamed Creek	18N	08w	20	NA
Geisler Road	4.35	Unnamed Creek	18N	08w	17	NA
Black Creek Road	0.40	Unnamed Creek	18N	08w	26	NA
Black Creek Road	0.85	Unnamed Creek	18N	08w	26	NA
Black Creek Road	1.48	Unnamed Creek	18N	08w	25	NA

Road Name	Road Mile	Stream Name	Township	Range	Section	Quantity Habitat Blocked
Black Creek Road	2.55	Unnamed Creek	18N	08w	23	NA
Black Creek Road	2.90	Unnamed Creek	18N	08w	23	NA
Black Creek Road	3.05	Unnamed Creek	18N	08w	14	NA
#58520	0.01	Caldwell Creek	18N	08w	27	NA
Old Wynoochee	0.28	Unnamed Creek	19N	08w	32	NA
Old Wynoochee	1.46	Unnamed Creek	19N	08w	28	NA
Wynoochee Valley	0.35	Unnamed Creek	17N	08w	01	NA
Wynoochee Valley	0.95	Unnamed Creek	17N	08w	02	NA
Wynoochee Valley	5.31	Unnamed Creek	18N	08w	21	NA
Wynoochee Valley	0.59*	Unnamed Creek	19N	08w	33	NA
Wynoochee Valley	1.00*	Unnamed Creek	19N	08w	33	NA
Wynoochee Valley	1.82*	Unnamed Creek	19N	08w	28	NA
Wynoochee Valley	3.60*	Unnamed Creek	19N	08w	22	NA
Wynoochee Valley	4.94*	Unnamed Creek	19N	08w	14	NA
Wynoochee Valley	7.75*	Unnamed Creek	19N	08w	02	NA

*Road miles north of the Wynoochee-Wishkah Road

Fish Passage Rating in the Wynoochee River Sub-Basin

Due to a lack of inventories and no assessment of habitat upstream of blockages, fish passage conditions in the drainage cannot be rated. Field experience by TAG members indicates that the list of culverts documented as barriers is conservative, underestimating the problem of fish access basin-wide. As ongoing culvert assessments by Columbia Pacific RC&D and the Olympic National Forest are completed, and timber companies begin implementing their five year monitoring plans, a more comprehensive assessment of the amount of habitat isolated by culverts will be available.

Floodplain Conditions in the Wynoochee River Sub-Basin

Downstream of the dam, the Wynoochee River meanders for six miles through a forested confined floodplain before entering a five-mile canyon and finally opening into a broad forested valley. The river course in the lower 22 miles has been modified with a variety of bank hardening to protect agricultural land from erosion during high flows. Wampler et al. (1993) identified 2.3 miles of bank hardening at 27 sites, with the majority of sites in Black Creek or downstream of Black Creek along the lower 5.5 miles of the mainstem.

An off-channel habitat inventory included the lower Wynoochee River, and identified five off-channel habitat sites that need restoration activities. These sites are located at RMs 1.6, 1.9, 3.0, 3.3, and 4.5, and a description of their restoration needs is listed in Table 7 (see Estuary section) (Ralph et al. 1994). Analysis of early 1990 aerial photos indicates there are several sites (RMs 2.7-3.0, 8.5-10, 12.0-14.0, 17.0, 21.5, 27.5, 31.0, 36.0, 46.0) that offer potential off-channel habitat if made accessible to the river. A side-channel with beaver activity near RM 9 was visited during medium flows. The outlet periodically fills with silt, and reed canary grass also blocks access. After deepening the outlet with hand tools, it is currently accessible by juvenile salmon during summer low flows. Field verification of these and other side-channels will determine if they are only isolated at low flows, or whether sedimentation or human-caused channel modifications block access at all flow stages. Off-channel habitat has been documented to produce more coho salmon smolt per area of habitat and produce larger fry and smolt due to greater primary productivity (Sammuelson et al. 1990). In addition to the impacts from bank hardening, it is likely that off-channel habitat has been reduced from historic levels due to the lack of flooding from dam operations (David Hamilton, Regional Enhancement Group, personal communication). This would greatly impact coho salmon.

The use of splash dams in the Wynoochee sub-basin was relatively minimal compared to the Humptulips and Wishkah Rivers, and was limited to two in Black Creek and two in Sylvia Creek. There were no splash dams on the mainstem, although log drives originating from Black Creek would have affected floodplain function and instream debris for the lower 7 miles of the Wynoochee River. It is difficult to determine if splash dams on the Wynoochee caused considerable channel incision, as was the case on the Humptulips River. The fact that Black Creek is the most productive coho tributary in the watershed suggests that the current floodplain is functioning well enough to support significant coho salmon rearing.

There is extensive beaver activity in tributaries to the lower 28 miles of the Wynoochee sub-basin. Wampler et al. (1993) inventoried 119 beaver dams with the majority of activity in Sylvia, Mooney, Wedekind, Black, Helm, Schaefer, and Neal Creeks. A comprehensive habitat survey of the Sylvia Creek watershed identified 126 beaver dams, but many of them are located upstream of the natural barrier falls immediately below Sylvia Lake (Mattice and Schillinger 1994). Beaver dams provide important off-channel rearing habitat for juvenile coho salmon during seasonal high water periods. Woody vegetation used by beavers to construct dams provides cover for rearing salmon. Beaver ponds create a nutrient sink, which increases productivity of aquatic invertebrates, both in the ponds, and in tributaries downstream of the ponds. Beaver dams also provide storage areas of fine sediment, and stabilize flows during high water events because water is stored in ponds and released slowly over the beaver dams (Cederholm et al. 2000).

Gravel mining was a common practice in the Wynoochee River, both from gravel bars (until 1986) and from pits located in the floodplain. Gravel bar mining at low water created problems when rising water filled the pits and trapped salmon fry as flows dropped. For this reason, WDFW required that gravel bars be graded, and over the years has encouraged off-channel gravel pit operations (Steve Keller, WDFW, personal communication). WDFW requires that an impermeable dike surround gravel pits to prevent channel avulsion (Collins and Dunne 1987). WDFW also requires that egress channels be maintained when gravel pits are closed because the abandoned pits can be restored into rearing ponds. Near RM 16, an abandoned gravel mining operation was converted into a series of five interconnected rearing ponds, with a common access channel to the river. The Weyco-Brisco Ponds were restored during the 1980s through the early 1990s with riparian plantings and introduction of large woody debris. Today, there is dense riparian vegetation of alder and willow, and the ponds have been colonized with aquatic vegetation. The ponds appear to provide excellent juvenile salmon rearing habitat; however, the access road needs maintenance to prevent further erosion and eventual washout. In 1990, Grays Harbor College Natural Resources Program conducted periodic monitoring of juvenile salmon use of the ponds and determined that off-channel pond reared coho and chinook were significantly larger than those rearing in the adjacent Wynoochee River (Samuelson et al. 1990).

Another gravel pit operation has been restored into three off-channel ponds near RM 1.9, but there is no egress channel to the Wynoochee and no connectivity between the ponds (Ralph et al. 1994). The pond has good riparian vegetation and was designed to include pond margin islands to increase productivity.

Floodplain Rating in the Wynoochee River Sub-Basin

Bank hardening in the lower 6 miles of the river (Wampler et al. 1993) and agricultural development in the lower 22 miles of the mainstem, have reduced connectivity of the channel to the floodplain. Based on this, floodplain ratings in the lower river are "poor". The large amount of beaver activity in Sylvia, Wedekind, Black, and Helm Creek provide "good" floodplain function in these lower river tributaries. A more thorough assessment of floodplain impacts is needed.

<u>Streambed and Sediment Conditions in the Wynoochee Sub-Basin.</u>

Past timber harvest techniques have significantly modified sediment delivery and substrate composition throughout the entire Wynoochee sub-basin. In addition, agricultural activities have impacted the lower 22 miles of the mainstem, gravel bar mining has impacted the lower 12 miles of the mainstem, and historical splash dams have degraded the streambed in the lower river tributaries. In the early 1960s, sediment-loading studies for the Chehalis River showed that the Wynoochee River is the second greatest contributor of the sediment load to the Chehalis Basin, delivering 30.6% of the total sediment (Pickett 1992).

In lower 45 miles of the Wynoochee River mainstem and associated tributaries, Wampler et al. (1993) identified over 71 miles of streambank erosion, with 42% related to timber management, 31% to agriculture, and 27% to other or natural causes. Approximately 32% of the agricultural-related erosion was due to livestock grazing. Implementation of livestock exclusion fencing projects reduced grazing related erosion impacts, but that reduction hasn't been quantified.

In the upper sub-basin, over 1,500 erosion sites have been identified in the Upper Wynoochee Watershed Analysis area (U.S Forest Service 1996). Most sediment sources delivering to streams are road-related, and are the result of sidecast road construction, slumping from decomposing log debris road fills, and blocked or undersized culverts creating saturated fill slopes (U.S. Forest Service 1996). Upstream of the Wynoochee Dam, there were 313 erosion sites affecting the watershed, and from the dam downstream to Save Creek at RM 39, there were 200 sites delivering sediment to streams. Streambank and inner gorge failures are common, particularly on the outside meanders along the West Branch Wynoochee watershed above the current reservoir and in the lower mainstem Wynoochee River below the dam (U.S Forest Service 1996).

The upper sub-basin is naturally prone to landslides due to shallow soils on steep slopes. A mass wasting potential map was developed for the upper Wynoochee drainage, and these landslide hazard areas are listed by sub-watershed in Table 17 (U.S. Forest Service 1996). Three types of mass wasting events were identified from aerial photos: shallow rapid, deep-seated, and streambank landslides. Streambank landslides are often underestimated because they are not detected in aerial photographs due to canopy closure (U.S. Forest Service 1996).

Table 17. Summary of Landslide Hazards in the Upper Wynoochee River Watershed Analysis Area.

Sub-Watershed	Low Hazard Acres	Low Hazard %	Medium Hazard Acres	Medium Hazard %	High Hazard Acres	High Hazard %	Rating
Above Dam							
Trout Cr	672	44	350	23	516	34	Poor
Up. Wyn R	6105	55	1955	18	2977	27	Poor
WB Wyn R	2491	59	634	15	1114	26	Poor
Mid Wyn Tribs	10449	96	96	1	370	3	Good
NF Wyn Tribs	1034	72	141	10	260	18	Fair
Wyn Lake	5900	74	766	10	1285	16	Fair
Below Dam							
Anderson	2528	76	197	6	586	18	Fair
Big Creek	4087	66	592	10	1524	25	Poor
Harris Cr	1043	65	148	9	425	26	Poor
Save Cr	1973	89	61	3	189	9	Good

Because landslides are often road-related, road density data have been rated for many of the watersheds within the Wynoochee sub-basin (Table 18). Upstream of the Wynoochee Dam, there are 119.3 miles of National Forest roads and 2.8 miles of private timber roads, with road densities ranging from 2 miles road/sq. mi. watershed in the upper Wynoochee, to 4.6 mi. roads/sq. mi. watershed in the North Fork Wynoochee watershed. Downstream of the dam within the watershed analysis area, there are 94.9 miles of National Forest roads and 47.7 miles of private timber roads, with road densities ranging from 3.2 mi.road/sq. mi. watershed in the Middle Wynoochee watershed and 4.4 mi./sq. mi. in the Big Creek watershed. Ratings are mostly "poor" for road density with the exception of the upper Wynoochee sub-watershed, which is rated “fair”.

Table 18. Summary of Road Miles, Road Densities and Number of Erosion Sites in the Upper Wynoochee River Watershed (U.S. Forest Service 1996).

Sub-Watershed	Forest Service	Private	Total	Road Density (mi road/sq. mi watershed)	Road Density Condition Rating	# of Erosion Sites Affecting Watershed
Upstream of Dam	119.3	2.8	122.1			
Upper Wynoochee	37.3	0		2.15	Fair	148
N.F. Wynoochee	10.2	0		4.55	Poor	33
W. Br. Wynoochee	24.2	0		3.65	Poor	4
Trout Creek	9.1	0		3.78	Poor	74
Wynoochee Lake Tribs	38.5	2.8		3.31	Poor	54
Downstream of Dam	94.9	47.7	142.6			
Big Creek	39.8	3.0		4.41	Poor	102
Harris Creek	9.1	1.9		4.30	Poor	34
Anderson Creek	16.7	5.6		4.30	Poor	5
Save Creek	2.5	10.4		3.65	Poor	NA
Mid Wynoo. Tribs	26.8	26.8		3.23	Poor	59
*Upper Wynoochee			109.3	2.67	Fair	NA
*Lower Wynoochee			544.8	3.08	Poor	NA

* Data for upper and lower Wynoochee River (Lunetta et al. 1997)

Forest Service mass wasting hazard inventories have prioritized the worst sites, and since 1995, erosion control treatments have been conducted adjacent to Forest Service roads. Treatments have included a combination of revegetation, and bioengineering with logs and willow cuttings (Larry Ogg, Olympia National Forest, personal communication).

The Wynoochee Dam has changed the sediment regime of the river by reducing the amount of sediment entering the river downstream of RM 50. The trapping of fine sediment in the lake is beneficial to spawning habitat downstream, but the reduction of gravel supply is detrimental to overall spawning habitat. To mitigate the reduction in gravel supplied by the upper drainage, gravel accumulated at the fish collection facility water supply dam is periodically dredged at low water, and spread on a gravel bar immediately downstream of the dam to be distributed downstream during high flows. A similar process is done with large woody debris that is collected in the log boom above the dam. It is periodically loaded on a flatbed truck and transported to the gravel bar downstream of the fish collection facility (Shane Scott, Tacoma City Light, personal communication).

Beginning in the 1930s, the Wynoochee River mainstem was used to mine gravel to construct logging roads. Until the 1950s, gravel mining occurred almost exclusively from gravel bars during low water. These early gravel mining operations left open pits that often trapped fish as water levels subsided. WDFW then regulated gravel bar mining by requiring that gravel bars be regraded to prevent fish entrapment. After a study documented that the amount of gravel being removed was exceeding the natural gravel replenishment rate between RM 2 and 11 (Collins and Dunn 1986), gravel bar mining ceased. This occurred in the mid-1980s.

No data on instream levels of LWD were found for this report. This is a data need.

Ratings for Sedimentation Conditions in the Wynoochee River Sub-Basin

The following areas are rated "poor" for sediment quantity due to road densities: the North Fork Wynoochee River, the West Branch Wynoochee, Trout Creek, tributaries to Wynoochee Lake, Big Creek, Harris Creek, Anderson Creek, Save Creek, tributaries to the middle Wynoochee River, and the entire lower Wynoochee WAU. In addition, excess sedimentation upstream of the dam has been documented as a severe problem due to landslides (U.S. Forest Service 1996). The upper Wynoochee sub-watershed is the only area not rated "poor". It is rated "fair".

The lower 45 miles of the Wynoochee River, and its tributaries, are rated “poor” for sediment quantity not only because of high road densities, but also because of the 71 miles of streambank erosion impacts documented in the Wampler et al. (1993) study. Agriculture practices contributed 31% of the erosion impacts, but almost 13 miles of riparian protection from livestock exclusion fencing projects completed since that study have reduced this amount considerably.

Riparian Conditions in the Wynoochee River Sub-basin

Due to the lack of funding, the watershed analysis conducted for the upper Wynoochee River did not include a riparian vegetation assessment (U.S. Forest Service 1996). With no riparian module or other comprehensive study of riparian conditions available, a broad scale analysis of riparian conditions was made using 1993 USGS aerial photos online (Terra Server.Com), and by reviewing riparian vegetation classification for the Lower and Upper Wynoochee WAUs (Lunetta et al.1997). Because these are coarse-scale analyses, riparian condition ratings are made with the notation that a finer resolution of riparian conditions remains a data need.

Timber harvests in the upper Wynoochee River within the Olympic National Forest implemented riparian protection measures even before the spotted owl decision in 1994. Since then, there has been no commercial timber harvest on National Forest Land within the Wynoochee sub-basin except for salvage logging or pre-commercial thinning (U.S. Forest Service 1996). Therefore, riparian conditions are generally "good" in the upper 17 miles of the mainstem and its tributaries within the National Forest.

There were no harvest restrictions on private lands associated with the spotted owl decision, because no old growth forest remained outside of the Olympic National Forest. Downstream of the Forest Service boundary at RM 44.7 to RM 31, the riparian zone is exclusively second growth reforestation, consisting of mixed Douglas fir and alder. Riparian vegetation in this reach provides good shade and limited near-term large woody debris recruitment, but does provide a long-range future source of large woody debris. Between RM 31 and 22, the forest has been intensely managed in recent years. Riparian conditions are mostly "fair" within this reach, where narrow buffers of second growth conifer remain (Map 4a). Below RM 22, essentially all timberlands located with the floodplain were harvested and converted to agricultural land. The riparian zone in the lower 22 miles is primarily a narrow band of mostly alder trees mixed with Douglas fir, and is rated "poor" (Map 4a).

The Lunetta et al. (1997) database describes the Wynoochee River riparian conditions in two geographical regions (WAUs), with the reach break being the outlet to Wynoochee Lake. The lower WAU has a predominately (53%) hardwood riparian ("poor"), with 36% of the riparian consisting of more than 70% conifer ("good"). A 1997 aerial photograph indicates that within this lower reach, the majority of the conifer component is upstream of the Olympic National Forest boundary, while most of the hardwood riparian is within the lower 22 miles, where forested land has been converted to agricultural land. The upper WAU, upstream of the Wynoochee Dam, consists of 63% conifer reaches, 33% hardwood-dominated reaches, and 4% mixed hardwood and conifer riparian areas.

During the mid 1990s, the Grays Harbor Conservation District, in cooperation with landowners, administered several riparian livestock exclusion fencing projects. These projects successfully protect streambanks from livestock grazing through established buffers. The buffer widths are negotiated between the Grays Harbor Conservation District and the landowner.

Rating of Riparian Conditions in the Wynoochee Sub-Basin

Because there has been no riparian assessment in the Wynoochee River drainage, there is a data need to evaluate and rate riparian conditions. Based on the review of high elevation aerial photographs, and landuse patterns in the floodplain, some assumptions can be made on riparian conditions. Upstream of RM 44.7 (Olympic National Forest boundary), riparian vegetation is almost exclusively conifer forest, and is rated "good". Downstream of the Olympic National Forest to RM 22, there has been intensive forest management where riparian buffers do not meet current standards. Current riparian conditions in this reach are "fair" to "poor". However, as the Forests and Fish Agreement is implemented, riparian conditions will improve over time. Agricultural development in the lower 22 miles of the river has removed the majority of riparian conifers, and riparian buffers are now mostly narrow stands of red alder. Overall, riparian conditions in this lower reach are "poor".

Water Quality Conditions in the Wynoochee River Sub-Basin

Water quality was monitored monthly by Washington Department of Ecology from 1959 until 1977 in the Wynoochee River near RM 13.5. Currently, water quality in the Wynoochee River is not regularly monitored by Washington Department of Ecology River, and there was no evaluation of water quality, including water temperature, in the Upper Wynoochee Watershed Analysis. Based on data from the 1959 through 1977 sampling station, the overall water quality is classified as extraordinary (AA) in the upper drainage, and excellent (A) in the lower drainage (LCCD 1992). However, regular temperature exceedences above 16°C have resulted in the Wynoochee River being placed on the 1996 and 1998 Section 303(d) Lists (DOE 2000). Table 19 shows a summary of temperature exceedances from the DOE monitoring data. Because of the warm water temperatures, the lower Wynoochee River is rated "poor" for water quality. In addition, water quality parameters such as water temperature, dissolved oxygen levels, pH, and turbidity should be monitored on a regular basis.

Table 19. Summary of Temperature Exceedances from DOE Water Quality Monitoring (1959 – 1977).

Month	# of exceedances>14°C	# of exceedances>15.6°C	# of exceedances>17.8°C
May	1	1	0
June	3	0	3
July	4	1	4
August	1	4	3
September	4	2	1

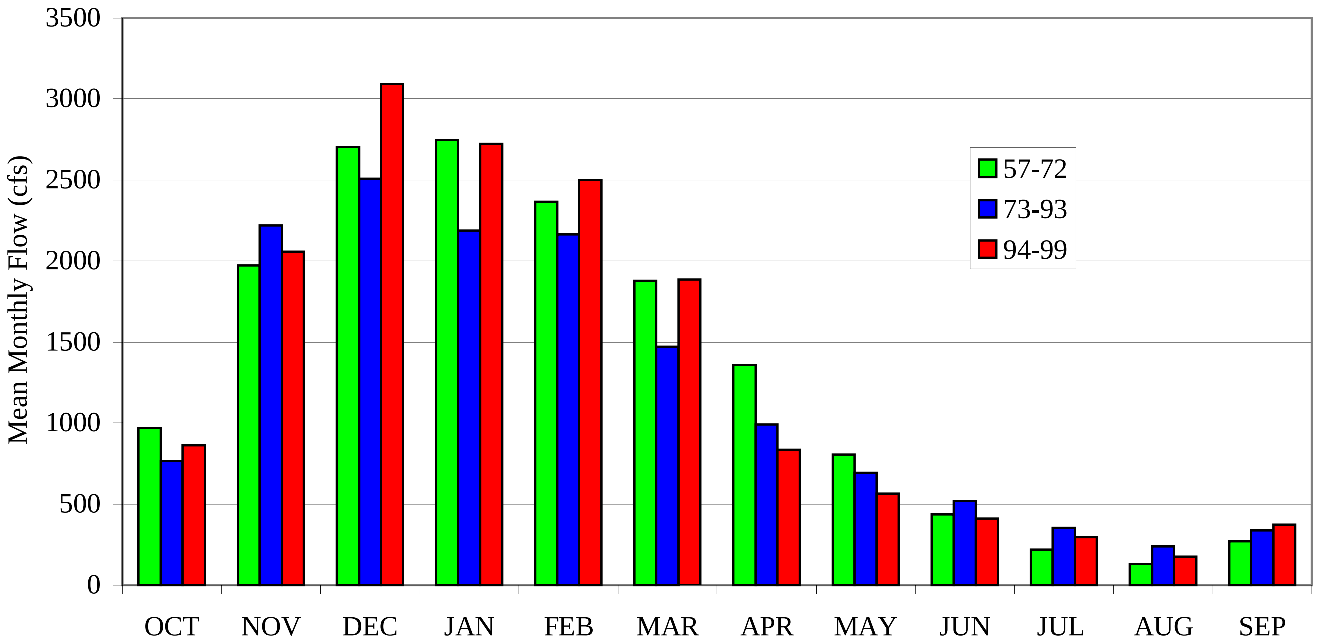
The recently completed Grays Harbor Fecal Coliform TMDL identified the Wynoochee River as contributing 10% of basin flows, but only 3.2% of the fecal coliform to the basin. This was the lowest rate of input from the major sub-basins in the lower Chehalis Basin, and the only sub-basin where no reduction in fecal coliform was recommended (Pelletier and Seiders 2000).

Water Quantity Conditions in the Wynoochee River Sub-Basin

Since 1957, the mean flow of the Wynoochee River at the Black River gage has been 1,276 cfs with a maximum recorded flow of 24,500 cfs in January 1968 and a minimum flow of 3 cfs in August 1967 (LCCD 1992). After the Wynoochee Dam was constructed in 1972, flows have been regulated for the lower 50.8 miles. Between 1972 and 1993, the primary objective for the dam was to provide flood control to protect agricultural and residential land in the floodplain. The secondary need was to mitigate low flows from Aberdeen's water withdrawal project by maintaining minimum flows of 140 cfs from April through June and 190 cfs the remainder of the year (ACOE 1983).

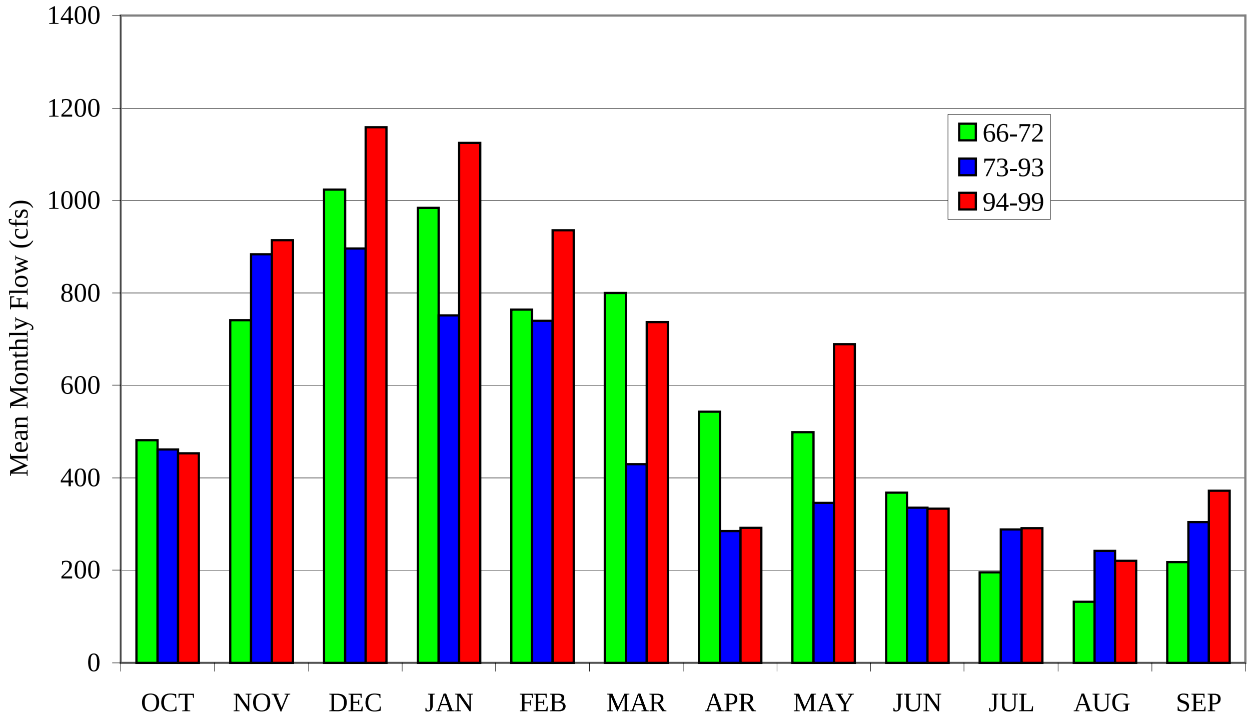
In the early 1990s, the dam was upgraded with hydroelectric turbines that began operation in 1994 (U.S. Forest Service 1996). Local residents believe that river levels are now higher and fluctuate more often since this conversion (Lee Hansmann, Grays Harbor County, personal communication). To examine potential changes in flows, mean monthly flows measured at the Grisdale (RM 50) and Black River (RM 5.5) USGS Gaging Stations are summarized before construction of the dam, as well as before (1973-1993) and after (1994-1999) hydroelectric generation at the Wynoochee (Figure 25 and Figure 26). During the flood control operations (1972-1993), the mean monthly flows in October and December through April at the Black River gage were 196-559 cfs lower than natural flows prior to construction of the dam. These flows represented 79% to 93% of the natural flows. However, since the hydropower project began operating in 1994, mean monthly flows have been 337 to 586 cfs higher between December and March, increasing from 15% to 28% over flows when the dam was operated for flood control (Figure 25). Also, the flows resulting from hydroelectric generation are higher than natural flows in December, but similar to natural flows in November, January, March, June, and August.

Figure 25. Comparison of Mean Monthly Flows at the Black River Gage: before Wynoochee Dam (green), before Hydroelectric Generation (blue), and after (red) Hydroelectric Generation.



A similar trend was found using data from the Grisdale Gage, located immediately downstream of the dam. After the dam began operating in 1972, the mean monthly flows were 33 to 370 cfs lower from December through June, representing 53% to 91% of the natural flows. Since the dam was converted to hydroelectric generation, flows at the Grisdale Gage increased 196 to 372 cfs from December through March and in May compared to when the dam was operated for flood control, although the increased flows in March are now more similar to natural conditions. This represents an increase of 26% to 99% over flows prior to construction of the dam (Figure 26). The increased flows over natural flows in winter could impact salmonids by increasing the risk of scour and altering channel conditions. There is also an apparent decrease in flows during April at both gages and in May at the Black River gage when comparing the hydroelectric data to natural conditions. This has a high likelihood of impacting outmigrating juvenile salmon. Lower flows slow the migration time, decreasing survival of juveniles.

Figure 26. Comparison of Mean Monthly Flows at the Grisdale Gage: Natural (green), Flood Control Operations (blue), and Hydroelectric Generation (red).

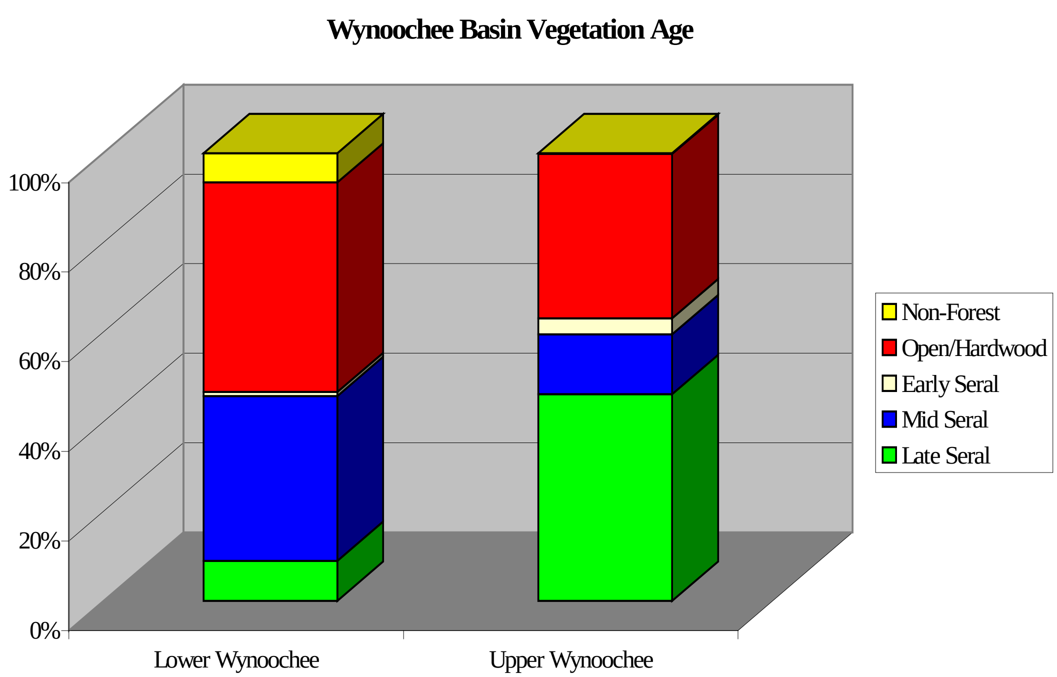


The summary of flows at the Grisdale Gage indicate that the Wynoochee Dam has regulated flows above the minimum flow of 140 cfs set at the dam and maintained summer low flows higher than natural flows in that area. However, the flow data from the gage in the lower Wynoochee River near Montesano (12037400) demonstrate that established base flows have not been met for an average of 59 days/year from May 1995 through September 1999 (data from USGS). This suggests that activities other than dam operations are worsening low flow conditions in the lower Wynoochee River.

In addition to flow changes from the dam operations, land management practices have reduced the forested land cover, which can increase the rate of water run-off into streams. This can result in a more rapid rise and fall in stream flows during and after rainfall events (U.S. Forest Service 1996). Forest seral stage and land cover data indicate that 58% of the upper Wynoochee WAU (upstream of the Wynoochee Dam) is hydrologically mature, and is rated "poor" for this report (Figure 27) (data from Lunetta et al. 1997). The lower Wynoochee WAU consists of 45% hydrologically mature land cover vegetation, also a "poor" rating (Figure 27) (data from Lunetta et al.1997). Other impacts of water flows are likely, but data have not been found to include these. A data need remains to identify and quantify water withdrawals in the Wynoochee sub-basin.

Overall, water quantity conditions are rated "poor" for the Wynoochee sub-basin. This is based upon the greatly altered land cover vegetation in the lower Wynoochee and the moderately altered land cover in the upper Wynoochee, coupled with flows that dip below established base flows in the summer months. The "poor" ratings are supported by the apparent change in flow patterns caused by dam operations in the winter and early spring. Of particular concern are the possible increased flows from December through March and decreased flows in April and May. The apparent change in flows needs to be examined in greater detail and that information alone did not result in the "poor" rating, and is a data need. It is noteworthy that the dam operations have aided summer low flows, but that other activities might be impacting the low flow conditions.

Figure 27. Land cover Vegetation Age and Type in the Wynoochee Sub-Basin (data from Lunetta et al. 1997).



Habitat Limiting Factors in the Satsop Sub-Basin

<u>Loss of Access for Anadromous Salmonids in the Satsop Sub-Basin</u>

Data Sources

Data sources for this section include the Salmonid Screening, Habitat Enhancement and Restoration Division barrier list (SSHEAR 1998), survey data from Columbia Pacific RC&D (Brian Erickson, personal communication 1999), the West Fork Satsop Watershed Analysis (Weyerhaeuser and Simpson Timber Co 1995), and personal communication from the TAG members especially Lonnie Crumley, LWC Consulting. It was not always determined if these blockages are partial or complete, nor if they block salmonid adults, juveniles, or both. Additional data are thought to exist with Simpson Timber Company, but those data were not available for this report.

Blockages

Table 20 lists currently-documented artificial blockages within the Satsop sub-basin, although field experience of the TAG members indicates that this list greatly underestimates the actual number of blockages within the basin. Not all listings are in priority order because the salmonid use and habitat quality upstream of the blockages have not been clarified. Information from Columbia Pacific RC&D (Brian Erickson, personal communication, 1999) is preliminary. Roads in Grays Harbor County are currently being inventoried for a detailed culvert assessment; however, this does not include roads on private forestland or on U.S. Forest Service property. An analysis that includes all salmonid blockages continues to be a data need.

These blockages are a major limiting factor in the Satsop sub-basin for three reasons. They are a considerable problem in the West and Middle Fork Satsop Rivers because overwintering rearing habitat during floods is limited, and blockages on tributaries decrease available winter refuge habitat. The blockages also interfere with two other major limiting factors: transport of spawning gravel and large woody debris (LWD). The lack of spawning gravel is a major problem in the West Fork Satsop River.

The SSHEAR database lists an additional culvert (on Simpson Timber Company property) on a tributary to the East Fork Satsop River (22.0471A), but does not quantify the lost habitat or the river mile location. The West Fork Satsop Watershed Analysis listed a few culverts and logjams as barriers to cutthroat (Weyerhaeuser and Simpson Timber Co 1995). These are not included because we are not addressing cutthroat-issues at this time.

Fish Passage Rating in the Satsop Sub-Basin

There is a great need for more complete data throughout the entire Satsop sub-basin, but based upon the information to-date, fish passage conditions are rated "poor" in the West Fork Satsop and Middle Fork Satsop watersheds. This is due to the limiting winter refuge habitat and the blockage of that habitat by culverts. The fish passage conditions in the East Fork Satsop are not rated due to a lack of data. However, winter refuge habitat is not as limiting in this watershed, lessening the overall impact to salmonids.

Table 20. Salmonid Blockages in the Satsop Sub-Basin.

Road Name	**Mile Location**	**Town-ship**	**Range**	**Section**	**Stream Name**	**Type of Blockage**	**Quantity of Blocked Habitat**	**Data Source**
West Boundary Rd #73650	2.49	19N	07W	12SE	Trib. Enters Middle Fork at RM 6.1	2 culverts (88' apart) blocking juvenile and adults	2.15 miles	Col-Pac RC&D, and Lonnie Crumley
Cougar Smith Rd #73700	2.26	20N	07W	34SW	Singer Creek	Culvert at RM 0.4, set of 2 culverts at RM 1.1, set of 2 culverts at RM 1.3	1.5 miles if all 3 culverts fixed.	Lonnie Crumley, and Col-Pac RC&D
West Satsop Rd. #73230	0.11 mi	18N	07W	15SE		Culvert	Not Available	Col-Pac RC&D
West Satsop Rd. #73230	0.59	18N	07W	15NE		Culvert	Not Available	Col-Pac RC&D
West Satsop Rd. #73230	1.16	18N	07W	10SE		Culvert	Not Available	Col-Pac RC&D
West Satsop Rd. #73230	1.32	18N	07W	10SE		Culvert	Not Available	Col-Pac RC&D
West Satsop Rd. #73230	3.06	18N	07W	03NW		Culvert	Not Available	Col-Pac RC&D
West Satsop Rd. #73230	3.61	18N	07W	03NW		Culvert	Not Available	Col-Pac RC&D
West Satsop Rd. #73230	3.92	18N	07W	04NE		Culvert	Not Available	Col-Pac RC&D
West Satsop Rd. #73230	4.94	19N	07W	33NE		Culvert	Not Available	Col-Pac RC&D
East Satsop Rd. #73850	2	18N	07W	25NW		Culvert	Not Available	Col-Pac RC&D
East Satsop Rd. #73850	2.22	18N	07W	24SW		Culvert	Not Available	Col-Pac RC&D
East Satsop Rd. #73850	2.77	18N	07W	23NE		Cement dam	Not Available	Col-Pac RC&D
West Boundary Rd #73650	5.11	20N	07W	36NW		Culvert	Not Available	Col-Pac RC&D
West Boundary Rd #73650	5.3	20N	07W	35NE		Culvert	Not Available	Col-Pac RC&D

Road Name	**Mile Location**	**Town-ship**	**Range**	**Section**	**Stream Name**	**Type of Blockage**	**Quantity of Blocked Habitat**	**Data Source**
West Boundary Rd #73650	7.42	20N	07W	13NE		Culvert	Not Available	Col-Pac RC&D
Cougar Smith Rd #73700	0.67	20N	07W	35NE		Culvert	Not Available	Col-Pac RC&D
Muller Rd. #73690	0.04	20N	07W	34SW		Culvert	Not Available	Col-Pac RC&D
Middle Satsop Rd. #97250	2.16	18N	07W	23SW		Culvert	Not Available	Col-Pac RC&D
Middle Satsop Rd. #97250	2.88	18N	07W	23NW		Culvert	Not Available	Col-Pac RC&D
Middle Satsop Rd. #97250	5.19	18N	07W	12NW	Trib. To Satsop River	Culvert	Not Available	Col-Pac RC&D and Lonnie Crumley
Middle Satsop Rd. #97250	5.54	18N	07W	12NE		Culvert	Not Available	Col-Pac RC&D

Floodplain Conditions in the Satsop Sub-Basin

Floodplain Problems In The Satsop Sub-Basin

Only one type of current floodplain impact was found in the literature for the Satsop sub-basin, the use of rip-rap along stream banks. Wampler et al (1993) documented 41 sites with rip-rap, and these are mapped in Figure 28. Most of the sites are located in the East Fork drainage, Decker Creek, and along the mainstem Satsop River. The West Fork Satsop has only 1 rip-rap site. Wampler et al (1993) also searched for evidence of channelization, and none was noted in this sub-basin.

Between RM 0-5 of the lower Satsop River, 6 freshwater off-channel sites have been identified as potential coho over-wintering habitat (Ralph et al. 1994). These areas are wetlands that are no longer connected to the main channel or need additional work such as vegetation and exclusion of cattle. The sites are shown in the estuary section, Figure 14, and Table 7 lists each site and the type of work necessary for restoration.

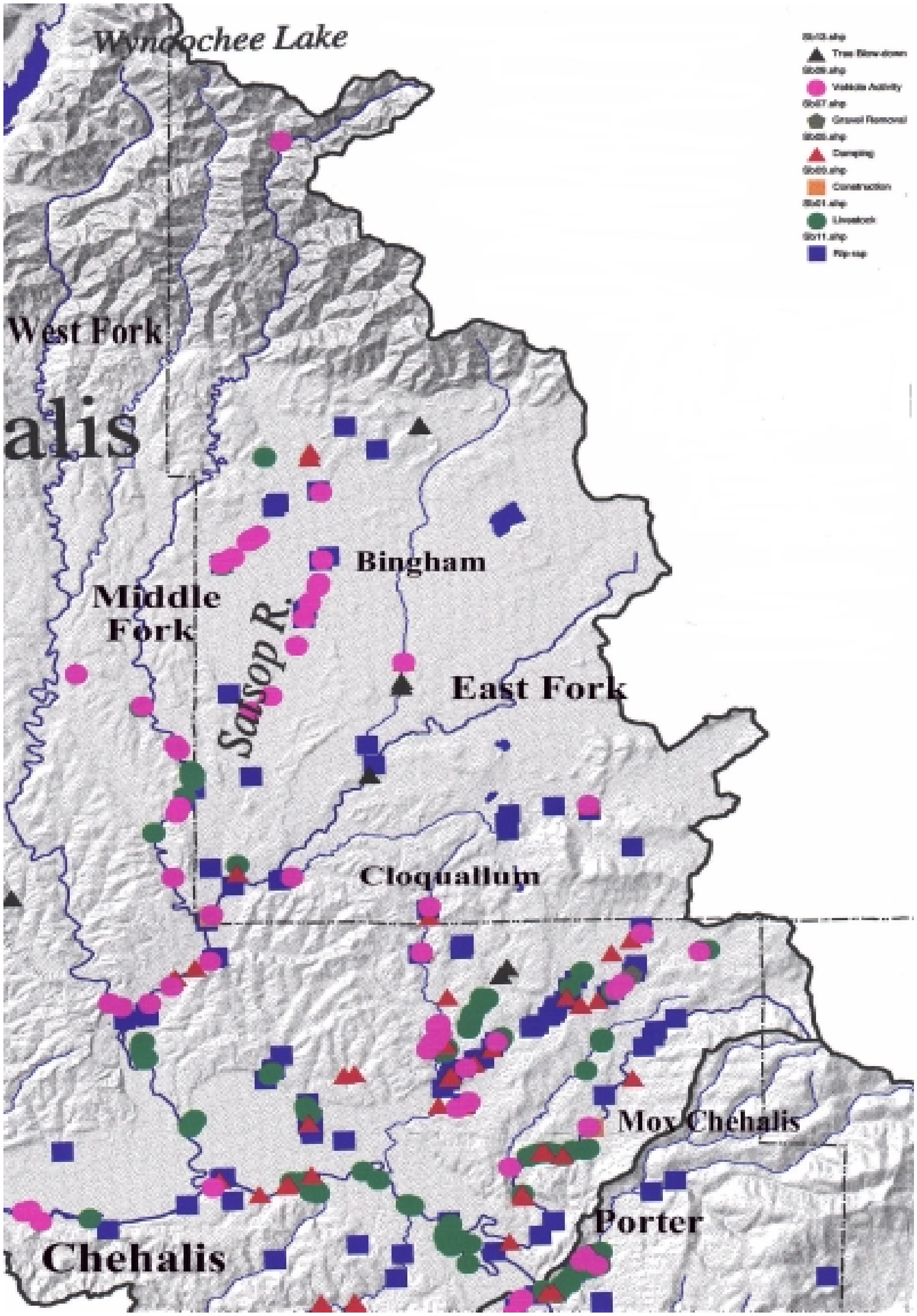
Natural off-channel wetland habitat is abundant in the East Fork Satsop, which has a high drainage density (total miles of streams divided by watershed area) (Owen 1989). In contrast, the Middle Fork Satsop watershed has a very low drainage density, suggesting that off-channel habitat is limiting. The West Fork Satsop drainage density is in-between that of the East and Middle Fork Satsop Rivers.

Historically, there were four splash dams in the Satsop sub-basin (Ellison Timber Company 1982). Although these were constructed and used in the early 1900s, their impacts are still seen today. Research on the impacts of splash dam operations in California rivers showed that channel alterations, and simplification of habitat have persisted since turn of the century logging (Napolitano 1998). The frequent release of high flows during log drives removed natural large woody debris and accelerated channel incision. Because side-channels were blocked off to prevent logs from being stranded outside the main channels, down-cutting in the side channels would not have occurred at the same rate, resulting in eventual isolation of side channels from the main channel. The reduction of large woody debris and side channel access has reduced the amount of juvenile rearing habitat.

Floodplain Rating in the Satsop Sub-Basin

Data are limited, and few current floodplain impacts within the Satsop sub-basin have been documented. However, concern exists because of the past splash dams coupled with current problems of scour risk and lack of off-channel habitat, particularly in the West Fork and Middle Fork Satsop watersheds. This suggests that floodplain impacts might be a significant problem, but data are lacking to show the presence and extent of the possible problem. For these reasons, floodplain conditions within the Satsop are not rated, but are a data need.

Figure 28. Rip-rap sites in the Satsop Sub-basin (Wampler et al. 1993).



Streambed and Sediment Conditions in the Satsop Sub-Basin

Streambed and Sediment Problems in the Mainstem Satsop River and lower tributaries

Road densities are high in the Satsop WAU at 4.1 miles of road/square mile watershed (Lunetta et al. 1997). This results in a "poor" rating for sediment quantity. In addition, the Satsop River has been estimated to transport about 10,000 cubic yards of gravel per year through the lower mainstem (Collins and Dunne 1986) and is the greatest sediment contributor to the mainstem Chehalis River (CRC 1992). The changes in riverbed elevation are another concern. There was a trend toward aggradation from 1943 to 1951, followed by degradation from the early 1950s to the mid-1980s (Collins and Dunne 1986). This has resulted in a lower riverbed elevation compared to the mean of the 50-year record, and indicates channel incision. Channel incision is a floodplain impact that dissociates the main channel from off-channel habitat that is important for salmonids. Collins and Dunne (1986) suggest that the degradation is at least partially the result of gravel harvesting, which occurred in the mainstem Satsop River. Efforts to maintain and increase functional floodplain habitat, including off-channel habitat in this area should be a high priority. The Satsop sub-basin is a major contributor of salmon and steelhead, and because all juveniles need to transport through the lower mainstem, functional floodplain habitat is extremely important.

Streambed and Sediment Problems in the West Fork Satsop Watershed

High levels of sediments combined with low levels of LWD are major problems in the West Fork Satsop. The relative contribution of sediments is 96.6% from landslides, 1.7% from roads, 1.1% from natural background, 0.5% surface erosion from landscape scars, and 0.04% from hillslope erosion (Clark 1995). The total contribution of fine sediment from natural background erosion was estimated at about 4,900 tons/year (Clark 1995). Canyon Creek had the highest natural sedimentation rates.

Landslides contribute most of the sediment delivery to the West Fork Satsop watershed. About 574 landslides have been identified in the West Fork Satsop. Of these, 59% (341) are associated with roads using sidecast technology (an old technique where spoils were not hauled away, but placed uncompacted near the road), and most of these are in the upper third of the basin (O’Connor 1995). Many of the remaining landslides are associated with clear-cutting on steep slopes. Most (53%) of the landslides are located in the upper third of the watershed, while 18% are in the lower third (Figure 29) (O’Connor 1995). Upper watershed landslides deliver both coarse and fine sediments. However, the coarse sediment needed for spawning habitat does not remain in the channel due to a lack of LWD. In turn, the increased transport of sediment reduces channel stability.

Most of the sediment delivered to Type 1-3 streams comes from the large persistent deep-seated landslides, which are more commonly found in the middle third of the basin (Figure 29) (O’Connor 1995). The large, deep-seated landslides can temporarily block the channel or divert flow into new channels, increasing channel instability. Shallow rapid landslides are the second greatest source of sedimentation delivery to Type 1-3 streams, and these are found throughout the upper two thirds of the basin. Debris torrents (landslides that carry materials such as trees into the streams) in the upper third of the basin deliver sediment primarily to Type 4-5 streams (O'Connor 1995). The mean annual sediment delivery was estimated to be about 1.2 m^3/ha (O'Connor 1995). The amount of sedimentation in undisturbed watersheds ranges from 0.1 to 0.8 m^3/ha.

Roads not only pose a landslide risk, but also contribute to sediment fines through erosion. The total annual contribution of fines from road erosion in the West Fork Satsop is about 4,500 tons (Clark 1995). Particularly high rates occur in the West Fork mainstem, Swinging Bridge, middle and upper Canyon River, lower Little River, Save Creek and Robertson Creek. Moderate road erosion (fine sediment delivery at 50-100% of the background rate) is projected for Still Creek, the West Fork Satsop near RM 19, lower Canyon River, and upper Little River (Clark 1995).

Hillslope erosion was less than 50% of the background rate for each site throughout the West Fork Satsop drainage, contributing relatively little sediment compared to landslides (Clark 1995). However, significant erosion is occurring at a few sites, such as near the West Fork Satsop mainstem at about RM 19, where a clear cut contributes between 9-10 tons/year. Surface erosion from landslide scars was about equal to 50% of the natural background rate for sedimentation.

Nearly all of the forests in the lower two thirds of the West Fork Satsop watershed were clear-cut 40 to 70 years ago. Harvest occurred down to the stream banks, resulting in a loss of riparian and subsequent LWD. The lack of LWD has likely contributed to increased surface erosion of stream banks, particularly in Types 4-5 streams. However, sediment from this source is small compared to the quantity generated by landslides in the basin (O'Connor 1995).

The high levels of sedimentation increase channel instability and scour. Aerial photographs show that the mainstem West Fork Satsop River near RM 30 to 32 and Canyon River (RM 5-8) widened following the 1951 flood (Kirtland 1995). After the peak flow in 1994, there were several new sites of streambank erosion and landslides. These are indicators of instability, which would impact the survival of salmon eggs. Overall, the stream channel disturbance frequency has increased in the past 50 years. This greatly impacts incubation survival of salmon, particularly those that spawn in the mainstem West Fork Satsop River where scour has been identified as a problem (Figure 30). Those species include chinook, coho, and chum salmon, as well as winter steelhead trout.

The quality of salmon incubation gravel in the West Fork Satsop watershed is rated "poor" for about 50% of the sampled areas (Baxter 1995). The lower two thirds of the basin is dominated by sedimentary rocks (O'Connor 1995). These weather and breakdown quickly, contributing little to the coarse sediment needed by salmon for spawning gravels, which results in low natural levels of spawning gravels. Landslides in the upper third of the basin are the major source of coarse sediment (O'Connor 1995), but without LWD to hold the gravels, the sediment is transported completely through the basin. Tributaries in the lower West Fork (Still Creek, streams 22.0369-22.0373) lack adequate spawning gravels (Figure 30), partially because of the natural geology, but also because of a lack of LWD (Figure 31) (Map 5a) (Baxter 1995). High levels of fine sediments are a problem in those same lower tributary streams (Figure 30).

Figure 29. Landslides in the West Fork Satsop Sub-Basin (O'Connor 1995).

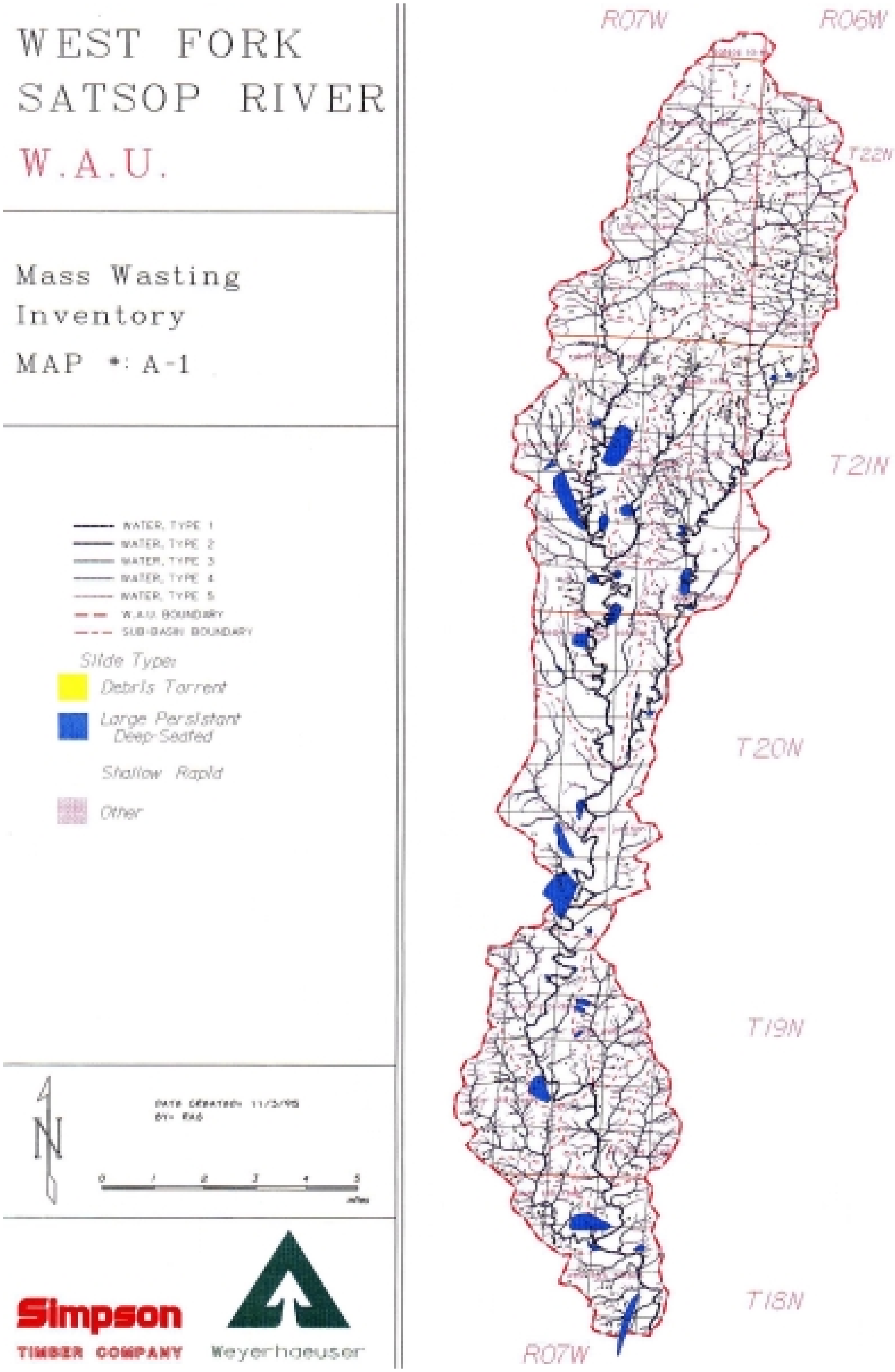


Figure 30. West Fork Satsop River Spawning Gravels and Scour (Baxter 1995).

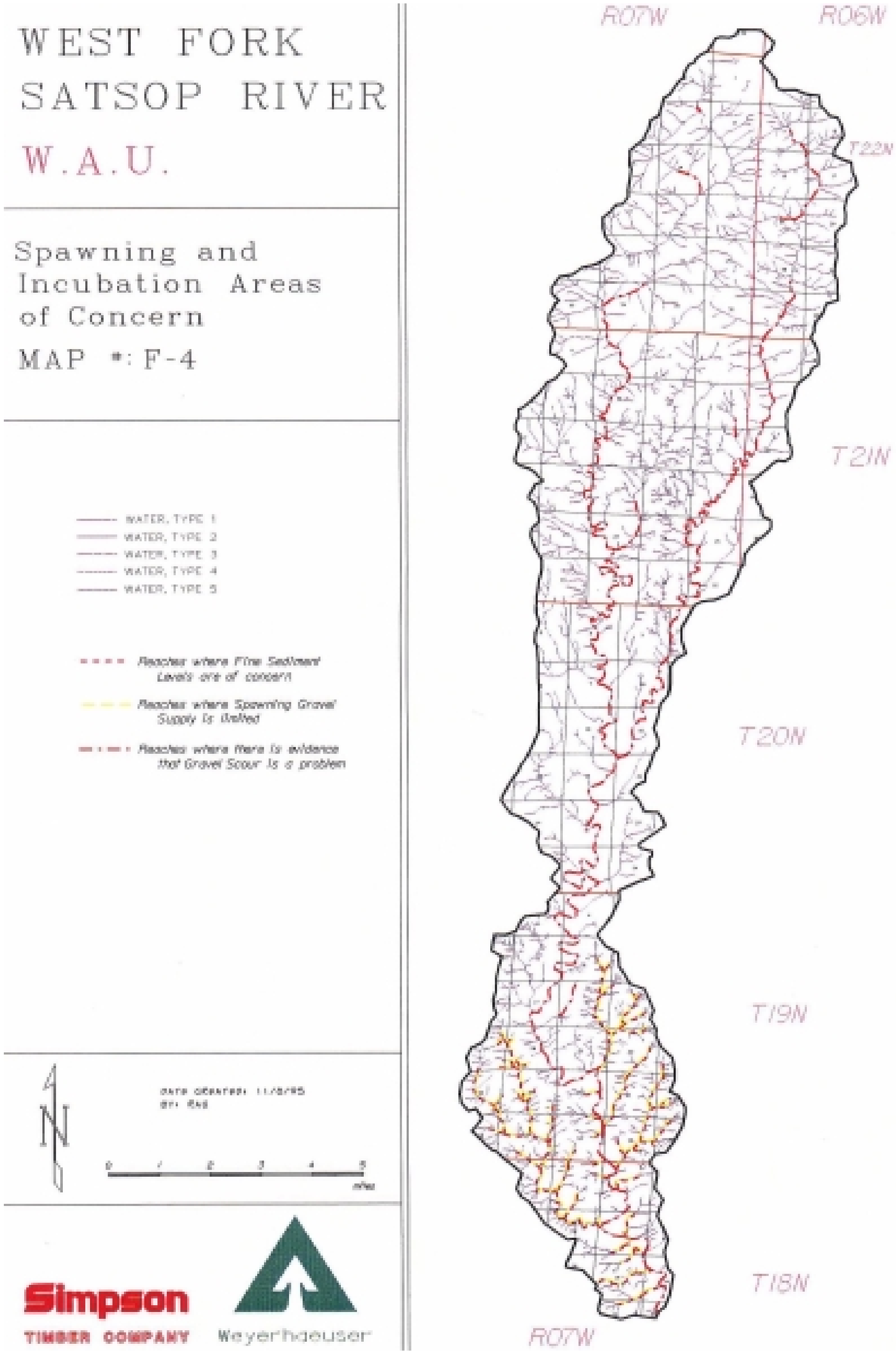
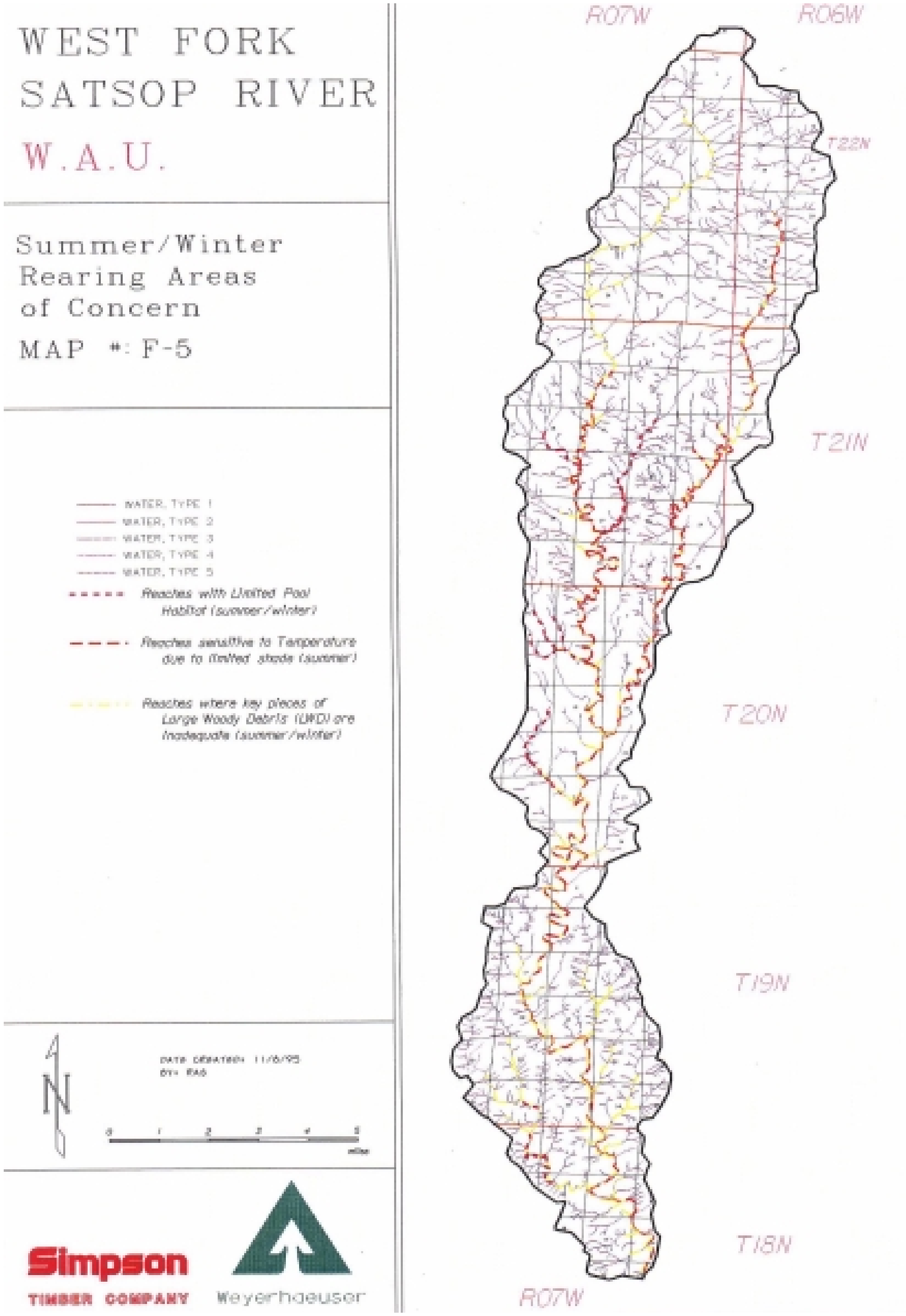


Figure 31. West Fork Satsop LWD, Pools, and Temperature (Baxter 1995).



Streambed and Sediment Problems in the Middle Fork Satsop Watershed

Data from the Middle Fork Satsop watershed were not as detailed because a watershed analysis has not been developed for this area. However, Wampler et al. (1993) documented nine sites of debris torrent inputs. This is the highest level of debris torrent sites in the entire Satsop sub-basin, and they are located in the upper Middle Fork watershed (Figure 32). Debris torrents are especially damaging to salmonid habitat. They lead to scour, channel incision, loss of LWD, and loss of spawning gravel. In addition to debris torrents, erosion was common throughout the Middle Fork Satsop drainage. Road densities are high in the Middle Fork Satsop WAU at 4.4 miles of roads/square mile of watershed (Lunetta et al. 1997). This results in a "poor" rating for sediment quantity. Simpson Timber Company has decommissioned 20 miles of roads throughout the upper Satsop Basin in the last five years (Simpson Timber Co. 1999). Continued road reductions and maintenance are recommended to reduce sediment loads.

Vehicle activity was documented in the lower Middle Fork mainstem (Wampler et al. 1993). This activity degrades spawning habitat and contributes to bank erosion. If done during spawning season, vehicle activity could directly kill salmonid eggs that are buried in the gravel.

Streambed and Sediment Problems in the East Fork Satsop Watershed

No debris torrents were noted in this watershed, but the highest density of reach erosion was recorded in Decker Creek (Figure 32) (Wampler et al. 1993). Lower numbers of erosion sites were documented in the East Fork Satsop mainstem and in Bingham Creek. Road densities are high in the East Fork Satsop WAU at 4.3 miles of road/square mile watershed (Lunetta et al. 1997). This results in a "poor" rating for sediment quantity.

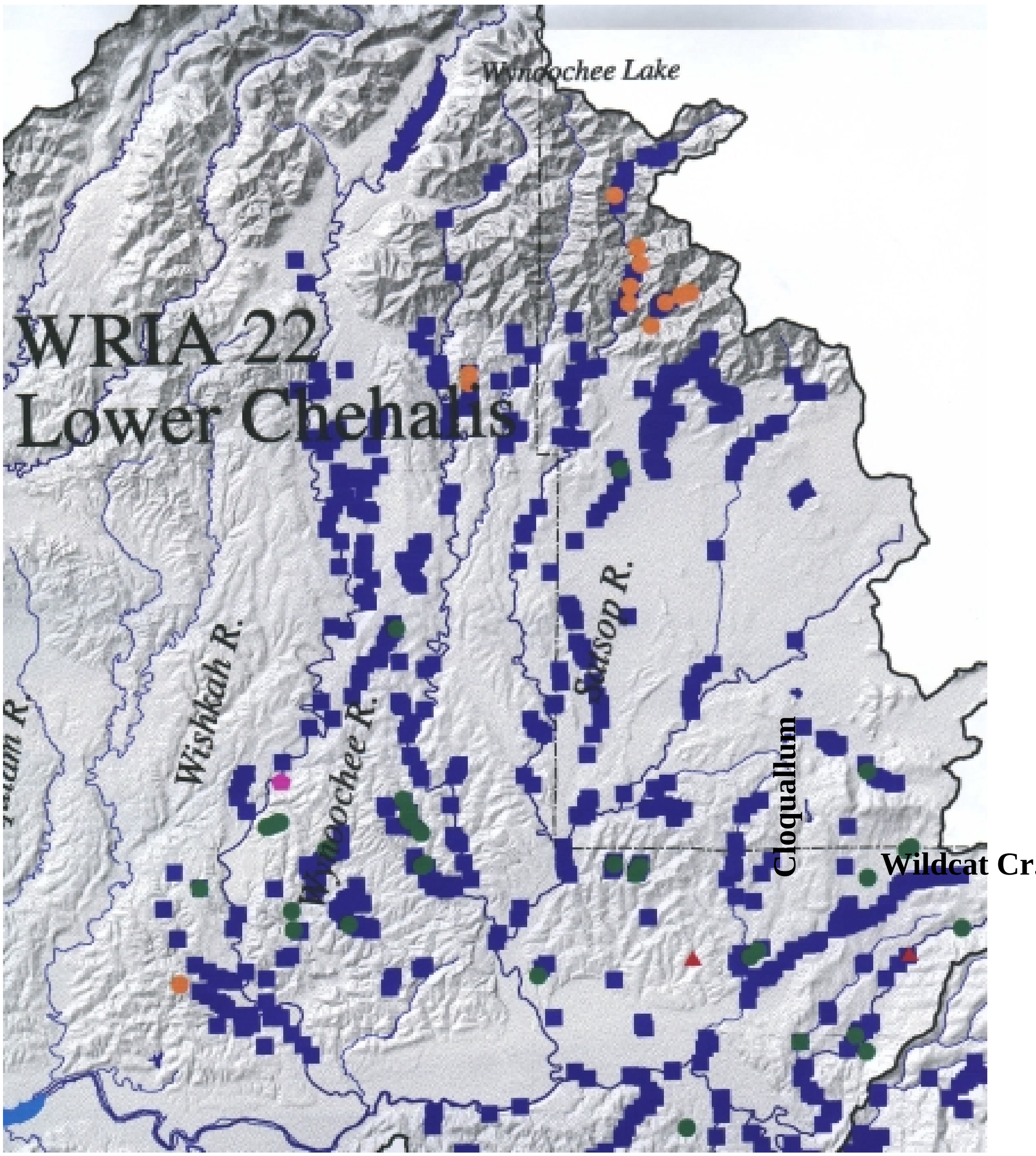
Vehicle activity is a big problem for Decker Creek and the lower East Fork Satsop (Wampler et al. 1993). Crossings degrade salmonid spawning areas, and contribute to bank erosion. Education regarding the impacts of this activity is needed.

Rating for Streambed Sediment Problems in the Satsop Sub-Basin

Instream quantity of LWD rated as “poor” in the West Fork Satsop watershed and remains a data gap for the remainder of the sub-basin. Spawning gravel quantity rated “fair” for the West Fork Satsop watershed because of the limited amounts in the lower portions of the watershed, and this problem is partially due to the lack of LWD. Excess sedimentation is a "poor" condition throughout the Satsop sub-basin due to high road densities, but a more extensive sediment analysis is greatly needed. The quality of sediment is rated “poor” in the West Fork Satsop watershed, due to high levels of fine sediments, and “fair”, with some uncertainty, in the East Fork Satsop watershed because of the high density of erosion sites. Sediment quality remains a data gap for the Middle Fork Satsop Watershed. Channel stability rated as “poor” in both the Middle Fork and the West Fork Satsop watersheds. The Middle Fork had a high number of debris torrents, while scour was a concern for the West Fork. Channel stability is a data gap for the East Fork Satsop watershed.

Reducing sedimentation, particularly from sidecast roads, and maintaining spawning gravels within the sub-basin should be very high priority needs. Because the Satsop sub-basin is the greatest sediment contributor to the mainstem Chehalis River (CRC 1992), the effects of high sediment transport rates not only impact the Satsop sub-basin, but also translate downstream, impacting the mainstem Chehalis River.

Figure 32. Sites of erosion and debris torrents in the Satsop Sub-Basin (Wampler et al. 1993).



Riparian Conditions in the Satsop Sub-Basin

Riparian Conditions In The Mainstem Satsop Watershed

A loss of bank vegetation was noted for sections of the mainstem Satsop River, but very little tree canopy loss was documented in the mainstem (Wampler et al. 1993). However, the Satsop WAU riparian data indicates that most of the riparian (79%) is either lacking vegetation or is dominated by hardwoods and is rated "poor" (Figure 33) (data from Lunetta et al. 1997).

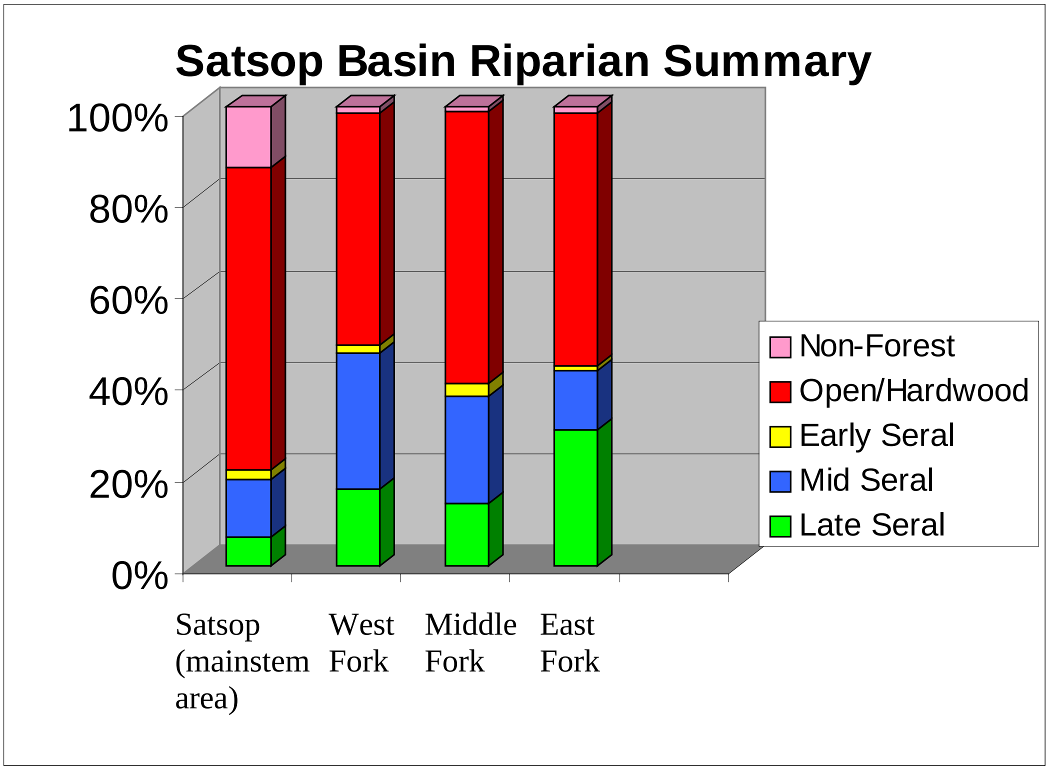
Riparian Conditions in the West Fork Satsop Watershed

Early logging in the lower two thirds of the West Fork Satsop watershed removed the old-growth forest, including the riparian areas, and burned the land without replanting. This has led to the conversion of the riparian from old-growth fir to alder (Jordan 1995). From the late 1940s to 1990, old growth in the upper watershed was harvested, including some in the riparian areas. In 1995, watershed analysis results documented the widespread conversion of the riparian zone from conifer to deciduous, particularly in the middle and lower West Fork Satsop watershed (Map 4a).

The lower West Fork Satsop River is a wide meandering channel with a high percentage of naturally low shade (Jordan 1995). The riparian in this area is mostly alder, and the land use is agricultural, rural residences, or commercial forest management. The riparian stands of the middle reaches of the West Fork Satsop River (until just south of the Canyon River confluence) are mostly dense deciduous or mixed mature stands (Map 4a). The upper West Fork Satsop River is more confined with a conifer-dominated riparian. The upper portion is owned by the U.S. Forest Service and has a few stands of old growth Douglas fir remaining (Jordan 1995). The Canyon River riparian is contained within an incised canyon with dense deciduous and mixed mature stands in the lower drainage, to mature and old conifer in the upper region.

The most common riparian stand in the West Fork Satsop watershed is 48% deciduous, 62% mature, and 73% dense. This classification accounts for about 32% of the total riparian miles in the West Fork Satsop watershed (Jordan 1995), and is rated "poor". Mature, dense conifer account for only 5% of the riparian miles; old, dense conifers form 4% of the riparian; and old, sparse conifers comprise another 4% of the riparian miles (Jordan 1995). Using the Lunetta et al. (1997) data, "poor" riparian conditions are found in about 52% of the West Fork Satsop watershed (Figure 33).

Figure 33. Riparian Vegetation Type in the Satsop WAUs (data from Lunetta et al. 1997).



The predominance of alder greatly impacts the potential recruitment of large woody debris (LWD). Near-term LWD recruitment potential in the lower West Fork Satsop watershed (downstream of RM 13, including associated tributaries such as Still Creek) is rated as generally "moderate" to "low" (Table 21) (Jordan 1995). Long-term LWD potential in the area is generally "poor" due to the high percentage of mature deciduous riparian stands on the tributaries and "poor" riparian conditions along the mainstem (Jordan 1995).

Table 21. Near-Term LWD Recruitment Potential in the West Fork Satsop (Jordan 1995).

Location	Percent High	Percent Moderate	Percent Low
Lower West Fork			
Mainstem	3%	62%	35%
Tributaries	22%	40%	38%
Middle West Fork			
Mainstem	20%	58%	22%
Tributaries	45%	21%	34%
Upper West Fork			
Mainstem	53%	37%	10%
Tributaries	10%	45%	45%
Canyon River			
Mainstem	31%	53%	16%
Tributaries	27%	40%	33%

Near-term LWD recruitment potential in the middle reaches of the West Fork Satsop watershed (RM 13 to 30, including tributaries such as lower Little River) is variable. Both the middle mainstem and tributaries had a greater percentage of samples rated as “high”, but both also had very significant percentages rated as “low” (Table 21) (Jordan 1995). Long-term LWD recruitment potential is "poor" with 40% of the stands consisting of mature alder.

The upper West Fork Satsop River and tributaries such as upper Little River, Spoon Creek, and Pederson Creek, rate better for near-term LWD recruitment potential in the mainstem, but worse in the tributaries (Table 21) (Jordan 1995). Long-term LWD recruitment potential is "high" because of the greater percentages of conifer.

Near-term recruitment of LWD in the Canyon River mainstem rated mostly "moderate" to "high", but the tributaries rated generally "moderate" to "low" (Table 21) (Jordan 1995). The long-term LWD potential is primarily "good", although 25% of the sub-basin was classified as having "poor" long-term LWD recruitment potential.

Current LWD levels are highly variable. Most of the current functional pieces are from previous timber harvests or old mortality that remained in the stream channel; the riparian has added only small mobile wood (Jordan 1995). Most of the current levels are considered to be "poor" to "moderate" (Jordan 1995). Only 11% of the sampled areas are rated as "good" for LWD, with 33% rating "poor" (Baxter 1995). Key pieces of LWD rate even worse, with 88% of the samples classified as “poor” (Baxter 1995).

The low current levels of LWD are a major factor in the number of pools available for salmon. Pool frequency is rated as "fair" for 47% of the segments and "poor" for 35% of the segments (Baxter 1995). This reduces coho and steelhead rearing habitat, and increases stress of migrating adults for all salmonids. The areas with the lowest pool abundance include Black Creek, Little River, and some of the smaller tributaries (Figure 31).

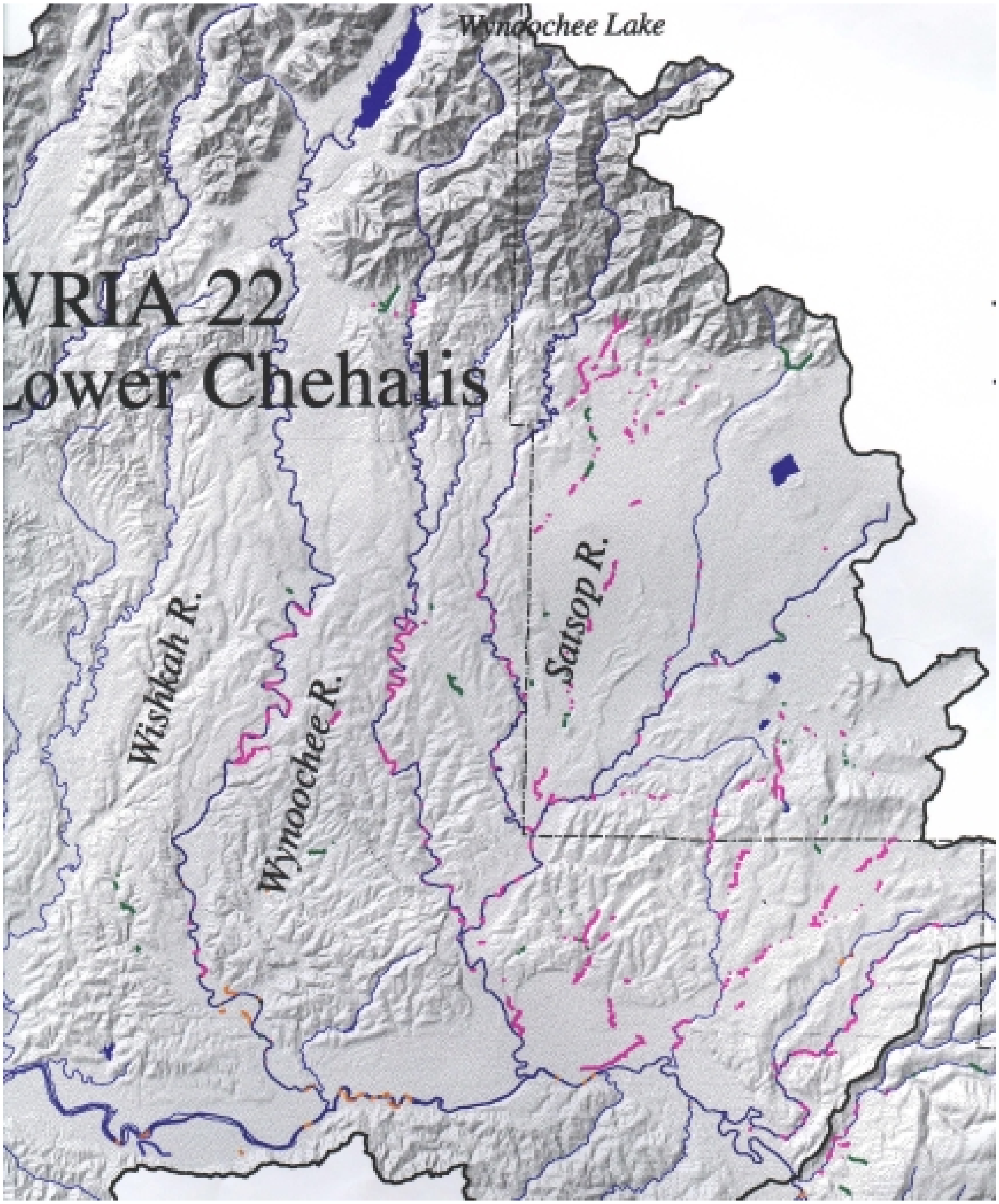
Riparian Conditions in the Middle Fork Satsop Watershed

Loss of riparian vegetation is documented in the middle and lower reaches of the mainstem Middle Fork Satsop, as well as extensive loss in Rabbit Creek (Figure 34) (Wampler et al. 1993). Small areas of tree canopy loss are noted in the middle and upper reaches of the Middle Fork Satsop. Overall, 61% of the Middle Fork Satsop riparian reaches are either lacking in trees or dominated by hardwoods, and are rated "poor" (Figure 33) (data from Lunetta et al. 1997).

Riparian Conditions in the East Fork Satsop Watershed

Areas lacking riparian vegetation in the East Fork Satsop watershed include Decker Creek and tributaries, the lower mainstem East Fork Satsop River, and upper Bingham Creek (Figure 34) (Wampler et al. 1993). The East Fork mainstem from the confluence of Cook Creek to just south of the Township 20 boundary with Township 19 has an extensive loss of tree canopy (Wampler et al. 1993). Loss of tree canopy was also recorded in upper Bingham Creek. About 57% of the riparian buffers are either open or dominated by hardwoods and are rated "poor" (Figure 33) (data from Lunetta et al. 1997). However, the East Fork Satsop watershed has the greatest percentage (29%) of late seral riparian trees in the Satsop drainage (Figure 33). Preservation of these "good" riparian buffers is recommended.

Figure 34. Riparian vegetation loss in the Satsop Sub-Basin (Wampler et al. 1993).



Rating of Riparian Conditions in the Satsop Sub-Basin

All four WAUs within the Satsop drainage consist of mostly "poor" rated reaches for riparian conditions due to the predominance of hardwood or open areas. The riparian zones in the West Fork Satsop watershed were assessed by a much more rigorous methodology than used in the Middle and East Fork watersheds, and the ratings given the Middle Fork and East Fork Satsop watersheds have been assigned with less confidence.

Water Quality in the Satsop Sub-Basin

High water temperatures are a likely problem in many areas of the West Fork Satsop sub-basin based upon shade analysis (Jordan 1995). Target shade ranges from 50% to 80%, with fewer of the larger streams meeting target shade requirements (75% below target), than smaller streams (83% met target). Rabbit Creek is on the 303(d) List because of high water temperature, with 14 samples warmer than the standard in 1990 (DOE 1999). At the DOE water quality monitoring site in the Satsop River near Satsop (RM 2.7), temperature measurements did not exceed the upper limit in the years sampled (1960-1991, 1993). However, dissolved oxygen levels fell below the standard at this site in late summer and early fall.

Three major segments of the Satsop River have been listed as threatened by the Washington State Department of Ecology (DOE) due to siltation and suspended solids (DOE 1990). These reaches include: 1) the mainstem Satsop River, 2) the mainstem West Fork Satsop River, and 3) the mainstem East Fork Satsop River from its confluence with the West Fork Satsop River to the confluence with the Middle Fork Satsop River. The source of the siltation and suspended solids has been listed as “unspecified nonpoint sources” in the mainstem Satsop River and unknown in the West and East Fork Satsop Rivers.

Another potential water quality problem in the Satsop River is toxicity. Using a waterflea reproduction bioassay, Michaud (1989) found significant toxicity from water samples collected at RM 2.2 in the Satsop in September 1987. The type and source(s) of toxicity were not determined, and future studies should examine this water quality issue in greater detail. It is unknown what effect this has on salmonid production, but concern should exist regarding potential direct effects in addition to ecosystem impairments.

Wampler et al (1993) documented sites within the Satsop River that could be contributing to water quality problems. They found two wastewater outfalls, nine miscellaneous inputs, and two inputs associated with animal waste, sediment, or chemicals. This is a relatively low level of inputs. When the authors rated this level of water quality degradation against other problems such as erosion and loss of bank vegetation, the water quality problem sites were very minor in comparison.

Ratings for Water Quality Conditions in the Satsop Sub-Basin

Water quality is rated “poor” in the West Fork Satsop watershed because of high water temperature, a 303(d) listing, and siltation. The East Fork Satsop watershed rates “poor” for water quality due to siltation. Water quality in the Middle Fork Satsop watershed remains a data gap.

Water Quantity in the Satsop Sub-Basins

Water Quantity Problems in the Satsop Sub-Basin

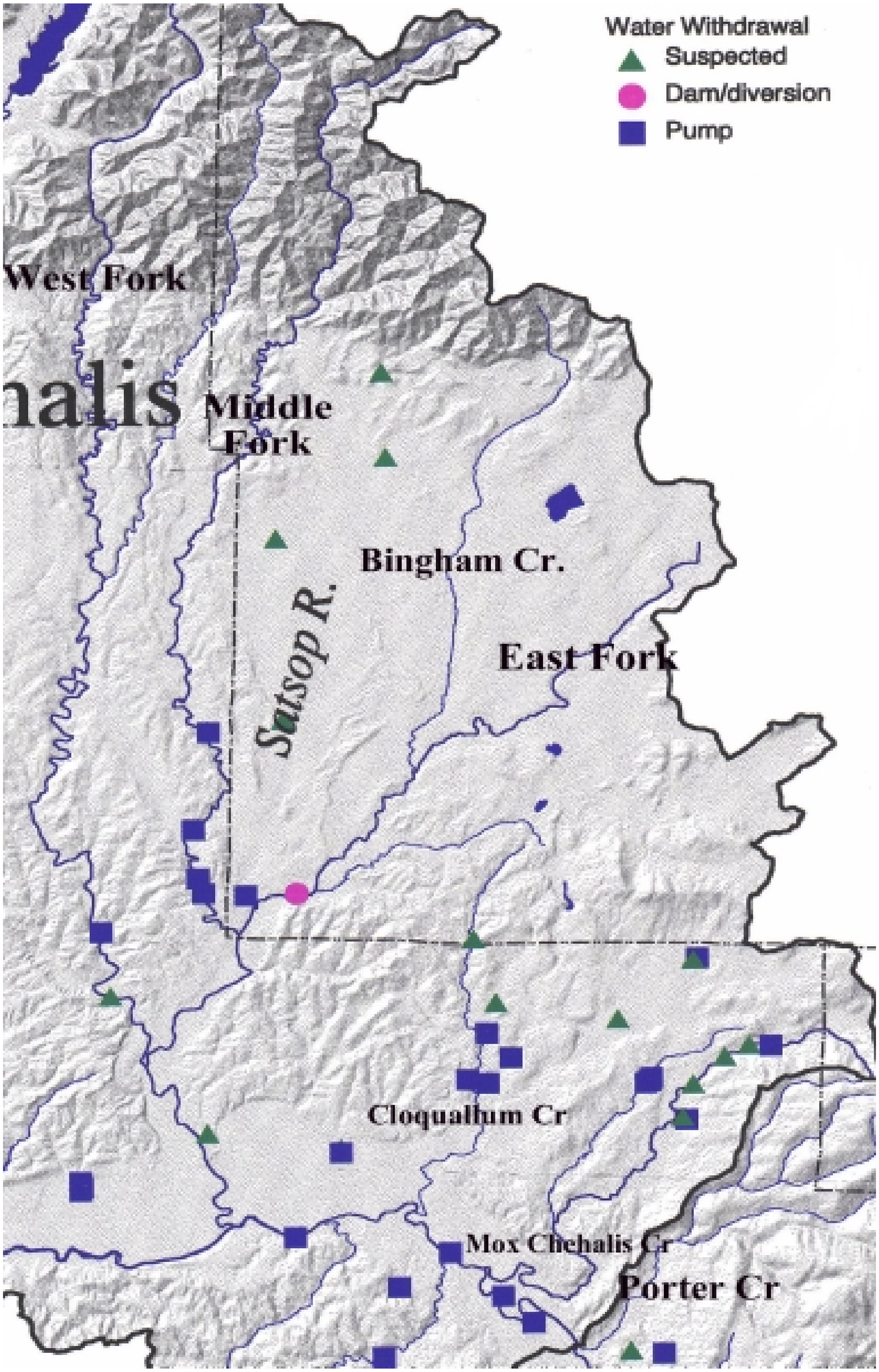
Low water flows are likely a problem in the Satsop sub-basin. In the last five years, the Satsop sub-basin has not met established base flows for an average of 63 days/year measured at the gage near Satsop (12035000) (data from USGS). This results in a "poor" rating for water quantity. Wampler et al (1993) documented a relatively low number of water withdrawals in the Satsop River sub-basin. They listed two dams or diversions, six sites of water pumping, and six sites of suspected water withdrawals (Figure 35). For the size of the sub-basin, these documented withdrawals are low relative to other problems, but the frequency of flows lower than base flows merits concern. One data need is to examine water usage within the sub-basin and quantify impacts to low flows. Also, it is not known whether the low flows are linked to the low dissolved oxygen levels noted in the late summer/early fall (see Water Quality section). More research is needed to ascertain whether the cause of the low dissolved oxygen is the result of low flows or due to riparian vegetation loss (warm water temperatures) or both.

Concern also exists for high flows and their impact on salmonids. In the West Fork Satsop drainage, 55% of the watershed is classified as lowland dominated, 20% is rain dominated, 25% is in a rain-on-snow zone, and less than 1% is snow dominated. Also, 96% of the West Fork Satsop watershed is subjected to forest management. An upward trend in peak flows was documented in watershed analysis (Kirtland 1995). Using 5 year or greater return interval as the measurement, one peak flow was recorded from 1930 to 1950; four peak flows were documented between 1950 to 1970, and ten peak flows noted from 1970 to 1995. The cause of the upward trend is unknown because it did not correlate with increased precipitation. A similar trend was noted in the upper Skokomish River, which is not subjected to timber harvest. Stream flows in excess of the 10 year return interval flow were recorded in 1951, 1968, 1973, 1980, 1987, and 1991. The largest discharge occurred in December 1994 and had a return interval in excess of 130 years. The gauge is located near RM 1, the old Highway 12 Bridge.

Another source of data to support the increase in peak flows is from Owens (1989). He demonstrated that the average month-per-year flow measured at the Satsop gage has risen since the late 1940s, and suggests that the cause is likely due to development in the watershed. He also estimated drainage densities and ranked the East Fork Satsop watershed as having the highest drainage density (total miles of streams divided by watershed area), the Middle Fork Satsop watershed with the lowest density, and the West Fork Satsop watershed in-between the two. This is because the East Fork Satsop River has the shortest mainstem in addition to the largest basin area. Watersheds with high drainage densities respond more quickly to precipitation (Owens 1989).

One of the major impacts of high flows is increased scour of salmonid nests (Baxter 1995). The risk of scour has been rated high for the following areas of the West Fork Satsop watershed: the mainstem West Fork Satsop River, Canyon River, and lower Little River (Figure 30).

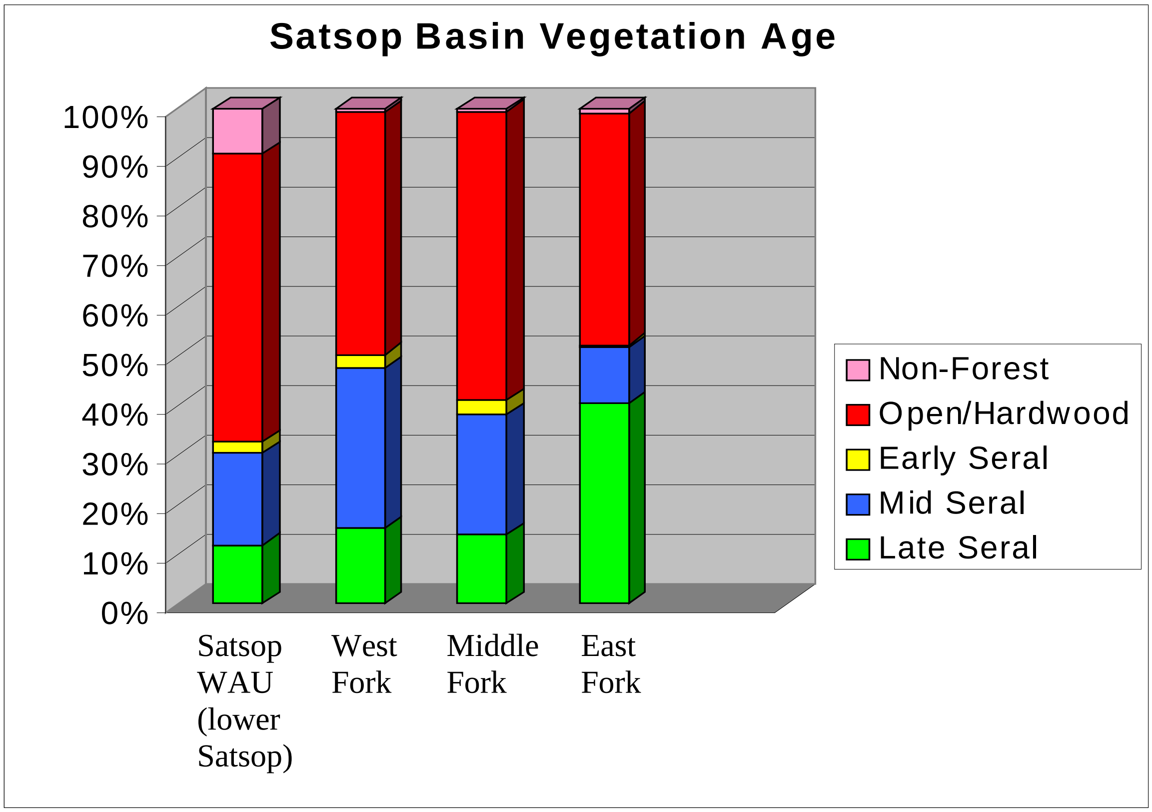
Figure 35. Water Withdrawals in the Satsop River Sub-basin (Wampler et al. 1993).



Vegetation land cover in the watershed is an index to describe how fast water filters through the landscape before entering the surface water flow. When large areas of watersheds are converted from a mature, conifer forest to an open or hardwood vegetation (hydrologically immature), water flows much faster into streams. This can increase the magnitude and frequency of peak flow events, impacting the survival of salmonid eggs and juveniles.

Using Lunetta et al. (1997) data, the two WAUs with more than 60% hydrologically immature trees are the Satsop WAU (lower Satsop) and the Middle Fork Satsop WAU (Figure 36), resulting in "poor" ratings for those areas. The West Fork Satsop WAU and the East Fork Satsop WAU both rated "good" using these data. However, because the West Fork Satsop Watershed Analysis listed scour as a major concern for salmonids, the area is rated as a data gap for water quantity, pending further clarification. The potential scour risk is likely the result of other altered processes such as increased sedimentation and lack of LWD.

Figure 36. Land cover Vegetation in the Satsop Basin (data from Lunetta et al. 1997).



Biological Processes in the Satsop Sub-Basin

Nutrient cycling is assessed for this report by the attainment of escapement goals, due to a lack of other standards. There are five stocks of salmon and steelhead in the Satsop sub-basin that have stock assessment data: summer chinook, fall chinook, chum, and coho salmon, as well as winter steelhead trout. Two of these are known to be depressed, summer chinook salmon and winter steelhead trout (WDFW and WWTIT 1994). The chum salmon is managed as part of a much larger population that extends throughout the lower Chehalis and up to just upstream of the Black River confluence in WRIA 23. Although the chum salmon stock is listed as "healthy" in the SASSI report (WDFW and WWTIT 1994), their distribution has been greatly reduced from historic use. The fall chinook and coho salmon populations are considered to be "healthy". To summarize, two out of five stocks with existing data indicate that levels have declined from historic numbers, in addition to a reduced distribution of chum salmon, and this results in a "fair" rating for nutrient cycling.

Habitat Limiting Factors in the Cloquallum, Mox Chehalis, Workman, and Delezene Creek Sub-Basins

<u>Loss of Fish Access in the Cloquallum, Mox Chehalis, Workman, Delezene, and Newman Creek Sub-Basins</u>

The WDFW SSHEAR database does not list any fish habitat blocking culverts in these streams, but that is likely due to a lack of inventories. Grays Harbor County Public Works has inventoried culverts on county roads and has a database listing the roads and culverts, but did not assess whether the culverts block fish access (Bob Oliver, personal communication). Due to the lack of information, fish access conditions in these watersheds is not rated, and remains a data need.

<u>Floodplain Conditions in the Cloquallum, Mox Chehalis, Workman, Delezene, and Newman Creek Sub-Basins</u>

Cloquallum, Delezene, Workman, and Mox Chehalis Creeks have relatively low gradients and moderate topography over most of their watersheds. Cloquallum Creek ranges from 250’ in the headwaters to 40’ elevation at the mouth. Mox Chehalis Creek and its major tributary, Sand Creek, have low gradients as well (Phinney and Bucknell 1975).

Many of these streams had splash dams, and impacts are likely considerable due to the small size of these streams. Although these dams were constructed and used in the early 1900s, their impacts are still seen today. Research on the impacts of splash dam operations in California rivers showed that channel alterations and simplification of habitat have persisted since turn of the century logging (Napolitano 1998). The frequent release of high flows during log drives removed natural large woody debris and accelerated channel incision. Because side-channels were blocked-off to prevent logs from being stranded outside the main channels, down-cutting in the side channels would not have occurred at the same rate, resulting in eventual isolation from the main channel. The reduction of large woody debris and side channels has reduced the amount of juvenile rearing habitat. Delezene Creek was the most impacted, with seven splash dams in a relatively small stream (Ellison Timber 1982). Cloquallum Creek and Wildcat Creek had three splash dams in each, and Vance Creek had two splash dams (Ellison Timber 1982). One splash dam was located in each of Mox Chehalis Creek and Workman Creek. Channel incision is a problem in Workman and Delezene Creeks (Lonnie Crumley, LWC Consulting, personal communication), and these streams are rated “poor” for floodplain conditions.

Bank protection (rip-rap) has been inventoried by the U.S. Fish & Wildlife Service, with a total of 2.2 miles of rip-rap/bank protection documented in Newman, Vance, Cloquallum, and Mox Chehalis Creeks and 40 linear feet in Workman and Delezene Creeks (Wampler et al. 1993). Most of the rip-rap is located in Wildcat Creek and along Cloquallum Creek (about 28 sites), with seven sites along Mox Chehalis Creek, three along Newman Creek, five along Vance Creek, two in Delezene Creek, and one along Workman Creek (Figure 28). The numerous rip-rap sites along Wildcat and Cloquallum

Creeks coupled with historic splash dam use, result in a "poor" rating for floodplain conditions in these two streams, but further assessment is still required to determine the extent of impact and potential recovery options.

Agricultural and residential development has occurred within the floodplains of many of these streams, but impacts such as channelization or incision have not been formally assessed. However, two impacts are noteworthy. The lower two miles of Newman Creek have been channelized. Also, the lower two miles of Mox Chehalis Creek has been filled for agricultural use, and the river has been re-routed near its confluence with the Chehalis River (aerial photo comparison with the 1975 WDFW Stream Catalog).

In addition, roads have been constructed near many of these streams, with some obvious confinement. The westbound lanes of Highway 8 and the Elma-McCleary Road closely parallel Wildcat Creek on each side for approximately 3.5 miles. Throughout this reach the roads follow a low terrace above the creek, but there are areas where the presence of the road is limiting natural channel migration. County roads are located in the lower valleys along approximately 10 miles of Cloquallum Creek, and along many sections of Mox Chehalis Creek and Newman Creek, particularly the East Branch. The road confinement coupled with the lower stream channelization in Newman Creek results in a "poor" floodplain rating. Potential impacts from other roads and past splash dams need further assessment. Without these additional data, the floodplain conditions for Delezene, Workman, Vance, and Mox Chehalis Creeks are not rated and are listed as a data need, but suspected floodplain problems likely exist in Delezene Creek because of numerous splash dams and Vance Creek and Mox Chehalis Creeks because of road impacts and landuse conversion.

<u>Streambed and Sediment Conditions in the Cloquallum, Mox Chehalis, Workman, Delezene, and Newman Creek Sub-Basins</u>

The relatively low gradients of the Newman, Vance, Cloquallum, and Mox Chehalis Creeks and moderate topography in this analysis area pose a low risk for landslides in these streams, but a higher risk exists for Workman and Delezene Creeks (Figure 16 Mainstem Chehalis River section). The mass wasting (landslide) hazard database presented in the Salmon Recovery Data Viewer for WRIA 22 shows that Newman, Vance, and Wildcat Creeks have an insignificant to low potential for landslides in the lower reaches with low to medium potential in the upper sections. The majority of the Cloquallum Creek drainage has a low to medium potential for mass wasting, and Mox Chehalis Creek consists mostly of an insignificant potential for landslides with some areas of low and medium potential mass wasting. However, much of Workman and Delezene Creeks have a medium to high potential for landslides (WDNR 2000). This information is important when considering landuse changes and impacts. Timber removal and road construction in high-risk areas will have a greater future impact in areas with medium to very high hazard risks. Landslides are a problem in Workman Creek (Lonnie Crumley, LWC Consulting, personal communication), and it is rated “poor” for sediment quantity.

Soil erosion potential is another measure of impact of landuse changes (both current and future) on sedimentation. Erosion potential for Mox Chehalis and Delezene Creeks is predominantly medium, with low to medium soil erosion potential in Cloquallum Creek and medium to high erosion potential in Workman Creek. Vance and Newman Creeks have low erosion potential in the lower reaches and medium to high potential elsewhere (Figure 17) (WDNR 2000). If similar projects are proposed for reducing sedimentation impacts, the mass wasting and erosion potential maps can be used to prioritize projects in high-risk areas over those in lower risk areas.

Road densities are very high in the analysis area, ranging from over 4.5 miles of road per square mile in Cloquallum to 4.6 in the Delezene/Workman WAU and 4.7 in the Newman/Vance WAU and the Mox Chehalis WAU (Lunetta et al. 1997). These road densities result in "poor" ratings for sediment quantity, although specific impacts need to be determined.

Bank erosion is the only type of sediment input that has been documented in this region. Other needed data, such as landslide impacts, sediment budgets, specific road impacts, instream fine sediments, and levels of LWD have not been assessed. Because of this, ratings are not assigned for sediment quality and instream LWD levels for most of these streams. Bank erosion is common in Workman, Delezene, Wildcat, Cloquallum, and Mox Chehalis Creeks, and less prevalent along Newman, Vance, and Sand Creeks (Wampler et al. 1993). Excessive sediment was documented for 16 miles of the Newman, Vance, Cloquallum, and Mox Chehalis sub-basins, while bank erosion was noted for 10.5 miles of the same region (Figure 32). Workman and Delezene Creeks is also heavily impacted with 16.2 miles of documented excessive sedimentation and 0.3 miles of bank erosion (Wampler et al. 1993). Low levels of instream LWD are a problem in Delezene, Workman, and Mox Chehalis Creeks (Lonnie Crumley, LWC Consulting, personal communication). These streams are rated “poor” for LWD.

Two sources of sedimentation were also documented in the Wampler et al. (1993) report. These include vehicle activity, which was common in Cloquallum and Wildcat Creeks, and livestock impacts, which were common near the mouths of Delezene and Workman Creeks, as well as in Cloquallum, Wildcat, and in the Mox Chehalis Creek reach just upstream of the confluence of Sand Creek.

Riparian Conditions in the Cloquallum, Mox Chehalis, Workman, Delezene, Newman Creek Sub-Basins

In general, riparian conditions are "poor" throughout the four WAUs that comprise this area. An estimated 91% of the riparian conditions in Newman and Vance Creeks are "poor", consisting of hardwood dominated, open, or non-forested riparian (Figure 37) (data from Lunetta et al. 1997). Workman and Delezene Creeks have 78% "poor" riparian conditions, while the Cloquallum and Mox Chehalis sub-basins have 80% and 83% "poor" riparian conditions, respectively (Figure 37).

The U.S. Fish & Wildlife survey documented 44.4 miles of vegetation loss and 7.2 miles of tree canopy loss in the area that includes Newman, Vance, Cloquallum, and Mox

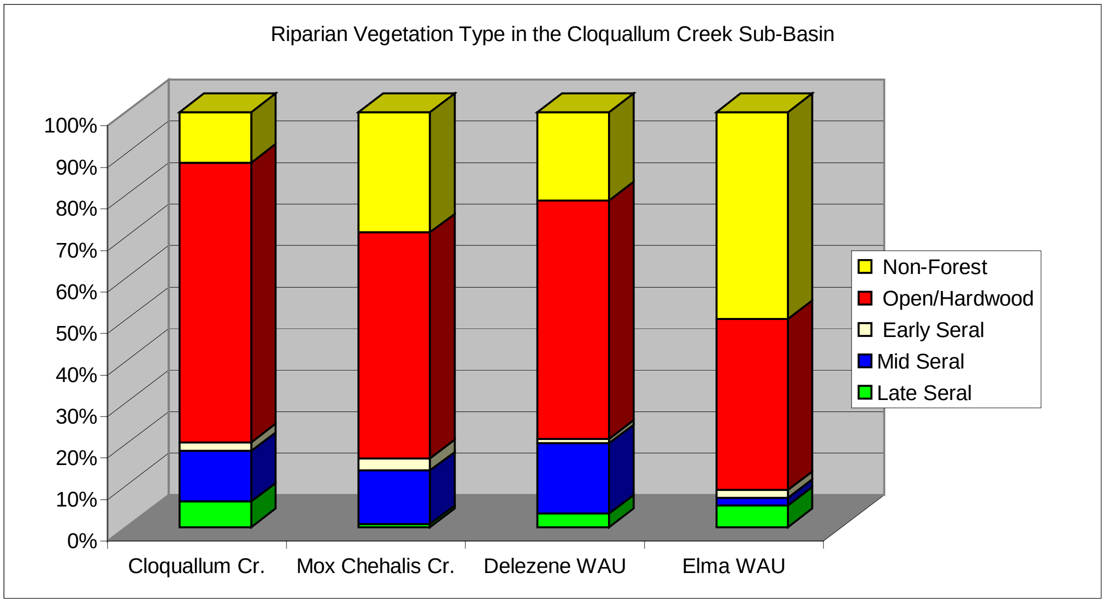
Chehalis Creeks (Wampler et al. 1993). They listed riparian degradation and loss as the most extensive habitat degradation for this region. Most of the cause of the loss was listed as unknown, while agriculture accounted for 9% and logging accounted for 7.4%. The logging impacts were more common in Workman and Delezene Creeks. Other heavily impacted areas (from mixed causes) include Wildcat Creek, Mox Chehalis Creek, and parts of Cloquallum and Vance Creeks (Wampler et al. 1993).

In addition to these impacts, some field visits were made and a coarse level riparian condition map is provided in the Map Appendix (Map 4a). The map shows generalized riparian conditions for assessed reaches based upon the most common riparian classification in that section. There may be isolated pockets of differing riparian conditions within these reaches. High elevation aerial photos were also reviewed in combination with some site visits, to determine riparian conditions on a broad scale. For Cloquallum and Mox Chehalis Creeks, ortho-photos were available from the Salmon Recovery Data Viewer for WRIA 22 (DNR 2000).

The lower 1.5 miles of Cloquallum Creek flows through agricultural land. From RM 1.5 to RM 7 there is rural residential land along the creek, where riparian conditions are mostly "poor". Upstream of river mile 7 the drainage is predominantly managed timberlands where buffer widths and conditions vary. Wildcat Creek is a major tributary to Cloquallum Creek, and most of its riparian buffers are "poor".

"Poor" riparian conditions dominate Newman Creek from the confluence with the West Branch to the mouth of Newman Creek, while the lower reach of the East Branch is "fair" (Map 4a). The Vance Creek riparian is also predominately "poor" from RM 5.8 to the mouth. Significant amounts of tree canopy loss and riparian vegetation loss has been documented throughout Delezene, Eaton, and Workman Creeks.

Figure 37. Riparian Vegetation Type in the Cloquallum, Mox Chehalis, Delezene, and Newman (Elma WAU) Creek Sub-Basins.



<u>Water Quality Conditions in the Cloquallum, Mox Chehalis, Workman, Delezene, and Newman Creek Sub-Basins</u>

The only water quality data found for streams within this region are data for Wildcat Creek, a tributary to Cloquallum Creek. Wildcat Creek is currently on the 303(d) List due to warm water temperatures (DOE 2000), which results in a "poor" rating for water quality in this report. This stream has generally "poor" riparian conditions, which likely contributes to warm water temperatures. While data are lacking for the other streams in this region, their generally degraded riparian vegetation suggests that water quality problems (temperature and dissolved oxygen) may also exist and should be a high priority data need within these sub-basins. Grays Harbor College's Natural Resource program has monitored water quality in Mox Chehalis Creek, but those data are not yet available.

In the 1970s, the McCleary Waste Water Treatment Facility was discharging a high quantity of nutrients into Wildcat Creek, but facility upgrades have successfully reduced fecal coliform and nutrient levels within standards (Kendra 1987). Prior to the upgrade of the facility, Wildcat Creek was periodically toxic to salmonids (Kendra 1987).

Other problems have been documented that also relate to water quality, such as livestock access and waste inputs, road run-off, and other pollution inputs. Livestock access has been documented at six sites in Cloquallum Creek and three sites in Wildcat Creek, with numerous livestock waste inputs in the lower Mox Chehalis Creek (Wampler et al 1993). Road run-off was noted in Wildcat Creek (four sites) and Mox Chehalis and Sand Creeks (five sites). These documented problems coupled with "poor" riparian conditions suggests that water quality is likely degraded in these streams, but further monitoring is needed before a rating can be assigned.

Water Quantity Conditions in the Cloquallum, Mox Chehalis, Workman, Delezene, and Newman Creek Sub-Basins

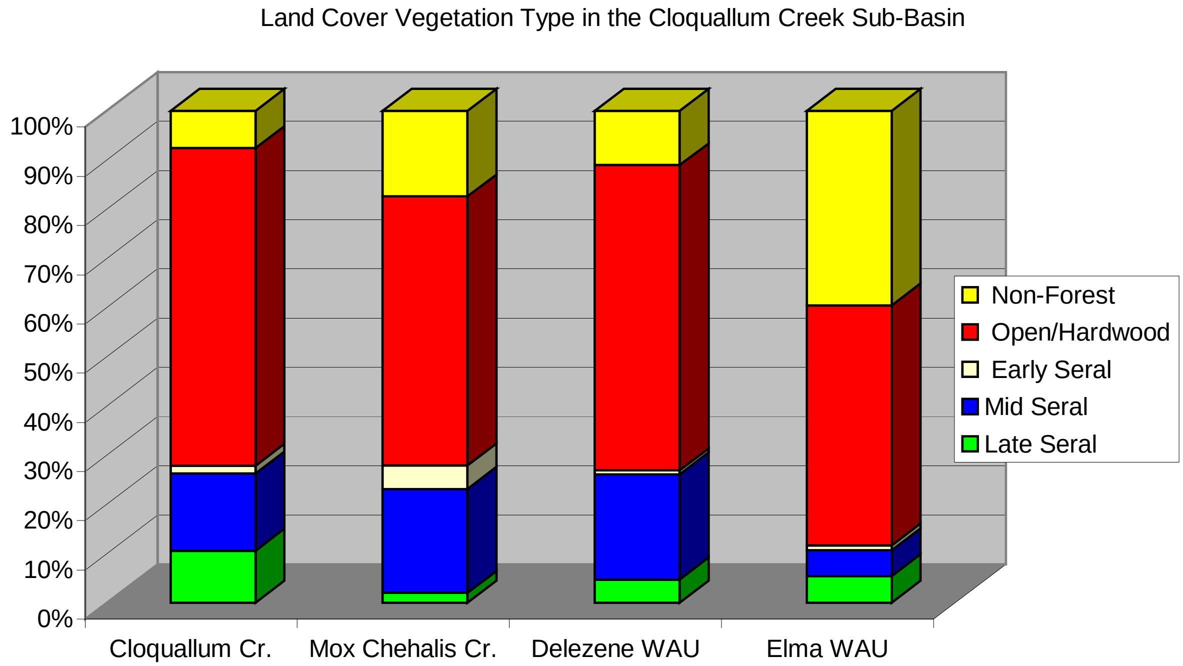
Specific current stream flow data are lacking for streams within this region. Direct measurements of stream flow in the Cloquallum sub-basin ceased in 1972, and because of that, flow trends or comparison of current flows to established base flows is not possible. However, some information regarding impacts to flows can be derived indirectly. The low gradient landform of much of the Cloquallum and Mox Chehalis drainages results in water draining slowly through the watershed. Vegetation land cover in the watershed is an index to describe how fast water filters through the landscape before entering the surface water flow. When large areas of watersheds are converted from a mature, conifer forest to open or hardwood vegetation (hydrologically immature), water flows much faster into streams. This can increase the magnitude and frequency of peak flow events, impacting the survival of salmonid eggs and juveniles.

All of the regions rate "poor" for hydrologic maturity. The land cover in the Elma WAU (Newman and Vance Creeks) is greater than 89% hydrologically immature, while the Delezene, Mox Chehalis, and Cloquallum WAUs are 74%, 77%, and 73% hydrologically immature, respectively (Figure 38). The conversion of mature conifer vegetation to non-forest uses, such as urbanization and agriculture, are most pronounced in the Elma WAU, while conversion to open spaces and deciduous trees is a problem within all four WAUs.

Low flows also impact salmonids, but specific analyses of flow impacts on salmonids are lacking within these areas. Mox Chehalis Creek and Wildcat Creek are closed to further consumptive water appropriations, which strongly suggests that low flows are a problem for fish use in the summer months. These two creeks are rated "poor" for low water flows.

In the Chehalis River Basin Level 1 Assessment, Envirovision selected Cloquallum Creek as one of the sub-basin to conduct a detailed assessment of water rights and use. Allocated consumptive water use from commercial, domestic, irrigation and other water rights totaled 17.28 cfs, while mean low flows during August (26.5 cfs), September (24 cfs) and October (28.5 cfs) were only slightly above the allocated use. Based on instream flows set by WDOE in 1975, the medium stream flow was insufficient to meet allocated water rights and minimum instream flows during June through October. Since no records of actual water use are available, it is difficult to determine the affect on salmon habitat during summer low flows. The Level 1 Assessment recommends that detailed mapping of the water rights to determine actual water use (Envirovision 2000 Draft).

Figure 38. Land cover Vegetation Type in the Cloquallum, Mox Chehalis, Delezene, and Elma (Newman Creek) WAUs.



<u>Conditions of Lakes in the Cloquallum, Mox Chehalis, Workman, Delezene, and Newman Creek Sub-Basins</u>

Cloquallum Creek flows through Stump Lake for approximately ½ mile near RM 12, while Star and Arrowhead Lakes are located in a small drainage that enters the Cloquallum at RM 14. Star and Arrowhead Lakes have been heavily developed for residential and recreation property. Arrowhead Lake has a conservatively planned recreational development, with 25% of the shorelines in a natural state and approximately 50% of the shoreline with low impacts from recreational development. No data on water quality were available for these three lakes. Development of the lakeshores has reduced riparian vegetation and margin habitat important for juvenile coho salmon rearing, and for this reason, Star and Arrowhead Lakes are rated "poor". Stump Lake is undeveloped with some logging activity, and is rated "good".

<u>Biological Processes in the Cloquallum, Mox Chehalis, Workman, Delezene, and Newman Creek Sub-Basins</u>

Nutrient cycling is assessed for this report by the attainment of escapement goals, but all of the salmon and steelhead stocks in these watersheds are managed as part of a much larger population that extends throughout most of WRIA 23. Four stocks of salmon and steelhead have been documented in this area: fall chinook, chum, and coho salmon, as well as winter steelhead trout (WDFW and WWTIT 1994). Coho salmon escapements throughout WRIA 23 have declined in the 1990s (John Linth, WDFW, personal communication), although winter steelhead were listed as "healthy" in the SASSI report (WDFW and WWTIT 1994). Chum salmon were listed as "healthy" in the SASSI report, even though their distribution is greatly reduced from historic use. To summarize, one out of four stocks with existing data indicate that levels have declined from historic numbers, coupled with reduced distribution of chum salmon. However, because the data are not specific to these streams, nutrient cycling is not rated.

Habitat Limiting Factors in the Gaddis, Rock, Garrard, Independence, and Lincoln Creek Sub-Basins

Loss of Access in the Gaddis, Rock, Garrard, Independence, and Lincoln Sub-Basins

Rodney Lakey, Lewis County Planning provided most of the data regarding barriers within Lewis County. Additional barrier information was obtained from the Salmonid Screening, Habitat Enhancement and Restoration Division of WDFW and the Washington State Department of Transportation list of barriers (Johnson et al. 1999). The culvert assessment by Lewis County has been completed through its first level. In an additional study, they plan to inventory habitat upstream of barriers as well as determine the status of "unknown" fish presence culverts. Because analysis of habitat upstream of culverts has not been done and fish distribution data are very incomplete, we are unable to fully rate the condition of access issues in this sub-basin.

Numerous blockages exist throughout Lincoln and Independence Creeks (Table 22), and this quantity is high enough to warrant concern and list the blockage assessment as a high priority data gap. Documentation of blockages was not found for the streams in Grays Harbor County (Garrard, Rock, Williams, Gaddis Creeks), but information about two blockages in Rock Creek was provided by a TAG member. Also, data were not available for roads in managed forestlands. This is a data need that is listed as a medium priority due to the "fair" road density level.

In addition to the blockages listed below, two barriers exist in upper Rock Creek, reducing fish access. One barrier is a set of cascades caused by historic timber management, while the other is a logging road culvert (Lonnie Crumley, LWC Consulting, personal communication). The amount and quality of habitat blocked has not been assessed.

Table 22. Culverts in the Lincoln and Independence Creek Sub-Basins.

Road Name	Watershed	Township, Range, Section	Fish Presence
Harris Rd	Independence trib	15N, 04W, 15NW	Yes
Harris Rd	Independence trib	15N, 04W, 15NW	Yes
Harris Rd	Independence trib	15N, 04W, 16NE	Yes
Harris Rd	Independence trib	15N, 04W, 16NE	Unknown
Nelson Rd	Independence trib	15N, 04W, 21NE	Unknown
Nelson Rd	Independence trib	15N, 04W, 21NE	Yes
Nelson Rd	Independence trib	15N, 04W, 21SE	Unknown
Nelson Rd	Independence trib	15N, 04W, 28NE	Yes
Nelson Rd	Independence trib	15N, 04W, 28NE	Yes
Lepisto Rd	Lincoln	15N, 05W, 36SE	Yes
Buck Rd	NF Lincoln	15N, 04W, 33SE	Yes
Buck Rd	NF Lincoln	15N, 04W, 33SE	Yes
Blacksmith Rd	Lincoln	15N, 04W, 34NW	Unknown
Blacksmith Rd	Lincoln	15N, 04W, 34NW	Unknown
Blacksmith Rd	Lincoln	15N, 04W, 34NW	Unknown
Michigan Hill Rd	Lincoln	15N, 03W, 25NW	Yes
Lincoln Cr Rd	Lincoln	14N, 04W, 6NW	Unknown
Lincoln Cr Rd	Lincoln	14N, 04W, 6NW	Yes
Lincoln Cr Rd	Lincoln	14N, 04W, 6SW	Yes
Lincoln Cr Rd	Lincoln	14N, 04W, 7SE	Yes
Lincoln Cr Rd	Lincoln	14N, 04W, 7NW	Yes
Lincoln Cr Rd	Lincoln	14N, 04W, 7NW	Yes
Lincoln Cr Rd	Wildcat	14N, 04W, 7SW	Yes
Lincoln Cr Rd	Wildcat	14N, 04W, 7SW	Yes
Mattson Rd	Lincoln	14N, 03W, 3NW	Unknown
Independence Rd	Independence	15N, 04W, 20SE	Yes
Ingals Rd	Lincoln	14N, 04W, 4NW	Unknown
Manners Rd	Independence	15N, 04W, 29NW	Yes
Garrard Cr Rd	Independence	15N, 05W, 30NW	Yes
Garrard Cr Rd	Independence	15N, 05W, 25NE	Yes

Road Name	Watershed	Township, Range, Section	Fish Presence
Garrard Cr Rd	Independence	15N, 05W, 25NE	Yes
Garrard Cr Rd	Independence	15N, 05W, 25NE	Yes
Garrard Cr Rd	Independence	15N, 05W, 26NE	Yes
Garrard Cr Rd	Independence	15N, 05W, 26NE	Yes
Garrard Cr Rd	Independence	15N, 05W, 26NW	Yes
Garrard Cr Rd	Independence	15N, 05W, 22SW	Yes
Garrard Cr Rd	Independence	15N, 05W, 15SW	Yes
Lincoln Cr Rd	Eagle Cr	15N, 03W, 34SE	Unknown
Lincoln Cr Rd	Eagle Cr	15N, 03W, 34SE	Yes
Lincoln Cr Rd	Eagle Cr	15N, 03W, 34SE	Yes
Lincoln Cr Rd	Eagle Cr	15N, 03W, 34SE	Unknown
Lincoln Cr Rd	Eagle Cr	15N, 03W, 34SE	Unknown
Lincoln Cr Rd	Lincoln	15N, 03W, 28SE	Unknown
Lincoln Cr Rd	Lincoln	15N, 03W, 28SW	Yes
Lincoln Cr Rd	Lincoln	15N, 03W, 29NE	Yes
Lincoln Cr Rd	Lincoln	15N, 03W, 29NE	Yes
Lincoln Cr Rd	Lincoln	15N, 03W, 29NW	Yes
Lincoln Cr Rd	Lincoln	15N, 03W, 30NE	Unknown
Lincoln Cr Rd	Lincoln	15N, 03W, 30NW	Unknown
Lincoln Cr Rd	Lincoln	15N, 03W, 30NW	Unknown
Lincoln Cr Rd	Lincoln	15N, 03W, 30NW	Yes
Lincoln Cr Rd	Lincoln	15N, 03W, 25NE	Yes
Lincoln Cr Rd	Lincoln	15N, 03W, 25NE	Yes
Lincoln Cr Rd	Lincoln	15N, 03W, 26SE	Yes
Lincoln Cr Rd	Lincoln	15N, 03W, 26SW	Yes
Lincoln Cr Rd	Lincoln	15N, 03W, 26SW	Yes
Lincoln Cr Rd	Lincoln	15N, 03W, 34NE	Yes
Lincoln Cr Rd	Lincoln	15N, 03W, 34NE	Unknown
Lincoln Cr Rd	Lincoln	15N, 03W, 34NE	Unknown
Lincoln Cr Rd	Lincoln	15N, 03W, 34SE	Yes
Lincoln Cr Rd	Lincoln	14N, 04W, 6NW	Unknown

Floodplain Conditions in the Gaddis, Rock, Garrard, Independence, and Lincoln Sub-Basins

Rip-rap was documented in Wildcat Creek (a tributary to Lincoln Creek), upper Lincoln Creek, lower Independence Creek, throughout Garrard Creek, and in lower Rock Creek (Wampler et al. 1993). The quantity of bank hardening per stream length is not known, and therefore, ratings based upon riprap were not assigned. This is a data need.

Roads within floodplains are a habitat degradation because they can act as dikes, impeding the natural stream channel migration, as well as disconnecting the stream from surrounding wetlands and riparian vegetation. About five miles of Lincoln Creek are associated with roads within its probable floodplain (Lincoln Creek Road and Lepisto Road), compared to a stream length of about 16 miles. This results in a "fair" floodplain condition rating. Independence Road and Garrard Creek Road periodically border Independence Creek, but the extent of impact is unknown.

In Garrard Creek, Garrard Road occasionally flanks the lower 3.5 miles of South Fork Garrard Creek, but the impact needs better quantification, and might not be enough of an impact to result in a degraded condition rating. Short sections of the mainstem Garrard Creek are also bordered by this road, but not in a sufficient quantity to result in a degradation under our criteria. Norton Road parallels about 2.2 miles of Rock Creek, and this is not a large impact. Potential road impacts also need to be quantified for Williams Creek and a tributary to Williams Creek (23.0606).

Rock Creek, Williams Creek, and Gaddis Creek have incised channels (Lonnie Crumley, LWC Consulting, personal communication), and these streams are rated "poor" for floodplain conditions. Better quantification of this impact is needed.

Streambed Sediment Conditions in the Gaddis, Rock, Garrard, Independence, and Lincoln Sub-Basins

Extensive bank erosion was documented in Gaddis Creek, Williams Creek, upper Garrard Creek, Kellogg Creek (tributary to Garrard Creek), the middle reaches of Independence Creek, Independence tributaries 23.0705 and 23.0712, Wildcat Creek (tributary to Lincoln Creek), and upper Lincoln Creek (Wampler et al. 1993). These streams are rated "poor" for sediment quantity, with a note that more information regarding sediment inputs are needed. In addition, a debris torrent was documented in stream 23.0712, a tributary to Independence Creek. Phinney and Bucknell (1975) noted siltation of spawning gravels, but current conditions of gravel quality are unknown.

Road density is high (3.4 miles of road/square mile watershed) in the Lincoln Creek WAU, and that area is rated "poor" for sediment quantity. Garrard Creek rates "fair" for road density with a value of 2.7 mi./sq. mi. watershed (data from Lunetta et al. 1997). The road density data are likely conservative for Gaddis Creek and Rock/Williams Creeks. Specific road density data are needed for each watershed, and will likely show a greater road density for Gaddis and Rock/Williams watersheds after analysis. Livestock access also contributes to streambank degradations and was documented in lower Rock Creek, Williams Creek, Garrard Creek, lower Independence Creek, and throughout

Lincoln Creek (Wampler et al. 1993). Livestock access is also an issue in lower Gaddis Creek (Lonnie Crumley, LWC Consulting, personal communication). Instream vehicle activity was recorded in upper Lincoln Creek and Wildcat Creek.

Information was lacking regarding channel stability, but scour is suspected in Garrard Creek and Lincoln Creek (Lonnie Crumley, LWC Consulting, personal communication). No data was found regarding stream channel stability or instream counts of large woody debris for any of these streams. However, Rock Creek and Williams Creek are thought to have reduced levels of LWD based upon professional observations (Lonnie Crumley, LWC Consulting, personal communication).

Riparian Conditions in the Gaddis, Rock, Garrard, Independence, and Lincoln Sub-Basins

Overall, the riparian conditions in the Lincoln Creek WAU are "poor" with most of the native vegetation converted to sparse, deciduous trees (data from Lunetta et al. 1997) (Figure 39). Deciduous riparian conditions dominate from the mouth of Lincoln Creek to about RM 7.5, with many of those reaches very sparsely vegetated. From RM 7.5 to 10.2, conditions vary from "good" (conifer) to open ("poor") (Map 4b). Some of the riparian areas along Lincoln Creek were historically hardwood, and restoration efforts should take this into account. However, currently, much of the riparian is too sparse to be considered anything other than "poor".

Along Independence Creek, "poor" riparian conditions have been documented from RM 3.5 to RM 7 (data from Wampler et al. 1993), and generally "poor" conditions have been observed along the lower two miles. Several tributaries to Independence Creek also have sections of "poor" riparian conditions including streams 23.0697, 23.0705, 23.0707, and 23.0712 (Map 4b). Better clarification of riparian conditions is needed within Independence Creek. The currently documented impacts are based upon loss of tree canopy, but further analysis is needed to also determine impacts for other functions of the riparian vegetation, such as LWD recruitment.

In the Garrard Creek WAU, riparian conditions are mostly "poor", with 53% of the reaches dominated by deciduous trees and 25% of the reaches converted to non-forest use (data from Lunetta et al. 1997) (Figure 40). Documented sections of degraded riparian zones along Garrard Creek include RM 1.4-3.1, RM 4-5.2, and RM 6.5-7.6 (Map 4b) (Wampler et al. 1993), and observed "poor" riparian conditions are noted along the lower 4.6 miles, consisting mostly of sparse deciduous trees and brush. The lower two miles of South Fork Garrard Creek also has "poor" riparian conditions. Some of the riparian areas along the lower reaches were historically hardwood, and restoration efforts should take this into account.

A loss of riparian vegetation was noted along Rock Creek from RM 1.5-2.9 and in two reaches of Williams Creek (RM 0-1, RM 2.2-3.8) (Wampler et al. 1993). A loss of canopy cover was recorded in Gaddis Creek from RM 2.5-3. All of the above mentioned reaches are rated "poor" (Map 4b). Some of the riparian areas along the lower reaches were historically hardwood, and restoration efforts should take this into account. Riparian condition assessments are very limited in this region and remain a data need.

Figure 39. Riparian Vegetation Conditions in the Lincoln Creek WAU (data from Lunetta et al. 1997).

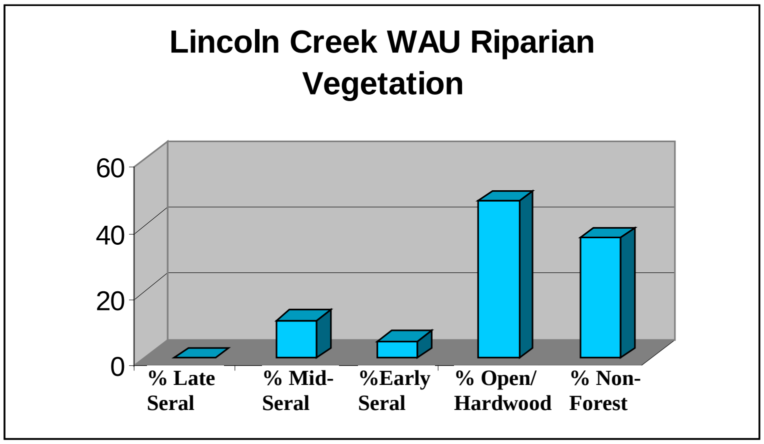
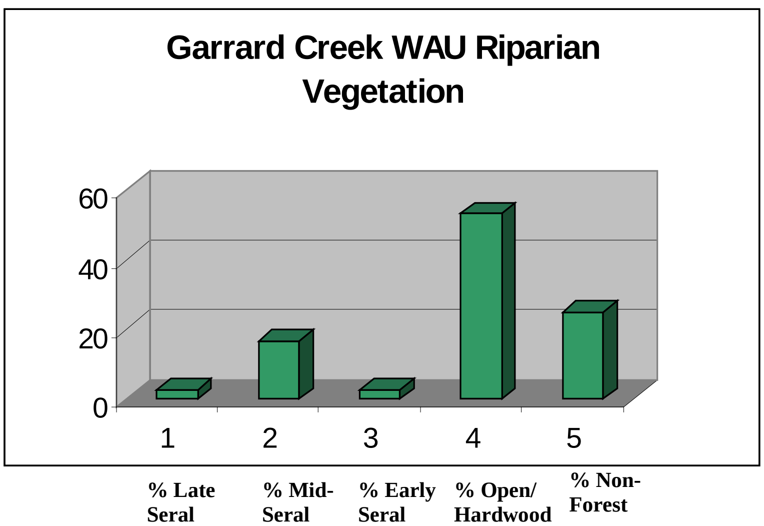


Figure 40. Riparian Vegetation Conditions in the Garrard Creek WAU (data from Lunetta et al. 1997).



<u>Water Quality in the Gaddis, Rock, Garrard, Independence, and Lincoln Sub-Basins</u>

The 1998 303(d) List includes Lincoln Creek because of warm water temperatures (DOE 1999). This stream has also exhibited low dissolved oxygen levels and high fecal coliform levels (Jennings and Pickett 2000). The suspected causes of the low dissolved oxygen and high fecal coliform levels are failing septic systems and livestock access, while warm water temperatures are likely related to poor riparian conditions. Low dissolved oxygen has also been documented in Independence Creek and the suspected cause is livestock impacts (Jennings and Pickett 2000). Because of these exceedances, Independence Creek and Lincoln Creek are rated "poor" for water quality.

A few sites of livestock access were documented along Independence, Garrard, and Williams Creek, while livestock waste inputs were noted along Lincoln, Independence, and Garrard Creeks (Wampler et al. 1993). Livestock access occurs in lower Gaddis Creek, as well (Lonnie Crumley, LWC Consulting, personal communication). Because specific water quality data were not available for Gaddis, Rock, William, and Garrard Creeks, they were not rated and remain a data need.

Water Quantity in the Gaddis, Rock, Garrard, Independence, and Lincoln Sub-Basins

Phinney and Bucknell (1975) noted low summer flows as a limiting factor in all of these streams. The low flow conditions are worsened by the numerous water withdrawals in the area, especially in Wildcat Creek (a Lincoln tributary), upper Lincoln Creek, Independence Creek, Garrard Creek, and Williams Creek (Wampler et al. 1993). Base flows have not been met in several of these creeks resulting in the following streams closed to further water appropriations: Garrard Creek, Lincoln Creek, Williams Creek and Rock Creek (DOE 1998). Because these streams are used by coho salmon, adequate summer flows are important, and the low flow conditions result in "poor" ratings for water quantity for each of these streams.

Historically, the majority of land cover consisted of Douglas fir (Fredriksen and Harr 1979). During precipitation events, these types of forests temporarily capture from 24 to 35% of the rainfall (Dingman 1994). The loss or change of vegetative cover can contribute to an increase in peak flows that results in increased bank erosion and riverbed scour, degrading salmonid habitat. The Lincoln Creek WAU has a greatly altered land cover with large percentages of forests lost (16%) or converted to hardwoods (48%) (Figure 41) (data from Lunetta et al. 1997). The Garrard Creek WAU has similar conditions with 14% of forest cover converted to other uses and 47% existing as hardwoods (Figure 42) (data from Lunetta et al. 1997). These areas rate "poor" for water quantity due to a likely impact on peak flow events. However, considerable areas of lower Lincoln Creek, Gaddis Creek, lower Rock Creek, and lower Garrard Creek historically consisted of hardwoods. A more thorough land cover analysis is needed that considers these historic vegetation types.

Figure 41. Vegetative Land cover Type in the Lincoln Creek WAU (data from Lunetta et al. 1997).

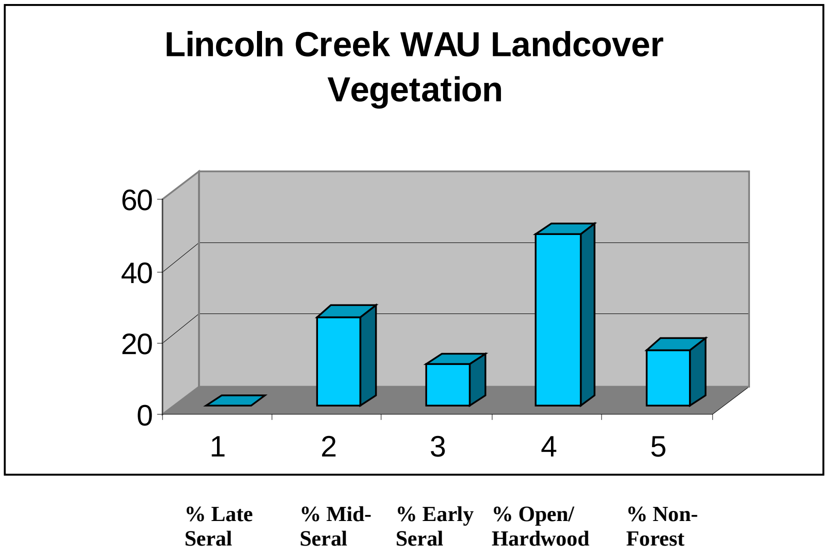
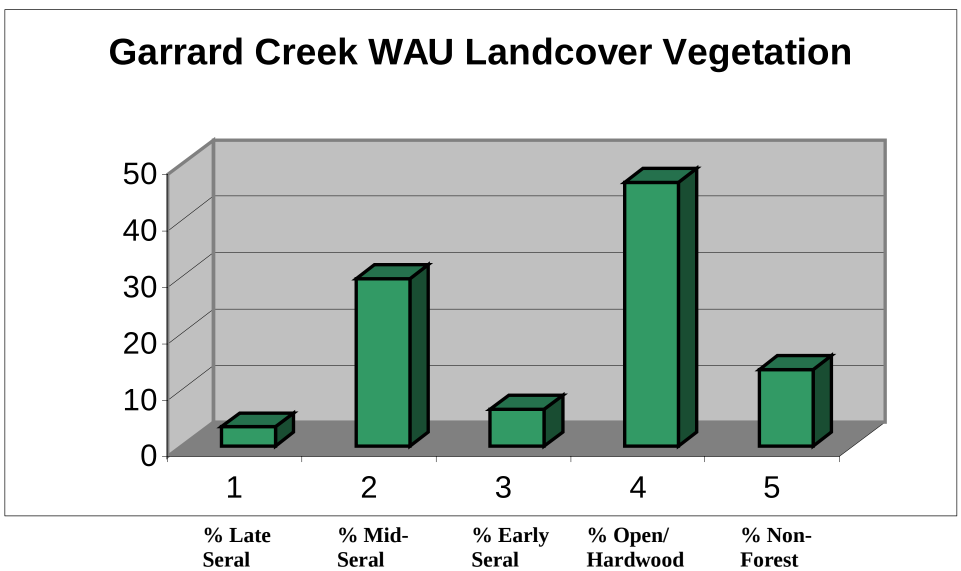


Figure 42. Vegetative Land cover Type in the Garrard Creek WAU (data from Lunetta et al. 1997).



<u>Biological Processes in the Gaddis, Rock, Garrard, Independence, and Lincoln Sub-Basins</u>

Nutrient cycling is assessed for this report by the attainment of escapement goals, but all of the salmon and steelhead stocks in these watersheds are managed as part of a much larger population that extends throughout most of WRIA 23. Two species of salmon or steelhead (coho and winter steelhead) were documented in many of these streams

(Streamnet 1999). Coho salmon escapements throughout WRIA 23 have declined in the 1990s (John Linth, WDFW, personal communication), but data are needed specific to each of these streams. Winter steelhead were classified as "healthy" in SASSI (WDFW and WWTIT 1994). In addition, small numbers of fall chinook have been documented in Rock Creek. Fall chinook are also a part of a larger population that extends throughout much of WRIA 23, and this stock is listed as "healthy" in SASSI (WDFW and WWTIT 1994). However, without specific information regarding escapement estimates to each of these streams for each salmonid stock, biological processes are not rated based upon escapement levels.

Nutrient cycling is "poor" in Gaddis Creek due to a culvert that blocked a considerable quantity of habitat. That culvert has been replaced. Biological processes is rated "poor" in Rock and Williams Creeks for several reasons. The index of macroinvertebrates is noted as "impaired" in Merritt et al. (1999). Also, two barriers exist in upper Rock Creek, reducing fish access and nutrient cycling. One barrier is a set of cascades caused by historic timber management, while the other is a logging road culvert (Lonnie Crumley, LWC Consulting, personal communication).

Habitat Limiting Factors in the Black River, Cedar Creek, Gibson Creek, and Porter Creek Sub-Basins

Loss of Access in the Black River, Cedar, Gibson, and Porter Creek Sub-Basins

Due to the low gradient of the drainages in these streams, salmon and steelhead have historically accessed the upper basins. The WDFW SSHEAR Program conducted a culvert assessment on Thurston County roads in the Black River drainage, and those culverts are listed in Table 23. It is likely that not all of the blockages to salmon and steelhead are documented in this area. In addition to the SSHEAR database, the only other barrier data comes from Wampler et al. (1993), which list two culvert fish blockages on a tributary to upper Waddell Creek and four logjams in tributaries to Waddell Creek. The Porter Creek drainage has one culvert blockage and nine logjams documented as fish passage barriers (Wampler et al. 1993). Cedar Creek has one culvert blockage in the very upper basin, and Gibson Creek has one logjam barrier in a mid-drainage tributary. Listing logjams as barriers to salmon movement is contradictory to what we know today. Logjams create complex habitat features, store sediment, and divert water to off-channel habitat. Most logjams are beneficial. Detrimental logjams are those comprised of logging debris, and located within confined channels. Because a thorough inventory of culverts has not been conducted in the Porter, Gibson, and Cedar Creek drainages, those areas are not rated for access conditions and are listed as a data need. It is not known whether the logjams listed in Wampler et al. (1993) are beneficial or detrimental.

One notable barrier in this area is the lost access to Black Lake. Black River chinook, coho and chum salmon historically spawned in tributaries to Black Lake and used the lake and upper Black River for rearing. However in 1922, the Black River Ditch was excavated at the north end of the lake to help control flooding. Since then, the ditch has downcut, draining increasing amounts of water. This results in less flow to the Black River. In the 1960s, a gas pipeline was constructed across the Black River. The decreased flows, wetland filling, and pipeline crossing with accumulated beaver debris have all combined to block access to the upper Black River (upstream of the confluence of Dempsey Creek) and Black Lake, except during high flows (J. Roach, Association of Black Lake Enhancement, personal communication; Hawkins 2000). It has also resulted in reversing the water flow of the upper Black River into Black Lake, which then flows via the ditch to Puget Sound. Salmon that currently spawn in tributaries to Black Lake are stray chinook salmon from a salmon net pen operation in Budd Inlet and coho hatchery strays (J Roach, Black Lake resident, personal communication). There is no screen installed at the lake outlet to Black River Ditch, which allows Puget Sound salmon to access Black Lake and potentially intermingle with Chehalis origin salmonids. The access problems in the upper Black River result in a "poor" access rating.

Table 23. Culvert Barriers to Salmon and Steelhead Rearing and Spawning Habitat (WDFW SSHEAR 2000)

Road Name	Watershed	Tributary	Township, Range, Section	Habitat Upstream (meters)
Porter Creek Rd	Porter Creek	Porter Cr. Trib	17N, 05W, 14NW	NA
Little Rock Rd	Black River	Trib 23.0663	16N, 03W, 27	322
Old Highway 99	Black River	Beaver Cr. Trib	16N, 01W, 7	NA
Old Highway 99	Black River	Beaver Cr. Trib	16N, 01W, 6	NA
Case Rd SW	Black River	Beaver Cr. Trib	16N, 02W, 8	800
Alpine Rd	Black River	Lehman Creek	17N, 03W, 11	240
Waddell Cr Rd	Black River	Pants Creek	17N, 03W, 10	562
Waddell Cr Rd Private Dr.	Black River	Pants Creek	17N, 03W, 15NE	NA
Waddell Cr Rd	Black River	Pants Creek	17N, 03W, 10	NA
Fairview Rd SW	Black Lake	Trib 23.0693	17N, 02W, 8	NA
Fairview Rd SW	Black Lake	Trib 23.0694	17N, 02W, 5	1837
Fairview Rd SW (double culverts)	Black Lake	Trib 23.0694	17N, 02W, 5	NA

Floodplain Conditions in the Black River, Cedar, Gibson, and Porter Creek Sub-Basins

The floodplains of these streams range from the highly developed residential lands surrounding Black Lake, to agricultural land along the lower 10 miles of Black River, Beaver Creek, Salmon Creek and Blooms Ditch, and to commercial timberlands along Dempsey, Waddell, Porter, Cedar and Gibson Creeks. The only undeveloped or unaltered floodplains in these streams are the wetlands along the middle and upper reaches of Black River.

The low gradients of the floodplains provide ideal conditions for beaver colonization and an abundance of off-channel habitats preferred by juvenile coho salmon. Beaver impounded wetlands provide important off-channel rearing area for juvenile coho salmon during seasonal high water periods, and submerged vegetation and woody debris associated with beaver ponds provide excellent cover for rearing salmon. Beaver ponds also create a nutrient sink, which increases productivity of aquatic invertebrates, both in the ponds, and in tributaries downstream of the ponds. Beaver dams provide storage areas of fine sediment, and stabilize flows during high water events as water is stored in ponds and released slowly over the beaver dams (Cederholm et al. 2000).

Much of the off-channel and floodplain habitat has been filled, drained, or channelized in the lower reaches of these drainages for residential and agricultural development. The eastern tributaries of the Black River, such as Bloom's Ditch, Salmon, Allen and Beaver Creeks, have been channelized for irrigation (Washington Department of Game 1980). Besides agricultural development, there has been some confinement of stream channels in the analysis area from roads and the railroad. County roads are located in the lower valleys along the lower 3 miles of Porter Creek and 8 miles of Cedar Creek, but the extent of actual confinement in these stretches needs quantification. Approximately 1 mile of lower Black River, immediately upstream of the Highway 12 crossing, is confined by the railroad grade on the east side of the river.

Bank hardening is a common type of floodplain impact. About 42 sites of riprap have been documented in the Black River sub-basin, in addition to slightly less than one mile of channelization (Wampler et al. 1993). The riprap is located along the lower Black River, Waddell Creek and Salmon Creek. In the Gibson and Cedar Creeks, 13 sites of bank hardening were noted, with no documentation of channelization. In the Porter watershed, eight sites of riprap were recorded with no stream channelization.

Splash dams were not as extensively used in this area relative to the Humptulips, Wishkah, Hoquiam and South Grays Harbor sub-basins, but there were two splash dams in Mima Creek and three in South Fork Porter Creek (Ellison Timber 1982). The impacts of splash dams specific to these creeks is not documented, but it is well documented that the impacts from splash dam operations on fish habitat and channel shape are extensive and slow to recover (Napolitano 1998). Channel incision and removal of large woody debris and gravel were the primary impacts of splash dams on small creeks. This information is discussed in detail in the Humptulips River and Wishkah, Hoquiam and South Grays Harbor sections.

Channel incision is commonly seen in streams located in areas that are heavily managed for timber production or have served as splash dam sites. Cedar Creek has areas of channel incision (Lonnie Crumley, LWC Consulting, personal communication), which results in a "poor" rating, with the note that more data are needed to clarify the extent of impact. Channel conditions are not known for Gibson and Porter Creeks. Because South Fork Porter Creek has had three splash dams in the past, it is likely that the channel conditions are degraded.

Without quantifiable data, the floodplain ratings for many of these watersheds cannot be rated, with the exception of Salmon Creek, Beaver Creek, Bloom's Ditch, and Allen Creek, which have substantial off-channel loss and channelization impacts and are rated "poor". Also, channel incision has been noted in Cedar Creek, which is also rated "poor" with a note that more data are needed to define the extent of impact. However, the above information indicates considerable floodplain impacts have occurred within the Black River sub-basin due to wetland filling, rip-rap, channelization, and past splash dams. A data need is to quantify the loss and recommend restoration and protection actions for floodplain habitat.

Streambed Sediment Conditions in the Black River, Cedar, Gibson, and Porter Creek Sub-Basins

There is no information on landslide hazards in the Black River, Cedar, Gibson, and Porter Creek sub-basins. The relatively low gradients of the watersheds and moderate topography of these drainages would suggest a relatively low hazard for landslides.

Information on the potential of sediment input from surface erosion is more readily available. Livestock access to streams was documented for nearly a mile in the Porter Creek watershed, 2.6 miles in Cedar and Gibson Creek, and 23.9 miles in the Black River drainage (Wampler et al. 1993). Livestock exclusion fencing projects and the closure of two major dairy farms in the Black River drainage have reduced some of the sediment inputs from grazing. Bank vegetation loss from timber and unknown sources also has the potential of creating sediment input to streams by exposing more soils to erosive sources. Porter Creek has over 4.9 miles of banks with bank vegetation loss, Cedar and Gibson Creeks have 2.2 miles of vegetation loss, and the Black River drainage 23 miles of bank vegetation loss (Wampler et al. 1993).

Bank erosion sites were numerous throughout Mima and Waddell Creeks, and also located in Salmon Creek and lower Beaver Creek. A total of 82 bank erosion sites (6.4 miles) were recorded in the Black River drainage. In the smaller Porter drainage, 72 (2.6 miles) sites of bank erosion were noted, and 52 sites (3088 feet) were recorded in the Gibson and Cedar Creek sub-basins (Wampler et al. 1993).

Road densities are high in these drainages, ranging from over 4.5 miles of road per square mile in Black River to just under 3 mi/sq. mi. in Porter and Cedar Creeks (Lunetta et al. 1997). Drainages with higher road densities have a higher potential of increased delivery of sediment to streams from road run-off, because roads can serve as a conduit for transport of fine sediment to the streams at stream crossings. Road-related sediment transport results from exposed soil, such as clearcuts and landings. Based on road densities, sedimentation conditions are “poor” in the Black River and “fair” in the Porter and Cedar and Gibson Creek sub-basins.

No data were found regarding large woody debris levels in any of the streams in this analysis area. Large woody debris was once believed to be a hazard to salmon migrations, and was purposely removed from channels. Later, studies have shown that LWD was a benefit to streams and salmon. LWD traps gravel in the channel, deflects current away from banks, provides structural complexity, and provides cover for fish. In a low gradient system such as Black River, recruitment of new LWD is slow to recover.

Riparian Conditions in the Black River, Cedar, Gibson, and Porter Creek Sub-Basins

Because there was no riparian vegetation assessment available for the analysis area, high elevation aerial photos at TerraServer.com and at the Thurston County Water Resources Web Page were reviewed to determine riparian conditions on a broad scale. The only information available on riparian vegetation in the analysis area was from an inventory of vegetation in the Black River drainage that provided a brief description of riparian vegetation types (Washington Department of Game 1980).

Riparian Conditions in the Black River

The Black River is different in character from many Olympic Peninsula rivers in that it flows through large expanses of swamp, marsh, and sloughs surrounded by relatively undisturbed riparian habitat. The forested riparian areas consist of hemlock, Douglas fir, western red cedar, and Sitka spruce. Typically, red alder are found in the disturbed riparian areas, but natural red alder and Oregon ash riparian areas are also common since there is an abundance of poorly drained soils in the low gradient drainage (Washington Department Game 1980). A unique vegetation feature in the Black River drainage are the mounded prairies in the Mima Mounds Natural Area Preserve, all other mounded prairie habitat has been developed or invaded by Scotch Broom (Washington Department Game 1980).

The lower 9 miles of Black River flows through agricultural lands with only a narrow buffer of trees in most areas. Riparian conditions in this lower 9-mile reach are “poor” (Map 4b). From RM 9 to RM 17, the river flows though wetland and marsh habitat, where the riparian vegetation is dominated by grasses, rushes and sedges with willow, red alder, black cottonwood, and some western red cedar comprising a sparse over-story (Washington Department Game 1980). Because riparian vegetation in this reach is native, the riparian conditions are considered “good”. However, the naturally sparse over-story does not provide much stream canopy to reduce summer water temperatures. Between RM 17 and 20, the Black River flows through residential and agricultural land near the community of Littlerock where riparian vegetation overall is rated as “poor” (Map 4b). Upstream of RM 20 to the outlet of Black Lake (river mile 25) the river flows through native wetland habitat with extensive beaver activity, where riparian conditions are rated “good”. Tree canopy conditions were listed as degraded in the lower Black River, lower Beaver Creek, and parts of Mima and Salmon Creeks (Wampler et al. 1993). In all, over 26 miles of lost tree canopy was documented in the U.S. Fish and Wildlife Service report (Wampler et al. 1993).

Riparian Conditions in Cedar Creek and Gibson Creek

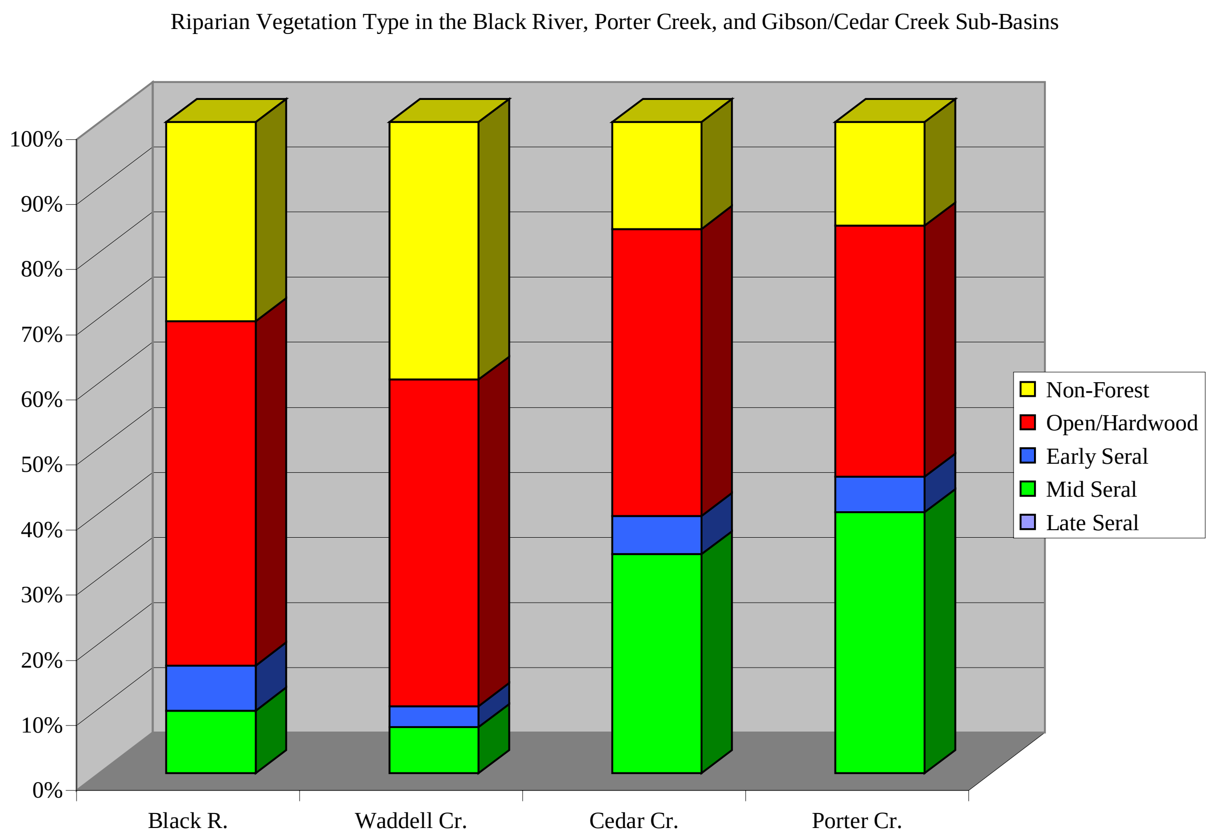
The lower 2 miles of Cedar Creek are primarily agricultural land, where riparian conditions are “poor”, except for "fair" conditions along the lower 0.5 mile near the confluence with the Chehalis River (Map 4b). From RM 2 to 7.5, the managed timberlands have adequate riparian buffers in “good” condition. Upstream of RM 7.5, the riparian canopy is “poor” due to clear-cut harvest units. A total of 3.2 miles of lost tree canopy was documented in the Cedar and Gibson Creek drainages (Wampler et al. 1993).

The lower 0.5-mile of Gibson Creek is bordered by agricultural land consisting of “poor” riparian conditions (Map 4b). From the agricultural land upstream to approximately RM 1.8, there have been recent clear-cuts having “poor” riparian buffer conditions (DNR Data Viewer 2000). The remainder of the drainage is comprised of managed timberlands with mostly “good” riparian conditions. In general, the Cedar and Gibson Creek WAU consists of no late-seral stage riparian trees, 34% mid-seral stage trees, 6% early seral stage conifer, 44% hardwoods, and 16% non-forest (Figure 43) (Lunetta et al. 1997). Using our criteria, 60% of the riparian conditions in this WAU are rated “poor”.

Riparian Conditions in Porter Creek

The lower 2 miles of Porter Creek consists of rural residential and agricultural lands, with the remainder of the drainage is managed timber in the Capital Forest. While only 1.2 miles of tree canopy loss was recorded in the Porter Creek sub-basin (Wampler et al. 1993), overall riparian conditions are mostly “poor” using data from Lunetta et al. (1997). These “poor” conditions consist of 39% hardwoods and 16% non-forest riparian areas (Figure 43). In addition, there are 40% mid-seral stage conifer riparian buffers and 6% early seral stage buffers.

Figure 43. Riparian Conditions in the Black River, Porter Creek, and Gibson/Cedar Creek Sub-Basins (data from Lunetta et al. 1997).



<u>Water Quality Conditions in the Black River, Cedar, Gibson, and Porter Creek Sub-Basins</u>

The low gradient and long reaches of wetlands drained by the Black River creates a unique palustrine river that stratifies similar to a lake. The river has a deep stretch with naturally low dissolved oxygen levels in the lower zone of the stratified reach. The combination of low water velocity, high nutrient concentrations, high productivity, and stratified pools increases the risk of anoxia in the lower Black River. This condition has been magnified from land use practices along the river, which became apparent during the 1989 Black River fish kill, which resulted in the death of adult chinook salmon (Pickett 1992). Evaluation never identified a specific source, but it was documented that low dissolved oxygen with high nutrient levels and warm water temperatures caused the fish kills. The study concluded that the increase in nutrients and aquatic plant density downstream of RM 10 worsens water quality because high productivity typically leads to dramatic swings in oxygen concentrations. This is particularly troublesome in a stream like the Black River, which has a very low velocity and thus little capacity for physical aeration (DOE 1989). Nutrient levels can be increased by several possible sources including agriculture and aquaculture, both were operating during the fish kill period.

Since the 1989 fish kill, there have been numerous sampling programs and clean-up plans that have improved water quality associated with dairy farms (Sargent 1996a and 1996b). Between 1991 and 1995 best management practices were implemented at the Black River Ranch which included installation of a waste management system, overwinter waste storage pond, water conservation practices, and eventually reduction in herd size. Water quality improved above standards for ammonia, nitrogen, total phosphorus, and turbidity. However, Black River continues to be on the 303(d) List for warm water temperature (Butkis 1999), and is a segment within the upper Chehalis dissolved oxygen TMDL (Jennings and Pickett 2000). Besides natural conditions that result in relatively low dissolved oxygen levels, urban stormwater, fertilizers, and dairy farms are identified as impacts that further decrease dissolved oxygen levels.

Thurston County Environmental Health Division has annually monitored water quality in Black Lake since 1992 to assess conditions for public use. Evaluations included stratified sampling for pH, temperature, dissolved oxygen, and nutrient levels. The lake is thermally stratified during June, July and August, with surface water temperatures above 20^{o}C. Temperatures below the four-meter thermocline have reached 18.5^{o}C with depleted dissolved oxygen levels. High total phosphorus levels during summer months result in blue-green algae blooms, which could decrease oxygen levels (Thurston County 1993 and 1999; DOE 2000). In 1992, total phosphorus levels at the bottom of the lake were 0.424 mg/l in June, 0.037 in July, and 0.333 in August. The summer 1998 samples were 0.022 mg/l in June, 0.032 in July and 0.093 in August (Thurston County 1993 and 1999). Total phosphorus concentrations during summer sampling have decreased between 1992 and 1998, but Black Lake continues to be on the DOE 303(d) List of impaired waters for total phosphorus levels over the standard of 0.05 mg/l (Pickett 1997).

Raising the level of Black Lake by installing a control structure at Black Lake Ditch and removing the vegetative buildup at the gas pipeline, would reestablish an outlet to Black River, and would increase flows to the Black River to a more historical, normal range. However, this is a controversial proposal because flow through the ditch contributes to Percival Creek, which supplies fish habitat for stray hatchery chinook and coho from south Puget Sound stocks. Another concern is that the exotic fish species in Black Lake will prey on juvenile salmonids. Also, water quality sampling in Black Lake will need to be evaluated to determine if lake water would further contaminate Black River. (Thurston County Environmental Health Division). Lake water quality has improved since several Black Lake residential septic systems were upgraded (J. Roach, personal communication). The Association of Black Lake Enhancement has been proposing to open Black River with the objective of enhancing salmon production in Black Lake and River. Because of the preponderance of water quality and flow problems in Black River, the Black Lake drainage issue is very important to the fish resources in the Black River. It needs to be studied and all aspects of a change need to be considered.

No water quality data were found for Porter Creek, Gibson Creek, and Cedar Creek. However, because these areas have considerable components of "poor" riparian conditions, water quality monitoring should be a priority. Water quality is not rated for these streams.

Water Quantity Conditions in the Black River, Cedar, Gibson, and Porter Creek Sub-Basins

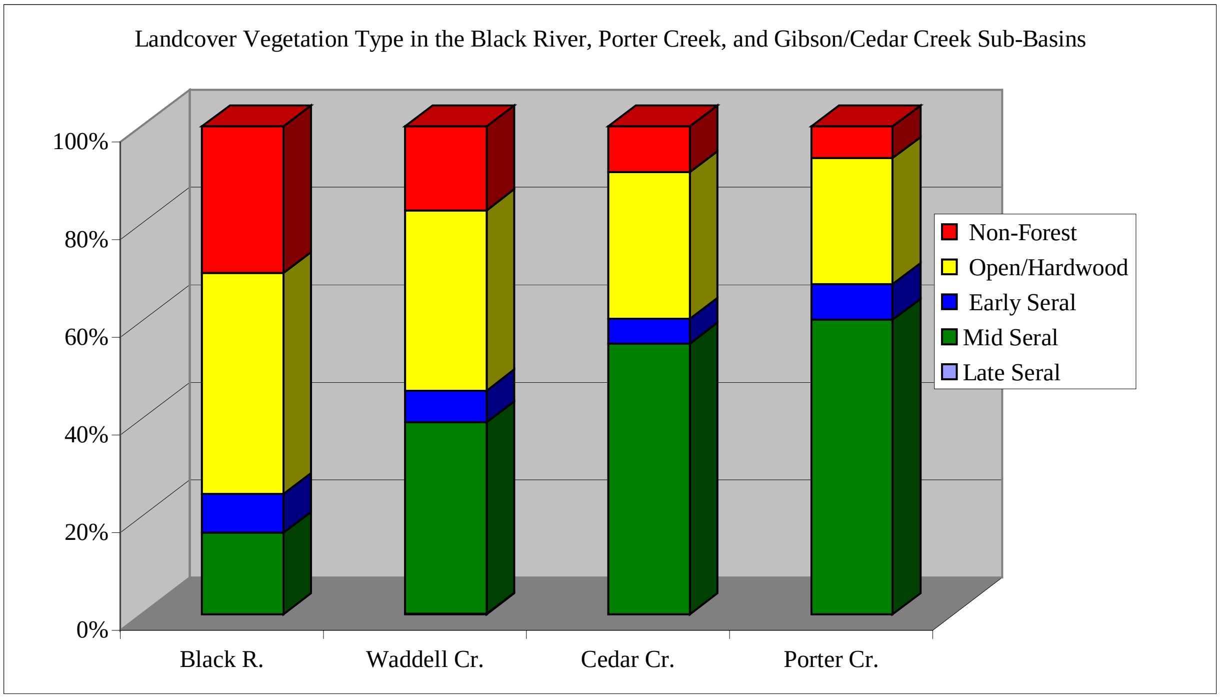
The hydrology of the Black River has been severely altered after the Black Lake Ditch was excavated at the north end of Black Lake in 1922, 1952, and 1976. Originally, Black Lake drained into Black River, but the Black Lake ditch was developed at the other end of the lake to help control flooding of private property along Black Lake. However, as the ditch down-cut, it became the primary outlet for Black Lake. Since then, the wetlands near the upper Black River have slowly filled in, resulting in greatly decreased flows into Black River except during flooding (J. Roach, Association of Black Lake Enhancement; Hawkins 2000). Thurston County Environmental Health Division currently identifies Black Lake as part of the Puget Sound drainage (Thurston County Environmental Health Department 2000). The Chehalis River Basin Action Plan also indicates that Black Lake drains to Black Lake Ditch and then to Percival Creek, except during flooding (LCCD 1993). However, it acknowledges that Black River is hydrologically connected to Black Lake via ground water.

These flow and access problems were further exacerbated in 1965, when a gas pipeline was constructed across the river. The pipeline excavation had left spoils along the sides of the pipeline trench, and subsequently, beaver dam debris and vegetative dams have developed in the area. This resulted in a reversal of the wetland drainage, such that the upper 1.5 miles of Black River flows north into Black Lake. These changes in the natural hydrology of the river have worsened the summer low flow conditions, contributing to warm water temperatures and low dissolved oxygen levels. In addition, the Black River, Beaver Creek, and Salmon Creek are closed to further consumptive water appropriations in the dry season (DOE 1988). Numerous water withdrawals were documented in the lower Black River, near the mouth of Beaver Creek, and in Salmon Creek (Wampler et al. 1993). For these reasons, water quantity conditions in the Black River are rated “poor”.

Direct measurements of streamflow in the Porter Creek sub-basin ceased in 1948, with no direct flow information for Cedar Creek or Gibson Creek. Because of that, flow trends or comparison of current flows to established base flows is not possible. However, some information regarding impacts to flows can be derived indirectly. High flow events can increase in frequency and magnitude when other types of land cover vegetation replace native, mature conifer forests. Figure 44 shows recent land cover vegetation types in each of the sub-basins. Gibson and Porter Creek sub-basins have predominately mid- to late seral stage conifer and are rated “good” for hydrologic maturity. Water withdrawals from Porter Creek and Gibson/Cedar Creeks were uncommon with only two potential withdrawals noted in Porter Creek and three in Gibson and Cedar Creeks (Wampler et al. 1993).

The land cover vegetation for the Black River WAU was not rated because significant quantities of prairie land are native to these areas, and the natural levels of conifer forest are atypical. However, Waddell Creek is historically a conifer-dominated area. Less than 40% of this WAU consists of mid- to late seral stage vegetation, which results in a "poor" rating for hydrologic maturity (data from Lunetta et al. 1997).

Figure 44. Land cover Vegetation in the Black River, Gibson/Cedar Creek and Porter Creek Sub-Basins (data from Lunetta et al. 1997).



<u>Conditions of Lakes in the Black River Sub-Basin</u>

In addition to Black Lake, there are seven small lakes (5 to 67 acres) in the Black River drainage. Deep and Scott Lake are heavily used for recreation and have extensive residential development. Deep Lake is within Millersylvania State Park, which draws 500,000 visitors annually (LCCD 1993).

Since 1992, Thurston County Environmental Health Division has annually monitored water quality in Black Lake to assess conditions for public use. Evaluations include stratified sampling for pH, temperature, dissolved oxygen, and nutrient levels. The lake is thermally stratified during June, July and August, with surface water temperatures above 20^{o}C. Temperatures below the four-meter thermocline sometimes reach 18.5^{o}C with depleted dissolved oxygen levels. High total phosphorus levels during summer months resulted in blue-green algae blooms that can result in low dissolved oxygen levels (Thurston County 1993 and 1999; DOE 2000). In 1992, total phosphorus levels at the bottom of the lake were 0.424 mg/l in June, 0.037 in July, and 0.333 in August. The summer 1998 samples were 0.022 mg/l in June, 0.032 in July and 0.093 in August (Thurston County 1992 and 1999). Total phosphorus concentrations during summer sampling have decreased between 1992 and 1998, but Black Lake continues to be on the most recent updates (1996 & 1998) of the DOE 303(d) List of impaired waters for total phosphorus levels over the standard of 0.05 mg/l (Pickett 1997).

Biological Processes in the Black River, Gibson Creek and Cedar Creek Sub-Basins

Nutrient cycling is assessed for this report by the attainment of escapement goals, but all of the salmon and steelhead stocks in these watersheds are managed as part of a much larger population that extends throughout most of WRIA 23. Two species of salmon or steelhead (coho and winter steelhead) were documented in many of these streams (Streamnet 1999). Coho salmon escapements throughout WRIA 23 have declined in the 1990s (John Linth, WDFW, personal communication), and winter steelhead are classified as "healthy" in SASSI (WDFW and WWTIT 1994). In addition, fall chinook salmon are present in these streams, but are also a part of a larger population that extends throughout much of WRIA 23, and this stock is listed as "healthy" in SASSI (WDFW and WWTIT 1994). Chum salmon are found in this area and are listed as "healthy" in SASSI, but are reduced in distribution, although data from are lacking to determine a reduction in numbers from earlier time periods. However, because the data are not specific to the Black River, Porter Creek, Gibson Creek or Cedar Creek, nutrient cycling is not rated. More work is needed to better clarify salmonid distribution and abundance in these streams.

Habitat Limiting Factors in the Scatter and Prairie Creek Sub-Basins

Loss of Access in the Scatter Creek and Prairie Creek Sub-Basins

Barrier information was obtained from the Salmonid Screening, Habitat Enhancement and Restoration Division of WDFW, the Washington State Department of Transportation (Johnson et al. 1999) and by personal communication with Jeanne Kinney (Thurston County). Four culverts within the Scatter Creek watershed were documented by WDFW, but one of those (Vantine Road) has been replaced (Jeanne Kinney, personal communication). The other three culverts are listed below and should be field verified for fish passage prior to restoration plans. This quantity of blockages is low, resulting in a "good" rating for access conditions in Scatter Creek.

1) A culvert associated with tributary 23.0720 (near RM 0.25) blocks about 2 miles of coho habitat. Burlington Northern Railroad is the landowner (WDFW 1998).

2) A culvert and earthen dam on a tributary to Dry Creek (near RM 0.35) blocks about 0.21 miles of coho habitat (WDFW 1998).

3) A culvert associated with tributary 23.0721 is blocking an unknown quantity of coho habitat on Burlington Northern Railroad property (WDFW 1998).

Floodplain Conditions in the Scatter Creek and Prairie Creek Sub-Basins

In 1999, the Thurston Conservation District surveyed Scatter Creek. Within their sampled sections, side-channel habitat was uncommon except between RM 11 and 12 (Thurston Conservation District 1999). The lack of side-channel habitat was uncommon both in undeveloped areas, as well as in developed reaches, suggesting that this is a naturally limiting habitat feature (Scott Brummer, Thurston Conservation District, personal communication).

Several types of floodplain impacts have been documented in Scatter Creek. Channelization extends for over 2 miles, and bank hardening (riprap) was documented for 5659' of stream bank (Wampler et al. 1993). Although this quantity of floodplain impact is relatively low for the stream length, the impact might have greater importance because of the low frequency of side-channel and off-channel habitat. Using our rating system, this results in a "good" rating for floodplain conditions, but future impacts to the Scatter Creek floodplain should be avoided. No information on the floodplain conditions for Prairie Creek were found.

Streambed Sediment Conditions in the Scatter Creek and Prairie Creek Sub-Basins

Sediment quantity is rated as "poor" in the Scatter and Prairie Creek sub-basins. Road density is very high, an estimated 5.3 mi road/sq. mi watershed (Lunetta et al. 1997), and excess sedimentation is specifically noted for nearly 8.5 miles (Wampler et al. 1993). In addition, livestock access is documented for 11.7 miles, and general bank erosion is documented 0.9 miles (Wampler et al. 1993).

Sediment quality is mostly "poor" in Scatter Creek, with four out of five sampled segments containing more than 17% fine sediments (Thurston Conservation District 1999). These "poor" rated segments are located near RMs 1, 8, 11.5, and 12.5. One of these segments (near RM 8) contains 44.9% fines. One additional segment rates "fair", and is located near RM 5.

Channel conditions are generally poor within Scatter Creek. The width to depth ratio was measured at 10 different sites from RM 1 to 14.3, and all samples were greater than 12, which is rated as "not functioning" (Thurston Conservation District 1999). The average width to depth ratio in Scatter Creek was greater than 20.

Instream large woody debris (LWD) rated "good" in most sampled segments of Scatter Creek (near RMs 1, 5, 6, 7.5, 10, 10.6) (Thurston Conservation District 1999). "Fair" ratings were located near RMs 8, 11.5, and 12.5, and one segment near RM 9 rated "poor" for instream LWD pieces per bank full width.

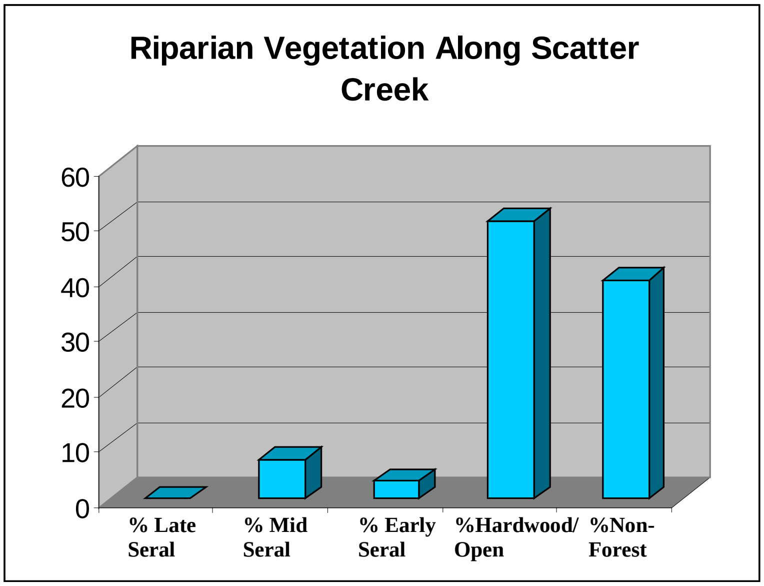
Riparian Conditions in the Scatter Creek and Prairie Creek Sub-Basins

Riparian conditions are generally "poor" along Scatter Creek (Map 4b). Most of the riparian consists of open or hardwood areas (50%), which will be unable to supply sufficient LWD in the future (Figure 45) (data from Lunetta et al. 1997). In addition, another 40% of the riparian have been converted to other land uses such as agriculture, urbanization, and residences. This type of conversion results in a lack of shade, an inability to contribute to future LWD, and reduction in other processes, such as bank stability and food web contribution. Only 7% of the riparian rated "good".

Shade conditions along Scatter Creek are generally poor. The mean canopy closure along Scatter Creek is especially low near RMs 1, 5, 8, 9, and 12.5 with values of less than 35% of complete coverage (Thurston Conservation District 1999). The remaining measurements range from 47%-67%, none of which are considered adequate. Also, the loss of tree canopy is listed as the greatest salmon habitat impact in Wampler et al. (1993), and the loss is located along most of the mainstem Scatter Creek. They noted about 17.6 miles of lost riparian canopy due to agricultural conversion and another 1.1 miles of loss due to other causes. Bank vegetation loss is estimated at 16.3 miles, with most of the degradation due to unknown causes. The bank vegetation loss is located in the lower reaches, as well as in a few dispersed areas in the upper sub-basin (Wampler et al. 1993). Bank vegetation loss also extended along most of Prairie Creek.

The number of pools (percent pools of total area) are rated "good" near RMs 1 and 6, "fair" near RMs 8 and 11, and "poor" near RMs 5 and 9 (Thurston Conservation District 1999). However, the "good" rating near RM 6 is due to this segment being dry except for one pool. Pool spacing (pool frequency) is worse. Pool frequency is rated "poor" in all of the sampled segments downstream of RM 11 in the mainstem Scatter Creek, and rated "fair" in one additional segment between RM 11-12 (Thurston Conservation District 1999). Pools are relatively shallow as well, except near RM 1 where the mean residual pool depth is 2.54m. The remaining sampled segments all measure less than 1m, and these areas are located near RMs 6, 8, 9, 11, and 12 (Thurston Conservation District 1999).

Figure 45. Riparian Vegetation Type in the Scatter Creek WAU (data from Lunetta et al. 1997).



Water Quality in the Scatter Creek and Prairie Creek Sub-Basins

Scatter Creek is on the 1998 303(d) List for problems with water temperature, pH, and fecal coliform (Jennings and Pickett 2000). Water temperatures have reached as high as 21^{o}C, which results in a "poor" water quality rating. The primary contributor to the warm water temperatures is likely the poor riparian conditions. The loss of tree canopy is listed as the greatest salmon habitat impact in Wampler et al. (1993) and extends for most of the mainstem of Scatter Creek. The mean canopy closure along Scatter Creek is especially low near RMs 1, 5, 8, 9, and 12.5 with values of less than 35% of complete coverage (Thurston Conservation District 1999). The remaining measurements ranged from 47%-67%, none of which are considered adequate.

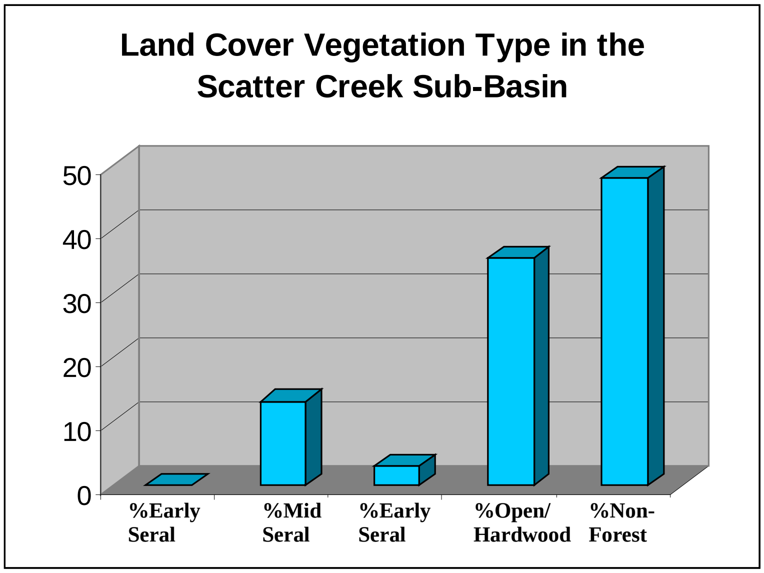
Livestock access has been extensive, documented for about 11.7 miles in the sub-basin (Wampler et al. 1993). This is a likely cause of at least some of the fecal coliform problems, as well as contributing to low dissolved oxygen levels.

Water Quantity in the Scatter Creek and Prairie Creek Sub-Basins

Low water flows have been identified in Scatter Creek and in Prairie Creek. In Prairie Creek, much of the stream is dry during the summer, providing little rearing habitat for salmonids (Phinney and Bucknell 1975). It is unknown how much of this is due to natural conditions, and because of this, water quantity is not rated for Prairie Creek. Dry stream reaches are also noted in Scatter Creek (Thurston CD 1999). Wampler et al. (1993) documented four known withdrawals and one suspected withdrawal in the Scatter Creek sub-basin, but this is a relatively low quantity of surface withdrawals. Of greater concern is the high groundwater pumping rate that exists in the Scatter Creek sub-basin (Envirovision 2000). Groundwater pumping can lower the water table, altering stream flows. The impact of the high pumping rate on salmonids in this sub-basin is not known and needs quantification. However, adequate concern exists that Scatter Creek is not meeting base flow requirements that it has been closed to further appropriations from May 1 through October 31 (Jennings and Pickett 2000). This results in a "poor" rating for water quantity due to low flows.

Historically, the land cover consisted of forest in the headwaters with prairie land in the middle and lower sections of the sub-basins (Thurston Conservation District 1999). During precipitation events, the forested land cover temporarily captures from 24-35% of the rainfall (Dingman 1994), which slows down the water inputs to streams in potential flood events. In predominantly forested areas, the loss or change of vegetative cover can contribute to an increase in peak flows that results in increased bank erosion and riverbed scour, degrading salmonid habitat. However, in the Scatter and Prairie Creek sub-basins, a significant amount of prairie land exists, and the forested land cover data cannot be applied with confidence. The data indicate that currently most of the land (48%) is used for agriculture or urban (data from Lunetta et al. 1997). The remaining categories are shown in Figure 46. No rating is assigned to land cover type given the uncertainty of the quantity of conversion. Further data collection and analysis is needed to fill this data gap.

Figure 46. Land cover Vegetation in the Scatter Creek Sub-Basin (data from Lunetta et al. 1997).



Biological Processes in the Scatter Creek and Prairie Creek Sub-Basins

Nutrient cycling is assessed for this report by the attainment of escapement goals, but all of the salmonid stocks in the Scatter Creek watershed are managed as part of a much larger population that extends throughout most of WRIA 23. Two species of salmon or steelhead (coho and winter steelhead) were documented for Scatter Creek in the SASSI report (WDFW and WWTIT 1994). In addition, chum salmon and summer steelhead were mentioned in an assessment by Thurston Conservation District (1999). Coho salmon escapements throughout WRIA 23 have declined in the 1990s (John Linth, WDFW, personal communication), but data specific to Scatter Creek do not show a declining trend (WDFW, Montesano, unpublished data). Winter steelhead are classified as "healthy" in SASSI (WDFW and WWTIT 1994). No data are available for summer steelhead production, and chum salmon were listed as "healthy". To summarize, most stocks with existing data indicate that levels have not declined from recent historic numbers. However, because the data are not specific to Scatter Creek, nutrient cycling is not rated. While it would be more appropriate to compare to historic numbers, such information is not available.

Habitat Limiting Factors in the Skookumchuck Sub-Basin

Loss of Access for Anadromous Salmonids in the Skookumchuck Sub-Basin

Data Sources

Lewis County (Rodney Lakey, Lewis County, personal communication) documented most of the barriers listed in this section. Additional barrier information was obtained from the Salmonid Screening, Habitat Enhancement and Restoration Division of WDFW, the Washington State Department of Transportation (Johnson et al. 1999), and the Upper Skookumchuck Watershed Analysis (Weyerhaeuser 1997). The culvert assessment by Lewis County has been completed through its first level. In an additional study, they plan to further inventory habitat upstream of barriers and assess whether each culvert blocks fish habitat access. Because analysis of habitat upstream of culverts and the extent of fish impact have not been done, we are unable to fully rate the condition of access issues in this sub-basin.

Blockages in the Skookumchuck Sub-Basin

Culverts should be field verified for fish passage prior to restoration planning, and those with "unknown fish presence" need further assessment to determine if they impact salmonids or not. Priority order was not assigned.

The greatest impediment to salmonid distribution in the Skookumchuck sub-basin is the Skookumchuck Dam located at RM 21.9. The dam currently blocks passage to all anadromous fish, but steelhead trout are trucked to stream reaches upstream of the dam. It is estimated that 3.6 miles of spring and fall chinook mainstem habitat was lost when the dam was constructed, along with 8 miles of coho salmon habitat (Weyerhaeuser 1997).

In the upper Skookumchuck sub-basin, only two blocking culverts were identified as problems for steelhead (Weyerhaeuser 1997). One of these is located at RM 1.5 on Hospital Creek at the 2000 Road. The other is located near RM 1.2 on Twelve Creek, and is associated with the 2200 Road.

Many culverts were identified in the Skookumchuck River downstream of the dam, as well as in the Hanaford Creek and China Creek sub-basins. These are listed in Table 24, and are not assigned priority order. The high number of potentially blocking culverts in Hanaford and China Creeks suggests that fish habitat access conditions might be a major problem and an assessment to define the impact should be a high priority. Also, the very high road density (5.4-6.0 mi/sq. mi) also suggests that road-related problems, such as culverts and sedimentation, should be a concern.

Table 24. Blockages in the Lower Skookumchuck, Hanaford, and China Watersheds (Rodney Lakey, Lewis County).

Road Name	Watershed	Township, Range, Section	Fish Presence	Notes
Halliday Rd	Hanaford Cr.	14N, 02W, 3NW	Yes	Chinook, coho
Lundberg Rd	China Cr.	14N, 02W, 4NE	Unknown	
Lundberg Rd	China Cr.	14N, 02W, 4NE	Yes	
Lundberg Rd	China Cr.	14N, 02W, 4NE	Yes	
Lundberg Rd	China Cr.	14N, 02W, 4NE	Yes	
McAtee Rd	China Cr.	14N, 02W, 3SW	Yes	Coho
McAtee Rd	China Cr.	14N, 02W, 3SW	Yes	Coho
McAtee Rd	China Cr.	14N, 02W, 3SW	Yes	Coho
McAtee Rd	China Cr.	14N, 02W, 3SW	Yes	Coho
McAtee Rd	China Cr.	14N, 02W, 3SW	Yes	Coho
Loop Rd	China Cr.	14N, 02W, 3NW	Yes	
Grimes Rd	China Cr.	14N, 02W, 11SE	Yes	
Little Hanaford Rd		14N, 02W, 3NW	Yes	
Little Hanaford Rd		14N, 02W, 2SW	Yes	
Little Hanaford Rd	South Hanaford Cr.	14N, 02W, 7SE	Yes	
Little Hanaford Rd	South Hanaford Cr.	14N, 02W, 7SE	Yes	
Little Hanaford Rd	South Hanaford Cr.	14N, 02W, 17NW	Yes	
Little Hanaford Rd	South Hanaford Cr.	14N, 02W, 17NW	Yes	
Little Hanaford Rd	South Hanaford Cr.	14N, 02W, 17SW	Yes	
Little Hanaford Rd	South Hanaford Cr.	14N, 02W, 17SE	Yes	
Little Hanaford Rd	South Hanaford Cr.	14N, 02W, 16NW	Yes	
Little Hanaford Rd	South Hanaford Cr.	14N, 02W, 16NW	Yes	
Jones Rd	South Hanaford Cr.	14N, 01W, 17	Yes	
Jones Rd	South Hanaford Cr.	14N, 01W, 17	Yes	
Jones Rd	South Hanaford Cr.	14N, 01W, 17	Yes	
Wigley Rd	Hanaford Cr.	15N, 02W, 27SW	Unknown	
Teitzel Rd	South Hanford Cr.	14N, 02W, 1NE	Yes	
Teitzel Rd	South Hanford Cr.	14N, 02W, 1NE	Yes	
Big Hanaford Rd		15N, 01W, 27NW	Yes	
Big Hanaford Rd	Snyder Cr.	15N, 01W, 26SW	Unknown	
Lowery Lane	Skookumchuck Trib (Coffee Cr.)	14N, 02W, 29SE	Yes	
Blair Rd	Skookumchuck tributary	15N, 02W, 31SE	Unknown	

Road Name	Watershed	Township, Range, Section	Fish Presence	Notes
Blair Rd	Skookumchuck tributary	15N, 02W, 31SE	Unknown	
Blair Rd	Skookumchuck tributary	15N, 02W, 31NE	Unknown	
Blair Rd	Skookumchuck tributary	15N, 02W, 31NE	Yes	Runs under I-5
Delano Rd	Skookumchuck tributary	15N, 02W, 31NE	Unknown	
Reynolds Rd	Skookumchuck tributary	14N, 02W, 5NW	Yes	
Reynolds Rd	Skookumchuck tributary	14N, 02W, 5NW	Yes	
Reynolds Rd	Skookumchuck Trib,Coffee Cr.	14N, 02W, 32SE	Unknown	
Big Hanaford Rd	Packwood Cr.	15N, 01W, 30SW	Unknown	
Big Hanaford Rd	Snyder Cr.	14N, 01W, 29SE	Yes	
Big Hanaford Rd	Hanaford Cr.	15N, 01W, 28NW	Unknown	
Big Hanaford Rd	Hanaford Cr.	15N, 01W, 28NW	Yes	
Big Hanaford Rd	Hanaford Cr.	15N, 01W, 28NW	Unknown	

Floodplain Impacts in the Skookumchuck Sub-Basin

In the Hanaford watershed, permanent side-channel and wetland habitat loss has been significant, at an estimated 4.6 miles (SSHIAP 1997). Conversion of active channel to inaccessible ponds also poses a considerable impact, spanning 8.25 miles of the lower Hanaford watershed. Mining and agriculture have been the major causes of the changes, due to ditching and pond construction for settlement of mine tailings. The settlement ponds for mining encompass 1.6 linear miles of channel, and most of the ponds are associated with dams and were developed in active channels (SSHIAP 1997). Roads in the floodplains also impact streams by restricting lateral movement into floodplains and increasing sedimentation. Floodplain roads are listed in Table 25. In the Hanaford watershed, they account for an estimated 11.6 stream miles. Known salmon and steelhead distribution span for roughly 47.5 miles throughout the Hanaford watershed. Impacts from all known sources, except ditching and channel realignment, extend over 26 miles, or 55% of the salmon and steelhead distribution. This results in a “poor” rating for floodplain condition in the Hanaford watershed. This is a conservative estimate because bank hardening, ditching, and channel realignments are very significant impacts, and were not included in this percentage because those data were merged with the Skookumchuck River data.

Ditching and channel realignment have also impacted the floodplains and channel conditions associated with the mainstem Skookumchuck River, Coffee Creek, Salmon Creek, and Johnson Creek. The total impact of ditching and channel realignment is estimated at 36 miles of stream, or 22% of the anadromous salmonid habitat in the lower watershed, but much of that includes Hanaford Creek (SSHIAP 1997). Another type of impact in the Skookumchuck River is bank hardening (rip-rap and dikes), which encompasses 2.2 miles of the mainstem Skookumchuck from RMs 3 to 6 and parts of Hanaford Creek (SSHIAP 1997). Floodplain roads and railways closely parallel an estimated 3 miles of the mainstem Skookumchuck River, 0.8 miles of Salmon Creek, 2 miles of Johnson Creek, 3.4 miles of Thompson Creek, and 0.5 miles of an unnamed tributary to the Skookumchuck River. The total known mainstem Skookumchuck floodplain impacts account for a conservative estimate of 6 miles or 26.9% of the length of the lower Skookumchuck River, resulting in a “fair” rating. “Fair” ratings are also given to Johnson Creek and Thompson Creek for the length of stream impacted by floodplain roads. To include ditching and channel realignment impacts, the entire lower Skookumchuck sub-basin was examined. Out of a total of 185.1 miles of salmon and steelhead habitat (SSHIAP 1997), 74 miles of floodplain is impacted. The percent impact in the entire lower Skookumchuck sub-basin is 40%, a “fair” rating.

In the upper Skookumchuck sub-basin (upstream of the Skookumchuck Dam), many channel segments are naturally confined, flowing through steep canyons. In these areas, the floodplains are limited, and low gradient rearing habitat is naturally very low. However, two human-caused floodplain impacts have been identified. One problem is the encroachment of the Mainline Road into floodplain and riparian areas (Weyerhaeuser 1997). This occurs from RM 27 to 36.2, which is 68% of the upper Skookumchuck mainstem steelhead distribution. Road impacts also occur from RM 0.2-1.4 in Twelve Creek, and this results in a “poor” condition rating for the upper Skookumchuck mainstem and Twelve Creek. Other road encroachments to the floodplain exist along Laramie Creek (RM 0.2-1.1 and 0.3 miles in a tributary) and Range Creek (0.7-1.3), resulting in “poor” floodplain conditions for these streams.

Channel incision in another floodplain impact in the upper Skookumchuck sub-basin, and is caused by dam break floods (Weyerhaeuser 1997). A more detailed description of dam break floods and causes is in the Streambed and Sediment Condition Chapter, below. However, areas impacted by channel incision include long stretches of Eleven, Twelve, Drop, Deer, Three Forks, Bigwater, Range, Fall, and Pheeney Creeks, as well as in the mainstem headwaters (Weyerhaeuser 1997). These streams are rated as “poor” for floodplain conditions.

In the China Creek watershed, the lowest two miles are contained in long culverts and rock and concrete lined channels, which provide no useable streambed habitat for salmonids (SCS 1977). This reach is rated "poor" for floodplain conditions. Floodplain conditions upstream of that reach are unknown.

Table 25. Roads and Railroads in the Lower Skookumchuck Floodplain.

Stream	Range (RM) Impacted	Species Impacted
South Hanaford Cr.	5.2-8.2 plus 0-2 miles in stream 23.0774	Coho, steelhead
Hanaford Cr.	1.5-2.8, 10.4-11.5	Coho, steelhead
Packwood Cr.	1.3-3.9	Coho, steelhead
Packwood Trib. 23.0780	0.0-0.8	Coho, steelhead
Packwood Trib. 23.0779	0.0-0.3, 2.0-2.5	Coho, steelhead
Skookumchuck Trib. 23.0790	0.0-0.5	Coho, steelhead
Salmon Cr.	1.1-1.9	Coho, steelhead
Johnson Cr.	1.8-3.8	Coho, steelhead
Thompson Cr.	0.4-1.4, 3.2-5.6	Coho, steelhead
Skookumchuck R.	3.4-3.9, 6.7-8.3, 21.1-22	Coho, steelhead

Streambed and Sediment Conditions in the Skookumchuck Sub-Basin

Road densities in the lower Skookumchuck sub-basin are very high (an average of 5.4 mi/sq mi) (Lunetta et al. 1997). Even greater road densities exist in the Hanaford Creek watershed at 6.0 mi./sq. mi., and both watersheds are rated as "poor" for road density (see Assessment Chapter for more details on ratings). While the predominant percent of channel type in the upper Skookumchuck watershed is a source type of channel (contributes sediment), very little source channel types exist in the lower Skookumchuck River and in Hanaford Creek (18 and 19% respectively) (Lunetta et al. 1997). This is particularly important in the lower Skookumchuck River because the dam hinders the downstream transport of sediment and wood from the headwaters, limiting spawning gravels and LWD in the lower reaches.

Bank erosion is common along the lower Skookumchuck River, with 180 observations of erosion (20.8 miles) documented by Wampler et al. (1993) (Figure 47). Locations for these erosion sites include the mainstem Skookumchuck River, Thompson Creek, Johnson Creek, and Bloody Run Creek. Whether the type of bank erosion sediment is beneficial (coarse for spawning gravel) or detrimental (clay/fine sediments) is unknown, and needs further assessment. It is likely that the erosion is related to the loss of riparian (see Riparian section), as well as other activities, such as vehicle crossings and livestock access (Figure 48). Nine sites of livestock access to streams were noted, and the extent of access impacts is high, at 40 miles of stream length. This resulted in livestock access listed as the second highest habitat degradation type in the Skookumchuck sub-basin by Wampler et al (1993). Vehicle activity was also prevalent, with documentation of 15 stream bank observations and 9 instream sites (Wampler et al. 1993). For all of the above reasons, sediment quantity and quality are rated "poor" for the lower Skookumchuck River and tributaries.

Fine sediment inputs can suffocate salmonid eggs and reduce interstitial spaces used by small juveniles for rearing. Recent measurements of fine sediments are needed, but in the 1970s, the percent of fine sediments was estimated at 19% between RM 7.2-22.1, to 26% from RM 0-7.2 in the Skookumchuck River; both values are very high (Phinney and Bucknell field notes 1975). High levels of fine sediments were also estimated in Salmon Creek (50%), Johnson Creek (33%), and Thompson Creek (30%) (Phinney and Bucknell field notes 1975), and R.W. Beck and Associates (1973) state that high levels of fines exist in the lower Skookumchuck River. The methodology used for both of these reports is unknown, and combined with the age of the data, should be repeated.

In the 1970s, the streambed substrate for Hanaford Creek was listed as 100% clay in the lower 8.9 miles (Phinney and Bucknell field notes 1975). It is not known whether this is a completely natural condition or caused by increased channel incision or other problems, but upstream, the substrate rated "good", with only 10% fine sediments (Phinney and Bucknell field notes 1975). North Hanaford Creek had high levels (40%) of fine sediments, while South Hanaford Creek had extremely high (90%) levels of fines in the 1970s. Packwood Creek had high levels of fines (75%), while Snyder Creek was described as a "clay lined ditch". Coal Creek fines were estimated at 10%, within acceptable ranges. Given the age of the data and the lack of methodology, reassessment of these streams is strongly recommended. Coal mining in the Hanaford basin exposes about 900 acres of land, and is a probable cause of increased sedimentation, especially in Packwood Creek (Hiss et al. 1982).

Because most of the tributaries to the upper Skookumchuck River (upstream of the Skookumchuck Dam) have high gradients (>8%), the watershed is a transport watershed; gravels and large woody debris tend to transport readily downstream (Weyerhaeuser 1997). However, transport of sediment, wood, and water has been increased by the removal of large woody debris through dam break floods and timber harvest, coupled with an altered riparian zone that no longer contributes key pieces of woody debris. Historically LWD was abundant. The lack of current LWD results in greater sediment transport (less gravel remains for spawning salmonids), greater channel instability, more energy during floods that can increase scour, and less pools and cover available for migrating and rearing salmonids. Spawning gravel is especially limited in upper Fall Creek, mid-upper Pheeney Creek, Eleven Creek, Twelve Creek, and in the headwaters (from the confluence of Drop Creek upstream) (Weyerhaeuser 1997). The quality of spawning gravels is not a problem, as fine sediments are unable to accumulate, resulting in a "good" rating for sediment quality.

Specific information regarding levels of LWD could only be found for the upper Skookumchuck River. In the upper sub-basin, current levels of instream LWD are very low throughout, with most sampled areas rating "poor" (Map 5b) (Table 26). Because of the high gradient and channel confinement, the size of wood necessary to stay in many of these streams is large, 20" or greater diameter (Weyerhaeuser 1997). A few areas have naturally low levels of LWD, such as the mainstem upper Skookumchuck to the confluence of Eleven Creek, lower Baumgard Creek, lower Pheeney Creek, Hospital Creek, and Fall Creek (Weyerhaeuser 1997). Projects that place LWD in these canyon areas are not recommended because the wood would likely not remain in place to serve as fish habitat.

Figure 47. Bank Erosion Impacts in the Skookumchuck and Newaukum Sub-Basins (Wampler et al. 1993).

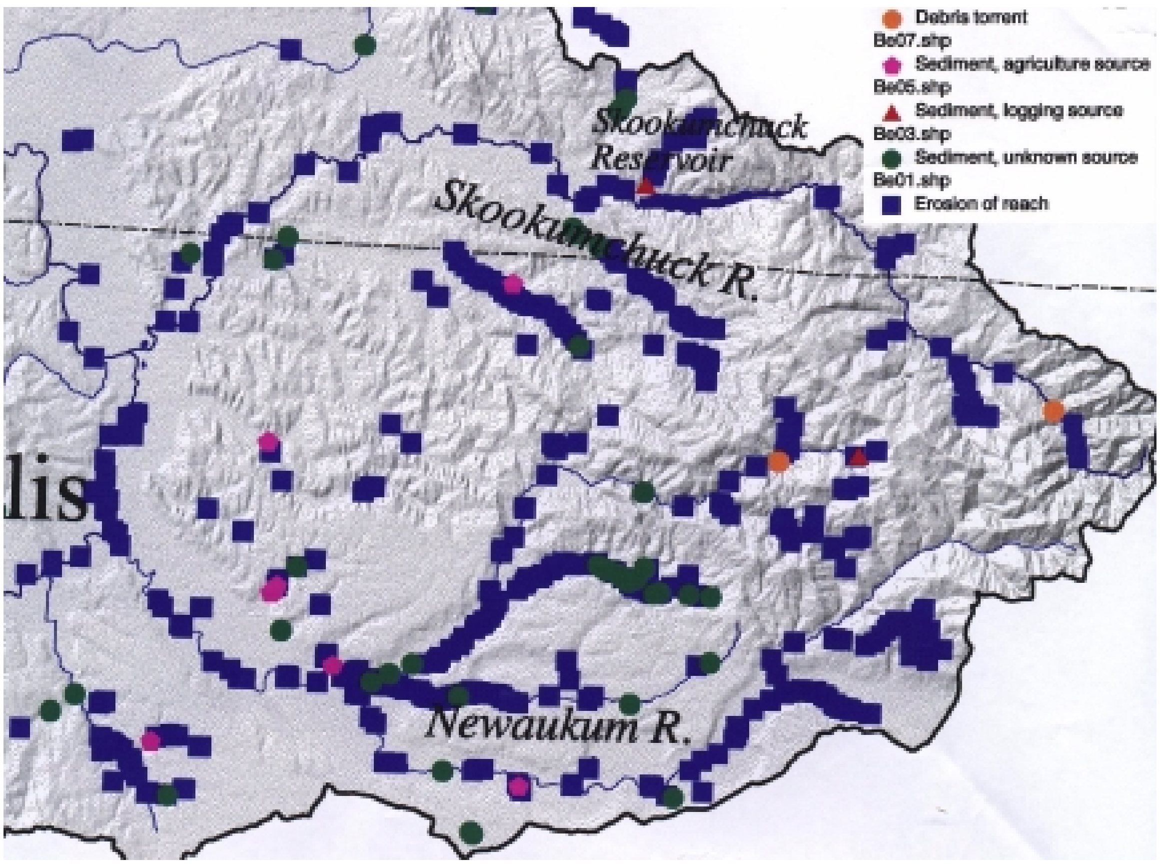


Figure 48. Instream and Streambank Livestock and Vehicle Activity in the Skookumchuck and Newaukum Sub-Basins (Wampler et al. 1993).

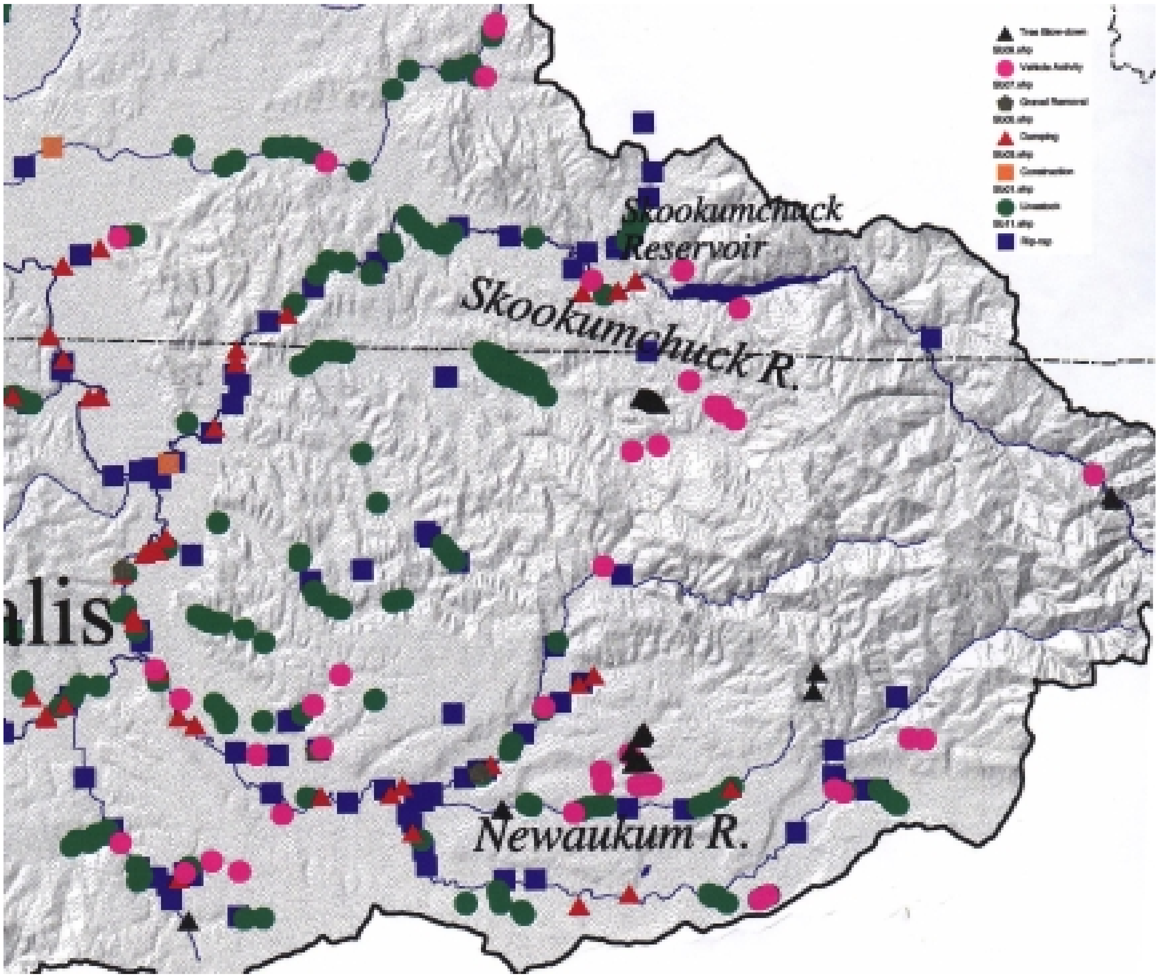


Table 26. LWD and Pool Habitat Conditions in the Upper Skookumchuck Sub-Basin (Weyerhaeuser 1997).

Stream Name	LWD pieces/ channel width	LWD Rating	% Pool Habitat	Pool Habitat Rating
Mainstem Skookumchuck	0-0.7	Naturally Low		
Mainstem Headwaters	1.6	Fair	76	Good
Fall Creek	0.3-0.8	Naturally Low	15 in lower; 20-45 elsewhere	Poor in lower; fair-good elsewhere
Pheeney Creek	0.3	Naturally Low	20	Poor
Laramie Creek	0.6-0.8	Poor	29-38	Poor-Fair
Hospital Creek	0.3	Naturally Low	33	Fair
Eleven Creek	0.4	Poor	30	Fair
Drop Creek	0.5	Poor	15	Poor
Lower Bigwater	0.8	Poor	37	Good
Upper Bigwater	1.0	Fair	43	Good

In addition to very low levels of LWD, dam break floods are another major problem in the upper Skookumchuck watershed. Nineteen dam break floods have been identified from the 1970s to the 1990s (Weyerhaeuser 1997). These originate in the upper watershed, but travel long distances. They are triggered by storm events acting upon the large quantities of fine slash left in the channels. The heavy precipitation results in run-off that builds up behind the slash impoundments, until the slash breaks. The floodwaters then scour channels, remove LWD, destroy the riparian vegetation, and erode valley walls (Coho and Burgess 1993). This results in incised channels containing less gravel and LWD than natural conditions. An estimated 15 miles of channel length has been scoured as the result of dam break floods in the area (Weyerhaeuser 1997) (Figure 49). Specific areas include Drop, Deer, Three Forks, Eleven, Twelve, Bigwater, Range, Fall, and Pheeney Creeks, as well as the mainstem headwaters. These areas are rated "poor" for sediment quantity and channel instability.

Mass wasting (landslides) occurs in the upper Skookumchuck watershed, but it is not as great a problem as in other nearby areas (Weyerhaeuser 1997). Sediment inputs have increased along with timber harvest, but to put it into perspective, the sediment production in the upper Skookumchuck is estimated at 20,000 tons per year compared to 3 million tons per year from the Chehalis Headwaters WAU (Weyerhaeuser 1997). From

1960 to 1993, 105 landslides have been identified in the upper Skookumchuck watershed, with most of the non-natural landslides from roads (25 of the landslides are from sidecast roads, while 8 are from other road activities). Most of the sidecast road problems originate in Bigwater and Drop Creeks, and these two areas rate "poor" for sediment quantity.

Most non-natural surface erosion in the upper Skookumchuck watershed comes from roads. Road densities are high, averaging 5.4 mi/sq. mi watershed, with specific road densities listed in Table 27 (Weyerhaeuser 1997). Roads contribute an estimated 854 tons per year, which is 16% of the total background yield (Weyerhaeuser 1997). An estimated 50% of the road sediment comes from heavy hauls on the 2000 Mainline Road, and watershed analysis prescriptions should greatly reduce that quantity of sediment.

Figure 49. Areas of Fish Habitat Concerns in the Upper Skookumchuck Sub-Basin (Weyerhaeuser 1997).

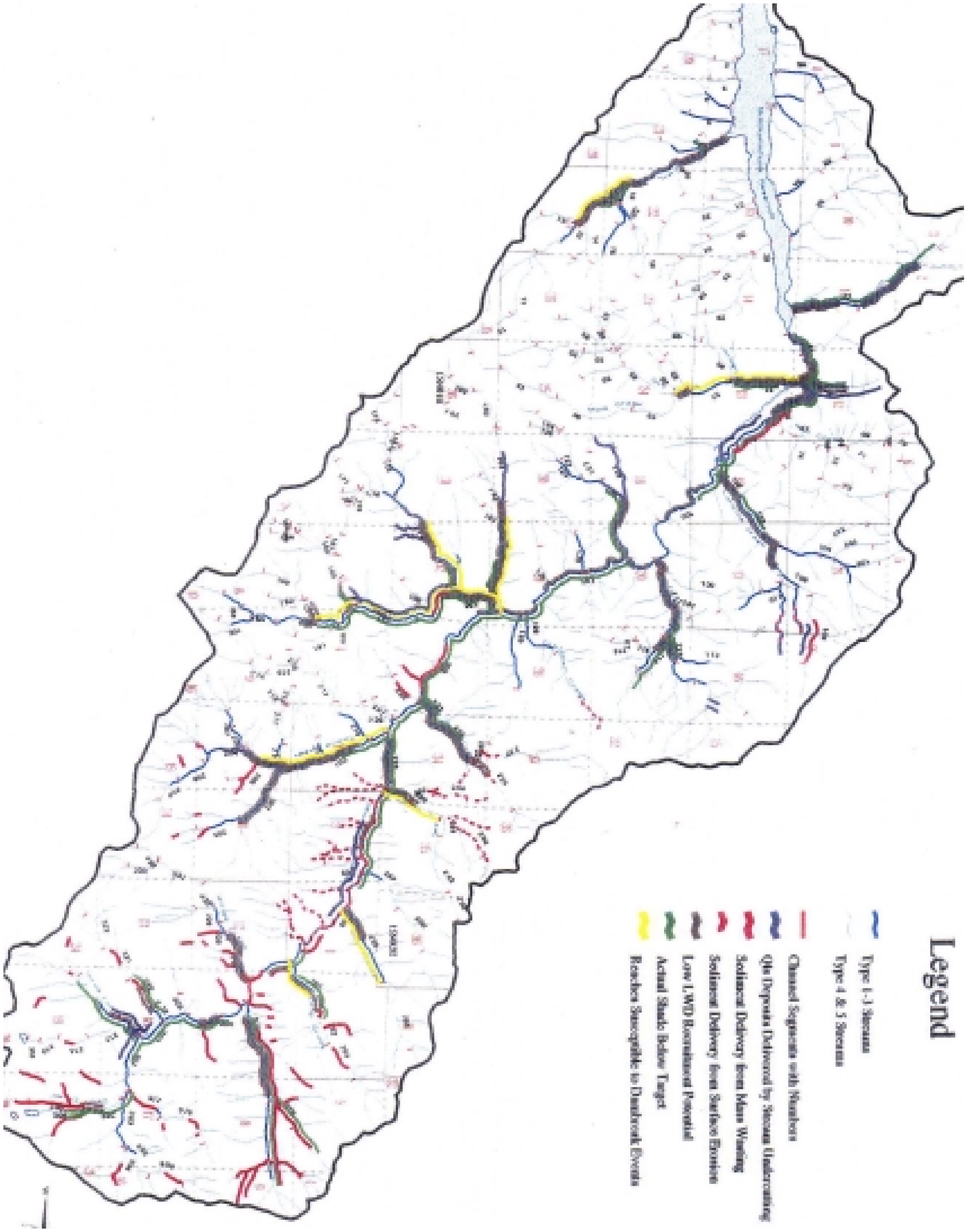


Table 27. Road Densities in the Upper Skookumchuck Sub-Basin (Weyerhaeuser 1997).

Watershed	Road Density (mi./sq. mi.)	Condition Rating
Reservoir	4.8	Poor
Pheeney	5.4	Poor
Hospital	4.8	Poor
Eleven	4.4	Poor
Twelve	5.9	Poor
Drop	5.5	Poor
Skookumchuck Headwaters	6.8	Poor

Channel stability in the upper Skookumchuck sub-basin has been a problem in the past. From 1960 to 1978, channels generally widened in the upper sub-basin. Since 1978, channels narrowed due to riparian regrowth. However, in watersheds impacted by dam break floods, scour and channel widening have been a significant impact, particularly in Pheeney Creek, Fall Creek, Eleven Creek, and Twelve Creek. Other areas noted for scour include the mainstem headwaters, Hospital Creek, and lower Laramie Creek. These streams are rated “poor” for channel stability.

Phinney and Bucknell (1975) described the streambed sediment conditions for China Creek as predominately sand and silt with very little spawning habitat. The lower two miles of China Creek are contained in long culverts and rock and concrete lined channels, which provide no useable streambed habitat for salmonids (SCS 1977). A small population of coho salmon use habitat upstream of this point (Phinney and Bucknell 1975).

Riparian Conditions in the Skookumchuck Sub-Basin

In the lower Skookumchuck sub-basin, riparian impacts were listed as the most wide-spread habitat impact in the sub-basin (Wampler et al. 1993). The locations of impact include the lower mainstem Skookumchuck River, Thompson Creek, Johnson Creek, Salmon Creek, stream 23.0762, stream 23.0799, Hanaford Creek, and especially South Hanaford Creek. These areas are rated “poor” for riparian condition. In the lower sub-basin, agriculture was the greatest reason for riparian degradation, followed by urban/suburban development and logging (Wampler et al. 1993). The poor riparian conditions contribute to high water temperatures, increased bank erosion and instability, and decreased levels of LWD. In the 1970s, riparian vegetation was estimated at 60% deciduous (Phinney and Bucknell field notes 1975), which would be unable to contribute adequate pieces of LWD.

The riparian zone has been significantly altered in the upper Skookumchuck sub-basin. Historically the riparian consisted of mature conifers with some local alder-dominated areas in areas with high water tables or a high disturbance frequency. Currently, the most common type of riparian consists of dense, young deciduous trees, comprising 25% of the stream miles (Weyerhaeuser 1997). Mature conifer trees constitute only about 15% of the stream miles, and most of this is located in plantations. Conifer of all ages border about 30% of the stream miles, with red alder of all ages comprising 41%. Mixed deciduous and conifer account for 26% of the riparian type, while 3% is indeterminate (Weyerhaeuser 1997). Compared to historic levels, the riparian impact is high and the condition rating is frequently “poor”. See Map 4b for the specific locations of riparian ratings.

The reasons for “poor” riparian conditions in the upper Skookumchuck River include riparian harvest, dam break floods, and a mainstem that has high energy peak flows that may naturally limit the ability of conifers to be sustained. Recent riparian harvest has occurred in Fall, Pheeney, Eleven, Twelve, Drop, Three Forks, Deer, Hospital, and Laramie Creeks (Weyerhaeuser 1997).

The poor riparian conditions result in several problems for fish habitat. The lack of shade potentially increases water temperatures (see Water Quality chapter). Also, the lack of conifer in many of the riparian areas reduces the near-term recruitment of LWD. Of the surveyed stream miles, 25% rated low and 55% rated moderate for near-term LWD recruitment, with most of the "low" rated areas in the tributaries (Weyerhaeuser 1997). The long-term recruitment is better due to young conifers. However, there is a recommendation to incorporate conifers into deciduous riparian areas as long as canopy cover (shade) is not compromised.

Pool habitat quantity rated “good” in the mainstem upper Skookumchuck River and in Bigwater Creek, but rated “poor” in Pheeney, lower Fall, Drop, and parts of Laramie Creeks (Weyerhaeuser 1997). The presence of cover (LWD) in pools was rare. Historically, LWD was abundant and aided in the formation of pools, but now, rock is the current primary pool formation structure. Pool information for the lower Skookumchuck River and tributaries, as well as for China Creek was not found, and is a data need.

<u>Water Quality in the Skookumchuck Sub-Basin</u>

The lower Skookumchuck River is on the 1998 303(d) List for water temperature, pH, and fecal coliform (DOE 1999). The listed stream reach is located at 14N, 02W, 07, near the mouth of the Skookumchuck River, and is designated a Class A stream along with Hanaford Creek. This classification is a lower one than for the upper Skookumchuck River. For Class A waters, water temperatures should not exceed 18^{o}C and dissolved oxygen levels should be 8 mg/l or greater, except that the Hanaford Creek recommended dissolved oxygen levels are lower than the State standard (6.5 mg/l or greater compared to the standard of 8mg/l). Also, the mainstem Chehalis River near the mouth of the Skookumchuck River has tested high for levels of ammonia, biochemical oxygen demanding material, and water temperature. The suspected causes of water quality problems are urban stormwater and loss of riparian canopy (Jennings and Pickett 2000). Because of the listing for water temperature and long stretches with livestock access, the mainstem Skookumchuck River is rated “poor” for water quality. Stream 23.0762, South Hanaford Creek, lower Salmon Creek, and lower Johnson Creek are also rated “poor” for water quality, due to the lack of riparian canopy, but water temperatures in these tributaries should be monitored.

Ground water contamination has been identified in the Skookumchuck Valley, and likely causes are failing septic systems, wood waste, solvents, agricultural waste, automotive waste, mining spoils, landfills, and industrial waste (CRC 1992). Septic systems near the Skookumchuck River are problematic because the soils are either too dense or too porous to allow effective filtration (CRC 1992). Very few of the nearby residents are served by municipal sewers.

From 1970 to 1971, water quality problems were identified in Hanaford Creek at seven different stations (Pickett 1992). Six stations documented dissolved oxygen levels below the standard of 8.0 mg/l, and the station at the mouth of South Hanaford Creek recorded levels of dissolved oxygen at 4.0 or less from June to September (Pickett 1992). Warm water temperatures exceeding 18^{o}C were documented at three stations. Other problems included water turbidity and increased iron. Mercury was found in coal piles, but these data have been questioned. In 1991, Hanaford Creek temperatures were elevated above 18 ^{o}C and dissolved oxygen fell to very low levels of less than 6.5 mg/l (Pickett 1994c). Hanaford Creek is rated "poor" for water quality, particularly because of the high temperatures and low dissolved oxygen measurements in the early 1990s. More water quality monitoring is strongly recommended.

The upper reaches of Hanaford Creek are impacted by coal, sand and gravel removal. The Centralia coal mine has a large pit in this area of the creek, and impacts include siltation, leaching from abandoned mine shafts, and ground water contamination from old coal (CRC 1992). Fortunately, the coal has a low sulfur content and the coal washing waters are recirculated to reduce water turbidity problems.

The upper Skookumchuck River is classified as a Class AA stream, which has more restrictive water quality criteria. Water temperatures should not exceed 16^{o}C and dissolved oxygen levels should be 9.5 mg/l or greater. Water temperatures, dissolved oxygen, and pH have not been monitored in the upper Skookumchuck watershed, but an assessment of shade was made in watershed analysis. The lack of adequate shade is a major concern in the upper Skookumchuck watershed. Overall, 66% of the surveyed streams were below target shade, 29% met or exceeded target shade, while 5% were indeterminate (Weyerhaeuser 1997). Much (79%) of the mainstem Skookumchuck River upstream of the dam was below target shade. Other areas of concern include Baumgard, Bigwater, Three Forks, Deer, Deep, Eleven, and Twelve Creeks, and to a lesser extent, Hospital and Laramie Creeks. These areas are rated "poor" for water quality.

Riparian harvest has caused the inadequate shade near Hospital, Bigwater, and parts of Laramie Creeks and along the headwaters of the Skookumchuck River. Dam break floods occurring in the 1970s and 1980s, destroyed riparian zones along Drop Creek, Deer Creek, Three Forks Creek, and in parts of Eleven Creek (Weyerhaeuser 1997).

China Creek receives urban stormwater, and during low flows, the stormwater contains high levels of pollutants (Pickett 1994c). High levels of nitrogen, phosphorus, as well as high turbidity and pH (8.8) was measured in August 1991 (Pickett 1994c). Stormwater controls have been recommended as part of the TMDL for the upper Chehalis River.

Water Quantity in the Skookumchuck Sub-Basin

Low Flows

The Washington Department of Ecology has established Instream flows for the Skookumchuck River (Table 28). Instream flows are developed by examining base flows and fish habitat needs. Base flows are defined as "the flow that comes from ground water feeding to the stream" (DOE 1998). This is the flow that sustains streams in periods without rainwater. Instream flows for the Skookumchuck River have often not been met for an average of 33 days per year as measured near Bucoda (Wildrick et al. 1995). For this reason, the Skookumchuck River and one of its major tributaries, Hanaford Creek, are closed to further consumptive water appropriations, with the exception of domestic stockwatering that has no alternative water supply. Hanaford Creek is closed from May 1 through October 31, while the Skookumchuck River is closed from July 1 through September 30 and includes all tributaries in the contributing drainage from the mouth to the headwaters. For these reasons, water quantity is rated "poor" for the Skookumchuck and Hanaford watersheds.

A major water use is power generation. The Skookumchuck Reservoir stores up to 35,000 acre-feet of water, and is used for power production and to supply water to the steam plant. The City of Centralia is considering using the Skookumchuck River as a potential source of municipal water in the future (CRC 1992). Other significant water uses include irrigation, mining, gravel quarries, and livestock rearing (CRC 1992). Water is diverted for irrigation uses, with surface water rights for 893 acres. The actual water use for irrigation is estimated at 400 acres (CRC 1992). Bucoda has water rights for 11.1 cfs from the Skookumchuck River, but that is currently unused. The Centralia Steam Generating Plant on Hanaford Creek has been permitted to divert up to 54 cfs of water from the Skookumchuck River (Lewis County 1999). Wampler et al. (1993) observed 22 sites with water-pumping equipment instream in the Skookumchuck sub-basin. Most of these were located along the mainstem lower Skookumchuck River, with a few in Hanaford Creek.

Low flows also exist in China Creek. In 1991, the flow was very low or nonexistent except during rainy periods. It is not clear whether the low flows are the result of human-caused impacts or not. Currently, China Creek appears to be predominantly a conduit of urban stormwater in the summer months (Pickett 1994c).

High Flows

Encroachment on the floodplain has reduced the storage capacity and increased flood heights (SCS 1977). Flooding has been a long-term problem for residents in the Skookumchuck and China Creek area, and has prompted the development of the Chehalis River Basin Flood Reduction Project, which is still under development. There have been eight large floods in the last ten years, with a 100 year flood event in 1996 (Lewis County 2000). Many of the alternatives in this plan will likely further degrade fish habitat. Of special concern are the construction of more levees and dams, as well as channelization of the streams and clearing streams of vegetation.

It is likely that past timber harvest has resulted in increased peak flows from the upper Skookumchuck watershed (Weyerhaeuser 1997). Coupled with the past riparian harvest and low levels of instream LWD, scour is a potentially large problem in the upper Skookumchuck River. Historically, the energy of floods and storms was dissipated by LWD. However, the current low levels of LWD along with the decreased ability of the riparian to contribute good future LWD, adds to the concern regarding the effect of high flows.

The upper sub-basin consists of 5% snow zone, 40% rain-on-snow zone, and 55% rain-dominated zone (Weyerhaeuser 1997). The average annual precipitation ranges from 40-90". Current timber harvest levels are not expected to increase peak flows, but historic actions that removed riparian trees and instream LWD will continue to degrade salmonid habitat.

The lowest two miles of China Creek are constricted, and access to historic floodplain has been lost due to urbanization. The constrictions increase water velocity and contributes to flooding problems. China Creek was rated as “poor” for water quantity due to its urbanized floodplain.

Table 28. Established Minimum Base Flows in the Skookumchuck River (Wildrick et al. 1995).

Month	Day	Base Flows (cubic feet/second)
January	All month	160
February	All month	160
March	All month	160
April	All month	160
May	1	160
	15	130
June	1	103
	15	83
July	1	67
	15	54
August	1	43
	15	35
September	1	35
	15	35
October	1	35
	15	35
November	1	59
	15	96
December	All month	160

Biological Processes in the Skookumchuck Sub-Basin

Nutrient cycling is assessed for this report by the attainment of escapement goals, but most salmonid stocks in the Skookumchuck watershed are managed as part of a much larger population. Escapement goals for these stocks include populations that range throughout either WRIA 23 or throughout the entire Chehalis Basin. Because of this, comparison of escapement to an escapement goal is not specific enough to rate a sub-basin. Instead, examination of lost habitat and current stock status is used.

Fall and spring chinook escapement levels have generally remained stable for WRIA 23, but in the Skookumchuck watershed, the dam has reduced their historic range by 3.6 miles for each stock, and this lost production results in less nutrient cycling. Coho salmon escapements in WRIA 23 have declined in the 1990s (John Linth, WDFW, personal communication). In addition, eight miles of their habitat were lost by the dam (Weyerhaeuser 1997), and this lost production results in less nutrient cycling. Winter steelhead have not made escapement goal in recent years, and are classified as "depressed" in SASSI (WDFW and WWTIT 1994). For these reasons, nutrient cycling is likely below historic levels, and is rated “poor”.

Habitat Limiting Factors in the Newaukum, Dillenbaugh, and Salzer Sub-Basins

Loss of Fish Habitat Access in the Newaukum, Dillenbaugh, and Salzer Sub-Basins

Data Sources

Lewis County (Rodney Lakey, Lewis County, personal communication) documented most of the barriers listed in this section. Additional barrier information was obtained from the Salmonid Screening, Habitat Enhancement and Restoration Division of Washington Department of Fish and Wildlife (WDFW), the Washington State Department of Transportation (Johnson et al. 1999), and the Upper North Fork and Upper South Fork Newaukum River WAU watershed analysis (Weyerhaeuser 1998). The culvert assessment by Lewis County has been completed through its first level. In an additional study, they plan to further inventory habitat upstream of barriers, as well as determine the status of "unknown" fish presence culverts. Because analysis of habitat upstream of culverts and impact to fish have not been done, we are unable to fully rate the condition of access issues in this sub-basin.

Blockages in the Newaukum Sub-Basin

Culverts should be field verified for fish passage prior to restoration planning, and those with "unknown fish presence" need further assessment to determine if they impact salmonids or not. Priority order was not assigned. Numerous culverts were identified as potential blockages in the Newaukum sub-basin, and this large quantity should raise concern about the potential impacts on salmonids. For this reason, the additional analysis of culvert impacts in the Newaukum sub-basin should be a high priority data need. The potential blocking culverts are listed in Table 29, and are not assigned priority order.

The diversion dam located at RM 12.5 in the North Fork Newaukum River was built in 1918 to provide water to the cities of Chehalis and Centralia. This dam blocked access for anadromous salmonids until 1970, when a fish ladder was constructed. Two other "pond dams" existed in the past. On the North Fork Newaukum, one dam was 6' high, blocking about 70% of the stream, and lasted from 1880 to 1920 (location S25 T13N R1W). The other was 10' high, a 55% stream blockage, and lasted from 1882 to 1902 (location S17 T13N R1W) (Wendler and Deschamps 1955). No splash dams were documented in the Newaukum sub-basin.

Table 29. Potentially Blocking Culverts in the Newaukum Area Sub-Basins (data from Lewis County, 2000).

Road Name	Watershed	Township, Range, Section	Fish Presence	Notes
Roberts Rd	Newaukum trib.	13N, 01E, 30	Yes	
Forest Napavine Rd	Newaukum trib.	13N, 02W, 25NE	Unknown	
Forest Napavine Rd	Newaukum trib.	13N, 02W, 25NE	Yes	
Forest Napavine Rd	Newaukum trib.	13N, 02W, 25NE	Yes	
Forest Napavine Rd	Newaukum trib.	13N, 02W, 25NE	Yes	
Forest Napavine Rd	Newaukum trib.	13N, 02W, 25NW	Yes	
Kirkland Rd	Newaukum trib	13N, 02W, 24SE	Yes	
Sommerville Rd	Newaukum trib.	13N, 02W, 27NW	Unknown	
Labree Rd	Dillenbaugh Cr.	13N, 02W, 9SE	Yes	Coho
Labree Rd	Dillenbaugh Cr.	13N, 02W, 9SE	Yes	Coho
Newaukum Valley Rd	Newaukum trib.	13N, 02W, 22NE	Yes	
Hewitt Rd.	Newaukum trib.	13N, 01W, 8SE	Yes	
Hewitt Rd.	Newaukum trib.	13N, 01W, 16NW	Yes	
Hewitt Rd.	Newaukum trib.	13N, 01W, 16NW	Unknown	
Taylor Rd	NF Newaukum trib.	13N, 02W, 13SE	Yes	
Pattee Rd	Newaukum trib.	13N, 01W, 6NW	Yes	
Pattee Rd	Newaukum trib.	13N, 01W, 6NW	Yes	
Borovec Rd	Berwick Cr.	13N, 02W, 15NE	Yes	
Borovec Rd	Berwick Cr.	13N, 02W, 15NE	Yes	
Ribelin Rd	Newaukum trib.	13N, 02W, 4SE	Unknown	
Ribelin Rd	Newaukum trib.	13N, 02W, 4SE	Unknown	
Macomber Rd	Newaukum trib.	13N, 02W, 11NE	Unknown	
Macomber Rd	Newaukum trib.	13N, 02W, 2SE	Yes	
Macomber Rd	Newaukum trib.	13N, 02W, 2SE	Yes	
Macomber Rd	Newaukum trib.	13N, 02W, 2SE	Yes	
Macomber Rd	Newaukum trib.	13N, 02W, 2SE	Unknown	Coho
Macomber Rd	Newaukum trib.	13N, 02W, 2SE	Unknown	
Macomber Rd	Newaukum trib.	13N, 02W, 2NE	Yes	
Macomber Rd	Newaukum trib.	13N, 02W, 2NE	Yes	
Macomber Rd	Newaukum trib.	13N, 02W, 2NE	Yes	Coho
Macomber Rd	Newaukum trib.	13N, 02W, 2NE	Yes	Coho
Tune Rd.	Newaukum trib.	13N, 03W, 12NE	Yes	
Logan Hill Rd	Berwick Cr.	13N, 02W, 11SE	Yes	
Logan Hill Rd	Berwick Cr.	13N, 02W, 12NE	Yes	
Logan Hill Rd	Berwick Cr.	13N, 01W, 5NE	Yes	
Logan Hill Rd	Berwick Cr.	13N, 01W, 5NE	Yes	
Logan Hill Rd	Berwick Cr.	13N, 01W, 32SE	Yes	
Logan Hill Rd	Berwick Cr.	13N, 01W, 32NE	Yes	
Vista Rd.	Newaukum trib.	13N, 02W, 19NE	Unknown	
Interstate Ave	Newaukum trib.	13N, 03W, 4NW	Unknown	
Interstate Ave	Newaukum trib.	13N, 02W, 4NW	Unknown	

Road Name	Watershed	Township, Range, Section	Fish Presence	Notes
Shorey Rd.	Newaukum trib.	13N, 02W, 6SE	Yes	
Deggler Rd.	Newaukum trib.	13N, 01E, 30NE	Yes	
Deggler Rd.	Newaukum trib.	13N, 01E, 30NE	Yes	
Deggler Rd.	Newaukum trib.	13N, 01E, 29NE	Unknown	
Maurin Rd.	Newaukum trib.	13N, 02W, 10SE	Unknown	
Maurin Rd.	Newaukum trib.	13N, 02W, 10SE	Unknown	
Clark Rd	Newaukum trib.	13N, 01W, 34SE	Unknown	
Gish Rd	Newaukum trib.	13N, 01W, 34NW	Yes	
Gish Rd	Newaukum trib.	13N, 01W, 35SW	Yes	
Gish Rd	Newaukum trib.	13N, 01W, 36SW	Yes	
Gish Rd	Newaukum trib.	13N, 01W, 31SE	Yes	
Gish Rd	Newaukum trib.	13N, 01W, 31SE	Yes	
Middle Fork Rd	Newaukum trib.	13N, 01W, 20SE	Yes	
Middle Fork Rd	Newaukum trib.		Yes	
Jensen Rd	Newaukum trib.	13N, 01W, 31SW	Unknown	
Valley Meadows Dr	Newaukum trib.	13N, 01W, 30SW	Unknown	
Valley Meadows Dr	Newaukum trib.	13N, 01W, 30SW	Unknown	
Valley Meadows Dr	Newaukum trib.	13N, 01W, 30SW	Unknown	
Valley Meadows Dr	Newaukum trib.	13N, 01W, 30SW	Unknown	
Tauscher Rd	Newaukum trib.	13N, 01W, 28SW	Unknown	
Tauscher Rd	Newaukum trib.	13N, 01W, 28SW	Unknown	
Tauscher Rd	Newaukum trib.	13N, 01W, 16SW	Unknown	
North Fork Rd	NF Newaukum	15N, 01E, 20SW	Yes	
North Fork Rd	NF Newaukum	13N, 01W, 18SE	Unknown	
North Fork Rd	NF Newaukum	13N, 01W, 3SE	Unknown	
North Fork Rd	NF Newaukum	13N, 01W, 35SW	Yes	
North Fork Rd	NF Newaukum	13N, 01W, 35SW	Yes	
North Fork Rd	NF Newaukum	13N, 01W, 24SE	Yes	
North Fork Rd	NF Newaukum	15N, 01E, 19SE	Yes	
Literal Rd	Newaukum trib.	14N, 01W, 26SW	Unknown	
Senn Rd	Jested Cr	13N, 01W, 11SE	Yes	
Lucas Creek Rd	Newaukum trib.	13N, 01W, 2SE	Unknown	
Lucas Creek Rd	Newaukum trib.	13N, 01W, 2NE	Unknown	
Lucas Creek Rd	Newaukum trib.	13N, 01W, 2NE	Unknown	
Lucas Creek Rd	Newaukum trib.	13N, 01W, 36SE	Unknown	
Lucas Creek Rd	Newaukum trib.	13N, 01W, 36SW	Yes	
Lucas Creek Rd	Newaukum trib.	13N, 01W, 36SE	Unknown	
Lucas Creek Rd	Newaukum trib.	13N, 01W, 31SE	Unknown	
Lucas Creek Rd	Newaukum trib.	13N, 01W, 32NW	Unknown	
Lucas Creek Rd	Newaukum trib.	13N, 01W, 2SE	Unknown	
2nd St W	Newaukum trib.	13N, 01W, 30SE	Yes	
Griel Rd	Newaukum trib.	13N, 01E, 15NW	Yes	
Beck Rd	NF Newaukum	13N, 01E, 8SW	Yes	
Beck Rd	NF Newaukum	13N, 01E, 17SE	Yes	
Dluhosh Rd	Newaukum trib.	13N, 02W, 16SE	Yes	

Road Name	Watershed	Township, Range, Section	Fish Presence	Notes
Stubb Rd	Newaukum trib.	13N, 01E, 13NE	Unknown	
Ficket Rd	Newaukum trib.	13N, 01E, 28SW	Unknown	
Berg Rd	Newaukum trib.	13N, 01E, 27SE	Yes	
Pigeon Springs Rd	Newaukum trib.	13N, 01E, 12SW	Unknown	
Pigeon Springs Rd	Newaukum trib.	13N, 01E, 12NE	Unknown	
Short Rd.	Newaukum trib.	13N, 01E, 15NE	Yes	
Hwy 603	Newaukum trib.	13N, 03W, 34NE	Unknown	
Hwy 603	Newaukum trib.	13N, 03W, 3NE	Yes	
Hwy 603	Newaukum trib.	13N, 03W, 4NW	Yes	
Hwy 603	Newaukum trib.	13N, 03W, 21 NW	Yes	
Hwy 603	Newaukum trib.	13N, 03W, 21NW	Yes	
Jackson Hwy	Newaukum trib.	13N, 02W, 33SW	Unknown	
Jackson Hwy	Newaukum trib.	13N, 02W, 33SW	Unknown	
Jackson Hwy	Berwick Cr.	13N, 02W, 10SE	Yes	
Jackson Hwy	Newaukum trib.	13N, 02W, 15SW	Unknown	
Centralia Alpha Rd	Newaukum trib.	14N, 02W, 36NE	Yes	
Centralia Alpha Rd	Newaukum trib.	14N, 02W, 31NW	Unknown	
Centralia Alpha Rd	Newaukum trib.	13N, 01W, 7NW	Yes	
Centralia Alpha Rd	Newaukum trib.	13N, 01W, 7NW	Yes	
Centralia Alpha Rd	Newaukum trib.	13N, 01E, 8	Unknown	
Riverside Rd	Newaukum trib.	13N, 02W, 31NW	Unknown	
Riverside Rd	Newaukum trib.	13N, 02W, 31NW	Unknown	
Rush Rd	Newaukum trib.	15N, 02W, 23SW	Unknown	
Rush Rd	Newaukum trib.	13N, 03W, 23SW	Unknown	
Rush Rd	Newaukum trib.	13N, 03W, 23SW	Unknown	
Rush Rd	Newaukum trib.	13N, 03W, 23SW	Unknown	
Bishop Rd	Newaukum trib.	13N, 02W, 9NE	Yes	
Bishop Rd	Newaukum trib.	13N, 02W, 9NE	Yes	
Bishop Rd	Newaukum trib.	13N, 02W, 10	Yes	
Bishop Rd	Newaukum trib.	13N, 02W, 10SW	Yes	
Centralia Alpha Rd	Newaukum trib.	13N, 01E, 14NW	Unknown	
Leonard Rd	Newaukum trib.	13N, 01E, 32NW	Unknown	
Leonard Rd	Newaukum trib.	13N, 01E, 32NW	Unknown	
Proffitt Rd	Salzer Trib	14N, 02W, 15NW	Unknown	
Proffitt Rd	Salzer Trib	14N, 02W, 15NE	Yes	
Proffitt Rd	Salzer Trib	14N, 02W, 23NW	Yes	
Proffitt Rd	Salzer Trib	14N, 02W, 25NE	Yes	
Salzer Valley Rd	Salzer Trib	14N, 02W, 15NW	Unknown	
Salzer Valley Rd	Salzer Trib	14N, 02W, 15SE	Yes	
Salzer Valley Rd	Salzer Trib	14N, 02W, 23NW	Yes	
Salzer Valley Rd	Salzer Trib	14N, 02W, 23NW	Yes	
Salzer Valley Rd	Salzer Trib	14N, 02W, 13NW	Unknown	
Salzer Valley Rd	Salzer Trib	14N, 02W, 13NW	Yes	
Salzer Valley Rd	Salzer Trib	14N, 02W, 13NW	Yes	
Reinke Rd	Salzer Trib	14N, 02W, 23NE	Unknown	

Road Name	Watershed	Township, Range, Section	Fish Presence	Notes
Reinke Rd	Salzer Trib	14N, 02W, 23NE	Unknown	
Reinke Rd	Salzer Trib	14N, 02W, 24SW	Unknown	
Reinke Rd	Salzer Trib	14N, 02W, 24SE	Yes	
Shafer Rd	Salzer Trib	14N, 02W, 14SE	Yes	
Shafer Rd	Salzer Trib	14N, 02W, 14SE	Yes	
Fair St	Salzer Trib	14N, 02W, 16NW	Yes	
Ramsaur Rd	Salzer Trib	13N, 02W, 14NW	Yes	

Floodplain Impacts in the Newaukum, Dillenbaugh, and Salzer Sub-Basins

Riparian Road Impacts

There are several roads that potentially impact floodplain function and migration by closely paralleling streams, acting as dikes. However, further analysis is needed to assess site-specific topography and floodplain delineation to determine actual impacts. The roads in question include the North Fork Road that closely parallels the North Fork Newaukum River for about eight miles. Lucas Creek Road borders Lucas Creek, a tributary to the North Fork Newaukum, for the lower three miles, which is roughly half the length of the mainstem Lucas Creek, and again follows the creek further upstream. Highway 508 borders the South Fork Newaukum River from about RM 13.8 to RM 19.5, with a few exceptions, and Pigeon Springs Road lies close to the South Fork Newaukum River from RM 27.9 to 30.2. Interstate 5 closely parallels Dillenbaugh Creek, but only for a few short sections.

Rip-Rap/Bank Hardening

Rip-rap is heavily concentrated along the lower South Fork, North Fork, and Middle Fork Newaukum Rivers (Figure 48 in the Skookumchuck section) (Wampler et al. 1993). In the Newaukum sub-basin, a total of 50 observations of bank protection or dumping was documented, encompassing a linear distance of 2,250 feet (Wampler et al. 1993). Bank hardening and loss of side-channels and sloughs were mentioned as significant problems in the Newaukum River (Hiss and Knudsen 1992), the actual extent of which has not quantified. They also noted that Lost Creek, a tributary to the South Fork Newaukum River, has been channelized. Members of the Limiting Factors TAG stated that more bank hardening has occurred in recent years.

Wetlands and Off-Channel Habitat in the Newaukum Sub-Basin

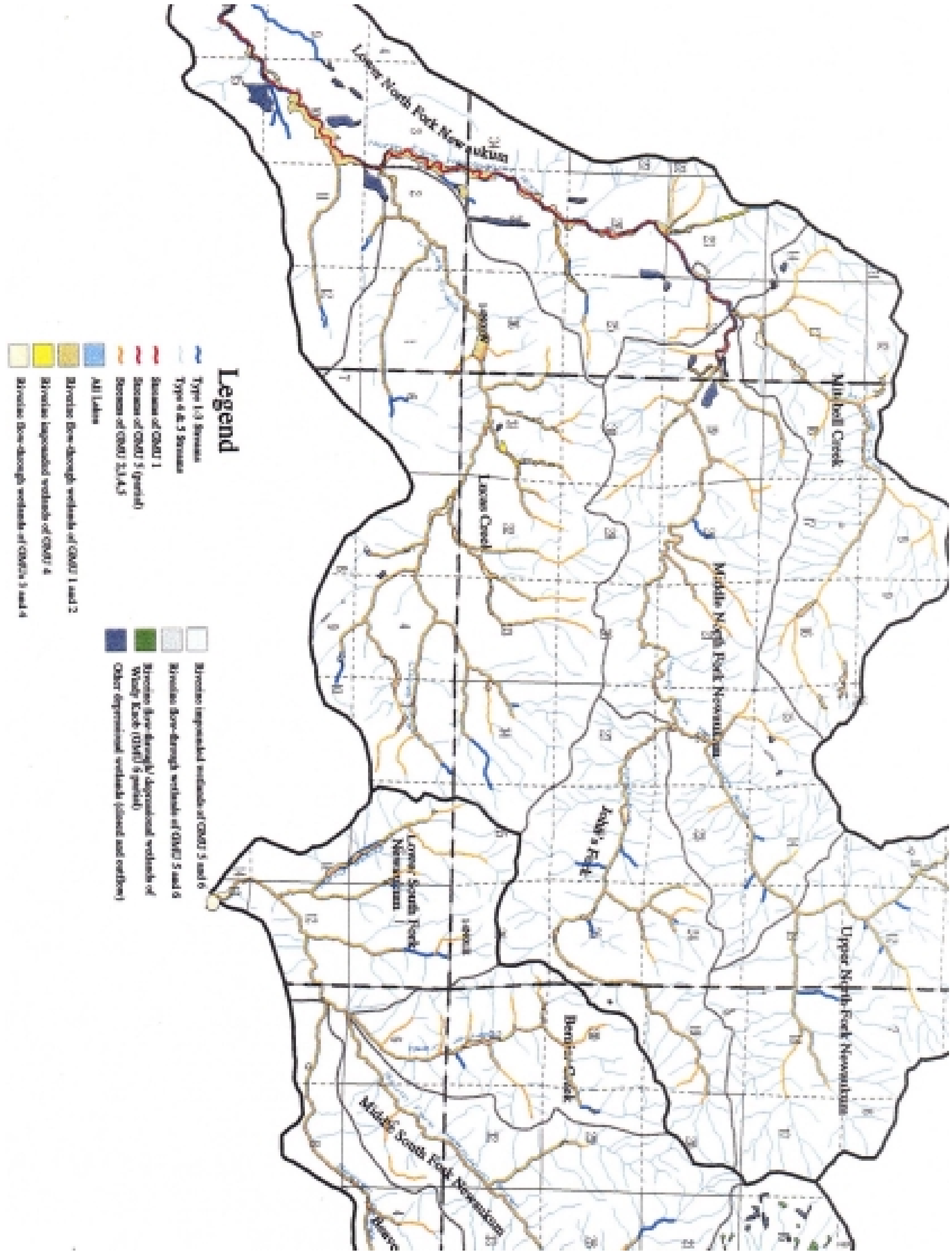
Wetlands are an important component of floodplain function, providing water storage, habitat for fish and wildlife, water temperature buffering, and nutrient contribution. Wetlands are common in the lower reaches of the Newaukum sub-basin, particularly near the lower North Fork Newaukum River (Figure 50) (Weyerhaeuser 1998). Most of the wetlands are directly connected to the streams, and impounded wetlands have been influenced by beaver activity. Weyerhaeuser (1998) suggests that the decline in beaver activity has resulted in a decrease of impounded wetlands in the sub-basin. Also, soil analysis suggests that historically, wetlands were more numerous in the lower reaches, and that some of this habitat has been lost due to draining for agricultural purposes, as well as by filling (Weyerhaeuser 1998).

This loss has not been quantified, but has also been discussed in Clark (1999). She states that the lower region of the Newaukum sub-basin has poorly-developed soils and perched aquifers, which results in a water table that is near the surface. Human population has increased about 60% from 1970 through 1995, and this has necessitated an increase in artificial drainage to accommodate development (Clark 1999). Overall, there has been a considerable but unquantified loss of off-channel habitat, especially in the type of habitat accessible on a 1.5 year frequency interval (TAG, personal communication). The causes for the loss include channel incision and diking. Efforts to restore this type of off-channel habitat in the Newaukum River should be a high priority.

Wetlands and Off-Channel Habitat in the Salzer and Dillenbaugh Sub-Basins

The lower reaches of Salzer Creek have been channelized (Phinney and Bucknell 1975), resulting in a loss of side-channel rearing habitat for salmonids. This is an important loss for coho salmon because the nearby mainstem Chehalis summer rearing habitat is also greatly impaired. A levee to protect the Centralia airport lies within the lower Salzer Creek floodplain, and heavy development has occurred in the lower Salzer watershed (Lewis County 1999). Lower Dillenbaugh Creek flows through marsh habitat (Joy 1988).

Figure 50. Wetlands in the Newaukum Sub-Basin (Weyerhaeuser 1998).



Floodplain Ratings for the Newaukum Sub-Basin

Overall, the South Fork Newaukum River has a heavily impacted floodplain with rip-rap in the lower reaches coupled with roads within the floodplain in the middle and upper reaches. This results in a "poor" rating for floodplain conditions. The North Fork Newaukum River is moderately impacted by the North Fork Road and rip-rap in the lower reaches, and is rated "fair". Lucas Creek is impacted for greater than 50% of its length, and is rated "poor". The mainstem Newaukum River is likely impacted, but because the impact has not been quantified, it is not rated in this report. All other streams are rated "good" for floodplain conditions given the available data. All of these ratings are tentative, pending further analysis of wetland loss, floodplain loss, and a full inventory of dikes and rip-rap. For this reason, each of these ratings is also labeled with a "DG" (data gap), signifying the need for further analysis and the uncertainty of the current rating. Floodplain and impact mapping are recommended to better determine the extent of impact and to lead to identification of restoration projects.

Streambed Sediment Conditions in the Newaukum, Dillenbaugh, and Salzer Sub-Basins

Bank erosion was common in the lower Middle Fork and lower North Fork Newaukum Rivers, with livestock access a major problem (Figure 47 in the Skookumchuck section) (Wampler et al. 1993). Bank erosion was also documented in the mainstem Newaukum River, the South Fork Newaukum River, lower Kearney Creek, Lucas Creek, and Mitchell Creek. Livestock access was noted in the South Fork Newaukum River and vehicle activity was documented in the mainstem Newaukum River, Middle Fork Newaukum River, the middle reaches of the South Fork Newaukum River, and sections of Dillenbaugh Creek and Berwick Creek (Figure 48 in the Skookumchuck section) (Wampler et al. 1993). Overall, Wampler et al. (1993) noted nearly 29 miles of bank erosion within the Newaukum sub-basin, with 11.6 miles of impact from livestock access. All of these activities increase fine sediments into the riverbed, which can suffocate incubating salmonid eggs. Since this inventory of livestock access, fencing projects have decreased the level of livestock access (Bob Amrine, Lewis County Conservation District, personal communication).

Gravel quality was measured in some reaches of the upper South Fork and North Fork Newaukum watersheds. None of the sampled reaches rated "poor" for sediment quality, while 12 out of 15 reaches rated "good", including Lucas Creek, John's Fork Creek, and parts of the North Fork and South Fork Newaukum Rivers (Weyerhaeuser 1998). The lower reaches in the sub-basin were not sampled in that analysis, and these would likely be the most impacted because sediment settles in the lower gradient sections. Also, the lower reaches of the North Fork Newaukum River and Salzer Creek were noted as having high siltation in field notes by Phinney and Bucknell (WDFW files 1975). Due to the information provided by Wampler et al (1993), "poor" ratings for sediment quality are assigned to the lower Middle Fork, lower North Fork, and the mainstem Newaukum River, with the note that better quantification is needed. However, "good" ratings are assigned to Lucas Creek, John's Fork Creek, the upper South Fork Newaukum River (RM 27.8 and upstream), and "good" to "fair" ratings to the upper North Fork Newaukum River and Bernier Creek.

Overall road densities are very high. Road density was greatest in the lower North Fork and mainstem Newaukum watersheds at 6 miles of road/square mile watershed (data from Lunetta et al. 1997). High road densities were also noted in the upper North Fork Newaukum watershed (3.2 miles road/sq. mi watershed), the South Fork Newaukum watershed (3.6 miles road/sq. mi watershed), and the Middle Fork/lower South Fork Newaukum watershed (4.1 miles road/sq. mi watershed). These densities result in "poor" ratings for sediment quantity in those areas. Specific road densities in the upper South and North Fork sub-basins have been estimated by Weyerhaeuser and are listed in Table 30. Using their road density estimates, all of the watersheds listed rate "poor" for road density.

Road problems are a documented source of excess sedimentation in the Newaukum sub-basin. In the upper South and North Fork Newaukum watersheds, 288 shallow landslides were identified; 53% were caused by roads, 28% were associated with young harvest units, and 7% were in mature forest (Weyerhaeuser 1998). Of the road-related impacts, sidecast roads were the most common problem. Other road-related sedimentation problems resulted from stream crossings, cutbank failures, and road drainage. The regions with the greatest road erosion values in the upper sub-basin include Newaukum Lake, the headwaters of the North Fork Newaukum River, and Wendy Knob. Under heavy use conditions, Beaver Creek, Bernier Creek, Lucas Creek, Mitchell Creek, and the middle reaches of the South Fork Newaukum River are also at risk (Weyerhaeuser 1998). The road-related problems on forest land will likely be resolved if the new forest practice regulations are fully implemented.

When total sediment loads were examined for the entire Chehalis Basin, it was found that about 24% comes from the upper WRIA (all waters upstream of Porter) (Pickett 1992). The highest contributors to that portion of sediment include the Newaukum sub-basin, the South Fork Chehalis sub-basin, and the mainstem Chehalis upstream of Doty. Overall, sediment quantity is higher than background in the Newaukum sub-basin, and is rated "poor".

Gravel mining has occurred in the lower North Fork Newaukum River and in the South Fork Newaukum River (Hiss et al. 1982). This activity can increase riverbed instability, contribute to down-cutting, and reduce the quantity of spawning gravels that should recruit downstream to provide spawning habitat. Usually, the gravel size desired by humans is about the same size as preferred by salmon for spawning.

Large woody debris (LWD) is important for spawning gravel retention and habitat complexity. While data for LWD were not available in the mainstem Newaukum River and the lower South Fork Newaukum River, data were available for other regions. Lucas Creek, parts of Bernier Creek and parts of the North Fork and South Fork Newaukum Rivers rate "poor" for quantity of LWD (Weyerhaeuser 1998). However, most of the surveyed areas in the upper sub-basin rate "good" for current instream LWD quantity, including parts of the South Fork and North Fork Newaukum Rivers. John's Fork Creek rates "fair" for LWD. Overall, four segments rate "poor", three segments rate "fair", and eight segments rate "good" for instream LWD quantity (Weyerhaeuser 1998).

Table 30. Road Densities in Watersheds of the Upper South and North Fork Newaukum Rivers (Weyerhaeuser 1998).

Watershed	Road Density (mi/mi^2)	Rating (Conservation Commission)
Beaver Creek	5.28	Poor
Bernier Creek	5.06	Poor
John's Fork	4.05	Poor
Lower North Fork	3.62	Poor
Lower South Fork	4.96	Poor
Lucas Creek	4.78	Poor
Middle North Fork	4.83	Poor
Middle South Fork	5.05	Poor
Mitchell Creek	4.36	Poor
Newaukum Lake	4.61	Poor
Upper North Fork	4.50	Poor
Wendy Knob	5.10	Poor

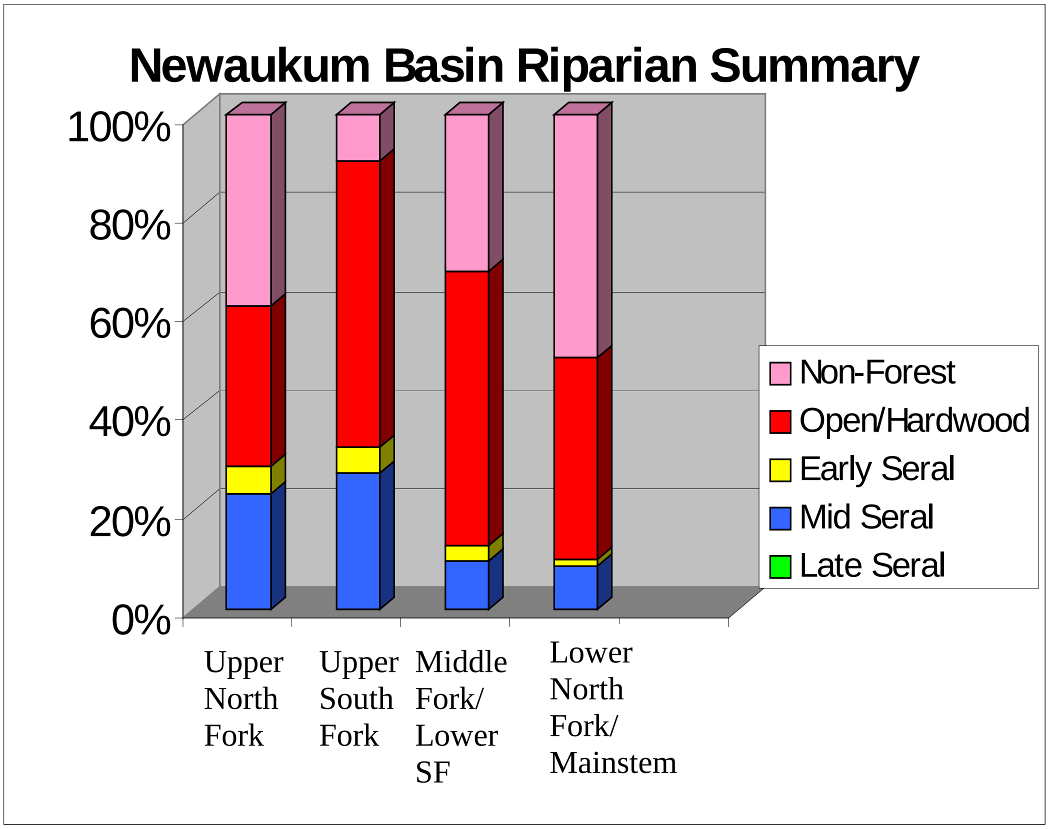
Riparian Conditions in the Newaukum, Dillenbaugh, and Salzer Sub-Basins

By 1959, most of the Newaukum sub-basin had been harvested for timber. A riparian buffer was left along the North Fork Newaukum River, upstream of the water diversion, and along parts of Bernier Creek (Weyerhaeuser 1998). The lower North Fork Newaukum River, the mainstem Newaukum River, and Lucas Creek had non-forest areas of prairies or wetlands and are considered to have areas with a natural low riparian mixed in with areas that have been converted from forest to open riparian.

Overall, the riparian conditions throughout the Newaukum sub-basin are "poor" with the majority of riparian land converted to non-forest uses such as agriculture, as well as conversion of historically conifer riparian to open or hardwood lands (Figure 51) (data from Lunetta et al. 1997). In addition, bank vegetation loss was the largest impact documented in the Newaukum sub-basin by Wampler et al. (1993), with about 43 miles of impact noted.

Specific riparian conditions are shown in Map 4b in the Map Appendix (a separate file on this CD). "Good" riparian buffers are documented along the upper North Fork Newaukum River, parts of the upper South Fork Newaukum River, tributaries to John's Fork Creek, and in sections of tributaries to Lucas Creek (data from Weyerhaeuser 1998). "Poor" riparian conditions exist along the middle of the North Fork Newaukum River, the middle of John's Fork Creek, and along the middle of Mitchell Creek. "Fair" riparian conditions predominate along Lucas Creek, most of John's Fork, Frase, Mitchell, and Beaver Creeks, and along the middle reaches of the South Fork Newaukum River (data from Weyerhaeuser 1998). Although general data regarding riparian conditions are available in the lower reaches, specific location and conditions are not available, and for this reason are not included on the map.

Figure 51. General Riparian Conditions in the Newaukum Sub-Basin (data from Lunetta et al, 1997).



These riparian conditions generally led to a mix of ratings regarding future recruitment of LWD. About 44% of the sampled segments rated "high" for near-term LWD recruitment, 20% rated "moderate" and 33% rated "poor" (Weyerhaeuser 1998). The ratings for long-term LWD recruitment were better with 51% rating "high", 29% rating "moderate", and 6% rating "low" (the remaining segments were indeterminate).

Shade problems exist in the lower North Fork Newaukum River due to land clearing for agriculture and development. Also, given the riparian conditions in the mainstem and lower South Fork Newaukum Rivers, shade is likely a problem there too. Shade problems were also documented in stream 23.0923, which is a tributary to the upper South Fork Newaukum River (Weyerhaeuser 1998). Shade conditions were not examined for the lower South Fork, Middle Fork, and the mainstem Newaukum River watersheds.

Pool habitat rated mostly "fair" for pool frequency (spacing) and "good" for percent of pool habitat (data from Weyerhaeuser 1998). Eleven out of 15 segments rated "good" for percent pool habitat, with only one segment (an unnamed tributary to the South Fork Newaukum River) rating "poor". For pool frequency, 11 out of 15 segments rated "fair", 3 out of 15 rated "poor" and 1 rated "good". The "poor" rated areas include the same unnamed tributary to the South Fork Newaukum River that rated "poor" for percent pool habitat, as well as one segment each in the North Fork and South Fork Newaukum Rivers. More reaches rated lower for cover in pools. Four out of 15 segments rated "poor" for pool cover, 8 out of 15 rated "fair", and 3 out of 15 rated "good" (data from Weyerhaeuser 1998).

Water Quality in the Newaukum, Dillenbaugh, and Salzer Sub-Basins

Water quality problems have been documented in Dillenbaugh Creek, Salzer and Coal Creeks, and in the Newaukum River. The mainstem Newaukum River is on the 303(d) List for elevated water temperatures and fecal coliform (DOE 1999). Water temperatures as warm as 19^{o}C have been recorded in the mainstem Newaukum River (Pickett 1992), and a suspected cause of the elevated temperature is loss of riparian canopy (Jennings and Pickett 2000). Other water quality problems in the sub-basin include warm temperatures and increased turbidity in the North Fork Newaukum River downstream of the diversion dam, as well as high temperatures in the South Fork Newaukum River (Pickett 1992). In addition, concern exists regarding buried barrels of chemicals near LaBree Road between the mainstem Newaukum River and Berwick Creek (Dillenbaugh tributary).

Sections of Dillenbaugh Creek are on the 1998 303(d) List for elevated water temperatures, low dissolved oxygen, and elevated fecal coliform levels (DOE 1999), and the dissolved oxygen problem is now under an EPA-approved TMDL (Jennings and Pickett 2000). Suspected causes for the water quality problems in Dillenbaugh Creek are industrial activity in the Chehalis Industrial Park, woodwaste landfill input, and urban storm water (Pickett 1992). The low dissolved oxygen is attributed to dairy farm waste, while fecal coliform is probably the result of agriculture and failing septic systems. Recently, about 70 nearby land owners connected to a sewer service which should help improve water quality in Dillenbaugh Creek (DOE 1995). Contaminated soils located near a 37 acre wetland that drains into Dillenbaugh Creek have been identified as a Superfund site and have been contained. The soils were contaminated with dioxin, PCP (pentachlorophenol), and other chemicals from the American Crossarm and Conduit Company, which treated wood and discharged wastewater to the environment from the 1930s to 1983. The contaminants in the soils leached into the streams during flood events, but should no longer pose a problem.

Salzer Creek is on the 303(d) List because of warm water temperature and fecal coliform (DOE 1999), but the creek also has water quality problems associated in low dissolved oxygen levels. Salzer and Coal Creeks were monitored for temperature and dissolved oxygen from July 1996 through January 1998 (Lewis County Conservation District, unpublished data). In Salzer Creek, water temperatures warmer than 18^{o}C occurred in July and August, while low levels of dissolved oxygen were recorded from May through October. Near the mouth of Salzer Creek, the warmest water temperature was 21.3^{o}C. During the entire sampling period, 11 out of 19 samples rated "poor", 6 out of 19 rated "fair", and 2 out of 19 rated "good" for water temperature. Water quality problems were also noted upstream. At RM 0.8 (just below the confluence with Coal Creek), the warmest water temperature measured 20.7^{o}C. At RM 1.5, the highest water temperature measurement was 18.9^{o}C and the lowest dissolved oxygen sample was 4.2 mg/l. At RM 2.7, the water temperature was as high as 20.3^{o}C, while the dissolved oxygen levels were as low as 3.4 mg/l. At RM 4.2, the warmest water temperature was 16.8°C and the lowest dissolved oxygen level was 4.2 mg/l (Lewis County Conservation District, unpublished data). All of these measurements rate "poor", using our water quality criteria. Tributaries 23.0873 and 23.0874 also rate "poor" for water quality due to warm water temperatures and low dissolved oxygen levels.

Coal Creek, a tributary to Salzer Creek, also rates "poor" for water quality based upon warm water temperatures and low dissolved oxygen. Out of 19 samples taken near the mouth of Coal Creek, 5 rated "poor", 4 rated "fair", and 10 rated "good" for water temperature (Lewis County Conservation District, unpublished data). The dissolved oxygen samples resulted in 1 out of 19 samples rating "poor", 13 out of 19 rating "fair", and 5 out of 19 rating "good". A few additional water quality exceedances were recorded further upstream in Coal Creek (Lewis County Conservation District, unpublished data), although the proportion of samples that rated "poor" was much lower in Coal Creek than in Salzer Creek.

The low dissolved oxygen levels in Salzer Creek have been attributed to a variety of causes, such as the Centralia landfill and livestock (Pickett 1992). However in 1979, a spill from a food processing plant resulted in low dissolved oxygen levels in Salzer Creek, and in the nearby mainstem of the Chehalis River. Alarms have been installed to reduce the risk of this accident in the future. The warm water temperatures are a result of reduced shade (Jennings and Pickett 2000). The landfill near Salzer Creek has also been listed as a concern for leaching toxics into the environment (Pickett 1992).

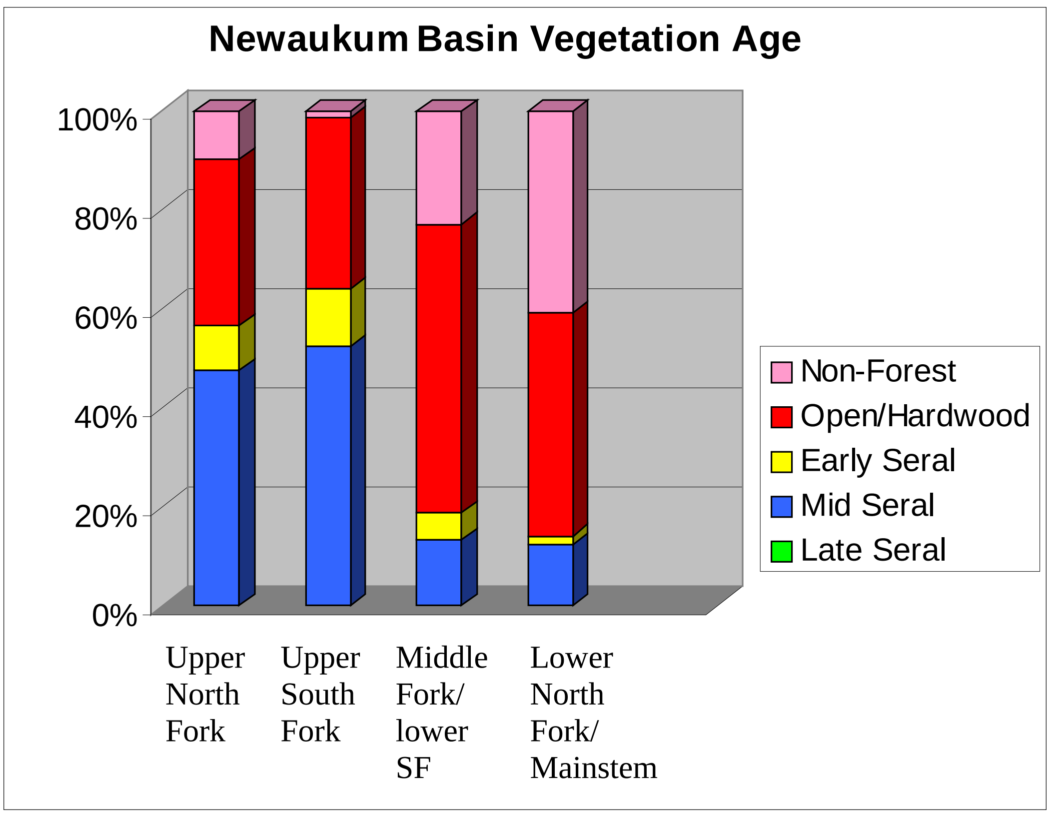
<u>Water Quantity in the Newaukum, Dillenbaugh, and Salzer Sub-Basins</u>

The lower Newaukum River mainstem flow has been gauged for several decades, and has shown a large variation, ranging from 12 cfs (September 1949) to 10,300 cfs (December 1977), with a total average discharge of 504 cfs (CRC 1992). Low flows are a problem within the sub-basin. In the Newaukum sub-basin, base flows have not been met for an average 59 days per year (DOE 1995), contributing to the closure of the following to further appropriations: Newaukum River, Dillenbaugh, Salzer, and Kearney Creeks (South Fork Newaukum tributary), and the Middle Fork Newaukum River (DOE 1998). The lower reaches of the Middle Fork Newaukum River often consist of isolated pools during summer months (Phinney and Bucknell, WDFW field notes 1975).

Many of the withdrawals are for agricultural purposes. Pumping equipment was documented at 28 sites within the sub-basin, and another four sites of suspected withdrawals was recorded (Wampler et al. 1993). About 3,000 acres of agricultural land had surface water rights in the late 1970s. In addition, a water diversion dam was built on the North Fork Newaukum River at RM 12.5 to supply the cities of Centralia and Chehalis. Downstream of the diversion tributary inflow comprised the bulk of the summer flows, resulting in lower flows, warmer water temperatures, and a potential increase in predation on juvenile salmonids (CRC 1992). However, a landslide upstream of the diversion greatly increased water turbidity, which resulted in a reduction of municipal water withdrawals for a number of years. Recently though, the water diversion has been re-activated.

Historically, the majority of land cover consisted of Douglas fir (Fredriksen and Harr 1979). During precipitation events, these types of forests temporarily capture from 24-35% of the rainfall (Dingman 1994). The loss or change of vegetative cover can contribute to an increase in peak flows that results in increased bank erosion and riverbed scour, degrading salmonid habitat. The mainstem Newaukum River/lower North Fork Newaukum River and the Middle Fork/lower South Fork Newaukum River have greatly altered land cover with large percentages of forests lost or converted to hardwoods (Figure 52) (data from Lunetta et al. 1997). These areas rate "poor" for water quantity. Land cover or hydrologic maturity is rated "good" in the upper North Fork and South Fork Newaukum Rivers (Figure 52) (data from Lunetta et al. 1997).

Figure 52. Land cover Conditions in the Newaukum Sub-Basin WAUs (data from Lunetta et al. 1997).



The land cover conditions in the mainstem, lower North Fork, and Middle Fork Newaukum Rivers, Dillenbaugh Creek, and Salzer Creek reflect the conversions of forest to agriculture and urban development in the lower floodplain. In this region, human population has increased about 60% from 1970 through 1995 (Clark 1999). Glacial activity resulted in poorly-developed soils, and these soils combined with a water table that is often near the land surface, has led to artificial draining to accommodate increased human growth (Clark 1999). Urbanization and agricultural tilling has decreased soil conductivity (flow of water through soil) and increased impervious surfaces. Both activities result in increased water transport to streams. Clark (1999) demonstrated both an increase in peak flows and an increase in water volume in the Newaukum River. This is not explained by precipitation patterns. Weyerhaeuser (1998) has also documented an increase in peak flow frequency.

Most of the Newaukum sub-basin does not rate high for flood risk (80% has no floodwater hazards), but 19% of the sub-basin has severe flooding at least once every 3-5 years. Most of the high hazard area is located along the mainstem Newaukum and the lower South Fork Newaukum Rivers (Clark 1999). Examination of flood-event hydrographs indicates that the Newaukum sub-basin has a more "natural" discharge that is more broadly distributed in time compared to the mainstem Chehalis River (Mike McGinnis, Chehalis Indian Tribe, personal communication). This is probably the result of the numerous wetlands in the lower sub-basin coupled with "good" hydrologic maturity conditions in the upper sub-basin. However increased peak flows and water volumes have already been documented, and further loss of wetlands and conversion of forest to other land uses, will increase the risk of flooding that is devastating for both fish and humans.

The upper South Fork and upper North Fork Newaukum Rivers are rated "good" for water quantity, but the Middle Fork Newaukum River, lower South Fork Newaukum River, and lower North Fork Newaukum River are rated "poor". These "poor" rated areas have both high flow and low flow problems, due to water withdrawals, changes in land cover, and likely loss of wetlands (see Floodplain section for wetland discussion).

Lake Habitat in the Newaukum Sub-Basin

Two lakes of significance are located in the Newaukum sub-basin, but neither provides direct support for salmon or steelhead. Newaukum Lake contributes to the headwaters of the South Fork Newaukum River (Phinney and Bucknell 1975). It is located far upstream from the uppermost extent of known salmon and steelhead habitat, but does supply habitat for coastal cutthroat trout, a species that is not included in this report. Carlisle Lake is located near Onalaska on Gheer Creek, a tributary to the South Fork Newaukum River. It is a man-made lake that has been stocked with trout to support local fisheries (CRC 1992). It also serves as rearing habitat for juvenile coho maintained in net pens by the Chehalis Basin Fisheries Task Force in cooperation with local schools.

Biological Processes in the Newaukum, Dillenbaugh, and Salzer Sub-Basins

Nutrient cycling is assessed for this report by the attainment of escapement goals, but all the salmonid stocks in the Newaukum watershed are managed as part of a much larger population. Escapement goals for these stocks include populations that range throughout either WRIA 23 or throughout the entire Chehalis Basin. Because of this, the use of escapement data combined for multiple watersheds results in nutrient cycling estimates that are not specific to the Newaukum watershed. A future data need is to provide escapement information specific to sub-basins, which will not only aid in nutrient cycling monitoring, but also monitoring efforts for other habitat projects and problems.

Fall and spring chinook escapement levels have generally remained stable for WRIA 23 and both are listed as "healthy" in the SASSI report (WDFW and WWTIT 1994). Coho salmon escapements in WRIA 23 have declined in the 1990s (John Linth, WDFW, personal communication). Winter steelhead have not made escapement goal in recent years, and are classified as "depressed" in the SASSI report (WDFW and WWTIT 1994). With half of the stocks within the Newaukum sub-basin classified as currently healthy and half not healthy, nutrient cycling is likely below historic levels and is rated “fair”.

Within the Dillenbaugh and Salzer sub-basins, only coho salmon were documented, and insufficient data exist to determine a trend.

Habitat Limiting Factors in the Scammon, Stearns, Mill, Van Ornum, and Bunker Creek Sub-Basins

Loss of Access in the Scammon, Stearns, Mill, Van Ornum, and Bunker Sub-Basins

Lewis County (Rodney Lakey, Lewis County, personal communication) documented most of the barriers listed in this section. Additional barrier information was obtained from the Salmonid Screening, Habitat Enhancement and Restoration Division of WDFW and the Washington State Department of Transportation (Johnson et al. 1999). The culvert assessment by Lewis County has been completed through its first level. In an additional study, they plan to further inventory habitat upstream of barriers and determine the status of “unknown” fish presence culverts. The lack of adequate fish distribution data in this area also impedes further assessment of impact. Because analysis of habitat upstream of culverts has not been done and fish distribution data are inadequate, we are unable to fully rate the condition of access issues in this sub-basin.

Culverts should be field verified regarding fish passage prior to restoration planning, and those with “unknown fish presence” need further assessment to determine if they impact salmonids or not. Priority order was not assigned. Numerous culverts were identified in the Stearns, Mill, Scammon, and Deep Creek sub-basins, and this large quantity should raise concern about the potential impacts on salmonids. The potential blocking culverts are listed in Table 31, and are not assigned priority order.

Table 31. Potential Fish Habitat-Blocking Culverts in the Stearns, Scammon, Mill, Van Ornum, and Bunker Creek Sub-Basins (data from Rodney Lakey, Lewis County).

Road Name	Watershed	Township, Range, Section	Fish Presence
Graf Rd	Scammon Cr.	14N, 03W, 13SE	Yes
Graf Rd	Scammon Cr.	14N, 03W, 13SW	Yes
Graf Rd	Scammon Cr.	14N, 03W, 13SW	Yes
Graf Rd	Scammon Cr.	14N, 03W, 14SE	Yes
Graf Rd	Scammon Cr.	14N, 03W, 14SE	Yes
Blanchard Rd	Scammon Cr.	14N, 03W, 11SE	Yes
Blanchard Rd	Scammon Cr.	14N, 03W, 11SE	Yes
Blanchard Rd	Scammon Cr.	14N, 03W, 13NW	Yes
Scheuber Rd S		14N, 03W, 13NE	Yes
Scheuber Rd S		14N, 03W, 13SE	Yes
Scheuber Rd S		14N, 03W, 24SE	Yes
Scheuber Rd S		14N, 03W, 25SW	Unknown
Scheuber Rd S		14N, 03W, 2NE	Yes
Scheuber Rd S		14N, 03W, 35SE	Yes
Brown Rd W	Stearns Cr.	13N, 03W, 25NE	Unknown
Brown Rd W	Stearns Cr.	13N, 03W, 25NE	Unknown
Brown Rd W	Stearns Cr.	13N, 03W, 25NW	Yes
Brown Rd W	Stearns Cr.	13N, 03W, 27NW	Yes
Brown Rd W	Stearns Cr.	13N, 03W, 19SE	Yes
Macronovic Rd	Stearns Cr.	13N, 03W, 27SW	Yes
Cousins Rd	Stearns Cr.	13N, 03W, 15NE	Yes
Cousins Rd	Stearns Cr.	13N, 03W, 22NE	Yes
Cousins Rd	Stearns Cr.	13N, 03W, 27SE	Yes
Cousins Rd	Stearns Cr.	13N, 03W, 27SE	Yes
Cousins Rd	Stearns Cr.	13N, 03W, 27SE	Yes
Cousins Rd	Stearns Cr.	13N, 03W, 34NE	Yes
Mohoric Rd	Stearns Cr.	13N, 03W, 26SW	Yes
Penning Rd	Stearns Cr.	13N, 03W, 8NE	Yes
Penning Rd	Stearns Cr.	13N, 03W, 21NE	Yes
Pleasant Hill Rd	Stearns Cr.	13N, 03W, 17SW	Yes
Curtis Hill Rd		13N, 03W, 18SE	Yes
Curtis Hill Rd		13N, 03W, 18SE	Yes
Brockway Rd	Mill Cr.	14N, 03W, 27NE	Yes
Jeffries Rd	Mill Cr.	14N, 03W, 33SW	Yes

Road Name	Watershed	Township, Range, Section	Fish Presence
Jeffries Rd	Mill Cr.	14N, 03W, 28SW	Yes
Jeffries Rd	Mill Cr.	14N, 03W, 28SE	Yes
Jeffries Rd	Mill Cr.	14N, 03W, 28SE	Yes
Chilvers Rd	Mill Cr.	13N, 03W, 34SW	Yes
Chilvers Rd	Mill Cr.	13N, 03W, 33SW	Yes
Kray Rd	Mill Cr.	14N, 03W, 34SE	Yes
Twin Oaks Rd		13N, 03W, 15NE	Yes
Twin Oaks Rd		13N, 03W, 9NE	Unknown
Deep Creek Rd	Deep Cr.	14N, 04W, 25NE	Yes
Deep Creek Rd	Tap Cr.	14N, 04W, 24SE	Yes
Deep Creek Rd	Deep Cr.	14N, 04W, 13NE	Yes
Deep Creek Rd	Tap Cr.	14N, 03W, 18NW	Yes
Bunker Cr Rd	Van Ornum Cr.	14N, 04W, 20NW	Yes
Bunker Cr Rd	Van Ornum Cr.	14N, 04W, 22NW	Yes
Bunker Cr Rd	Unknown	13N, 03W, 9NE	Yes
Bunker Cr Rd	Unknown	13N, 03W, 5NW	Yes
Bunker Cr Rd	Deep Cr.	13N, 03W, 36SE	Yes
Bunker Cr Rd	Unknown	14N, 04W, 36NW	Unknown
Bunker Cr Rd	Deep Cr.	13N, 03W, 26SE	Yes
Bunker Cr Rd	Deep Cr.	13N, 03W, 26SE	Yes
Bunker Cr Rd	Deep Cr.	14N, 04W, 26SE	Yes
Bunker Cr Rd	Deep Cr.	14N, 04W, 23SW	Yes
Bunker Cr Rd	Deep Cr.	14N, 04W, 22NE	Yes
Bunker Cr Rd	Bunker Cr.	14N, 04W, 15SE	Yes
Bunker Cr Rd	Bunker Cr.	14N, 04W, 16NE	Yes
Pleasant Valley Rd	Stearns Cr.	13N, 03W, 14SE	Unknown
Pleasant Valley Rd	Stearns Cr.	13N, 02W, 14NW	Yes
Jordan Rd	Stearns Cr.	13N, 02W, 35SE	Unknown
Jordan Rd	Stearns Cr.	13N, 02W, 35SE	Unknown
Pleasant Valley Rd	Stearns Cr.	12N, 02W, 9NW	Unknown
Pleasant Valley Rd	Stearns Cr.	12N, 02W, 8NE	Yes
Pleasant Valley Rd	Stearns Cr.	12N, 02W, 5NW	Unknown
Pleasant Valley Rd	Stearns Cr.	13N, 02W, 32SW	Unknown
Pleasant Valley Rd	Stearns Cr.	13N, 02W, 30NW	Yes
Pleasant Valley Rd	Stearns Cr.	13N, 02W, 30NW	Yes
Lentz Rd	Stearns Cr.	12N, 02W, 2SW	Unknown
Lentz Rd	Stearns Cr.	12N, 02W, 2SW	Unknown

Road Name	Watershed	Township, Range, Section	Fish Presence
Monroe Rd	Stearns Cr.	14N, 02W, 32NE	Unknown
Raubuck Rd	Stearns Cr.	12N, 02W, 6NE	Yes
Haywire Rd	Stearns Cr.	13N, 02W, 27SE	Yes
Haywire Rd	Stearns Cr.	13N, 02W, 29SE	Yes
Haywire Rd	Stearns Cr.	13N, 02W, 32NW	Yes
Haywire Rd	Stearns Cr.	13N, 02W, 32NW	Yes
Berry Rd	Stearns Cr.	14N, 02W, 9	Yes
Brown Rd E	Stearns Cr.	13N, 02W, 8NE	Yes
Brown Rd E	Stearns Cr.	13N, 02W, 18NE	Yes
Nix Rd	Stearns Cr.	13N, 03W, 12SE	Yes
Graf Rd	Scammon Cr.	14N, 03W, 13NE	Yes
Graf Rd	Scammon Cr.	14N, 03W, 13NE	Yes
Scammon Cr Rd	Scammon Cr.	14N, 03W, 12NE	Yes
Cooks Hill Rd	Scammon Cr.	14N, 03W, 12NE	Yes

Floodplain Conditions in the Scammon, Stearns, Mill, Van Ornum, and Bunker Sub-Basins

Wampler et al. (1993) did not note excessive bank hardening (rip-rap) in this region. Overall, 10 observations of rip-rap were recorded, mostly located in scattered reaches of Stearns Creek as well as in lower Bunker Creek (Figure 57 in the South Fork Chehalis Section). The total impact measured 163' and was given a degradation index rating of 0 (compared to other problems, this impact was not significant) (Wampler et al. 1993). Documentation of floodplain conditions in Scammon Creek was not found.

However, other floodplain problems are considerable. Lower Stearns Creek has been converted into a channelized ditch (Phinney and Bucknell 1975), and this area is rated "poor" for floodplain conditions. Channelization often disconnects the stream from surrounding off-channel and side-channel habitat and allows increased water flows during storms. The increased water velocities can further degrade habitat through scour and removal of habitat components. In addition, Pleasant Valley Road is sporadically located within the floodplain of the middle and upper reaches of Stearns Creek.

According to Wendler and Deschamps (1955), a splash dam was located in Deep Creek, a tributary to Bunker Creek. Splash dams result in extensive loss of gravel and large woody debris (LWD) in the reaches downstream of the dam. This leads to channel incision, where the channel cuts downward and disconnects the stream from its floodplain, reducing side-channel habitat access. No other splash dams were noted in this region. Roads within the floodplain are found along a considerable length of Deep Creek as well as along lower Bunker Creek, but the impact appears to comprise less than 50% of the stream length.

No floodplain rating was given to Scammon or Coal Creeks based upon a lack of data. A "poor" rating was assigned to Stearns Creek due to channelization and the presence of a road within significant sections of the floodplain. "Fair" ratings were given to Deep Creek and to lower Bunker because of floodplain road impacts. "Good" ratings were given to Mill Creek and Van Ornum Creek. These ratings are based upon older information, and floodplain mapping and current impact inventories are greatly needed.

Streambed Sediment Conditions in the Scammon, Stearns, Mill, Van Ornum, and Bunker Sub-Basins

Spawning gravel is naturally limited in Scammon Creek, Coal Creek, and Deep Creek (tributary to Bunker Creek) (Phinney and Bucknell 1975). A fair amount of spawning habitat was noted in Van Ornum Creek, but heavy siltation within that creek degrades the quality of that habitat. Good coho salmon spawning habitat was documented in Nicholson Creek over 25 years ago, but current, specific information is not available. In Stearns Creek, spawning gravel quantity was described as "fair", but degraded in quality by siltation (Phinney and Bucknell 1975). Because this information is old, it was not used to derive a habitat rating. However, it does indicate that sediment problems have occurred historically.

Road density is high throughout these sub-basins, averaging 4.9 mi roads/sq. mi. of watershed in the Scammon and Stearns Creek WAU and 4.4 mi roads/sq. mi. of watershed in the Bunker Creek WAU (Lunetta et al. 1997). This results in a "poor" rating for both areas. In addition, bank erosion was listed as the second highest habitat degradation in Stearns and Bunker Creeks (Wampler et al. 1993). The locations of the bank erosion and sedimentation inputs are concentrated in lower Bunker Creek and in upper Stearns Creek, which rate "poor" for sediment quality (Figure 59 in the South Fork section). Two erosion sites were also noted in Mill Creek, and a total of 12.6 miles within the Stearns sub-basin were recorded with erosion problems (Wampler et al. 1993). Vehicle activity was documented in a few scattered sites, while livestock access impacted about 5.1 miles, mostly in Mill Creek, Deep Creek, and the middle reaches of Stearns and Bunker Creeks (Figure 40 in the Skookumchuck section).

Data are greatly needed to better delineate potential sedimentation problems and LWD conditions within this region. No documentation on LWD was found for this area, but Bunker Creek is believed to have low current levels of instream LWD (Lonnie Crumley, LWC Consulting, personal communication).

Riparian Conditions in the Scammon, Stearns, Mill, Van Ornum, and Bunker Sub-Basins

Overall, riparian conditions are highly degraded in these sub-basins. Data from Lunetta et al. (1997) show that 53% of the riparian areas in Stearns and Scammon Creeks have been converted to either agricultural land or urban development (Figure 53). Another 36% of the riparian in these watersheds consists of deciduous trees, which cannot generally supply adequate large pieces of wood to streams. Large wood aids in channel stability, gravel retention, and pool development. Only about 10.8% of the riparian in this region consist of conifer. The riparian conditions in the Bunker Creek WAU are better, but still rate "poor" for many areas. In the Bunker Creek WAU, 27% of the riparian have been converted to non-forest uses and 47% to hardwoods (Figure 54) (data from Lunetta et al. 1997). About 26% of the riparian zones consist of conifers.

Tree canopy loss (lack of shade) was documented in lower and upper Bunker Creek and attributed to logging (Wampler et al. 1993). Streamside vegetation loss was more extensive and was located throughout most of Stearns Creek and all but the upper reaches of Bunker Creek and Deep Creek (Figure 63 in the South Fork section) (Wampler et al. 1993). The bank vegetation loss extended for about 18 miles total, and was listed as the primary habitat problem in Wampler et al. (1993). This results in "poor" ratings for Stearns, Bunker, and Deep Creeks, with problem reaches shown on Map 4b. The mapping was done on a coarse level, and specific areas slated for restoration or protection projects should be field verified. It is likely that the other streams in this region are also highly degraded, but specific data are lacking.

No data on riparian conditions in Scammon or Coal Creeks were found, and more specific assessments that documented species, age and size of riparian buffers on a reach by reach basis are needed for Stearns, Bunker, Deep, Mill, Van Ornum, and Scammon Creeks.

Figure 53. General Riparian Conditions in Scammon, Stearns and Nearby Sub-Basins (data from Lunetta et al. 1997).

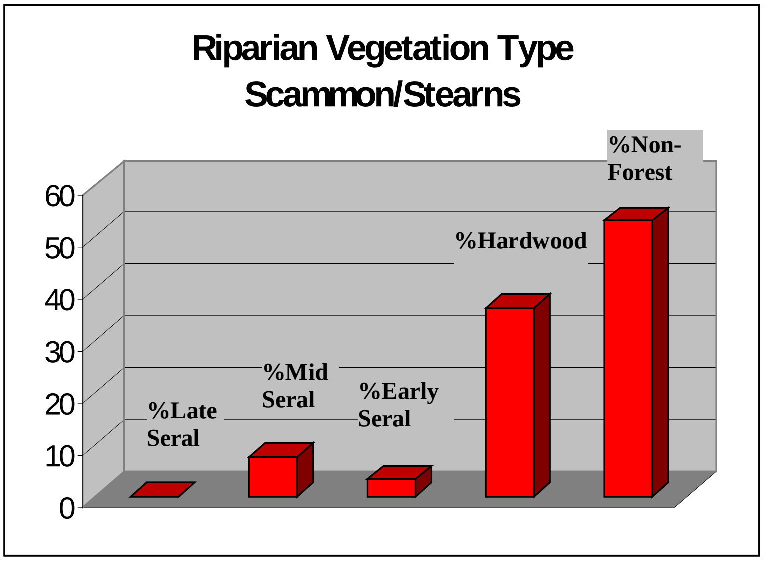
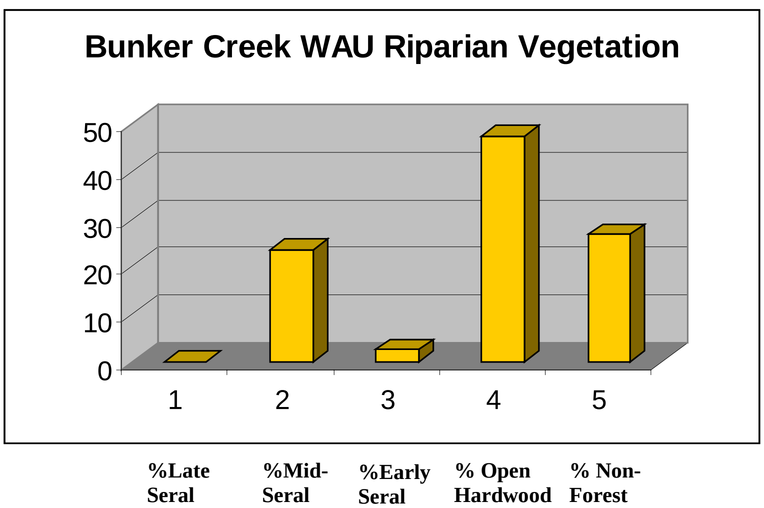


Figure 54. General Riparian Conditions in Bunker Creek and Nearby Sub-Basins (data from Lunetta et al. 1997).



<u>Water Quality in the Scammon, Stearns, Mill, Van Ornum, and Bunker Sub-Basins</u>

Water quality problems are well documented in Stearns and Bunker Creeks. Low dissolved oxygen levels have resulted in the inclusion of both streams on the 1998 303(d) List, and both are currently part of the recently adopted TMDL to resolve the low dissolved oxygen problems (Jennings and Pickett 2000). Livestock access is listed as the probable cause of the low dissolved oxygen levels in Bunker and Stearns Creeks, and failing septic systems is another contributing factor in Bunker Creek. Fecal coliform has been a problem in Bunker Creek, and NH_3 is an impact in both Stearns and Bunker Creeks, a result of livestock access. Low dissolved oxygen levels have also been recorded in Coal Creek. For these reasons, Stearns, Bunker, and Coal Creeks are rated "poor" for water quality.

Specific water quality data were not found for Mill, Deep, Van Ornum, and Scammon Creeks. Some of these streams have degraded riparian areas, and all of them run through agricultural or urban lands, increasing the likelihood of water quality problems. As mentioned in the Streambed/Sediment section, livestock access is significant in this region with 5.1 miles of impacts verified in Mill and Deep Creeks, and the middle reaches of Stearns and Bunker Creeks (Wampler et al. 1993). Even though specific water quality measurements were not found for Mill and Deep Creeks, it is very possible that water quality problems exist. At this time, no rating is given for water quality for these streams, and a data need is to assess summer water temperatures and dissolved oxygen levels.

Water Quantity in the Scammon, Stearns, Mill, Van Ornum, and Bunker Sub-Basins

Low flows have been an identified limiting factor in Phinney and Bucknell (1975) for Stearns, Mill, Van Ornum, Bunker, Deep, and Nicholson Creeks. Because these streams all provide spawning habitat for coho salmon, a species that requires good summer rearing habitat, the limited rearing habitat caused by low flows is a considerable impact. To escape the poor summer rearing conditions in these creeks caused by warm water temperatures and low dissolved oxygen (see the Water Quality section above), the coho salmon must find refuge elsewhere, such as in the mainstem Chehalis River. Unfortunately, the mainstem Chehalis River near this location has water temperature and dissolved oxygen problems that worsen in the summer months, as well. Irrigation has been noted in Mill, Van Ornum, Bunker, Deep, and Stearns Creeks (Phinney and Bucknell 1975). Also, Bunker, Mill, and Stearns Creeks have been closed to further water appropriations because base flows have not been met in the summer months (Pickett 1994).

An increase in peak flows is a likely problem as well. Historically, the majority of land cover consisted of Douglas fir (Fredriksen and Harr 1979). During precipitation events, these types of forests temporarily capture from 24-35% of the rainfall (Dingman 1994). The loss or change of vegetative cover can contribute to an increase in peak flows that results in increased bank erosion and riverbed scour, degrading salmonid habitat. Overall, the land cover has been greatly altered. About 38% of the land cover in the Stearns/Scammon Creek WAU have been converted to non-forest uses such as agriculture and urban development (Lunetta et al. 1997). Another 43% have been converted to deciduous vegetation, leaving only 19% as conifer (Figure 55). In the Bunker Creek WAU, conditions are better, but still rate "poor" with 36% mature conifer, 7% non-forested, 49% deciduous trees or open land, and 9% young conifer (Figure 56) (Lunetta et al. 1997). Because of the converted land cover and the documented low flow problems, Stearns, Mill, Bunker, Deep, and Van Ornum Creeks rate "poor" for water quantity. Recent timber harvest has likely reduced these levels of mature conifer (Lonnie Crumley, LWC Consulting, personal communication).

Figure 55. Land cover Vegetation Type in the Scammon/Stearns WAU (data from Lunetta et al. 1997).

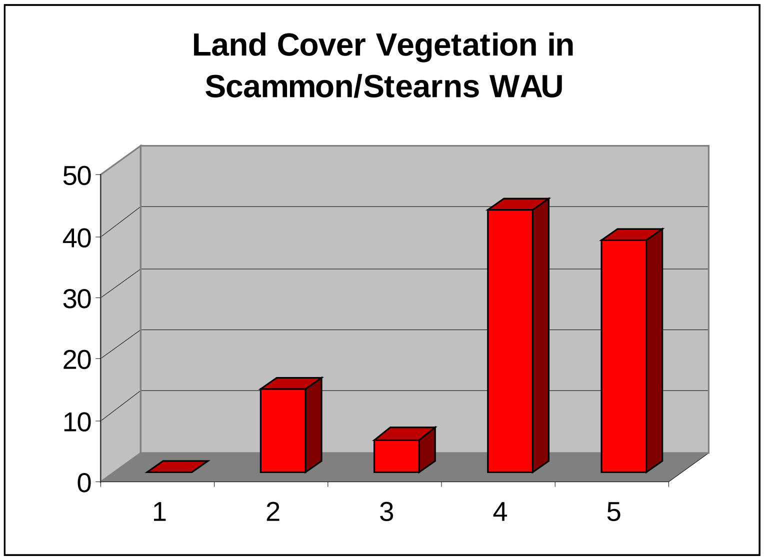
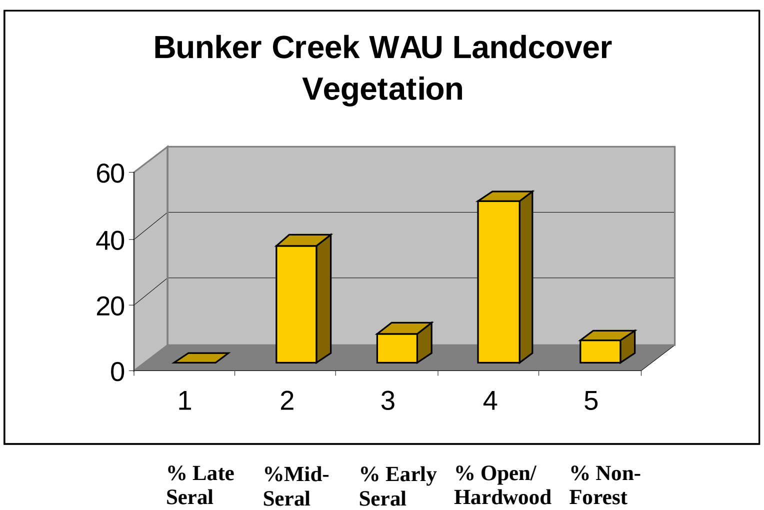


Figure 56. Land cover Vegetation Type in the Bunker Creek WAU (data from Lunetta et al. 1997).



<u>Biological Processes in the Scammon, Stearns, Mill, Van Ornum, and Bunker Sub-Basins</u>

Coho salmon is the most common salmon or steelhead species in these smaller sub-basins. The stock is considered part of a larger population that is found throughout the upper Chehalis Basin, and insufficient data exist to determine whether current levels are adequate or healthy. "Biological processes" (nutrient cycling) are not rated for this area.

Habitat Limiting Factors in the South Fork Chehalis Sub-Basin

Loss of Access in the South Fork Chehalis Sub-Basin

Data Sources

Lewis County (Rodney Lakey, Lewis County, personal communication) documented most of the barriers listed in this section. Additional barrier information was obtained from the Salmonid Screening, Habitat Enhancement and Restoration Division of WDFW, the Washington State Department of Transportation (Johnson et al. 1999), survey data from Lewis County (Forth memo. 1997), the Stillman Creek Watershed Analysis (Weyerhaeuser 1994b), WDFW files located in Montesano, the Instream Culvert Habitat Survey, T. Taylor 1995), and personal communication from the TAG members especially Lonnie Crumley, LWC Consulting.

The culvert assessment by Lewis County has been completed through its first level. In an additional study, they plan to further inventory habitat upstream of barriers and determine the status of "unknown" fish presence culverts. The lack of adequate fish distribution data in this area also impedes further assessment of impact. Because analysis of habitat upstream of culverts has not been done and the extent of blockage and life history stage impacted are yet unknown, we are unable to fully rate the condition of access issues in this sub-basin. The Stillman Creek Watershed Analysis listed a few culverts and logjams as barriers to cutthroat (Weyerhaeuser 1994b). These are not included because we are not addressing cutthroat-issues at this time.

Blockages

Table 32 lists barriers that were identified in the Stillman Creek Watershed Analysis, WDFW files, a Lewis County memo (Forth 1997), and the Washington State Department of Transportation list of barriers (Johnson et al. 1999). These are known barriers to salmon and/or steelhead. Many more potential barriers are listed in Table 33 (Rodney Lakey, Lewis County, personal communication). The culvert assessment by Lewis County has been completed through its first level. The blockages are not in priority order because the quantity and salmonid use of habitat for some of the areas upstream of the blockage has not been clarified. An analysis that includes all salmonid blockages continues to be a data need.

Loss of access to rearing habitat can be a major limiting factor for the South Fork Chehalis sub-basin. The area lacks overwinter rearing habitat during floods, and blockages on tributaries decrease available winter refuge habitat. The blockages also interfere with two other major limiting factors: transport of spawning gravel and large woody debris (LWD).

Table 32. Salmon and Steelhead Blockages in the South Fork Chehalis Drainage.

Stream Name	Township, Range, Section	Road Name	Type of Blockage	Miles of Habitat Blocked	Data Source
Trib. To South Fork Chehalis	12N, 4W, 25	5000J	Culvert	Not Available	WDFW files
Slide Creek	12N, 4W, 20		2 Culverts	Not Available	WDFW files
Slide Creek	12N, 4W, 16		Culvert	Not Available	WDFW files
Trib. To Raccoon Cr.	11N, 4W, 16		Culvert	Not Available	WDFW files
Lost Creek	12N, 4W, 4	Lost Valley Rd.	Culvert[1]	Not Available	Forth 1997
Trib. To South Fork Chehalis River	12N, 3W, 30	Wildwood Rd.	Culvert[1]	Not Available	Forth 1997

[1] This culvert is slated for replacement or repair in the near future. Please check with data source prior to restoration planning.

Table 33. Potential Fish Habitat-Blocking Culverts in the South Fork Chehalis Sub-Basin (Rodney Lakey, Lewis County).

Road Name	Watershed	Township, Range, Section	Fish Presence	Notes
Curtis Hill Rd	Lake Cr.	13N, 03W, 30NW	Yes	coho
King Rd	Lake Cr.	12N, 03W, 9SW	Yes	Coho
King Rd	Lake Cr.	12N, 03W, 8NE	Yes	Coho
King Rd	Lake Cr.	12N, 03W, 5NW	Yes	
King Rd	Lake Cr.	12N, 03W, 26SW	Yes	Coho
King Rd	Lake Cr.	13N, 03W, 32SW	Unknown	
King Rd	Lake Cr.	13N, 03W, 31NE	Yes	Coho
King Rd	Lake Cr.	13N, 03W, 31NE	Yes	Coho
King Rd	Lake Cr.	13N, 03W, 31NE	Yes	Coho
Pe Ell McDonald Rd	WF Stillman Cr.	12N, 04, 5SW	Yes	Coho
Pe Ell McDonald Rd	WF Stillman Cr.	13N, 05, 35NW	Yes	
Pe Ell McDonald Rd	WF Stillman Cr.	13N, 05, 35NE	Unknown	
Pe Ell McDonald Rd	Slide Cr.	13N, 05, 36SW	Yes	
Pe Ell McDonald Rd	Keller Cr.	12N, 04, 5SE	Yes	
Pe Ell McDonald Rd	Keller Cr.	12N, 04, 5SE	Yes	
Pe Ell McDonald Rd	Halfway Cr.	12N, 04, 5SE	Yes	
Pe Ell McDonald Rd	Halfway Cr.	13N, 04, 31SE	Yes	
Pe Ell McDonald Rd	Halfway Cr.	12N, 04, 5NW	Yes	
Pe Ell McDonald Rd	Halfway Cr.	12N, 04, 5SW	Yes	
Pe Ell McDonald Rd	Halfway Cr.	12N, 04, 5SW	Yes	
Pe Ell	Stillman Cr.	12, 04, 8NW	Yes	

Road Name	Watershed	Township, Range, Section	Fish Presence	Notes
McDonald Rd	Trib.			
Pe Ell McDonald Rd	Stillman Cr Trib	12N, 05, 15NE	Unknown	
Pe Ell McDonald Rd	Stillman Cr. Trib.	12N, 04, 13SE	Yes	
Lake Cr Rd	Lake Cr.	13N, 03W, 30NW	Yes	
Lake Cr Rd	Lake Cr.	13N, 03W, 30SE	Unknown	
Lake Cr Rd	Lake Cr.	13N, 03W, 27SE	Yes	Coho
Lost Valley Rd	South Fork Chehalis Trib.	12N, 04W, 11NW	Yes	
Lost Valley Rd	Lost Cr.	12N, 04W, 2SW	Yes	
Lost Valley Rd	Lost Cr.	12N, 04W, 10SE	Yes	
Lost Valley Rd	Lost Cr.	12N, 04W, 3SW	Yes	
Lost Valley Rd	Lost Cr.	12N, 03W, 3SW	Yes	
Roundtree Rd	South Fork Chehalis trib.	12N, 04W, 2NE	Yes	
Wendling Rd	Lost Cr.	13N, 04W, 33SE	Yes	
Wendling Rd	Lost Cr.	13N, 04W, 33SE	Yes	
Wendling Rd	Lost Cr.	13N, 04W, 33SE	Yes	
Radmaker Rd	Lost Cr.	13N, 04W, 33SW	Yes	
Kahout Rd	SF Chehalis trib	12N, 04W, 1SW	Yes	
Burri Rd	Lake Cr.	12N, 03W, 8NW	Yes	
Moon Hill Rd	SF Chehalis Trib	13N, 04W, 25NE	Unknown	
Moon Hill Rd	SF Chehalis Trib	13N, 04W, 25NE	Unknown	
Black Rd	SF Chehalis Trib	13N, 04W, 25NW	Unknown	
Black Rd	SF Chehalis Trib	13N, 04W, 25NW	Unknown	
Beaver Creek Rd	SF Chehalis Trib	13N, 04W, 36NW	Yes	
Wildwood Rd	SF Chehalis Trib	11N, 03W, 29NE	Unknown	
Wildwood Rd	Black Cr.	11N, 03W, 29NE	Unknown	
Wildwood Rd	Black Cr.	11N, 03W, 29NE	Unknown	
Wildwood Rd	Black Cr.	11N, 03W, 20SE	Unknown	

Road Name	Watershed	Township, Range, Section	Fish Presence	Notes
Wildwood Rd	Black Cr.	11N, 03W, 20NE	Unknown	
Wildwood Rd	Black Cr.	11N, 03W, 20NE	Unknown	
Wildwood Rd	Laughlin Cr.	11N, 03W, 8SE	Unknown	
Wildwood Rd	SF Chehalis Trib	11N, 03W, 6NE	Unknown	
Wildwood Rd	Sears Cr.	11N, 03W, 6NE	Unknown	
Wildwood Rd	SF Chehalis Trib	12N, 03W, 31SE	Unknown	
Wildwood Rd	Paint Hill Cr.	12N, 03W, 31SE	Unknown	
Wildwood Rd	Bullpen Cr.	12N, 03W, 31NE	Yes	
Wildwood Rd	Lentz Cr.	12N, 03W, 30SE	Yes	
Boistfort Rd	SF Chehalis Trib	13N, 04W, 24NW	Unknown	
Boistfort Rd	SF Chehalis Trib	13N, 04W, 30SW	Unknown	
Boistfort Rd	SF Chehalis Trib	13N, 04W, 36NE	Unknown	
Boistfort Rd	SF Chehalis Trib	12N, 04W, 1NW	Unknown	
Boistfort Rd	Lake Cr.	12N, 04W, 1NW	Unknown	
Boistfort Rd	SF Chehalis Trib	12N, 04W, 13NW	Unknown	
Boistfort Rd	SF Chehalis Trib	12N, 04W, 13NW	Unknown	

Floodplain Conditions in the South Fork Chehalis Sub-Basin

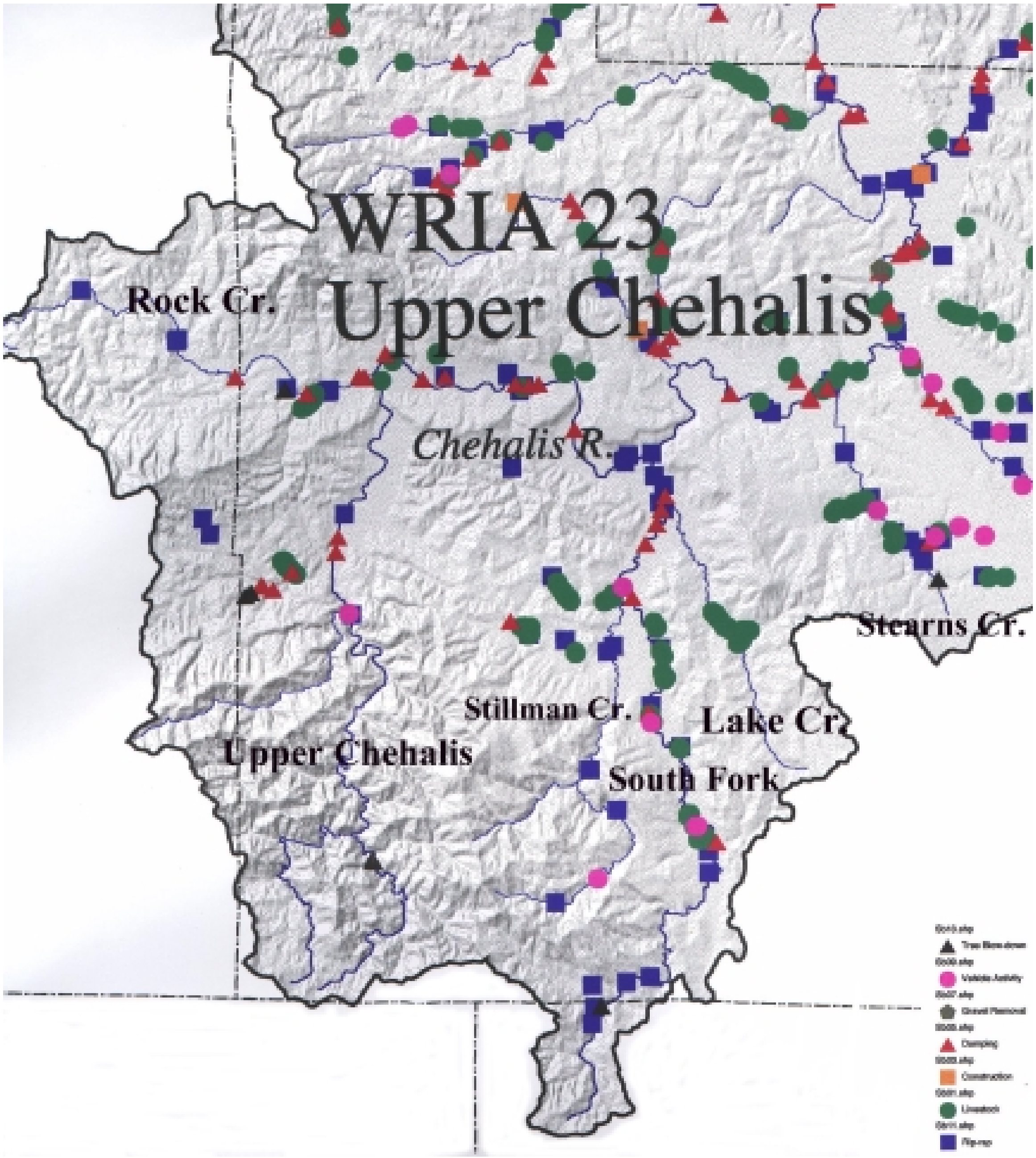
Wampler et al (1993) documented 33 sites within the South Fork Chehalis sub-basin where stream banks are supported with rip-rap. These are mapped in Figure 57, and locations are scattered in the lower South Fork mainstem, the upper South Fork mainstem, and a few sites in Stillman Creek and the middle mainstem South Fork Chehalis River. No rip-rap was noted in Lake Creek. The rip-rap reduces the development of side-channels, which provide important rearing habitat that is already limited in the area. Bank hardening also contributes to scour, impacting incubation survival of all salmonid species in the area. Wampler et al (1993) also searched for evidence of channelization, and none was noted in this sub-basin.

The lower mainstem Stillman Creek has shown a decrease in sinuosity (Sullivan and Massong 1994). This area has a well-developed floodplain, while the southern portion of Stillman Creek has steeper gradients and is damaged by debris torrents. Where the southern mainstem has low gradients, the channel is confined, and side-channels are limited. The channel in lower Lost Creek has incised, and because this area has been shown to be important winter rearing habitat for coho, channel incision decreases valuable habitat.

Rating of Floodplain Problems in the South Fork Chehalis Sub-Basin

The mainstem South Fork Chehalis River rates “fair” for floodplain conditions due to the numerous rip-rap sites throughout. Lake Creek rates “good”, while Stillman Creek rates “fair”. The Stillman Creek rating is based upon side-channel loses and the channel incision in Lost Creek, which is important winter refuge habitat for coho salmon. However, all of these ratings have considerable uncertainty because a thorough inventory of floodplain conditions has not been done in this area.

Figure 57. Rip-Rap Sites in the South Fork and Upper Chehalis Sub-Basins (Wampler et al. 1993).



Streambed and Sediment Conditions in the South Fork Chehalis Sub-Basin

Sediment Conditions in the Stillman Creek Watershed

The northern third of the Stillman Creek watershed consists of soft sedimentary rock that decomposes quickly to fines, creating naturally low spawning habitat in those tributaries (Laprade and Wilson 1994). The southern two thirds of the watershed consists of hard volcanic rock, which creates good spawning gravels. Because of the natural geology, spawning habitat is considered to be abundant in scattered locations, and low in others. The best spawning locations are the lower mainstem, lower Slide Creek, lower Keller Creek, and lower Halfway Creek (just downstream of Slide and Keller). The upper Stillman watershed (upstream of Raccoon Creek) has abundant spawning habitat as well, and is used by steelhead and coho. The southern area may supply good spawning gravels, but has little storage capacity (Sullivan and Massong 1994). Sediment is transported from the southern watershed to Halfway Creek and the mainstem Stillman.

Future gravel availability depends not only on an adequate source, but also on sufficient levels of LWD to store the gravel. Current levels of LWD are low, and this is a major problem for anadromous salmonid production in Stillman Creek (Hawe and Fulton 1994). In-channel LWD was rated as "below target" for 140 out of 143 sampled sites (Hawe and Fulton 1994). The three sites that met or exceeded target levels consisted of large stacked jams in the lower mainstem Stillman Creek.

Landslides are another major problem, creating debris torrents (large quantities of material such as mud and trees are carried into the stream by a landslide) and dam-break floods. Debris torrents and dam-break floods have scoured channels and removed LWD, particularly in the West Fork Stillman Creek, Slide Creek, and the upper mainstem Stillman Creek (Laprade and Wilson 1994). The risk of scour was listed as high in the upper Stillman watershed. This would mostly impact coho incubation survival, and is due partially to the confined channel, as well as to landslides. The risk to chinook redds is lower because they spawn in the lower reaches where confinement is less and the geology is more stable (Laprade and Wilson 1994). The scour risk to steelhead nests is low due to the spawn timing. About 194 landslides have been identified (Figure 58) (Laprade and Wilson 1994). Of these, 69% are shallow, rapid landslides, 21% debris torrents, and 7% deep-seated slumps. Most of the shallow rapid landslides are associated with roads, especially failures of sidecast roads (an old technique where spoils were not hauled away, but left uncompacted near the road) on steep slopes in winter storms (Laprade and Wilson 1994).

Figure 58. Landslides in the Stillman Creek Watershed (Laprade and Wilson 1994).

In most areas of the Stillman watershed, fine sediment (<0.85 mm) levels were generally low to moderate (2.5%-15.3%) (Hadley 1994). One sample in the upper Stillman contained 36% fines, an extremely high level that was probably due to the presence of a debris jam that once existed downstream of the sampling site. Overall sediment input from roads and hillslope erosion isn't large, but some road segments are problematic, such as roads in the lower Stillman, Lost Valley, and Halfway Creek watersheds. Most of the impacting roads are mainline roads close to streams, for example, the 4000 Road next to Slide Creek (Raines 1994). Overall road density is very high in the Stillman Creek WAU, at 4.5 miles of road/sq. mi. watershed (Lunetta et al. 1997).

Channel changes over time include an overall decrease in sinuosity in the lower mainstem, and channel incision in lower Lost Creek (Sullivan and Massong 1994). The channel incision contributes to a high percentage of fine sediments. The West Fork Stillman Creek has had a series of debris flows and dam-break floods, resulting in large channel disturbances, such as scour to bedrock and loss of LWD (Sullivan and Massong 1994).

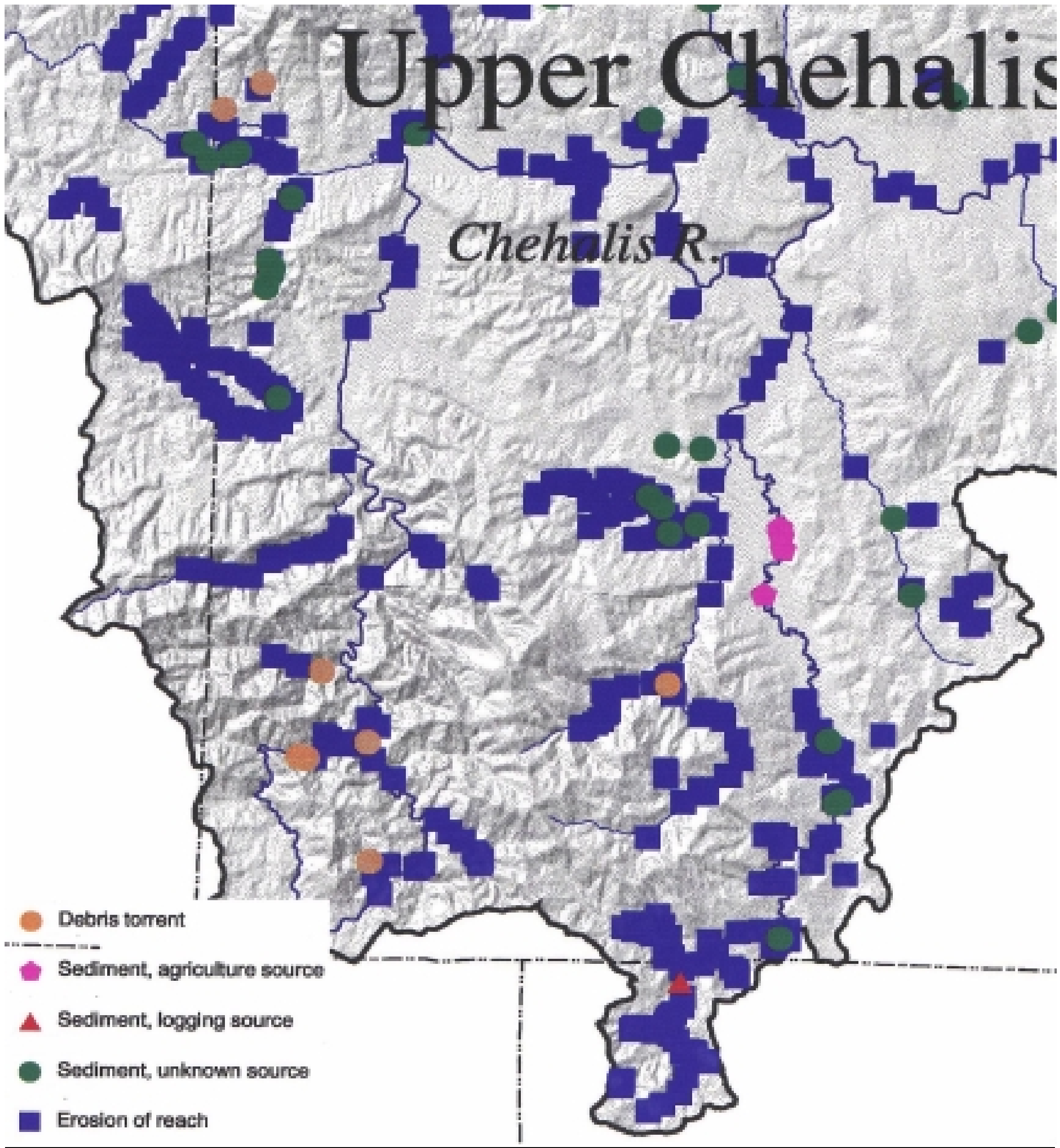
Lost Creek is particularly important for winter rearing for coho, probably because of its low gradient, numerous side-channels, and the ability for high flows to go readily over its banks (Sullivan and Massong 1994).

Sediment Conditions in the South Fork Chehalis Watershed

Data from the South Fork Chehalis watershed were not as detailed due to a lack of watershed analysis. However, Wampler et al. (1993) documented many sites of erosion throughout the watershed, especially in the mid- to upper reaches (Figure 59). The total impact measured 55.9 stream miles. A few sites of bank erosion in the middle reaches were attributed to agriculture, but these impacts are minimal compared to the erosion further upstream. In addition, the South Fork Chehalis WAU has a high road density (3.7 miles of roads/sq. mi. watershed) (Lunetta et al. 1997). Because high road densities are related to sediment delivery to streams, this results in a "poor" rating for sediment quantity, and this rating is supported by the excessive miles of bank erosion impacts.

Another major problem in the lower 10 miles of the South Fork Chehalis mainstem is the lack of LWD (Bob Amrine, Lewis County Conservation District, personal communication) (Map 5b).

Figure 59. South Fork Chehalis and Upper Chehalis Stream Bank Erosion Sites (Wampler et al. 1993).



Sediment Conditions in the Lake Creek Watershed

No debris torrent sites were noted in this watershed, and nine sites of bank erosion were recorded (Wampler et al. 1993). However, the WAU that includes Lake Creek has a high road density (4.2 miles of roads/sq. mi. watershed) (Lunetta et al. 1997). Because high road densities are related to sediment delivery to streams, this results in a "poor" rating for sediment quantity. One of the greatest problems in Lake Creek is the lack of LWD. This is a pervasive problem throughout the lower reaches (Bob Amrine, Lewis County Conservation District, personal communication) (Map 5b). The quantity of LWD in Beaver Creek, a Lake Creek tributary, is believed to be "fair" based upon our criteria (see Assessment Chapter for criteria).

Rating of Sediment and Streambed Conditions in the South Fork Chehalis Sub-Basin

All regions of the sub-basin rate "poor" for the amount of instream LWD, where levels of LWD are known. In addition, Stillman Creek and the South Fork Chehalis mainstem rate "poor" for channel stability, while Lake Creek rates "good" for stability. The rating is the result of documented erosion, debris torrents, and channel changes. Stillman Creek rates "fair" for spawning gravel quality because of moderate levels of fines, and rates "poor" for sediment quantity due to the high level of landslides and the low levels of gravels in the southern part of the watershed. Increased levels of LWD would aid in the retention of spawning gravels. The other areas of the sub-basin did not have documentation for spawning gravel quantity and quality conditions, and this is a data need, but the South Fork Chehalis WAU and the Curtis WAU (Lake Creek) have high road densities, which results in a "poor" rating for sediment quantity.

<u>Riparian Conditions in the South Fork Chehalis Sub-Basin</u>

Riparian Conditions in the South Fork Chehalis Watershed

Wampler et al. (1993) documented an extensive loss of riparian vegetation throughout the lower and middle reaches of the South Fork Chehalis River mainstem (Figure 60) (Map 4b). There was also a loss of tree canopy due to logging in the upper watershed and a lessor amount of loss in a few of the middle reaches. Black Creek was noted as having an extensive loss of tree canopy due to agriculture, and the lower few miles of Lake Creek has "poor" riparian conditions (Map 4b). Barney Creek, a tributary to Lake Creek has "fair" riparian conditions in the lower reaches and "good" riparian areas in the upper reaches (Bob Amrine, Lewis County Conservation District, personal communication) (Map 4b). Overall, the South Fork Chehalis River sub-basin has 14.4 stream miles of impaired riparian due to agriculture, 19.2 miles impacted by logging, and 2.1 by unknown causes (Wampler et al. 1993). The South Fork Chehalis WAU consists of 38% open or deciduous riparian and 33.6% non-forest (agriculture/urban), resulting in 71.6% of the riparian buffers rating "poor" (data from Lunetta et al. 1997).

Riparian Conditions in the Stillman Creek Watershed

Most riparian areas along salmon producing streams in the Stillman Creek watershed are dominated by red alder due to logging, agriculture clearing, and forest fires (Hawe and

Fulton 1994). Overall, 66.3% of the Stillman Creek riparian areas are rated "poor", consisting of either open, hardwood-dominated, or non-forest land (agriculture/urban) (data from Lunetta et al. 1997). Red alder and other deciduous trees cannot supply adequate LWD. Large woody debris is an important roughness component given the lack of boulders in the basin, and unfortunately, LWD is lacking throughout the watershed. The lack of LWD contributes to poor pool spacing and depth, and is one of the major problems for anadromous salmonid production in Stillman Creek. Stands of mature conifer exist in the riparian areas of the mainstem Stillman (between Little Mill Creek and Raccoon Creek), some areas of Little Mill Creek, and lower Halfway Creek. In these areas, the near and long-term LWD recruitment potential is high (Hawe and Fulton 1994).

About 20% of the Stillman Basin has "good" near-term LWD recruitment potential, 34% has "fair", and 46% has "poor" near-term LWD recruitment potential (Hawe and Fulton 1994). Agricultural clearing along Lost, Halfway and Keller Creeks account for the poor LWD recruitment in those areas, while logging and fires account for poor ratings in parts of Little Mill Creek, West Fork Stillman Creek, and parts of upper Stillman Creek (Hawe and Fulton 1994). Long-term recruitment is "poor" in the Type 1 waters below the West Fork Stillman Creek confluence due to agricultural conversion.

While the percentage of pools is relatively high (30-80%), they are widely spawned, shallow, and lack overhead or instream cover (Figure 61) (Hadley 1994). Areas with the greatest percentages of pools include Lost Creek, Halfway Creek, upper Keller Creek, and the upper mainstem Stillman Creek. Elsewhere, pool frequency is rated as "poor" to "fair" (Hadley 1994).

Figure 60. Vegetation Loss in the South Fork and Upper Chehalis Sub-Basins (Wampler et al. 1993).

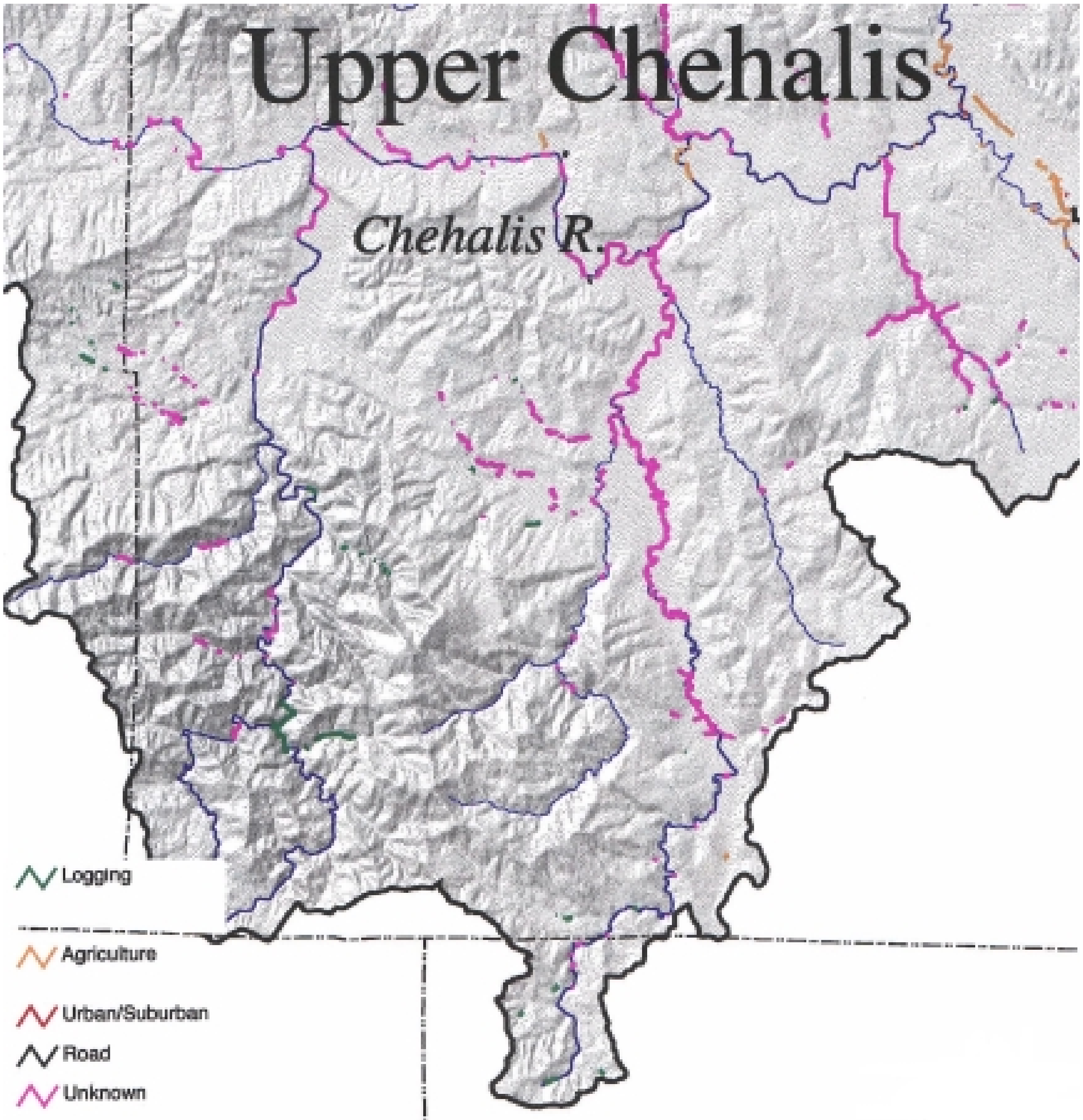
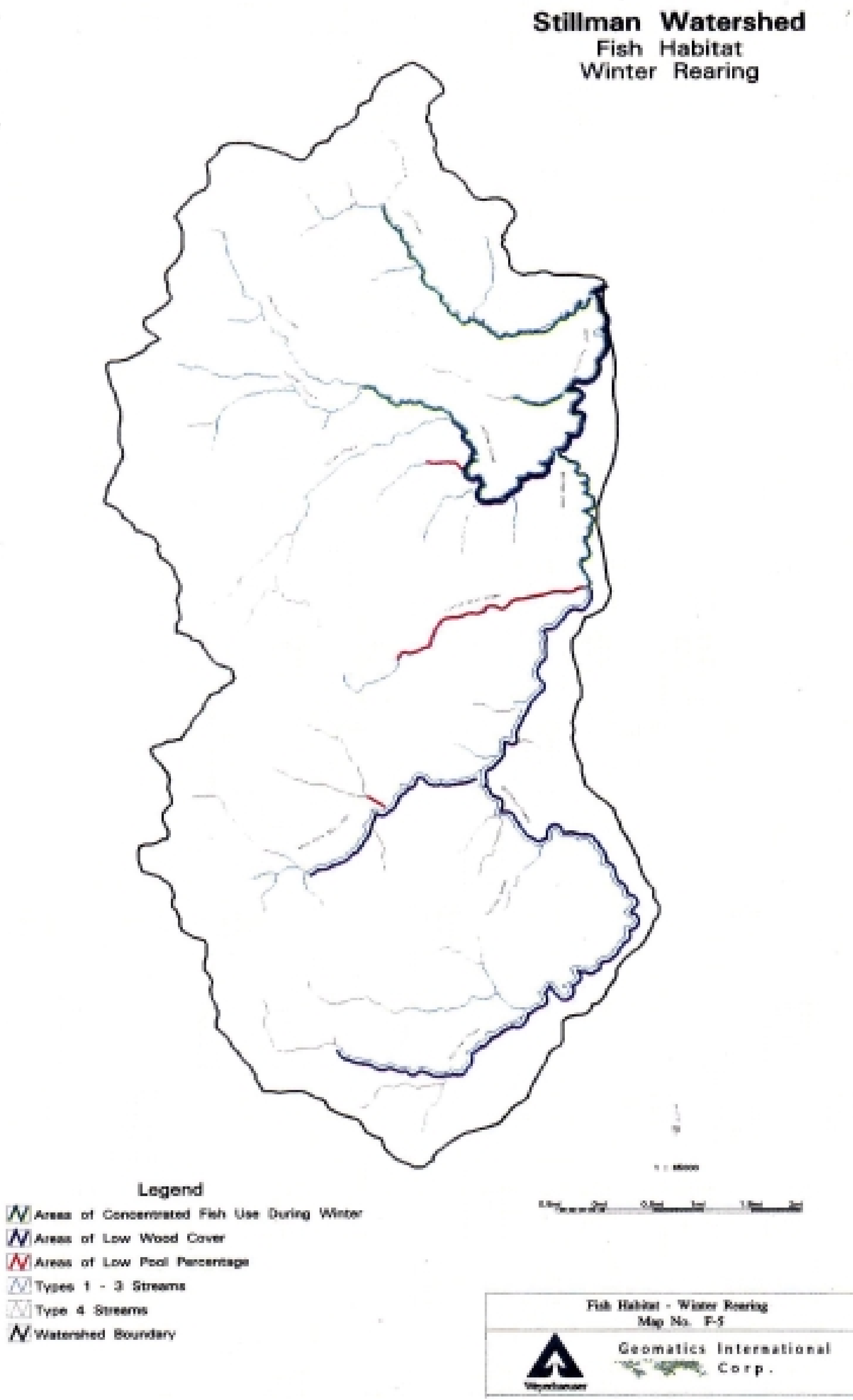


Figure 61. Pool Habitat in the Stillman Creek Watershed (Hadley 1994).



Riparian Conditions in the Lake Creek Watershed

Tree canopy loss is extensive in the lower and middle reaches of Lake Creek, primarily due to agriculture (Figure 63) (Wampler et al. 1993). An extensive loss of tree canopy was also noted in Deep Creek and attributed to logging. Overall, the Curtis WAU, which includes Lake Creek, consists of 36% non-forest (agriculture and urban) riparian areas and 50% open or hardwood riparian areas (data from Lunetta et al. 1997), resulting in 86% "poor" riparian areas.

Rating of Riparian Conditions in the South Fork Chehalis Sub-Basin

The entire sub-basin rated “poor” for riparian conditions. This is due to a loss of riparian in the lower stream reaches, coupled with a dominant riparian of hardwoods, which will be unable to supply adequate instream LWD in the future.

Water Quality in the South Fork Chehalis Sub-Basin

High water temperatures are a recognized problem in the South Fork Chehalis River. The Washington Department of Ecology (DOE) has recommended a segment (13N, 4W, 24) of the South Fork for inclusion on the 303(d) List (DOE 1998). High water temperatures are also a problem in the lower mainstem Stillman Creek, where water temperatures as high as 24^{o}C were documented in 1994 (Hawe and Fulton 1994). Water temperatures exceeded 20^{o}C in Halfway Creek and Keller Creek, and exceeded 18^{o}C in Lost Creek, the middle Stillman Creek, and Slide Creek. For Type 1-3 streams, 32% have less than 40% shade, and 48% have greater than 70% shade (Hawe and Fulton 1994). About 37% of the stream miles in Stillman Creek are below target shade levels. Areas of temperature concern are mapped in Figure 62. The primary areas are the lower mainstem Stillman Creek, Halfway Creek, Keller Creek, upper Lost Creek, and segments of upper Stillman Creek (Hawe and Fulton 1994).

Loss of tree canopy has been recorded in lower Lake Creek and in Black Creek, and attributed to agricultural use. Logging has reduced tree canopy in sections of the upper and middle South Fork Chehalis sub-basin, in reaches of Stillman Creek, and in Deep Creek (Figure 63) (Wampler et al. 1993). However, temperature measurements were not found for Lake Creek. The water quality rating for Lake Creek is "suspected poor" because of the poor riparian conditions coupled with lack of specific water quality data.

In the South Fork Chehalis drainage (including Stillman and Lake Creeks), ten inputs of wastewater, chemicals, or sediment from agricultural sources were documented (Wampler et al. 1993). In addition, fourteen other inputs from unknown sources were noted. Compared to other types of degradations, Wampler et al. (1993) rated these water quality problems lower than other problems, such as bank erosion, riparian vegetation loss, sedimentation, livestock access, and reduced tree canopy.

The U.S. Environmental Protection Agency ranked 2110 watersheds having agricultural runoff data available (EPA 1999). A ranking of 2110 indicates the highest impact. In this ranking, the upper Chehalis River ranked 1057. The two greatest concerns were nitrogen and sediment inputs.

Figure 62. Stillman Creek Salmonid Summer Rearing Concerns (Hawe and Fulton 1994).

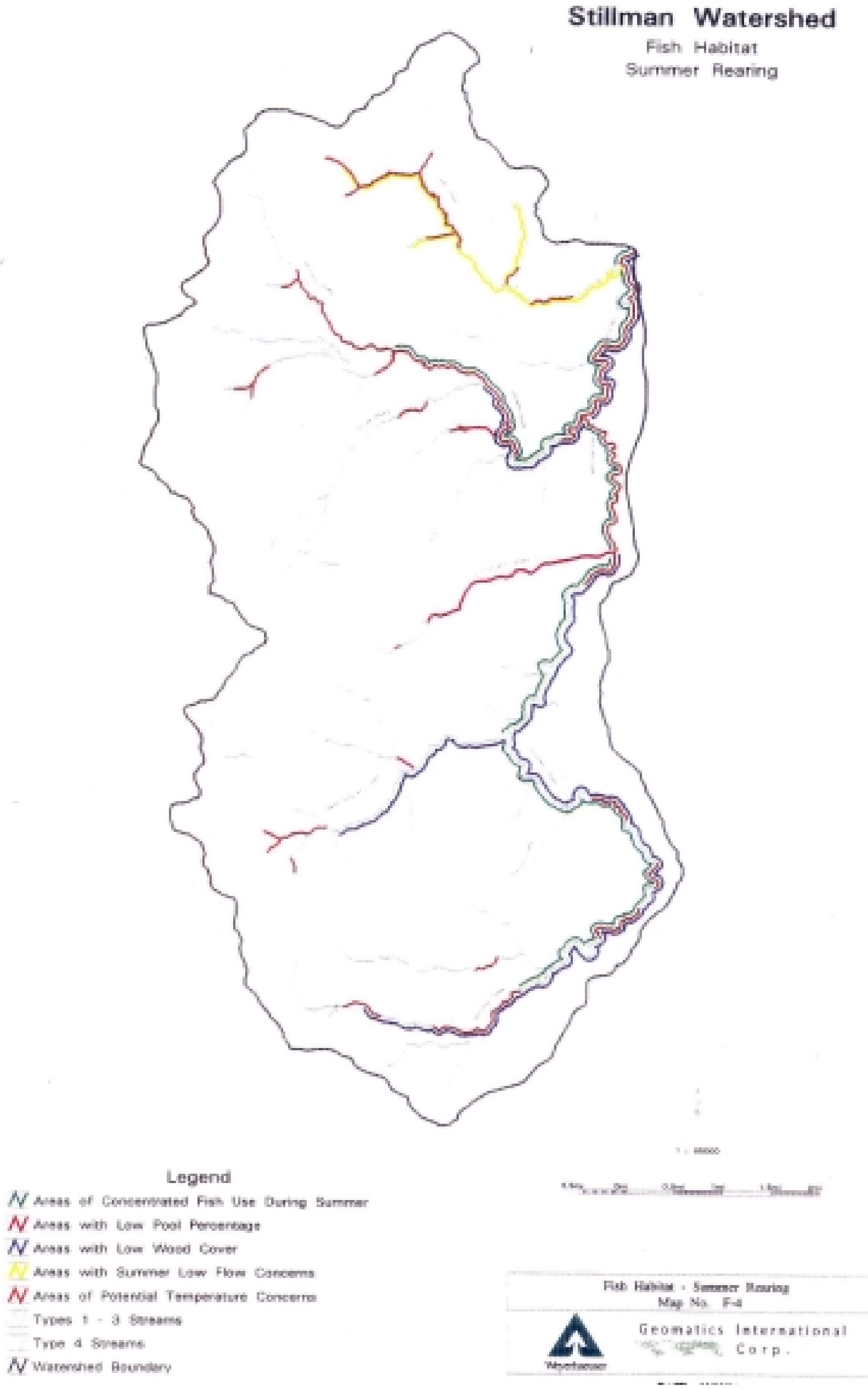
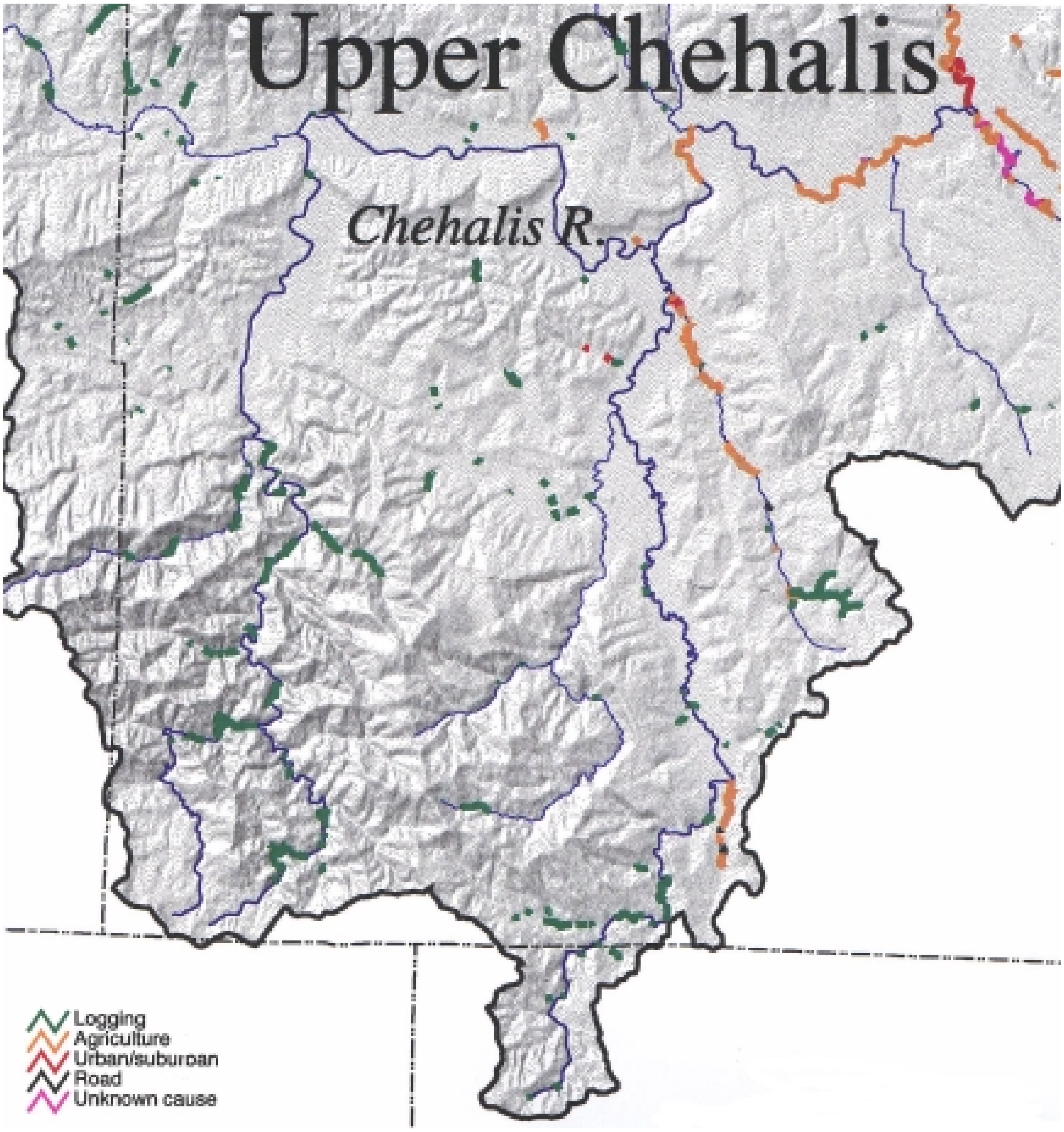


Figure 63. Loss of Tree Canopy in the South Fork and Upper Chehalis Sub-Basins (Wampler et al. 1993).



Rating of Water Quality Conditions in the South Fork Chehalis Sub-Basin

The entire sub-basin rates "poor" for water quality conditions. The South Fork Chehalis has a reach on the 303(d) List for high water temperatures, and Stillman Creek has documented high water temperatures. Lake Creek is rated as "suspected poor" because of the loss of riparian canopy, as well as the numerous documented waste water inputs. However, specific water quality data needs to be obtained.

Water Quantity in the South Fork Chehalis Sub-Basin

The South Fork Chehalis River and one tributary, Beaver Creek, are closed to additional water consumption beyond the rights granted earlier (with the exception of domestic and livestock watering that has no alternate sources) (Chapter 173-522 WAC). This closure occurred because base flows are often not met in those streams, and when flows are too low, impacts to salmonids occur. This is a strong indication that low flows are a major problem for salmonids in this sub-basin, and results in a "poor" rating for water quantity in the South Fork Chehalis River. Low water flows have been an identified concern in Lost Creek where most of the creek dries up in the summer (Hadley 1994). However, this is thought to be a natural condition.

Wampler et al (1993) documented several water withdrawals in the South Fork Chehalis Sub-Basin (Figure 64). Most are located in the middle and upper reaches of the South Fork mainstem. They noted 26 sites with pumping equipment and an additional four suspected sites. Two water intakes for the Boistfort Valley Water Corporation withdraw water from Stillman Creek. One is located in Little Mill Creek and the other is in the mainstem of Stillman Creek, just upstream of the confluence with Little Mill Creek.

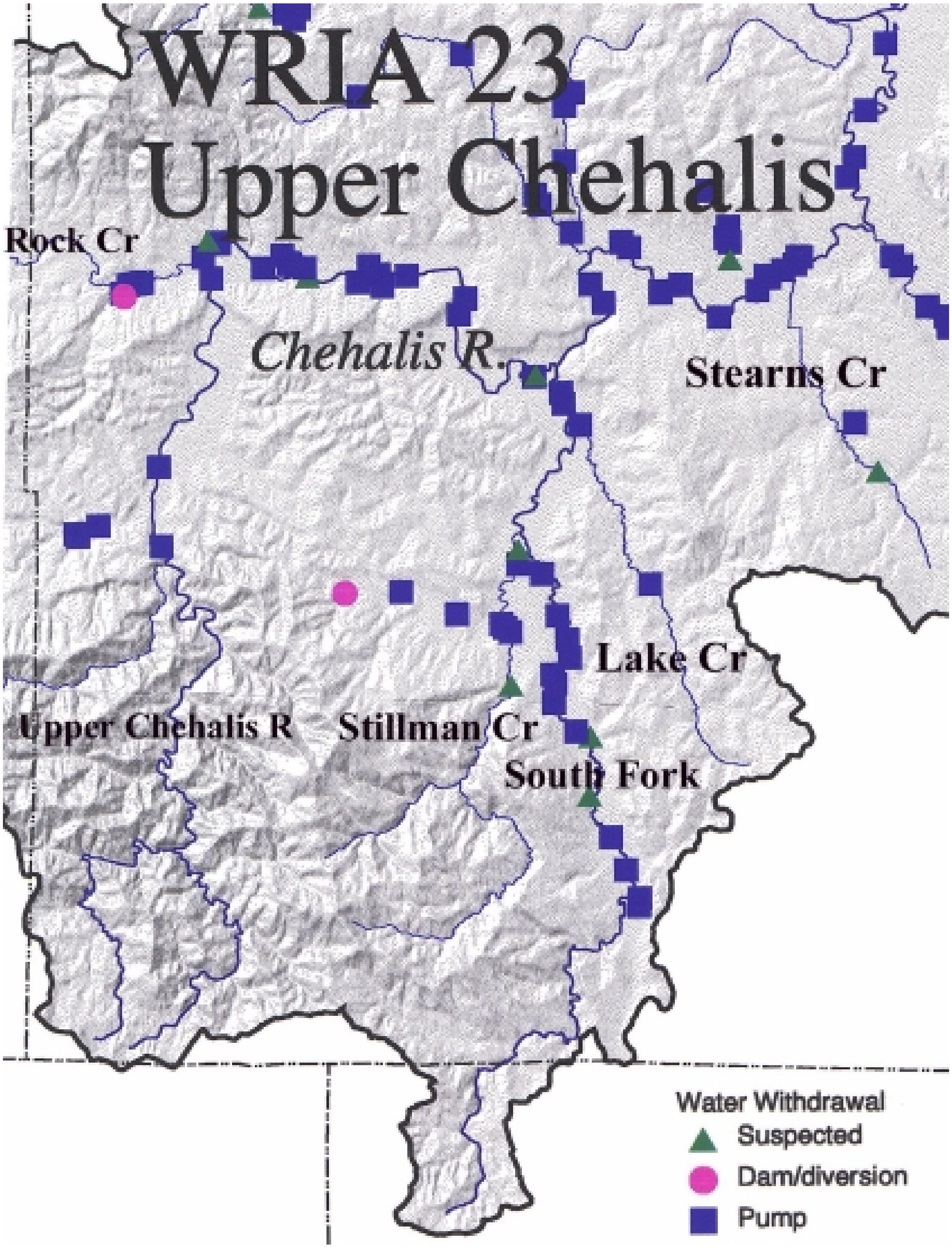
High flows are also a concern for salmonids in the sub-basin. Five year event peak flows occurred 14 times in 52 years of measurements (about 3.7 years per event) (Sullivan and Carlson 1994). The majority of the Stillman Creek sub-basin is hydrologically mature; with about 5 to 17% of the sub-basin rated as immature (Sullivan and Carlson 1994). Control of sediment sources coupled with increased LWD is recommended to aid in peak flow concerns.

Most of the Lake Creek watershed consists of immature land cover (74.1%) (data from Lunetta et al. 1997). This results in a "poor" rating for hydrologic maturity. The South Fork Chehalis WAU has 58.7% hydrologically immature vegetation, resulting in a "good" rating because it is just under the 60% standard used to define "poor" from "good" conditions.

Rating of Water Quantity Conditions for the South Fork Chehalis Sub-Basin

The South Fork Chehalis sub-basin rated “poor” for water quantity because it is closed for further water allocations. While the South Fork Chehalis WAU has a "good" hydrological maturity, it is very close to the "poor" rating. There is concern about the numerous water withdrawals in the South Fork Chehalis River mainstem, but their impact on salmonid production has not yet been quantified. The high risk of scour is a concern as well, but is more likely a function of a loss of LWD. The Stillman Creek watershed rates "good" for water quantity because of the "good" hydrologic maturity. However, concern was expressed in the Watershed Analysis that peak flows are becoming more common. Lake Creek rates "poor" for water quantity due to low hydrologic maturity.

Figure 64. Water Withdrawals in the South Fork and Upper Chehalis Sub-Basins (Wampler et al 1993).



Biological Processes in the South Fork Chehalis Sub-Basin

Nutrient cycling is assessed for this report by the attainment of escapement goals, but all of the salmonid stocks in the South Fork Chehalis sub-basin are managed as part of a much larger population. Escapement goals for these stocks include populations that range throughout either WRIA 23 or throughout the entire Chehalis Basin. Because of this, the use of escapement data combined for multiple watersheds results in nutrient cycling estimates that are not specific to the area. A future data need is to provide escapement information specific to sub-basins, which will not only aid in nutrient cycling monitoring, but also monitoring efforts for other habitat projects and problems.

Fall and spring chinook escapement levels have generally remained stable for WRIA 23 and both are listed as healthy in SASSI (WDFW and WWTIT 1994). Coho salmon escapements in WRIA 23 have declined in the 1990s (John Linth, WDFW, personal communication). Winter steelhead are classified as healthy in SASSI (WDFW and WWTIT 1994). With most of the stocks within the South Fork sub-basin classified as currently "healthy", nutrient cycling is rated “good”.

Habitat Limiting Factors in the Upper Chehalis Sub-Basin

Loss of Fish Habitat Access in the Upper Chehalis Sub-Basin

Data Sources

Lewis County (Rodney Lakey, Lewis County, personal communication) documented most of the barriers listed in this section. Additional barrier information was obtained from the Salmonid Screening, Habitat Enhancement and Restoration Division of WDFW, the Washington State Department of Transportation (Johnson et al. 1999), survey data from Lewis County (Forth memo. 1997), the Chehalis Headwaters Watershed Analysis (Weyerhaeuser 1994a), WDFW files located in Montesano, the Instream Culvert Habitat Survey (Taylor 1995), and personal communication from the TAG members.

The culvert assessment by Lewis County has been completed through its first level. In an additional study, they plan to inventory habitat upstream of barriers and determine the status of “unknown” fish presence culverts. The lack of adequate fish distribution data in this area also impedes further assessment of impact. Because analysis of habitat upstream of culverts has not been done and the extent of blockage and life history stage impacted are yet unknown, we are unable to fully rate the condition of access issues in this sub-basin.

Blockages

Table 34 lists artificial blockages that are known to block salmonid access within the upper Chehalis sub-basin, which includes salmon and steelhead waters upstream of the confluence with the South Fork Chehalis. These culverts are in a temporary priority order based upon number of species impacted and miles of habitat blocked. However, the list under-estimates the total amount of blockages within the sub-basin, and the priority order will likely change as the additional culverts are more fully assessed.

Table 35 lists potential blockages as identified by Lewis County (Rodney Lakey, Lewis County, personal communication). The blockages in the second list are not in priority order because the quantity and salmonid use of habitat for some of the areas upstream of the blockage has not been clarified. An analysis that includes all salmonid blockages continues to be a data need.

Known blockages to salmon and steelhead habitat are a major limiting factor for the upper Chehalis sub-basin. The area lacks overwinter rearing habitat during floods, and blockages on tributaries decrease available winter refuge habitat. The blockages also interfere with two other major limiting factors: transport of spawning gravel and large woody debris (LWD). There is considerable beaver activity in this area, but these dams are not generally blockages to salmon and steelhead. Beaver ponds provide beneficial habitat function for salmonids by storing sediments for short time periods and providing juvenile rearing habitat.

Because cutthroat issues are not included in this report at this time, barriers to cutthroat were included only when documented and readily available. These are listed in priority order behind blockages that impact salmon, steelhead, and cutthroat, due to the number of species impacted. The list of barriers to cutthroat trout is incomplete.

Table 34. Known Salmon and Steelhead Blockages in the Upper Chehalis Sub-Basin.

Stream Name	Township, Range, Section	Road Name	Type of Blockage	Miles of Habitat Blocked	Data Source
Trib to West Fork Chehalis	11N, 5W, 20		Culvert, blocks steelhead and cutthroat	5300 feet	Taylor 1995
Trib to West Fork Chehalis	11N, 5W, 29		Culvert, blocks steelhead and cutthroat	4579 feet	Taylor 1995
Trib to West Fork Chehalis	12N, 5W, 20		Culvert, blocks steelhead and cutthroat	1699 feet	Taylor 1995
Trib. To East Fork Chehalis	11N, 5W, 27		Culvert, blocks coho and cutthroat	1100 feet	Taylor 1995
Trib to Lester Cr.	12N, 6W, 12, 13		Culvert blocks cutthroat only	4750 feet	Taylor 1995
Trib to Lester Cr.	12N, 6W, 13		Culvert, blocks cutthroat only	3550 feet	Taylor 1995
Trib. To East Fork Chehalis	11N, 5W, 33		Culvert, blocks cutthroat only	3340 feet	Taylor 1995
Trib to West Fork Chehalis	11N, 5W, 20		Culvert, blocks cutthroat only	2610 feet	Taylor 1995
Trib to East Fork Chehalis	11N, 5W, 23		Culvert, blocks cutthroat only	2300 feet	Taylor 1995
Trib. To West Fork Chehalis	12N, 5W,		Culvert, blocks cutthroat only	2190 feet	Taylor 1995
Trib. To West Fork Chehalis	11N, 5W, 28		Culvert, blocks cutthroat only	1529 feet	Taylor 1995
Trib. To East Fork Chehalis	11N, 5W, 33		Culvert, blocks cutthroat only	1475 feet	Taylor 1995
Trib. To West	11N, 5W,		Culvert, blocks	1300 feet	Taylor

Stream Name	**Township, Range, Section**	**Road Name**	**Type of Blockage**	**Miles of Habitat Blocked**	**Data Source**
Fork Chehalis	28		cutthroat only		1995
Trib. To West Fork Chehalis	11N, 5W, 21		Culvert, blocks cutthroat only	700 feet	Taylor 1995
Trib. To Lester Cr.	12N, 5W, 18	W380S	Culvert, blocks cutthroat only	600 feet	Taylor 1995
Trib to Lester Cr.	12N, 5W, 32	2000	Culvert, blocks cutthroat only	470 feet	Taylor 1995
Trib. To West Fork Chehalis	11N, 5W, 32		Culvert, blocks cutthroat only	120 feet	Taylor 1995
Trib. To Lester Cr.	12N, 5W, 13	W380	Culvert, blocks cutthroat only	Not Available	WDFW files
Capps Cr.	13N, 5W, 3	Chandler Road Mile post 2.426	2 Culverts, salmonid use not documented	Not available	Forth 1997

Table 35. Potential Fish Habitat-Blocking Culverts in the Upper Chehalis Sub-Basin (Lewis County 2000).

Road Name	Watershed	Township, Range, Section	Fish Presence	Notes
Halsea Rd	EF Chehalis Trib.	12N, 04W, 6SW	Yes	
Harkum Rd	EF Chehalis Trib.	12N, 05W, 2NW	Yes	
Harkum Rd	EF Chehalis Trib.	13N, 05W, 35SW	Yes	
McCormick Creek Rd	McCormick Cr.	12N, 05W, 5NE	Unknown	
Cole Rd	Rock Cr.	13N, 05W, 6NW	Yes	
Jones Rd	EF Chehalis Trib.	13N, 05W, 33NE	Yes	
Meyer Rd	Water Mill Cr.	13N, 05W, 34SE	Yes	
Lech Rd	Katula Cr.	13N, 05W, 27SE	Yes	
Mauerman Rd	EF Chehalis Trib.	13N, 05W, 35NW	Yes	
Beam Rd	Katula Cr.	13N, 05W, 26NW	Yes	
Beam Rd	Katula Cr.	13N, 05W, 26NW	Yes	
Katula Rd	Upper Chehalis Trib.	13N, 05, 23SW	Yes	
Katula Rd	Upper Chehalis Trib.	13N, 05, 23SW	Yes	
Chandler Rd	Dunn Cr.	13N, 05W, 2NE	Yes	
Chandler Rd	Dunn Cr.	13N, 05W, 2NE	Yes	
Chandler Rd	Capps Cr.	13N, 03W, 2NE	Yes	
Chandler Rd	Capps Cr.	13N, 03W, 2NE	Yes	
Chandler Rd	Taylor Cr.	13N, 05W, 3NE	Yes	
Chandler Rd	Taylor Cr.	13N, 05W, 3SE	Yes	
Elk Creek Rd	Elk Cr.	13N, 05W, 3SE	Yes	
Elk Creek Rd	Elk Cr.	13N, 05W, 10NW	Unknown	
Elk Creek Rd	Elk Cr.	13N, 05W, 9NW	Unknown	
Leudinghaus Rd	Upper Chehalis Trib.	13N, 04W, 4SW	Unknown	
Leudinghaus Rd	Dell Cr.	13N, 04W, 5SE	Yes	
Leudinghaus Rd	Upper Chehalis Trib.	13N, 04W, 5SE	Unknown	
Leudinghaus Rd	Dell Cr.	13N, 04W, 6SE	Unknown	
Leudinghaus Rd	Dell Cr.	13N, 04W, 6SE	Unknown	
Leudinghaus Rd	Upper Chehalis Trib.	13N, 04W, 6SW	Yes	
Kobe Rd	Marcusen Cr.	13N, 05W, 1NW	Yes	
Hatchery Rd	Hope Cr.	13N, 04W, 9NW	Yes	
Hatchery Rd	Hope Cr.	13N, 04W, 9NW	Yes	
River Rd.	Upper Chehalis Trib.	13N, 04W, 3SW	Yes	Coho, Chinook, steelhead

Road Name	Watershed	Township, Range, Section	Fish Presence	Notes
River Rd.	Upper Chehalis Trib.	13N, 04W, 4SE	Yes	Coho, Chinook, steelhead
Meskill Rd.	Upper Chehalis Trib.	13N, 04W, 11NE	Yes	
Meskill Rd.	Upper Chehalis Trib.	13N, 04W, 10NE	Yes	
Meskill Rd.	Upper Chehalis Trib.	13N, 04W, 3NW	Yes	
Meskill Rd.	Garret Cr.	13N, 04W, 3NW	Yes	
Meskill Rd.	Upper Chehalis Trib.	13N, 04W, 3NW	Yes	
Ceres Hill Rd	Upper Chehalis Trib.	13N, 04W, 14SW	Unknown	
Ceres Hill Rd	Upper Chehalis Trib.	13N, 04W, 14SW	Unknown	
Ceres Hill Rd	Upper Chehalis Trib.	13N, 04W, 14NE	Yes	
Ceres Hill Rd	Upper Chehalis Trib.	13N, 03W, 7SW	Yes	
Ceres Hill Rd	Upper Chehalis Trib.	13N, 03W, 7NW	Unknown	
White Rd.	Upper Chehalis Trib.	13N, 04W, 22NE	Unknown	
White Rd.	Upper Chehalis Trib.	13N, 04W, 23SW	Unknown	
White Rd.	Upper Chehalis Trib.	13N, 04W, 23SW	Unknown	
White Rd.	Upper Chehalis Trib.	13N, 04W, 23SW	Unknown	
White Rd.	Upper Chehalis Trib.	13N, 04W, 22NE	Unknown	

No culverts (bridges are more commonly used in this area) were reported in the Chehalis Headwaters Watershed Analysis, which covered the sub-basin upstream of Pe Ell (Weyerhaeuser 1994a). However, one blockage was noted in the East Fork Chehalis where the river was rerouted because of a road (Weyerhaeuser 1994a). Other problems include failed road crossings that led to debris jams in Upper George, upper Thrash, and in an unnamed tributary to the East Fork Chehalis River.

Rating of Fish Passage Conditions in the Upper Chehalis Sub-Basin

Most of the sub-basin rates “poor” for fish passage conditions, although it was recognized that increased survey effort is needed. Although data are still lacking regarding fish access problems, the fish passage problems have increased importance in the region because of limited winter refuge habitat. In addition, the road density is extremely high in the region, suggesting that road-related problems, such as culverts and sediment, are a major problem. Three watersheds rate “good” within the sub-basin and those include Roger, Big, and Cinnabar Creeks.

Floodplain Problems in the Upper Chehalis Sub-Basin

Downstream of Pe Ell, including Rock Creek

Numerous sites of rip-rap were documented along the mainstem Chehalis River between the South Fork Chehalis confluence and Pe Ell (Figure 57 in the South Fork section), while low levels of rip-rap were noted in the tributaries in this area. Hope Creek had a single site of rip-rap, while Elk Creek had 13 sites, which impacted 125 linear stream feet (Wampler et al. 1993). Fourteen instances of rip-rap were also found in the Crim Creek/Rock Creek watershed, impacting 3214 linear feet of stream (Figure 57). No channelization was noted in any of these sub-basins (Wampler et al. 1993).

Channel incision is a problem in Elk Creek (Lonnie Crumley, LWC Consulting, personal communication). Efforts should be made to quantify historic versus current off-channel habitat, with prioritization of sites for protection or restoration. Protection of existing lateral habitat and restoration of potential lateral habitat should be a priority for Elk Creek. Quantification of historic versus current off-channel habitat is also needed in Rock Creek, and efforts to restore lost off-channel habitat and protect existing floodplain habitat are recommended.

Upstream of Pe Ell

In the waters upstream of Pe Ell, side-channel and off-channel habitat is limited (Weyerhaeuser 1994a). This type of habitat is naturally limited in some areas of the upper Chehalis due to channel confinement, examples include Crim, Thrash, and Cinnabar Creeks, and the East Fork Chehalis River. Because of the lack of natural lateral habitat, some streams (Crim, Thrash, and Cinnabar Creeks, and the East Fork Chehalis River) are not recommended for inventories to quantify historic versus current floodplain habitat.

Human-caused floodplain impacts include recent channel downcutting and incision, which have entrenched streams and decreased winter refuge habitat. Impacted streams are Roger Creek, Mack Creek and lower to middle George Creek. The upper mainstem Chehalis River also lacks lateral habitat due to channel incision, effecting coho salmon and steelhead trout. Restoration of off-channel habitat and activities to reduce channel incision are recommended for these areas.

Rating of Floodplain Conditions in the Upper Chehalis Sub-Basin

Crim, Thrash, and Cinnabar Creeks, as well as in the East Fork Chehalis River, are rated "good" for floodplain conditions, because the are naturally confined and further assessments or off-channel work should not be a priority. Roger, Mack, and George Creeks are rated "fair" due to downcutting and channel incision that has reduced lateral habitat in an already limited sub-basin. Elk Creek is rated "poor" and needs further assessment, while Rock Creek is listed as a data need for floodplain conditions. Known impacts exist but are not yet quantified. Restoration efforts would benefit these impacted areas. Insufficient data exists to rate the remainder of the streams in this area.

Streambed and Sediment Conditions in the Upper Chehalis Sub-Basin

Downstream of Pe Ell, including Rock Creek

Data on sediment and streambed conditions in this region are limited, but Wampler et al. (1993) documented extensive erosion (27.7 miles) along Elk Creek and in three major tributaries to Elk Creek, Swem, Nine, and Smith Creek (Figure 59 in the South Fork section). Erosion and two debris torrents were also documented in Ludwig Creek. Debris torrents occur when landslides deliver materials such as trees into the stream. In addition, a very high road density (4.4 miles of road/sq.mi. watershed) exists in the Elk Creek WAU (Lunetta et al. 1997). This impacts result in "poor" ratings for sediment quantity.

Rock Creek and its tributaries are major sites of sedimentation (Figure 59), with 19.7 miles of bank erosion noted (Wampler et al. 1993). The Rock Creek WAU has a very high road density (4.8 miles of road/sq.mi. watershed) (Lunetta et al. 1997). Both of these problems result in a "poor" rating for sediment quantity conditions in Rock Creek. A few erosion impacts were also noted in the mainstem Chehalis River in this region (Wampler et al. 1993). Hope Creek and the mainstem Chehalis River near Hope Creek had additional sites of erosion.

Low levels of LWD are a major problem, and are rated “poor” in lower Hope Creek, parts of Marcuson Creek, the lower mainstem Elk Creek, and lower Rock Creek (Map 5b) (Bob Amrine, Lewis County Conservation District and Lonnie Crumley, LWC Consulting, personal communication). Some reaches of Marcuson Creek rate “fair” for LWD amounts, and Eight Creek rates “good” for LWD. Many of the tributaries to Elk Creek appear to have "good" LWD levels, while upper Elk Creek is recovering from past logging. Upper Elk Creek has instream wood comprised of smaller trees that form jams and complexes (roughly 20 to 30 year old trees), with very little large key pieces of wood (Lonnie Crumley, LWC Consulting, personal communication). These jams and complexes do not appear to be stable, and most likely move or are periodically dismantled, causing additional scour and streambed disruption. The mainstem Chehalis River from the confluence with the South Fork to the headwaters, are rated “poor” for quantities of LWD.

Upstream of Pe Ell

Many reaches of the upper Chehalis mainstem River are naturally confined with low gradients, a combination that is not commonly seen (Weyerhaeuser 1994a). Streams that are less confined, and potentially more productive for salmonids are lower George, Big, Lester, Roger, and Sage Creeks. Beaver activity is noteworthy in upper Lester Creek and the East and West Forks of the Chehalis River. Beaver ponds act as sediment storage units, releasing sediment periodically, which contributes to spawning habitat. The ponds also provide rearing habitat, especially for coho salmon.

Landslides are the main source of sediment in the upper Chehalis sub-basin. From 1955 to 1991, 675 landslides were identified in the area upstream of Pe Ell (Weyerhaeuser 1994a). Road-related landslides account for 65% of the total, and most of those failures were sidecast roads after large storms. Many of the other landslides developed from recent timber harvest on steep slopes. The greatest sediment loads are found in Big, Thrash, and Sage Creeks. Thrash and Sage have extremely high road densities, both around 7.6 miles/sq. mile watershed. Road density in Big Creek is 4.6 mi/sq.mi (Weyerhaeuser 1994a). These road densities result in a “poor” habitat rating for sediment quantity (see Assessment Chapter).

Fine sediment levels are primarily derived from landslides, with very low levels from surface erosion (Weyerhaeuser 1994a). High levels of fine sediments impact salmonid egg survival. In the past, fine sediment problems have been identified in Crim, Lester, Browns, lower Big, Roger and tributaries, Alder, Thrash, Mack, lower Sage, George, and Cinnabar Creeks. Fine sediment levels are also high in the East Fork and upper West Fork Chehalis Rivers, where the most likely cause is bank failure. Fine sediment levels are low in the upper mainstem Chehalis. Because of the location of fine sediment problem areas, the species most likely impacted are coho salmon and steelhead trout. In addition, an extremely high road density (6.4 miles of road/sq.mi. watershed) was documented in the upper Chehalis WAU (Lunetta et al. 1997).

Even with considerable landslide contributions of sediment, the quantity of spawning gravels are limiting in the following streams: Lester, upper and lower Crim, lower Browns, Thrash, lower and middle Roger, lower and middle Mack , lower Big, Cinnabar, and lower and middle George Creeks, as well as the East Fork Chehalis and most of the West Fork Chehalis Rivers (Weyerhaeuser 1994a). These are areas that are important for coho salmon and steelhead trout habitat. The lack of spawning gravel could be addressed in some areas by an increase in LWD to reduce gravel transport, but appropriate sites in this region would need to be carefully chosen. LWD placement would be most effective if placed in an unconfined, low gradient channel, where current levels of LWD are known to be limited.

The amount of large woody debris, particularly of key pieces greater than 12” diameter, is very limited throughout the upper Chehalis sub-basin, and consists mostly of large scattered log jams containing small pieces of logging slash (Weyerhaeuser 1994a). Early splash dams and logging practices contributed to the loss, and “stream cleaning” in the 1970s removed significant remaining wood, particularly in Thrash, Sage and Roger Creeks. None of the sampled reaches were rated as “good” in 1994, with most rating “poor” (Weyerhaeuser 1994a). “Poor” rated streams include Thrash, Sage, Crim, Big, George, Mack, Cinnabar, and Big Roger Creeks. Lester Creek and the upper West Fork Chehalis River rated “fair”.

The scour potential is high in certain areas due to the confined channel and lack of LWD. Areas of high potential scour include the mainstem Chehalis River, lower West Fork Chehalis River, and parts of the East Fork Chehalis River, as well as lower Crim, lower Big, lower Big Roger, lower George, lower Cinnabar, and Thrash Creeks. The confined channel and lack of LWD also limits off-channel habitat, reducing winter refuge habitat (Weyerhaeuser 1994a). Scour would mostly impact chinook and coho salmon, and to a lesser extent, steelhead trout.

The strong influence of landslides was noted as channel changes in recent decades (Weyerhaeuser 1994a). Channel widening has occurred in Thrash, Roger, Sage, George Creeks and the East Fork Chehalis River. After the 100 year flood of 1972, there was an increase of 255 landslides in the Chehalis sub-basin upstream of Pe Ell. The channel widened shortly afterwards, and beginning in the late 1980s, narrowed as the riparian vegetation grew (Weyerhaeuser 1994a). Another 100 year flood occurred in 1990, and this resulted in an increase of 135 landslides. However, instead of channel widening, the channel became incised due to debris torrents. The lack of LWD increases sediment transport through the streams, which increases channel instability.

Rating of Streambed and Sediment Conditions in the Upper Chehalis Sub-Basin

The worst problems for streambed and sediment conditions are the high level of sediment delivery from landslides, "poor" quantities of LWD in nearly all areas, several streams with "poor" conditions for channel stability and the quality of spawning habitat (fine sediments). In addition, Big and Thrash Creeks rated "poor" for quantity of spawning gravel, and Elk Creek and Rock Creek rated "poor" for sediment quantity because of the high level of bank erosion coupled with high road densities.

<u>Riparian Conditions in the Upper Chehalis Sub-Basin</u>

Downstream of Pe Ell, including Rock Creek

Streamside vegetation loss was especially noteworthy throughout the mainstem Chehalis River between the confluence with the South Fork Chehalis and Pe Ell (Figure 60 in the South Fork section) (Wampler et al. 1993). Other riparian losses were documented in Elk Creek, Rock Creek and McCormick Creek (Figure 63 in the South Fork section) (Wampler et al. 1993). Lower Elk Creek, lower Hope Creek, and parts of Marcuson Creek rate "poor" for riparian conditions (Map 4b) (Bob Amrine, Lewis County Conservation District and Lonnie Crumley, LWC Consulting, personal communication). Riparian conditions are thought to be "good" in Elk Creek from about RM 3 through 7.6 and "good" in the lower reaches of Eight Creek (Lonnie Crumley, LWC Consulting, personal communication). The riparian conditions in Rock Creek rate "fair", but recent logging might have changed this. Also, pool habitat in Rock Creek is thought to be limiting (Lonnie Crumley, LWC Consulting, personal communication).

Upstream of Pe Ell

The most common type of riparian condition is mature, dense, mixed (conifer/hardwood) trees (Weyerhaeuser 1994a). Our rating system rates this type of riparian as "fair" because of the significant hardwood component. Sections dominated by deciduous trees are rated as "poor". Hardwoods are less able to provide adequate large woody debris of sufficient size and durability. Specific areas with "poor", "fair", or "good" ratings are pictured on Map 5b. "Poor" riparian exists in lower Brown, lower Big, Thrash, lower Hope, lower Elk, parts of Lester and Crim, Roger, lower Alder, and lower Sage Creeks. Parts of the mainstem Chehalis are also known to have currently "poor" riparian conditions.

The riparian condition in the upper Chehalis sub-basin results in generally good long-term recruitment potential of LWD. Areas that rate "poor" are the mainstem Chehalis from the West Fork to Cinnabar and near the Browns Creek area, and also lower to middle Thrash Creek (Weyerhaeuser 1994a). These areas might be good candidates for conifer plantings.

For near-term LWD recruitment potential, 64% of the stream length segments rate "good", 14% rate "fair", and 22% rate "poor" (Weyerhaeuser 1994a). Areas that are currently "poor" for near-term LWD recruitment potential include Crim, Rogers, Alder, and Mack Creeks, and scattered sections in Lester, Thrash, Cinnabar, and George Creeks. Parts of the mainstem upper Chehalis River as well as the West and East Forks of the Chehalis River also rate "poor" for near-term LWD recruitment potential.

A major problem limiting salmonid production in the upper Chehalis sub-basin is the lack of summer rearing habitat. Pools are important, particularly for coho salmon and steelhead trout rearing through the summer months. The quantity, spacing, and depth of pools are all consequential components. In most of the surveyed areas, the quantity of pools rates "poor", plus they were found to be widely spaced, shallow and lacking in overhead cover and LWD (Weyerhaeuser 1994a). Streams with documented "poor" ratings for pools include: Thrash, Sage, Crim, Big, George, Mack, Cinnabar, Roger, and Lester Creeks, as well as the upper West Fork Chehalis River. All of these streams except Crim Creek, Roger Creek, and the upper West Fork Chehalis River had shallow pools, when pools were found at all. The percentage of pools is listed in Table 36. In addition to the data provided below, the East Fork Chehalis River, Alder Creek, and Browns Creek were mentioned as being low in pool habitat.

Table 36. Pool Quantity in the Upper Chehalis Sub-Basin Streams (Weyerhaeuser 1994a).

Stream Name	Percentage Pools (Surface Area)	Rating (see Assessment Chapter)
Thrash	29-41%	Poor-fair
Sage	28%	Poor
Crim	45%	Poor
Big	17%	Poor
George	21-36%	Poor
Mack	24%	Poor
Cinnabar	23%	Poor
Roger	27%	Poor
Lester	24%	Poor
Upper West Fork Chehalis	30%	Poor

Rating of Riparian Conditions in the Upper Chehalis Sub-Basin

Most of the region rate “fair” for riparian conditions. The upper mainstem Chehalis River and parts of Elk and Big Creeks rate “poor”. In general, pool habitat rates "poor" throughout the sub-basin, where data are available.

Water Quality in the Upper Chehalis Sub-Basin

Water temperature data in the upper Chehalis sub-basin are scant with isolated measurements scattered through time. However, these data indicate that high water temperatures can be a significant problem in the summer months. In 1977, the mainstem upper Chehalis exceeded 25^{o} C, which would be very detrimental to salmonids, and may provide a thermal barrier to spring chinook migration as well as contribute to physiological stress (Weyerhaeuser 1994a). In 1987, Thrash Creek had several temperature exceedances above 16 ^{o}C in the summer, which could impact salmonids (Weyerhaeuser 1994a). A data need is to obtain water temperature data throughout representative sites in the upper mainstem Chehalis and major salmonid-producing tributaries. The Washington Department of Ecology (DOE) has recommended one segment of the mainstem Chehalis River (13N5W12, near the town of Dryad) for inclusion on the 303(d) List because of high water temperatures and fecal coliform (DOE 1998).

Canopy cover was used to assess potential water temperature problems in the Chehalis Headwaters Watershed Analysis (Weyerhaeuser 1994a). The following stream reaches were noted as potential high water temperature areas: the mainstem Chehalis River, the lower West Fork Chehalis River, the upper East Fork Chehalis River, upper Crim Creek, Cinnabar Creek, lower Mack Creek, and portions of George, Lester, and Thrash Creek (Weyerhaeuser 1994a). In general, 47% of the waters had lower than target levels of canopy closure through watershed analysis. Wampler et al. (1993) documented tree canopy loss in Elk, Crim, Big, and Thrash Creeks, in addition to losses in the West Fork and mainstem Chehalis Rivers (Figure 63 in the South Fork section).

The lack of deep pool habitat potentially worsens the effect of high water temperature problems in the upper Chehalis sub-basin, as less refuge from high water temperatures are available. The lack of pools is a likely outcome of excessive sediment supply and transport coupled with the lack of LWD.

Rating of Water Quality Conditions in the Upper Chehalis Sub-Basin

Most of the sub-basin rates "poor" for water quality conditions. This is due to high water temperatures and loss of canopy cover. One section within this sub-basin is on the 303(d) List for water temperature.

<u>Water Quantity in the Upper Chehalis Sub-Basin</u>

About half of the upper Chehalis sub-basin lies in a rain-on-snow zone (Weyerhaeuser 1994a). These areas are susceptible to higher peak flows, especially for the major flood events. Flow data from 1940 through 1990 from the Doty gage (USGS 12020000) were examined. In that time period, there were two 100 year floods (1972 and 1990), five 25 year event or greater floods (1945, 1972, 1986, 1987, 1990), and 14 five year peak flow events. Timber harvest can account for some of the increased flow, but increased precipitation is an even greater contributor. Under current hydrological maturity, there is an expected 6% increase in a 2 year event flow, a 4% increase in a 10 year peak flow, and a 3% increase in a 100 year event flood (Weyerhaeuser 1994a).

In the region upstream of Pe Ell, the overall hydrological maturity (age of trees) breakout is 64% mature, 19% intermediate, and 17% immature (Weyerhaeuser 1994a), which results in a "good" rating. Upper Crim Creek has the highest level of immature vegetation (22% immature). Immature vegetation is characterized as young, open, and sparse, and when the vegetation changes significantly from undisturbed to immature, flood frequency often increases (Pentec 1995).

There have been some moderate increases in channel-forming flows due to timber harvest in the upper Chehalis sub-basin (Weyerhaeuser 1994a). Currently though, most of the sub-basin is hydrologically mature, and road culvert sizing is a greater concern. A data need is a survey of culverts with an assessment of effective size.

Scour is a noted potential problem that is caused by increased sediment supply and transport, low levels of LWD, increased flows due to lower hydrological maturity and increased precipitation. This is discussed in the Streambed/Sediment Chapter.

In the upper region of this sub-basin, low flows have been noted above a few of the large logjams in tributaries, and have resulted in dewatered redds. The cause of this is likely the local build-up of sediment. Implementation of the Weyerhaeuser road management plan will help this problem. The areas of impact include upper Alder Creek, upper Thrash Creek, and portions of the East Fork Chehalis River (Weyerhaeuser 1994a).

Several documented water withdrawals are in the lower portion of this sub-basin, particularly in Elk Creek, Rock Creek, and throughout the mainstem Chehalis River (Figure 64 in the South Fork section) (Wampler et al. 1993). Hope Creek is closed to additional water consumption beyond the rights granted prior to 1973 (with the exception of domestic and livestock watering that has no alternate sources) (Chapter 173-522 WAC). This closure occurred because base flows are often not met in those streams, and when flows are too low, impacts to salmonids occur.

The Elk Creek WAU was over 53% hydrologically mature using data from the early 1990s (Lunetta et al. 1997), but recent logging is believed to have reduced that level considerably (Lonnie Crumley, LWC Consulting, personal communication). There is also concern that peak flow events have increased, but flow data are needed to analysis this condition. The Rock Creek/Jones Creek WAU is over 74% immature, which is a "poor" rating (data from Lunetta et al. 1997).

Rating of Water Quantity Conditions for the Upper Chehalis Sub-Basin

Water quantity in this sub-basin is mostly a data gap, with concern about increased peak flow events and sediment deposition that results in de-watered conditions. Elk Creek was rated “poor” because of the numerous water withdrawals coupled with the recent loss of mature forest. Rock Creek is rated "poor" due to hydrologic immaturity, and Hope Creek is rated "poor" because it is likely over-allocated.

Biological Processes in the Upper Chehalis Sub-Basin

Nutrient cycling is assessed for this report by the attainment of escapement goals, but all of the salmonid stocks in the upper Chehalis sub-basin are managed as part of a much larger population. Escapement goals for these stocks include populations that range throughout either WRIA 23 or throughout the entire Chehalis Basin. Because of this, the use of escapement data combined for multiple watersheds results in nutrient cycling estimates that are not specific to the area. A future data need is to provide escapement information specific to sub-basins, which will not only aid in nutrient cycling monitoring, but also monitoring efforts for other habitat projects and problems.

Fall and spring chinook escapement levels have generally remained stable for WRIA 23 and both are listed as "healthy" in the SASSI report (WDFW and WWTIT 1994). Coho salmon escapements in WRIA 23 have declined in the 1990s (John Linth, WDFW, personal communication). Winter steelhead are classified as "healthy" in the SASSI report (WDFW and WWTIT 1994). With most of the stocks within the upper Chehalis sub-basin classified as currently healthy, nutrient cycling is rated “good” for the sub-basin as a whole, but specific streams are considered to be a data need.

ASSESSMENT OF HABITAT 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 help lead entity groups and the Salmon Recovery Funding board in prioritizing salmonid habitat restoration and protection projects seeking state and federal funds. To provide the best guidance possible, current, known habitat conditions were identified and rated. Rating 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.

To develop a set of standards for rating salmonid habitat conditions, several tribal, state, and federal documents that use some type of habitat rating system (Table 37) 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.

The ratings adopted by the WCC are presented in Table 38 and Table 39. 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 to allow comparison of habitat conditions across the state. However, for many habitat factors, there might not be sufficient data available to use a rating standard or there might be data on habitat parameters where no rating standard is provided. For these factors, the professional judgement of the TAG should be used to assign the appropriate ratings. In some cases, local conditions could warrant deviation from the rating standards presented here. This is acceptable as long as the justification and a description of the procedures used are clearly documented in the limiting factors report.

A summary of the habitat conditions for WRIAs 22 and 23 is presented in Table 40. These represent generalized conditions within that stream. There are likely some reaches of the stream that will be in better or worse condition than the rating suggests. In many cases, insufficient data and knowledge about the conditions was found. For those instances, a DG is listed, which stands for data gap. The conditions are based upon the standards in Table 38 and Table 39, and are described in more detail in the Habitat Limiting Factors Chapter. In the following chapter, recommendations and data needs are described and prioritized.

Table 37. Source documents for the development of standards.

Code	Document	Organization
WSP	Wild Salmonid Policy (1997)	Washington Department of Fish and Wildlife
PHS	Priority Habitat Management Recommendations: Riparian (1995)	Washington Department of Fish and Wildlife
WSA	Watershed Analysis Manual, v4.0 (1997)	Washington Forest Practices Board
NMFS	Coastal Salmon Conservation: Working Guidance (1996)	National Marine Fisheries Service
Skagit	Skagit Watershed Council Habitat Protection and Restoration Strategy (1998)	Skagit Watershed Council
Hood Canal	Hood Canal/Eastern Strait of Juan de Fuca Summer Chum Habitat Recovery Plan (1999)	Point No Point Treaty Council and Washington Department of Fish and Wildlife

Table 38. Salmonid habitat condition standards.

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

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
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
	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)	Diameter (m)	Length (m)		
		0-5	0.4	8		
		6-10	0.55	10		
		11-15	0.65	18		
		16-20	0.7	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

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
	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
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					

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
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
	• 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

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
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
Lakes (further work needed)						
Estuaries – See Table 39 Below						

Table 39. System for rating estuarine habitat conditions

Rating of Estuarine Habitat Conditions									
All Values are Referenced to Historic Conditions of Estuary which is defined as both wetted and upland area.									
The following system can be applied for both large and small estuaries.									
Large Estuaries are defined as an estuary where the area of Zone 1 and 2 combined is greater than approximately 2.0 sq miles									
For large estuaries, treat zone 1, 2 and 3 seperately. For small estuaries, treat zone 1 and 2 as one area combined.									
	Zone Characteristics	Parameter	Poor		Fair		Good		
Upper	FW tidal to brackish marsh area.	**Upland Condition**							
	Zone is delineated mostly by vegetatio	1- % Developed lands (Non Agricultural, Non Vegetate	> 50%	1	25-50%	3	< 25%	5	Within historic estuary area.
	Dominant vegetation type is Carex.	2- % Agricultural lands	> 75%	1	50-75%	3	< 50%	5	
	Ranges down to where Fucus and	3- % Forested uplands	< 25%	1	25-50%	3	> 50%	5	
	Salnicornia become prevelant and	4- % Historic Floodplain Wetlands Remaining	< 25%	1	25-50%	3	> 50%	5	Mostly unconnected, non marsh areas.
	Carex is sparse.								
		Aquatic Conditions							
		1- % Historic Marsh Remaining	< 25%	2	25-50%	6	> 50%	10	Marsh only
		2- % Mainstem Channel Habitat Lost	> 50%	2	25-50%	6	< 25%	10	Reflects loss of sinuosity
		3- % Non-Mainstem Habitat Lost	> 75%	2	25-50%	6	< 25%	10	Sloughs, off channel areas
		4- % Estuary Disconnected From Floodplain	> 75%	2	25-50%	6	< 25%	10	Disconnected from floodplain
		5- % Covered by Aquatic Exotic Plants	> 25%	2	10-25%	6	< 10%	10	Primarily Spartina
		6- Hydrology (Amount of Water Arriving In Estuary)							
		Only one score depending on whether there has	> 50%	2	10-50%	6	<10%	10	% Reduction in Average Annual Flow
		been a net increase or decrease			OR				
			> 50%	2	10-50%	6	<10%	10	% Increase in Average Annual Flow
		7- Hydrology (% Deviation From Natural Flow Patterns	Large	2	Medium	6	High	10	Subjective rating
		8- Water quality (Subjective)	Poor	2	Fair	6	Good	10	Subjective rating
		Overall Zone Rating							
		Good	73-100						
		Fair	48-72						
		Poor	20-47						
Lower	Brackish Marsh to delta face.	**Upland Condition**							
	Zone is delineated mostly by vegetatio	1- % Developed lands (Non Agricultural, Non Vegetate	> 50%	1	25-50%	3	< 25%	5	Within historic estuary area.
	Dominant vegetation type is Fucus	2- % Agricultural lands	> 75%	1	50-75%	3	< 50%	5	
	and Salnicornia. Zone stops along	3- % Forested uplands	< 25%	1	25-50%	3	> 50%	5	
	shore where these marsh plant stops.	4- % Historic Floodplain Wetlands Remaining	< 25%	1	25-50%	3	> 50%	5	Mostly unconnected, non marsh areas.

		Aquatic Conditions				
		1- % Historic Marsh Remaining	< 25%	2 25-50%	6 > 50%	10 Marsh only
		2- % Mainstem Channel Habitat Lost	> 50%	2 25-50%	6 < 25%	10 Reflects loss of sinuosity
		3- % Non-Mainstem Habitat Lost	> 75%	2 25-50%	6 < 25%	10 Sloughs, off channel areas
		4- % Estuary Disconnected From Floodplain	> 75%	2 25-50%	6 < 25%	10 Disconnected from floodplain
		5- % Covered by Aquatic Exotic Plants	> 25%	2 10-25%	6 < 10%	10 Primarily Spartina
		6- Hydrology (Amount of Water Arriving In Estuary)				
		Only one score depending on whether there has been a net increase or decrease	> 50%	2 10-50%	6 < 10%	10 % Reduction in Average Annual Flow
				OR		
			> 50%	2 10-50%	6 < 10%	10 % Increase in Average Annual Flow
		7- Hydrology (% Deviation From Natural Flow Patterns)	Large	2 Medium	6 High	10 Subjective rating
		8- Water quality (Subjective)	Poor	2 Fair	6 Good	10 Subjective rating
		Overall Zone Rating				
		Good	73-100			
		Fair	48-72			
		Poor	20-47			
Nearshore Marine	Zone bounded by the edge of the delta to the boundary of the photic zone and continuing along the shore to a point halfway to the next estuary.	% Diked or Bulkheaded	> 66%	2 33-66%	6 < 33%	10
		Docks/km of Shoreline	> 10	1 4 to 9	3 < 4	5
		% Intact Riparian Zone	< 25%	1 25-50%	3 > 50%	5 Defined as within 100 ft of MLLW
		% Covered by Exotic Aquatic Plants	> 25%	1 10-25%	3 < 10%	5
		Overall Zone Rating				
		Good	19 to 25			
		Fair	12 to 18			
		Poor	5 to 11			

	Small	Large	
Overall Estuary Rating			In small estuaries zones 1 and 2 are combined into a single score.
Good	**92-125**	**164 to 225**	
Fair	**60-91**	**107 to 163**	
Poor	**25-59**	**65 to 106**	

Notes:

See Summer Chum Report from Hood Canal
Consider this a first order approximation
Vegetation zones will need to be more precisely defined but they should be more or less delineated in a field day.
All area calculations should be based upon the historically defined estuarine area and its associated floodplain.
Reveted and levees may be correlated with mainstem and off channel habitat lost.
One problem is that this is weighed heavily in favor of the marsh part of the estuary. The nearshore is diminished in importance. Will need to weigh this somehow.

Table 40. Summary of Chehalis Basin Limiting Factors Results

Stream Name	Fish Passage	Floodplain Conditions	Sediment: gravel quantity	Sediment: gravel quality	Channel Stability	Instream LWD (quantity)	Riparian	Water Quality	Water Quantity	Biological Processes
Grays Harbor Estuary		Good		NA	NA	Poor (DG)	NA	Poor		Good
Humptulips Sub-Basin	DG									Poor (DG)
Humptulips Mainstem		Good (DG)	Poor (DG)	DG	DG	DG	Poor (DG)	Poor	Good in lower; Poor in middle	
Big Creek		Poor (DG)	DG	DG	DG	DG	DG	DG	DG	
Stevens Creek		DG	Fair (DG)	DG	DG	DG	Poor (DG)	DG	Good	
East Fork Humptulips		Poor (DG)	Poor	Poor	DG	Good in mainstem, Poor in tribs	Good in upper, Poor in lower	Poor	Good	

Stream Name	Fish Passage	Floodplain Conditions	Sediment: gravel quantity	Sediment: gravel quality	Channel Stability	Instream LWD (quantity)	Riparian	Water Quality	Water Quantity	Biological Processes
West Fork Humptulips		Poor (DG)	Poor	Poor	DG	Good in mainstem, Poor in tribs	Good in upper, Poor in lower	Poor	Good	
Chehalis Mainstem	Good	Poor from Mid-Upper (DG)	Poor	DG	DG	Poor (DG)	Poor (DG)	Poor	Poor	
Elk River	DG	Good	Poor	DG	DG	DG	Good (DG)	Good	Poor	DG
Johns River	DG	Good	Poor	DG	DG	DG	Good lower; Fair middle; Poor upper (DG)	Good	Good	DG
Newskah Creek	DG	Fair-Good	DG	DG	DG	DG	DG	DG	DG	DG
Hoquiam River	DG	Poor lower; Fair-Good upper	Poor	DG	DG	DG	Poor lower (DG)	Fair (DG)	Poor	

Stream Name	**Fish Passage**	**Floodplain Conditions**	**Sediment: gravel quantity**	**Sediment: gravel quality**	**Channel Stability**	**Instream LWD (quantity)**	**Riparian**	**Water Quality**	**Water Quantity**	**Biological Processes**
WF Hoquiam R	DG			DG	DG	DG	Fair-Good (DG)			
MF Hoquiam R	DG			DG	DG	DG	Fair (DG)			
EF Hoquiam R	DG		Fair	DG	DG	DG	Poor (DG)			
Little Hoquiam	DG			DG	DG	DG	Fair			
Wishkah R	DG	Poor lower; Fair-Good upper	Poor lower; Fair upper	DG	DG	DG	Poor lower; Fair upper	Good (DG)	Poor lower; Good upper	
Wynoochee R	DG	Poor lower (DG)	Poor	DG	DG	DG	Poor lower; Poor-Good upper	Poor	Poor	Good (DG)
Wedekind, Black, Helm, Sylvia Cr	DG	Good (DG)	DG	DG	DG	DG	DG	DG	DG	DG

Stream Name	**Fish Passage**	**Floodplain Conditions**	**Sediment: gravel quantity**	**Sediment: gravel quality**	**Channel Stability**	**Instream LWD (quantity)**	**Riparian**	**Water Quality**	**Water Quantity**	**Biological Processes**
Satsop Sub Basin			Poor in mainstem				Poor in mainstem		Poor in mainstem	Fair (DG)
WF Satsop	Poor (DG)	DG	Poor	Poor	Poor	Poor	Poor	Poor	DG	
MF Satsop	Poor (DG)	DG	Poor (DG)	DG	Poor (DG)	Poor (DG)	Poor (DG)	DG	Poor	
EF Satsop	DG	DG	Poor (DG)	Fair (DG)	DG	DG	Poor (DG)	Poor	Good	
Newman/Vance	DG	Poor (DG)	Poor (DG)	DG	DG	DG	Poor (DG)	DG	Poor (DG)	DG
Workman Cr	DG	Poor (DG)	Poor (DG)	DG	DG	Poor (DG)	Poor (DG)	DG	Poor (DG)	DG
Delezene Cr	DG	Poor (DG)	Poor (DG)	DG	DG	Poor (DG)	Poor (DG)	DG	Poor (DG)	DG
Cloquallum Cr	DG	Poor (DG)	Poor (DG)	DG	DG	DG	Poor (DG)	DG	Poor (DG)	DG
Wildcat Cr	DG	Poor (DG)	Poor (DG)	DG	DG	DG	Poor (DG)	Poor	Poor (DG)	DG

Stream Name	**Fish Passage**	**Floodplain Conditions**	**Sediment: gravel quantity**	**Sediment: gravel quality**	**Channel Stability**	**Instream LWD (quantity)**	**Riparian**	**Water Quality**	**Water Quantity**	**Biological Processes**
Mox Chehalis	DG	DG	Poor (DG)	DG	DG	Poor (DG)	Poor (DG)	DG	Poor (DG)	DG
Sand Cr	DG	DG	DG	DG	DG	DG	Poor-Fair (DG)	DG	Poor (DG)	DG
Porter Cr	DG	DG	Fair (DG)	DG	DG	DG	Poor (DG)	DG	Good (DG)	DG
Gibson/Cedar	DG	Poor in Cedar (DG)	Fair (DG)	DG	DG	DG	Poor lower; Fair up (DG)	DG	Good (DG)	DG
Gaddis Cr	DG	Poor (DG)	Poor (DG)	DG	DG	DG	DG	DG	Poor (DG)	DG (likely poor)
Rock Cr	DG	Poor (DG)	Fair (DG)	DG	DG	DG (Suspect poor)	Poor (DG)	DG	Poor	DG
Williams Cr	DG	Poor (DG)	Poor (DG)	DG	DG	DG (Suspect poor)	Poor (DG)	DG	Poor	DG

Stream Name	Fish Passage	Floodplain Conditions	Sediment: gravel quantity	Sediment: gravel quality	Channel Stability	Instream LWD (quantity)	Riparian	Water Quality	Water Quantity	Biological Processes
Garrard Cr	DG	DG	Fair Low; Poor Up (DG)	DG	DG	DG	Poor (DG)	DG	Poor	DG
SF Garrard Cr	DG	DG		DG	DG	DG	Poor lower	DG	Poor (DG)	DG
Independence Cr	DG, Suspect Poor	DG	Poor (DG)	DG	DG	DG	Poor (DG)	Poor	Poor (DG)	DG
Lincoln Creek (Lower)	DG, Suspect Poor	Fair (DG)	Poor (DG)	DG	DG	DG	Poor (DG)	Poor	Poor	DG
Lincoln Creek (Upper)	DG, Suspect Poor	Fair (DG)	Poor (DG)	DG	DG	DG	Poor-Good (DG)	Poor	Poor	DG
Black R	Poor (DG)	DG	Poor (DG)	DG	DG	DG	Poor lower; Good upper (DG)	Poor	Poor	DG

Stream Name	**Fish Passage**	**Floodplain Conditions**	**Sediment: gravel quantity**	**Sediment: gravel quality**	**Channel Stability**	**Instream LWD (quantity)**	**Riparian**	**Water Quality**	**Water Quantity**	**Biological Processes**
Salmon Cr	DG	Suspect Poor (DG)	DG	DG	DG	DG	Good Lower; Poor Upper (DG)	DG	DG	DG
Waddell Cr	DG	DG	DG	DG	DG	DG	Mixed Poor-Good (DG)	DG	Poor (DG)	DG
Mima Cr	DG	DG	DG	DG	DG	DG	Mixed Poor-Good (DG)	DG	DG	DG
Beaver Cr	DG	Suspect Poor (DG)	DG	DG	DG	DG	Fair-Poor (DG)	DG	DG	DG
Allen Cr	DG	Suspect Poor (DG)	DG	DG	DG	DG	DG	DG	DG	DG
Scatter Cr	Good	Good	Poor	Poor	Poor	Good	Poor	Poor	Poor	DG
Prairie Cr	DG	DG	Poor (DG)	DG	DG	DG	Poor (DG)	DG	DG	DG

Stream Name	Fish Passage	Floodplain Conditions	Sediment: gravel quantity	Sediment: gravel quality	Channel Stability	Instream LWD (quantity)	Riparian	Water Quality	Water Quantity	Biological Processes
Skookumchuck River	DG	Fair in lower; Poor in upper	Poor	Poor in lower (DG); Good in upper	Poor in upper; DG in lower	Poor-Fair in upper; DG in lower	Poor	Poor	Poor	Poor (DG)
Hanford Creek	DG, Suspect Poor	Poor	Poor (DG)	Poor (DG)	DG	DG	DG	Poor	Poor	DG
China Creek	DG, Suspect Poor	Poor in lower; DG in upper	DG	Poor in lower reaches (DG)	DG	DG	DG	Poor	Poor (DG)	DG
Salzer Cr	DG	Poor in lower (DG)	DG	DG	DG	DG	DG	Poor	Poor	DG
Dillenbaugh Cr	DG	DG	DG	DG	DG	DG	DG	Poor	Poor	DG
Newaukum Sub-Basin									Poor (DG)	Fair (DG)

Stream Name	**Fish Passage**	**Floodplain Conditions**	**Sediment: gravel quantity**	**Sediment: gravel quality**	**Channel Stability**	**Instream LWD (quantity)**	**Riparian**	**Water Quality**	**Water Quantity**	**Biological Processes**
Newaukum Mainstem	DG, Suspect Poor	DG, Suspected Poor	Poor (DG)	Poor (DG)	DG	DG	Poor (DG)	Poor	Poor (DG)	Fair (DG)
North Fork Newaukum	DG, Suspect Poor	Fair (DG)	Poor	Good in upper, Poor in lower (DG)	DG	Good	Good in upper, Poor in lower	Poor	Good in upper; Poor in lower.	
Lucas Cr	DG	Poor (DG)	DG	Good	DG	Poor	Fair			
Middle Fork Newaukum	DG	DG	Poor (DG)	Poor (DG)	DG	DG	DG	DG	Poor (DG)	
South Fork Newaukum	DG, Suspect Poor	Poor (DG)	Poor	Good	DG	Good	Good in Upper, Fair in Middle, Poor in lower	Poor	Good in upper; Poor in lower.	
Scammon Cr	DG Suspect Poor	DG	Poor (DG)	DG	DG	DG	Poor (DG)	DG	Poor	DG

Stream Name	Fish Passage	Floodplain Conditions	Sediment: gravel quantity	Sediment: gravel quality	Channel Stability	Instream LWD (quantity)	Riparian	Water Quality	Water Quantity	Biological Processes
Stearns Cr	DG Suspect Poor	Poor (DG)	Poor (DG)	DG	DG	DG Suspect Poor	Poor (DG)	Poor	Poor	DG
Mill Cr	DG Suspect Poor	Good (DG)	Poor (DG)	DG	DG	DG	DG	DG	Poor	DG
Van Ornum Cr	Good	Good (DG)	Poor (DG)	DG	DG	DG	DG	DG	Poor	DG
Bunker Cr	DG	Fair (DG)	Poor (DG)	DG	DG	DG Suspect Poor	Poor (DG)	Poor	Poor	DG
Deep Cr	DG.	Fair (DG)	Poor (DG)	DG	DG	DG	Poor (DG)	DG	Poor	DG
South Fork Chehalis River										Good (DG)
SF Mainstem	DG. Suspect Poor in tribs.	Fair (DG)	Poor (DG)	DG	Poor (DG)	Poor (DG)	Poor (DG)	Poor	Poor (DG)	

Stream Name	Fish Passage	Floodplain Conditions	Sediment: gravel quantity	Sediment: gravel quality	Channel Stability	Instream LWD (quantity)	Riparian	Water Quality	Water Quantity	Biological Processes
Lake Creek	DG. Suspect Poor.	Good (DG)	Poor (DG)	DG	Good (DG)	Poor (DG)	Poor (DG)	DG. Suspect Poor	Poor (DG)	DG
Stillman Creek	DG	Fair (DG)	Poor	Fair	Poor	Poor	Poor	Poor	Good (DG)	DG
Upper Chehalis River & Tribs	DG. Suspect Poor.			Good		Poor in mainstem	Poor-Fair along mainstem	Poor in ms		Good (DG)
Hope, Marcuson, Rock Creeks	DG	DG	Poor (DG)	Poor (DG)	Poor (DG)	Poor (up Marcuson Fair) (DG)	Fair (DG)	DG	Poor (Hope, Rock)	DG
Elk Creek & tributaries	DG	Poor (DG)	Poor (DG)	Poor (DG)	Poor (DG)	Poor Lower; Good in tribs (DG)	Poor in Lower (DG)	DG	Poor (DG)	DG
Crim/Lester	Poor	DG	Poor (DG)	Poor	DG	Poor in Crim; Fair in Lester	Poor-Fair	Poor	DG	DG
Roger Creek	Good	Fair	Poor (DG)	Poor	Poor	Poor	Poor	Good	DG	DG

Stream Name	Fish Passage	Floodplain Conditions	Sediment: gravel quantity	Sediment: gravel quality	Channel Stability	Instream LWD (quantity)	Riparian	Water Quality	Water Quantity	Biological Processes
Big Creek	Good	Good	Poor	Poor in lower	DG	Poor	Poor	Poor	DG	DG
Thrash Creek	Poor	Good	Poor	Poor	Poor	Poor	Poor	Poor	DG	DG
Cinnabar Creek	Good	Good	DG	Poor	DG	Poor	Fair	Poor	DG	DG
George Creek	Poor	Fair	Poor	Poor	Poor	Poor	Fair	Poor	DG	DG
West Fork Chehalis	Poor	Good	DG	Poor	DG	Fair	Fair	Poor	Good	DG
East Fork Chehalis	Poor	Good	DG	Poor	Poor	Poor	Fair	Poor	Good	DG

DG = Data Gap
DG after a rating = Limited data available for rating. Rating was made with some uncertainty.
NA = Not Applicable

SALMON AND STEELHEAD HABITAT RESTORATION STRATEGY FOR THE CHEHALIS AND NEARBY DRAINAGES (WRIAS 22-23)

Introduction

The purpose of this strategy is to maximize our efforts to protect and restore salmonid habitat within WRIAs 22 and 23, which includes all of the Chehalis drainage, as well as the independent watersheds that drain into Grays Harbor. We first prioritized across sub-basins to focus efforts towards areas that will be most able to meet our underlying goals, then prioritized restoration actions and studies that are needed for each sub-basin. The goals are defined below, along with the data that we used to represent those goals. We reviewed a wide spectrum of data available to us, and chose data that met these criteria.

- The data must represent a goal.
- The data must be available for at least most, preferably all, of the tributaries that drain into the Chehalis River or Grays Harbor.
- The data should be specific to (collected from) the drainage it represents.

Goals

Our initial level of prioritization is based upon goals and data regarding the salmonid resource to provide the greatest benefit to fish. This produces our first tier of prioritization, which sorts sub-basins into groups of "high", "medium", or "low". Each of the goals and representative data are discussed below.

Primary Prioritization

1) **A high priority goal is to contribute to the biological diversity of salmonid stocks within Washington State.** Within the Chehalis region, we have numerous distinct stocks of salmonids that are important to the overall biological diversity in Washington State. These include one stock of spring chinook, one stock of summer chinook, seven stocks of fall chinook, two stocks of fall chum, seven stocks of coho salmon, two stocks of summer steelhead, and eight stocks of winter steelhead (WDFW and WWTIT 1994). In addition, cutthroat trout are found throughout the drainage, and bull trout have been documented as present, but specific distribution data do not exist. In order to achieve the goal of maintaining biological diversity, we will prioritize efforts that provide benefit to the greatest number of salmon and steelhead stocks.

2) **A high priority goal is to promote salmonid abundance by focusing efforts in larger sub-basins that have the greatest quantity of fish habitat.** The Chehalis and nearby drainages have important salmonid resources not only in terms of biological diversity, but also in terms of abundance. The Chehalis drainage is an important coho salmon producer. Estimates for the 1999 smolt production listed the

Chehalis drainage as the third highest coho smolt producer in Washington State (Seiler 2000). Some sub-basins within this region produce far more quantities of salmonids than others do. Because of this, restoration and protection of important habitat, such as functional floodplain, could have different fish abundance results depending on where the project is based. For example, having a functional floodplain in a sub-basin that produces large numbers of salmonids, such as the Satsop River, would have a greater overall benefit to the fish resource from the abundance perspective, than a similar set of actions in nearby Newman Creek. Sub-basins that have greater quantities of known salmon and steelhead habitat in terms of linear stream miles, referred to as "fish miles" will be prioritized above sub-basins with lower quantities of fish miles.

Sub-Basin Prioritization

Table 41 lists the sub-basins within WRIAs 22 and 23, and defines whether they are a "high", "medium", or "low" priority based upon number of salmon and steelhead stocks and number of miles of known salmon and steelhead habitat.

Table 41. Sub-Basin Prioritization within the Chehalis and Nearby Drainages.

High Priority Sub-Basins (fish scores of 12)	**Medium Priority Sub-Basins** (fish scores of 8-10)	**Low Priority Sub-Basins** (fish scores of 6 or less)
Chehalis River Mainstem	Upper Chehalis/tribs (upstream of Pe Ell)	Porter Sub-Basin
Grays Harbor Estuary	Johns River Sub-Basin	Cedar Creek Sub-Basin
Satsop Sub-Basin	Cloquallum Sub-Basin	Stearns Sub-Basin
Humptulips Sub-Basin	Elk Creek (WRIA 23) Sub-Basin	Bunker Sub-Basin
Wynoochee Sub-Basin	Mox Chehalis Sub-Basin	Rock Creek (near Crim Creek)
South Fork Chehalis Sub-Basin	Delezene Sub-Basin	Salzer Sub-Basin
Skookumchuck Sub-Basin	Rock/Williams Sub-Basin	Gibson Sub-Basin
Newaukum Sub-Basin	Garrard Sub-Basin	Newman/Vance Sub-Basin
Black River Sub-Basin	Lincoln Sub-Basin	Workman Sub-Basin
Hoquiam River Sub-Basin	Scatter Creek Sub-Basin	Independence Sub-Basin
Wishkah Sub-Basin	Elk River Sub-Basin	Dillenbaugh Sub-Basin
		Newskah, Charley, O'Leary, Stafford, Indian, Chapin Creeks

Ranking Rules

The rules for ranking the sub-basins based upon fish data are as follows. For number of salmon and steelhead stocks: 4-5 stocks = score of 6; 2-3 stocks = score of 4; 1 or less stocks = score of 2. For fish miles, >70 known linear fish miles = score of 6; 20-69 fish miles = score of 4; and <20 fish miles = score of 2. The scores for both parameters were summed to form the final score for between sub-basin prioritization, and those results are in Table 41. Appendix 1 shows the data for fish miles and number of stocks/sub-basin.

Secondary Prioritization (Restoration Actions and Assessments)

After sub-basins were prioritized relative to each other, restoration actions, protection recommendations, and assessments were prioritized as "high", "medium", or "low" for each sub-basin based upon the results in the Limiting Factors Report coupled with the professional judgement of the TAG. Generally, if a habitat condition was rated "poor" in the Limiting Factors Report, it was considered a "high" priority action. A "fair" habitat rating would result in a "medium" action recommendation. A "good" condition rating might result in either a "low" action or a "high" protection need, depending on the habitat category.

Data needs were also prioritized, based upon the probable impact in that category. For example, there is a broad-scale need for culvert/blockage inventories and assessments throughout the entire region. However, those assessments were given a higher priority in areas with known high road densities and/or stream crossings or where initial surveys suggest that blockages are a major problem. If a data need were identified to provide information that is desired, but not suspected to be a major problem for wild salmonid production, that assessment would be prioritized low. Professional judgement was also used to refine the ratings and provide more specific knowledge tailored to each sub-basin.

Action and Assessment Prioritization for each Sub-Basin

Lists of prioritized actions and assessments follow for each sub-basin within WRIAs 22 and 23. The sub-basins are organized from a downstream to upstream direction within the drainage.

Grays Harbor Estuary

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Estuary	Medium level of documented loss compared to Puget Sound.	**H** - Minimize the impacts of dredging on salmonid survival. **M** - Continue the Spartina eradication program in Grays Harbor.		
Floodplain Conditions		**H** - Reduce bank armoring along the lower reaches of rivers and in the estuaries, especially in the lower Wishkah and Hoquiam Rivers and along Johns River estuary. **H** - Reconnect the potential off-channel habitat in the lower Chehalis River as described in Ralph et al. 1994.	**H** - Protect the intact estuarine floodplain habitat in the lower Chehalis River (RM 13-20). **H** - Protect the Humptulips estuary and lower river from development within the floodplain.	**H –** Inventory and prioritize the estuarine shoreline, identifying good areas for preservation and areas for restoration.
Water Quality	Poor. Recent improvements but need to show link to salmonid survival.	**H** – Continue to enforce and monitor pollution discharge from mill effluent, following DOE's pollution discharge permit. **H** - Follow the recommendations of the future TMDL for dioxin.		**H** - Assess smolt survival in the inner harbor and compare to Humptulips smolt survival to see if water quality improvements have been successful in improving Chehalis coho smolt survival. **M** - Monitor eelgrass habitat in Grays Harbor to determine trends and salmonid use.
LWD		**L -** Introduce LWD in the estuary between the Wishkah and Hoquiam Rivers and in the lower tidal zone of rivers.	**H –** Prevent removal of appropriate pieces of LWD through increased education and enforcement.	
Nearshore		**H** - Discourage the development of seawalls along the coastline		

Mainstem Chehalis River

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	Good, except for potential temperature blockage near Centralia.	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages. **H** – Address potential water temperature blockage to juveniles and adults during the summer and fall low flow conditions.		**L -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **L** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor from mid to upper (DG). Known problems: incision, limited rearing habitat, bank protection (dikes).	**H** - Reconnect or create over-wintering, refuge habitat. **H** - Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes Appropriate riparian restoration to result in better future LWD levels. **H** – Remove riprap.	**H** - Conserve existing refuge, over-winter areas, especially the lower 10 miles of mainstem slough habitat identified in Ralph et al. (1994). **H** – Purchase flood easements from agricultural interests, let river flood here. **M** – Preserve beaver dams**.**	**H** - Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory. Use information to guide future projects and to provide a more accurate rating of mainstem floodplain conditions. **H** – Identify refuge areas.
Sediment	Poor. Known problems: high sediment transport, debris torrents, bank erosion.	**H** - Reduce sediment loads and increase LWD to slow sediment transport in the Satsop, Wynoochee, upper Chehalis (upstream of Doty), South Fork Chehalis, and Newaukum sub-basins. These contribute the greatest sediment loads to the mainstem. **M -** Provide education regarding the impacts livestock access and increase	**H** - Avoid activities that would increase sedimentation along the left bank (looking downstream) of the mainstem from RM 11.5-21. This is an area prone to landslides and erosion. **M** – Provide incentives for landowners to preserve spawning areas.	**H** - Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **M** – Survey cross-sections of the river every 2-5 years to determine extent of channel changes.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		enforcement. **H** – Rehabilitate old roads not used to reduce fines. **H** – Reduce bank erosion (riparian restoration, livestock exclusion, engineered logjams to deflect flows from eroding banks, etc.). **H** – Relocate gravel extraction activities away from shorelines and the 100-year floodplain.		
LWD	Poor (DG)	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. In the mainstem, the most viable option in most reaches is increasing natural recruitment through riparian restoration. In some areas, trees with attached rootwads could be placed in banks to help capture migrating pieces.	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (E.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement)
Riparian	Poor (DG). Known Problems: riparian loss, conversion to hardwoods.	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. Prioritize as follows 1) mainstem between Newaukum River and Skookumchuck River, 2) mainstem between Skookumchuck River and Scatter Creek, 3) mainstem between Scatter Creek and Porter, 4) mainstem from Elk Creek to Newaukum River, 5) mainstem headwaters to Elk Creek, and 6) all other mainstem reaches. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H –** Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Water Quality	Poor. Known problems: warm water temperatures, low dissolved oxygen (causes: low flows, riparian loss, sediment loads, livestock waste, urban stormwater).	**H** - Actions need to address sediment, riparian, and flow problems. Follow prioritized riparian restoration recommendations discussed above to improve water temperature conditions. **H** - Reduce livestock access to streams. **H** - Reduce livestock waste delivery to streams, especially in reaches from Porter to Scammon Creek, and from the Newaukum River to the East and West Fork confluence. **H** - Prioritize livestock waste reduction in the following tributaries in this order: 1) Salzer Creek, 2) Dillenbaugh Creek, 3) South Fork Chehalis River, 4) Black River, 5) Lincoln Creek, 6) Independence Creek, and 7) Scatter Creek. These tributaries contribute high BOD loads that result in low dissolved oxygen levels in the mainstem. **H** - Reduce urban stormwater and food processing plant inputs into the drainage near the cities of Centralia and Chehalis to improve dissolved oxygen conditions. **H** - Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat. **L** - Reduce groundwater inputs of contaminants, especially near Aberdeen, Hoquiam, Centralia, and	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity. **H** – Preserve riparian areas. **H** – Buy water rights that result in actual increases in stream flow (senior rights preferred).	**H** – Continue to monitor water temperature, dissolved oxygen, pH, and turbidity and several sites throughout the length of the mainstem.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		Chehalis. Address failing septic systems and improve agricultural practices near Montesano, Elma, the Chehalis Indian Reservation, and near Dillenbaugh and Berwick Creeks.		
Water Quantity	Poor. Known problems: low flows due to water use, loss of wetlands, loss of forestlands.	**H** - Reduce water withdrawals from surface sources. **H** - Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H** -Restore wetlands and off-channel habitat. **H** – Buy back water rights, prioritizing those that actually increase stream flow (senior rights). **H** - Encourage and reward water conservation efforts, especially for irrigation, hydropower, and domestic use (the three greatest water consumers in the drainage).	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity. **H** – Implement a moratorium on any further withdrawals.	**L** – Install staff gauges in the lower mainstem, and monitor stream flows.
Biological Processes	Known problems: need more complete salmonid escapement information, also lowered escapements from past levels.	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses. **H** – Catalog pools, ripples, spawning rearing areas and use by species.	**H** - Continue escapement data collection.	**H -** Increase field surveys regarding salmonid distribution, escapement and habitat use by life history stage. **L -** Assess marine-derived nutrient processes. **H** – Collect data on fish use and stream characteristics.

Humptulips Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. Known problems: Fair road density (2.8 mi/sq mi).	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**M -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **M** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor in WF & EF; Good in mainstem. Known problems: incision, limited off-channel habitat.	**H** - Reconnect potential off-channel habitat. **H** - Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, conserve and prioritize off-channel and side channel habitat and associated riparian.	**M -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG). Known problems: landslides caused by roads, bank erosion in lower reaches.	**H** - Improve road drainage at areas identified in watershed analysis. **H** - Decommission road segments that are at high risk of causing landslides (watershed analysis). **H** - Increase protection of steep and unstable slopes. **H** - Stabilize and revegetate exposed mass wasting sites to reduce surface erosion. **H** – Relocate gravel extraction activities away from shorelines and the		**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **M** - Identify sites, extent, and restoration actions for bank erosion downstream of the forks.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		100-year floodplain. **H** - Reduce livestock access to streams, especially to the mainstem Humptulips River and Deep Creek.		
Current Instream LWD	Good in mainstem; Poor in tributaries.	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places in the tributaries. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement)
Riparian	Poor except in upper EF and upper WF. Known problems: riparian loss and conversion to hardwoods.	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer and hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H –** Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions in the reaches downstream of the EF and WF confluence.
Water Quality	Poor. Known problems: warm water temperatures (likely due to poor riparian conditions).	**H** - Actions need to address sediment and riparian problems. **H** - Reduce livestock access to streams, especially to the mainstem Humptulips River and Deep Creek. **H** - Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Monitor water temperature, dissolved oxygen, pH, and turbidity.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Water Quantity	Good in most areas. Concern about peak flows.	**M -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**M** - Reinstate the flow monitoring gage in the Humptulips River and monitor stream flows.
Biological Processes	Poor	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys regarding salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Hoquiam River Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG Poor road density (3.6 miles/square mile)	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species throughout all life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dams, dikes, railroad grades, etc.). Passage structures should be designed to allow passage for all fish species throughout all life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data. **H** – Assess fish passage at dam.
Floodplain Conditions	Poor in lower (developed); fair to good in upper (DG).	**H** - Reconnect potential off-channel habitat. **H** - Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H -** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG) except in EF where it is rated fair. High road density.	**H**- Decommission roads at risk of landslides, especially side-cast roads. **H** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Increase protection of steep and unstable slopes. **H** - Stabilize and revegetate exposed mass wasting sites to reduce surface erosion. **L** – Reduce livestock access. **H** – Address the issues of coarse sediment blockage by dam and ramping rates for minimal sediment input.		**H -** Inventory roads and assess impacts to salmonids as well as prioritize restoration actions.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
LWD	DG	**M -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Poor in lower reaches and in EF; fair-good elsewhere. Lower reaches impacted by development.	**H -** Revegetate open riparian areas with native plants including conifers in historical/appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer/hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	Fair (DG)	**M** - Actions need to address sediment, riparian, and flow problems. **L** - Reduce livestock access to streams. **M** - Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **M** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**M -** Conduct water quality assessment to determine specific sources attributing to water quality issues, and identify activities to correct water quality. **M** - Monitor water temperature, dissolved oxygen, pH, and turbidity in each major fork of the Hoquiam River.
Water Quantity	Poor (DG) based on hydrologic maturity.	**H** - Reduce water withdrawals from surface sources **H** - Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. H -Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Install a stream flow gage and monitor stream flow.
Biological Processes		**L-** Increase contribution of marine –derived nutrients through increased use of carcasses.		**H -** Increase field surveys regarding salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Wishkah River Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG High road density (3.36 miles/square mile)	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species throughout all life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dams, dikes, railroad grades, etc.). Passage structures should be designed to allow passage for all fish species throughout all life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data. **H** – Assess fish passage at dam.
Floodplain Conditions	Poor in lower (developed); fair to good in upper (DG).	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H -** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG) in lower; fair (DG) in upper. High Road density, timberland in upper reaches, landslides related to sidecast roads.	**H**- Decommission roads at risk of landslides, especially side-cast roads. **H** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Increase protection of steep and unstable slopes. **H** - Stabilize and revegetate exposed mass wasting sites to reduce surface erosion.		**H -** Inventory roads and assess impacts to salmonids as well as prioritize restoration actions.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		L – Reduce livestock access. **H** – Address the issues of coarse sediment blockage by the dam and ramping rates for minimal sediment input.		
LWD	DG	**M -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration)..	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Poor in lower; fair in upper. Landuse = Predominately timberland in upper Wishkah Lower 3 miles impacted by development	**H -** Revegetate open riparian areas with native plants including conifers in historical/appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer/hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	Good	**L** - Actions need to address sediment, riparian, and flow problems. **L** - Reduce livestock access to streams. **L** - Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **L** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**L -** Conduct water quality assessment to determine specific sources attributing to water quality issues, and identify activities to correct water quality.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Water Quantity	Poor in lower; Good in upper based on hydrologic maturity.	**H -** Reduce water withdrawals from surface sources **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**M** – Install a stream flow gage, and monitor stream flows.
Biological Processes		**L-** Increase contribution of marine –derived nutrients through increased use of carcasses.		**H -** Increase field surveys regarding salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Johns River Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG, high road density	**H-** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H-** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**M-** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **M**- Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Good (DG)	**L**- Reconnect potential off-channel habitat. **L-** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, prioritize, and conserve off-channel and side channel habitat and associated riparian.	**L-** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG). High road density> 3 mi./sq. mi., high landslide potential.	**H** – Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc.	**H** - Enforce forest practice regulations.	**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **H** - Assess sediment delivery and source in upper reaches of sub-basin. Prioritize restoration actions.
LWD	DG	**L-** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**L**- Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
				valley confinement)
Riparian	(DG) Good in lower Johns; Fair in middle reaches, and poor in upper Johns due to timber harvest practices.	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H-** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	Good (DG) but likely poor in Newskah Creek.	**H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **M** - Remove cedar waste (spaults) from Newskah Creek. **L**- Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**M** - Clarify sources of fecal load. **M** - Monitor water temperature, dissolved oxygen, pH, and turbidity.
Water Quantity	Good (DG)	**M -** Reduce water withdrawals from surface sources. **M -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **M -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**L** – Monitor stream flow.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys regarding salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Elk River Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG, high road density	**H-** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H-** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**M-** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **M**- Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Good (DG)	**L**- Reconnect potential off-channel habitat. **L-** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, prioritize, and conserve off-channel and side channel habitat and associated riparian.	**L-** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG). High road density> 3 mi./sq. mi., high landslide potential.	**H –** Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc.	**H** - Enforce forest practice regulations.	**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **H** - Assess sediment delivery and source in upper reaches of sub-basin. Prioritize restoration actions.
LWD	DG	**L-** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**L**- Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		(riparian restoration).		structure size, gradient, near term LWD recruitment potential, and valley confinement)
Riparian	Good (DG)	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H-** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	Good (DG).	**H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **L**- Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**L** – Monitor water temperature, dissolved oxygen, pH, and turbidity. **L** - Clarify sources of fecal load.
Water Quantity	Poor (DG)	**M -** Reduce water withdrawals from surface sources. **M -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **M -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Monitor stream flow.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid escapement, distribution, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Wynoochee River Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. High road density in lower reaches, medium density in upper reaches.	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	DG – Poor in lower.	**H** - Reconnect potential off-channel habitat. **H** – Reconnect off-channel habitat identified in Ralph et al. (1994). **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H -** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment: Spawning gravel quantity	Poor, except in upper reaches. High road density, high bank erosion, landslides.	**H**- Decommission roads at risk of landslides, especially side-cast roads. **H** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Increase protection of steep and unstable slopes. **H** - Stabilize and revegetate exposed mass wasting sites to reduce surface	**H** – Preserve beaver dams in lower 28 miles.	**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **H** – Further study on WIN data.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		erosion. **H –** Relocate gravel extraction activities away from shorelines and the 100-year floodplain. **H** – Reduce livestock access to Black Creek.		
LWD	DG	**M -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (E.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement) **M** – Characterize LWD in basin.
Riparian	Poor in lower; poor-fair in middle; good in upper.	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to-late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Preserve good riparian areas in upper.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	Poor. Warm water temperatures	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to Black Creek. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Continue water quality monitoring, water temperatures, dissolved oxygen, pH, turbidity.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Water Quantity	Poor. Poor hydrologic maturity, dam operation, water withdrawals.	**H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H** – Dam operations should emulate natural flow conditions during adult migration and juvenile emigration periods. **H -**Restore wetlands and off-channel habitat**.** **H** – Restore water quantity and buy back water rights.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity. **H** – Place a moratorium on further water withdrawal.	**H** – Continue stream flow monitoring
Biological Processes	Good	**L -** Increase contribution of marine –derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid escapement, distribution, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Satsop Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG (Suspect Poor). Known problems: high road density (4 mi/sq mi), limited refuge habitat.	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks. **H -** Prioritize the restoration of culverts blocking passage in the WF and MF Satsop due to limited winter refuge. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	DG. Known problems: limited refuge habitat.	**H** - Reconnect potential off-channel habitat. Follow recommendations in Ralph et al. 1994. **H** - Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG). Known problems: very high sediment loads (sidecast roads) and sediment transport, high road densities,	**H**- Decommission roads at risk of landslides, especially side-cast roads. **H** – Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Increase protection of steep and		**H -** Inventory roads and assess impacts to salmon and steelhead as well as prioritize restoration actions. **H** - Inventory and prioritize sediment sources in the MF and EF Satsop watersheds.

	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
	and low LWD.	unstable slopes. **H** - Stabilize and revegetate exposed mass wasting sites to reduce surface erosion. **H** – Relocate gravel extraction activities away from shorelines and the 100-year floodplain. **H** - Reduce livestock access to streams, especially in Drybed, Decker, Bingham Creeks and the West Fork and East Fork Satsop Rivers. **L -** Provide education regarding the impacts of vehicle activity in streams and increase enforcement.		
LWD	Poor in WF, DG elsewhere. Known problems: low LWD.	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring or recruiting in the system. Priority should be given to the WF and MF watersheds.	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement)
Riparian	Poor (DG, based upon coarse data). Known problems: riparian loss, conversion to hardwoods.	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer and hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Continue enforcement and revision of current regulations that preserve and	**H** - Assess and prioritize recovery and protection for riparian conditions in all areas of the Satsop except in the WF.

	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
			enhance riparian regeneration.	
Water Quality	Poor, with some data gaps. Known problems: warm water temperatures likely due to poor riparian conditions, and high turbidity, related to sedimentation.	**H** - Actions need to address sediment, riparian, and flow problems. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Reduce livestock access to streams, especially in Drybed, Decker, Bingham Creeks and the West Fork and East Fork Satsop Rivers. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**M** - Monitor water temperature, dissolved oxygen, pH, and turbidity in each fork of the Satsop River.
Water Quantity	Poor in mainstem and MF; DG in WF; Good in EF. Known problems: increased peak flows, reduced hydrologic maturity, high risk of scour.	**H** - Actions need to address sediment, riparian, and flow problems. **H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Investigate and prioritize causes of low summer flow in the lower Satsop River. **M -** Monitor scour in the WF, MF, and mainstem Satsop.
Biological Processes	Fair	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid escapement, distribution, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Newman Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. High road density (4.71 miles of road/square mile watershed)	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor (DG). Road impacts, landuse conversion, splash dams, bank armoring, and channelization.	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, prioritize, and conserve off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG). High road density, Some areas of excessive bank erosion.	**L -** Provide education regarding the impacts of vehicle activity in streams and increase enforcement. **H** – Decommission/relocate high impact side-cast and stream adjacent parallel roads. **H** – Improve drainage to high impact roads to reduce direct sediment delivery to streams. **H** – Reduce livestock access to both Vance Creek and Newman Creek. **H** – Prioritize existing bank armoring projects for removal/modification.		**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **H** - Inventory extent and causes of bank erosion and prioritize restoration actions.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
LWD	DG	**M -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration)..	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement)
Riparian	Poor (DG) 91% is in poor condition.	**H -** Revegetate open riparian areas with native plants including conifers in historical/appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	DG Poor riparian conditions	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to both Vance Creek and Newman Creek. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H -** Conduct water quality assessment (temperature and dissolved oxygen), and identify activities to correct water quality problems.
Water Quantity	Poor (DG). Poor hydrological maturity.	**H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Install flow gauge and monitor stream flows.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		H -Restore wetlands and off-channel habitat**.**		
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys regarding salmonid distribution, escapement and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Cloquallum Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. Road density is high (4.5 mi/sq mi).	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor (DG). Known problems include rip-rap, channel incision, and roads.	**H** - Reconnect potential off-channel habitat. **H** – Reduce bank armoring. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, conserve, and prioritize off-channel and side-channel habitat and associated riparian. **H -** Develop and enforce Critical Areas Ordinances.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG). Known problems are high road density, bank erosion, logging impacts, livestock access.	**H** – Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **L -** Provide education regarding the impacts of vehicle activity in streams and increase enforcement. **M** - Provide education regarding the impacts of livestock. **H** - Reduce livestock access to	**H**. Allow forestlands to regenerate as per new forest practice regulations.	**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **H** - Assess bank failures, bulkhead and channel confinement, and riparian conditions, and prioritize restoration actions accordingly.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		Cloquallum River. **H** - Reduce roads and logging activities in sensitive areas near stream.		
LWD	DG. High peak flows, loss of riparian, channel incision.	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement. **H -** Allow forestlands to regenerate as per new forest practice regulations.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement). **H** - Assess to determine size, amount, and location or needed LWD.
Riparian	Poor	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas. **H** - Fence and revegetation where needed. **L** – Address human-caused bank erosion in a fish-friendly manner, where protection of private property is desired.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	DG (Known Poor in Wildcat). Warm water temps in Wildcat. Poor	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to Cloquallum River.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H -** Monitor water temperature, dissolved oxygen, pH, and turbidity.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
	riparian throughout. Livestock access a problem.	**H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat. **H** – Reduce sediment inputs from roads. **H** – Reduce waste inputs (livestock and urban).		
Water Quantity	Poor (DG). Poor hydrologic maturity and Wildcat Creek is a "closed" stream.	**H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Install stream flow gage and assess summer low flows, documenting human impacts.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys regarding salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Mox Chehalis Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG High road density (4.7 mi/sq mi).	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor (DG) Rip-rap, confined by roads, filled and rerouted.	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels **H** - Fence livestock and reconnect/reconstruct off-channel habitat.	**H -** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian. .	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory. **H** - Assess agricultural effects, road effects, residential effects
Sediment	Poor (DG) High road density, road confinement, bank erosion, Excessive sediment, vehicle activity.	**H** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **L -** Provide education regarding the impacts of vehicle activity in streams and increase enforcement. **M** - Provide education regarding the impacts of livestock. **H** - Reduce livestock access.	**H** - Allow watershed time to recover from logging.	**H -** Inventory roads and assess impacts to salmon and steelhead as well as prioritize restoration actions. **H** - Assess bank failures, LWD, bulkheads and bank confinement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
LWD	Poor (DG)	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).. **H** - Increase conifers in riparian zones.	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Poor (DG)	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas. **H** - Fence and revegetation where needed.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations.	**H** - Assess and prioritize recovery and protection for riparian conditions. **H** - Assess cause of riparian degradation (it is listed as unknown).
Water Quality	DG. Poor riparian, livestock access, road run-off.	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to streams. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat. **H** - Fence livestock and reduce road activities that contribute to sediment. Revegetate riparian.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H -** Review and assess water temperature, dissolved oxygen, road runoff, livestock access, and riparian degradation.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Water Quantity	Poor (DG). Poor hydraulic maturity, low summer flows.	**H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Install stream flow gage, and monitor stream flow. **H** - Assess summer flows, water withdrawals, and water rights.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid escapement, distribution, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Workman Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. High road density (4.6 mi/sq mi)	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor (DG). Incision due to splash dams & historic logging practices.	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H -** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory. **H** - Assess and prioritize existing off-channel areas that are disconnected due to main channel incision.
Sediment	Poor (DG). Mass wasting, high road density, bank erosion, livestock impacts.	**H**- Decommission roads at risk of landslides, especially side-cast roads. **H** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Increase protection of steep and unstable slopes.	**H** - Reduce activities in sensitive areas near stream.	**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **H** - Assess mass wasting locations, bank failures, and sensitive geographic areas.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		H - Stabilize and revegetate exposed mass wasting sites to reduce surface erosion. **M** - Reduce livestock access to streams.		
LWD	Poor (DG). Reduced due to splash dams And logging practices.	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).. **H** - LWD needs to be of appropriate size.	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement)
Riparian	Poor (DG) Logging impacts	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H –** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. .	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	DG Poor riparian, livestock access, road runoff.	**H** - Actions need to address sediment, riparian, and flow problems. **M** - Reduce livestock access to streams. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity. **M** - Reduce roads and logging in sensitive areas near streams.	**H** - Monitor water temperature, dissolved oxygen, pH, and turbidity.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		H - Restore wetlands and off-channel habitat.		
Water Quantity	Poor (DG). Poor hydrological maturity.	**H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity. **M** - Maintain remaining riparian vegetation along stream. **M** - Enforce new Timber regulations	**H** -Install stream flow gage and monitor stream flow.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys regarding salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Delezene Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. High road density (4.6 mi/sq mi).	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data. **H** - Conduct a thorough watershed assessment.
Floodplain Conditions	Poor (DG). Past splash dams and current rip-rap.	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian. **H** - Maintain recovering riparian zone	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory. **H -** Assess riparian and habitat conditions for spawning and rearing, and off-channel habitat. Determine current road density. **H** - Assess existing off-channel areas that are disconnected due to main channel incision.
Sediment	Poor (DG). High road density, high potential mass wasting and erosion area.	**H**- Decommission roads at risk of landslides. **H** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Increase protection of steep and unstable slopes. **H** - Stabilize and revegetate exposed mass wasting sites to reduce surface erosion. **L** - Reduce livestock access to streams. **H** - Reduce roads and logging activities	**H** - Stay clear of sensitive areas in upper watershed. Reduce logging near stream.	**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **H** - Assess mass wasting impacts and bank failures. Stream habitat assessment needed (banks, roads, LWD, riparian, etc.).

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		in sensitive areas near the stream.		
LWD	Poor (DG). Reduced due to splash dams and logging practices.	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration). **H** - If LWD is placed in-stream, use appropriate sized pieces with rootwads.	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement). Needs assessment to determine size and location based on recovery time of watershed
Riparian	Poor (DG)	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas. **L -** Mostly timber land in upper area, which has been replanted and mending in most areas. Will be functional in about 40 years.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **M** - Maintain currently functioning riparian. Reduce logging, road building near sensitive areas. **H** – Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	DG. Poor riparian (lack of shade) suggests this might be a problem. Livestock access. Also sedimentation may have degraded water quality.	**H** - Actions need to address sediment, riparian, and flow problems. **L** - Reduce livestock access to streams. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat. **H** - Reduce sediment loads by addressing roads/logging in sensitive areas and in areas of potential mass	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Monitor water temperature, dissolved oxygen, pH, and turbidity.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		wasting.		
Water Quantity	Poor (DG). Poor hydrologic maturity.	**M -** Encourage efforts to maintain and promote increased mature conifer land cover. **M –** Reduce water withdrawals from surface sources.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Install stream flow gage, and monitor stream flow.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys regarding salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Gaddis Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG Major culvert barrier complete in 2000, fair road density (2.7 mi/sq.mi)	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages. **L -** Replace undersized culverts under county road (these are not barriers).		**M -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **M -** Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor (DG) Incised from logging activities.	**H -** Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H -** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG) Fair road density, bank erosion, agricultural activity.	**H** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **M** - Reduce livestock access to streams. **L -** Provide education regarding the impacts of livestock.	**H** - Allow watershed to recover from logging	**H -** Inventory roads, bank erosion and causes, and livestock access, and assess impacts to salmonids and prioritize restoration actions accordingly.
LWD	DG	**M -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		(riparian restoration). **H -** Revegetate conifer in upper areas.		structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Poor (DG), loss of canopy cover in upper area, lacks assessment	**H -** Revegetation open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations.	**H -** Assess and prioritize recovery and protection for riparian conditions.
Water Quality	DG, livestock access, agricultural practices, fair road density	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to streams. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H -** Assessment to determine road impacts, livestock impacts and local farming practices.
Water Quantity	Poor (DG). Low summer flows, surging winter flows, scour.	**H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity. H Allow riparian areas to recover, Enforce new forest practices	
Biological Processes	DG (likely poor due to blocking culvert that was recently removed).	**H** - Nutrient enhancement is needed in the upper watershed due to past blocking culvert.		**H -** Increase field surveys regarding salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Rock/Williams Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. Road density is fair (2.7 mi/sq mi).	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**M -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **M** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor (DG). Rip-rap, channel incision due to logging and roads.	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Fair (DG) in Rock Creek; Poor (DG) in Williams Creek. Fair road density, livestock access in lower reaches. Bank erosion in	**M** – Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Reduce livestock access to both Rock Creek and Williams Creek. **L -** Provide education regarding the		**H -** Inventory roads and bank erosion, and assess causes and impacts to salmonids and prioritize restoration actions accordingly.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
	Williams.	impacts of livestock.		
LWD	DG (Suspect Poor). Limited numbers and type of LWD.	**H –** Priority depends on results in assessment. Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration)..	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement). **H** - Assess habitat conditions including LWD, riparian, and sediment.
Riparian	Poor (DG)	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions. **H** - Assess road density and riparian road impacts.
Water Quality	DG. Poor riparian, livestock access, roads.	**H** - Actions need to address riparian and flow problems. **H** - Reduce livestock access to both Rock Creek and Williams Creek. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H**- Restore wetlands and off-channel	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Monitor water temperature, dissolved oxygen, pH, and turbidity.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		habitat.		
Water Quantity	Poor (DG). Poor hydrologic maturity, low summer flows. “closed” to further appropriations.	**H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Install stream flow gage, and monitor stream flow.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys regarding salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Garrard Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG, fair road density (2.7 mi/sq mi).	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**M -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **M** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	DG, Rip-rap throughout basin.	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H -** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG). Bank erosion, livestock access, fair road density.	**M** – Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Reduce livestock access to streams. **M -** Provide education regarding the impacts of livestock.		**H -** Inventory roads, bank erosion and causes, and livestock access, and assess impacts to salmonids and prioritize restoration actions accordingly.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
LWD	DG	**M -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD or increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement). **H** - Assess stream channel stability and LWD.
Riparian	Poor (DG), 25% of forest area converted to non-forest use.	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	DG. Livestock access, livestock input.	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to streams. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Monitor water temperatures, dissolved oxygen, pH, and turbidity.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Water Quantity	Poor. Low summer flows, water withdrawals, forestlands converted to other use, high peak flows, and scour.	**H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Install a stream flow gage and monitor flow.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys regarding salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Porter Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	(DG) Road density is fair. (2.9 mi/sq mi)	**H** - Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects of less than three miles addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H** - Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**M** - Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **M** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	(DG) Low levels of rip-rap, no channelization.	**L** - Reconnect potential off-channel habitat. **M** - Restoration actions need to increase instream LWD to help address channel incision. This includes appropriate riparian restoration to result in better future LWD levels.	**H** – Maintain, prioritize, and conserve off-channel and side channel habitat and associated riparian.	**L** - Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Fair (DG) Fair road density, moderate bank erosion and livestock access.	**M** – Decommission roads at risk of landslides, especially side-cast roads. **M** – Correct high impact road sediment delivery problems via push-outs, cross-drains, sediment traps etc. **M** – Increase protection of steep and		**M** – Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **M** – Conduct a landslide inventory. **M** – Update the surface erosion degradation database collected in

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		unstable slopes. **M** – Stabilize and revegetate exposed mass wasting sites to reduce surface erosion. **M** – Reduce livestock access to streams. **M** – Provide education regarding the impacts of livestock.		Wampler et al. (1993).
LWD	DG	**M** - Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD or increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**L** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Poor (DG)	**H** - Revegetate open riparian areas with native plants including conifers in appropriate places. **M** - Interplant conifer into hardwood riparian areas that were historically conifer areas. **M**- Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H** - Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	(DG) Poor riparian.	**H** - Actions need to address sediment and riparian flow problems. **H** - Reduce livestock access to streams. **H** - Increase activities that lead to natural	**H** - Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Monitor water temperature, dissolved oxygen, pH, and turbidity.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.		
Water Quantity	Good (DG)	**L** – Reduce water withdrawals from surface sources. **L** – Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **L** – Restore wetlands and off-channel habitat.	**M** - Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**L** – Install a stream flow gage, and monitor stream flows.
Biological Processes	DG	**L** - Increase contribution of marine–derived nutrients through increased use of carcasses.		**H** - Increase field surveys regarding salmonid distribution, escapement, and habitat use by life history stage. **L** - Assess marine-derived nutrient processes.

Cedar Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG Road density is fair (2.9 mi/sq mile).	**H** - Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H** - Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages. **M** – New culvert structures should be sized to reflect expected increased flows. (High 20 – 30 year precipitation cycle expected).		**M** - Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. Specific to this sub-basin: the Cedar Creek Correctional Facility dam needs further assessment. **M** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor (DG)	**H** - Reconnect potential off-channel habitat.	**H** – Maintain and conserve off-channel and side-channel habitat and associated riparian.	**H** - Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Fair (DG) Known road density is fair.	**H** – Decommission roads at risk of landslide, especially side-cast roads. **H** – Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps et. **H** – Increase protection of steep and		**H** - Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **M** – Conduct a landslide inventory. **M** – Update the surface erosion degradation database collected in the Wampler et al. 1993 report.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		unstable slopes. **H** – Stabilize and revegetate exposed mass wasting sites to reduce surface erosion. **H** – Reduce livestock access to streams.		
LWD	DG	**M** - Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Poor – Lower Good – Middle Fair – Upper (DG)	**H** - Revegetate open riparian areas with native plants including conifers in appropriate places. **M** - Interplant conifer into hardwood riparian areas that were historically conifer areas. **M**- Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H** - Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	DG	**M** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to streams. **M** - Increase activities that lead to natural recharge of the aquifers and maintain or	**H** - Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**M** – Water quality monitoring is needed (water temperature, dissolved oxygen, pH, turbidity).

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		improve hydrological maturity. **M** - Restore wetlands and off-channel habitat.		
Water Quantity	Good (DG) Good hydrologic maturity.	**M** - Reduce water withdrawals from surface source. **M** - Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **M** - Restore wetlands and off-channel habitat.	**H** - Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**L –** Install in-stream flow gage, and monitor stream flow.
Biological Processes	DG	**L** - Increase contribution of marine derived nutrients through increased use of carcasses.		**H** - Increase field surveys for salmonid escapement, distribution and habitat use by life history stage. **L** - Assess marine-derived nutrient processes.

Gibson Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. Fair road density (2.9 mi/sq mi).	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**M -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **M** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	DG	**M** - Reconnect potential off-channel habitat. **M -** Restoration actions need to increase instream .	**H –** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian.	**L -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment: **Spawning gravel quantity**	Fair (DG). Fair road density, medium level of bank erosion. Livestock access in lower reaches.	**M**- Decommission roads at risk of landslides. **H** - Correct road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **M** - Increase protection of steep and		**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		unstable slopes. **L** - Reduce livestock access to streams. **L -** Provide education regarding the impacts livestock.		
LWD	DG	**M -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement). **H** – Survey streams to classify habitat (banks, LWD, riparian, etc.).
Riparian	DG Poor – Lower. Fair – Upper.	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		L - Exclude livestock access and replant riparian areas damaged by livestock.		
Water Quality	DG. Poor to fair riparian, some livestock access.	**M** - Actions need to address sediment, riparian, and flow problems. **L** - Reduce livestock access to streams. **M -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **M** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**M** - Monitor water quality such as water temperatures, dissolved oxygen, pH, and turbidity.
Water Quantity	Good (DG). Good hydrological maturity	**L -** Reduce water withdrawals from surface sources. **L -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **M -**Restore wetlands and off-channel habitat**.**	**M -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity. **L** - Preserve hydrologic maturity, i.e., mid and late seral conifer forest.	**L** - Install a stream flow gage and monitor stream flows.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid escapement, distribution, escapements, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Independence Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. Suspect Poor. Numerous blockages and high road density (3.4 mi/sq mi).	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	DG Rip-rap, roads in floodplain.	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H -** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory. **H** - Assess level of rip-rap and other bank protection and estimate impact.
Sediment	Poor (DG) Bank erosion, debris torrents, siltation of spawning gravel, livestock access.	**H** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **M** - Reduce livestock access to streams. **M -** Provide education regarding the impacts of livestock.		**H -** Inventory roads and assess impacts to salmon and steelhead as well as prioritize restoration actions.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
LWD	DG	**M -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Poor (DG)	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	Poor. Low dissolved oxygen, livestock access and waste inputs.	**H** - Actions need to address sediment, riparian, and flow problems. **M** - Reduce livestock access to streams. **H** - Implement the TMDL for water temperature. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Assess current level of livestock impacts and waste inputs.
Water Quantity	Poor (DG) Low summer flows, water withdrawals,	**H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Install a stream flow gage and monitor stream flow. **H** - Assess actual water usage and

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
	increased peak flows due to riparian impacts, poor hydrological maturity.	maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**		compare to water rights.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid escapement, distribution, and habitat use (life history stage). **L-** Assess marine-derived nutrient processes.

Lincoln Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG Suspect Poor, numerous culverts, high road density (3.4 mi/sq mi).	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Fair (DG). Rip-rap, roads within floodplain.	**H** - Reconnect potential off-channel habitat. **L -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels. Would not consider LWD projects as high priority within lower areas of Lincoln Creek.	**H -** Maintain and conserve off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG). Bank erosion, siltation of spawning areas, vehicle activity, livestock access, high road density.	**M** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Reduce livestock access to streams. **M -** Provide education regarding the impacts of livestock. **M** - Provide education regarding the		**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		impacts of vehicle activity in streams. Increase enforcement to decrease this activity.		
LWD	DG	**M -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchor LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Poor (DG) Livestock access.	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas. **H** - Fence riparian to protect vegetation.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	Poor warm water temperatures, low dissolved oxygen, leaking septic system, livestock access, reduced riparian, bank erosion, and	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to streams. **H** - Implement TMDL for water temperature and pH. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**L** - Assess fecal coliform sources as they relate to increased BOD loads. **H** - Assess riparian conditions and prioritize areas for restoration.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
	scour	habitat.		
Water Quantity	Poor. Low summer flows, water withdrawals, Increased peak flows, Scour.	**H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Install a stream flow gage, and monitor stream flow. **H** - Determine actual water usage and water rights.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Black River Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG.
The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	Poor (DG) Known problems: largest problem is blockage to Black Lake (access and flow issue)	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**M -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **L** - Develop a database housed with the lead entity, to contain all blockage data. **H** - Study flow control between upper Black River and Black Lake, considering fish passage to and from Black Lake to Black River. Include study of potential predation by exotic species in Black Lake.
Floodplain Conditions	DG, Poor in Beaver, Salmon, Allen Creeks and in Bloom's Ditch. Known problems include rip-rap, wetland filling, and channelization.	**H** - Reconnect potential off-channel habitat. **L -** Restoration actions need to increase instream LWD. This includes appropriate riparian restoration to result in better future LWD levels.	**H -** Maintain and conserve off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Sediment	Poor (DG). Known problems: bank erosion, livestock access, high road density (4.1 mi/sq mi).	**H** – Reduce bank erosion (riparian restoration, livestock exclusion, engineered logjams to deflect flows from eroding banks., etc). **H** - Reduce livestock access to streams. **H** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **M -** Provide education regarding the impacts of livestock access.		**H -** Inventory roads and assess impacts to salmon and steelhead as well as prioritize restoration actions. **H** - Stream surveys of key tributaries to Black River (Waddell, Beaver, Miraz, Salmon Creeks) should evaluate spawning and rearing conditions, including sediment, channel conditions and LWD.
LWD	DG. Low gradient and numerous wetlands likely result in lower priority for LWD.	**M -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**L** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (E.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Mixed. Poor and Good.	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas. **H** - Restore riparian vegetation/buffers in lower 9 river miles and between RM 17-20, and key tributaries where conditions are poor, such as Waddle/Beaver Creeks.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** - Preserve good riparian conditions from RM 9-17 and above RM 20 and in key tributaries.	**H** - Assess and prioritize recovery and protection for riparian conditions.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Water Quality	Poor. (DG most tribs). Known problems are warm water temperatures and low dissolved oxygen due to poor riparian, livestock waste, urban stormwater, and loss of flow from Black Lake.	**H** - Actions need to address riparian, livestock access, and flow problems. **H** - Reduce livestock access to streams. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Implement TMDL for water temperature and pH. **H** - Restore wetlands and off-channel habitat. **H** - Restore summer/low flows from Black Lake to Black River after analysis.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Analysis of potential flow controls in upper Black River near Black Lake to increase flow in low flow periods.
Water Quantity	Poor. (DG most tribs). Known low flow problem due to flow reversal to Black Lake.	**H -** Reduce water withdrawals from both surface and ground sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.** **H** - Restore summer/low flows from Black Lake to Black River after analysis.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity. Hydrological maturity should be a goal in the upper reaches of Mima and Waddell Creeks and aquifer recharge in the Black River, itself.	**H** - Analysis of potential flow controls in upper Black River near Black Lake to increase flow in low flow periods.
Biological Processes	DG	**L -** Increase contribution of marine –derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Scatter Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	Good	**H** - Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H** - Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages. **L** – New culvert structures should be sized to reflect expected increased flows. (High 20 – 30 year precipitation cycle expected).		**L** - Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **L** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Good	**L** - Reconnect potential off-channel habitat. **H** - Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H** – Maintain, conserve and prioritize off-channel and side channel habitat and associated riparian.	**L** - Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor. High road density (5.3 mi/sq mi), excess sedimentation, livestock access, poor channel	**H** – Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** – Reduce livestock access to streams.		**H** - Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
	conditions.	**L** – Provide education regarding the impacts of vehicle activity in streams and increase enforcement. **H** – Provide education regarding the impacts of livestock access and increase enforcement.		
LWD	Good	**L** - Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**L** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Poor	**H** - Revegetate open riparian areas with native plants including conifers in appropriate places. **M** - Plant oaks and appropriate under-story plants in appropriate prairie areas. **M** – Interplant conifer into hardwood riparian areas that were historically conifer areas. **M**- Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H** - Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Maintain and conserve existing functioning riparian areas.	**L** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	Poor. 303(d) listing for water temperature, pH, and fecal coliform (suggesting high BOD loads). Causes include: poor	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to streams.	**H** - Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity. **H** – Prevent or slow down conversion of rain permeable land to impervious	**H –** Continue to monitor water temperatures, dissolved oxygen, pH, and turbidity.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
	riparian and livestock access.	**H** – Provide education regarding the impacts of livestock access and increase enforcement. **H** – Implement TMDL for water temperature and pH. Address fecal coliform as it relates to increased BOD loads. **H** - Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	surfaces.	
Water Quantity	Poor. "Closed" to further water appropriations.	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce water withdrawals from both surface and ground sources. **H** - Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H** -Restore wetlands and off-channel habitat.	**H** - Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Assess actual and projected water use in areas of rapid residential and urban development (e.g., Rochester and Grand Mount) and potential impact on stream flows. **M** – Assess impact of groundwater pumping on stream flows.
Biological Processes	DG	**L** - Increase contribution of marine–derived nutrients through increased use of carcasses.		**H** - Increase field surveys for salmonid distribution, escapement, and habitat use by life history stage. **L** – Inventory macro-invertebrates to assess the abundance and diversity of "fish food". **L** – Assess marine-derived nutrient processes.

Skookumchuck River Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. High road density (5.4 – 6.0 mi/sq mi)	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Fair in lower, poor in upper, poor in Hanaford Creek.	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian. **H** – Preserve functional floodplain areas in the lower sub-basin.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG) in lower, good in upper. High road density, high levels of bank erosion and livestock access. In upper reaches, dam	**H -** Decommission roads at risk of landslides, especially side-cast roads. **H** – Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Increase protection of steep and		**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
	break floods.	unstable slopes. **M** - Stabilize and revegetate exposed mass wasting sites to reduce surface erosion. **H** - Reduce livestock access to streams. **L -** Provide education regarding the impacts of vehicle activity in streams and increase enforcement. **H -** Provide education regarding the impacts of livestock access.		
LWD	DG – In Lower. Fair – Poor in upper.	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (E.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Poor	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Water Quality	Poor. Warm water temperatures, failing septics, agriculture and industrial waste, coal mining.	**H** - Actions need to address riparian and flow problems. **H** - Reduce livestock access to streams. **H** - Implement TMDL for water temperature and pH. H - Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity**.** **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H –** Continue to monitor water temperature, dissolved oxygen, pH, and turbidity. **H** – Assess mercury in coal piles in the Hanaford Creek watershed.
Water Quantity	Poor. Closed to further water appropriations. Users: irrigators, mining, quarries, cities, livestock.	**H** - Actions need to address sediment, riparian, and flow problems. **H -** Reduce water withdrawals from both surface and ground sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Continue to monitor stream flow. **H** – Assess actual water usage and compare to water rights.
Biological Processes	Poor (DG)	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Salzer Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. High road density (6 mi/sq mi).	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.	**H** - Preserve streams that allow access.	**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	DG Poor in lower due to channelization.	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	DG	**H** - Reduce livestock access and bank erosion. **M -** Provide education regarding the		**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		impacts of livestock access to streams.		
Current In stream LWD	DG	**L -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**L** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (E.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	DG	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas. **H** - Restore riparian in lower watershed.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	Poor. Warm water temperature, low dissolved oxygen. Causes: livestock, processing plant, landfill, riparian loss.	**H** - Actions need to address riparian, point source, and livestock waste problems. **H** - Reduce livestock access to streams. **H** - Implement TMDL for water temperature and pH. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity. **H** – Preserve all streams with better than poor water quality.	**H** – Continue to monitor water temperature, dissolved oxygen, pH, and turbidity.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		habitat.		
Water Quantity	Poor. "Closed" to further water allocations.	**H -** Reduce water withdrawals from both surface and ground sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity. **H** – Place a moratorium on any further water withdrawals.	**H** – Determine where water can be redirected to improve quantities.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid distribution, escapements, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Dillenbaugh Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**M -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **M** - Develop a database housed with the lead entity, to contain all blockage data. **H -** Conduct salmonid surveys and a watershed assessment to determine the overall condition of the stream.
Floodplain Conditions	DG Unquantified reaches border I-5 and some is within city limits	**L** - Reconnect potential off-channel habitat. **L** - Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, prioritize, and conserve off-channel and side channel habitat and associated riparian.	**M -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	DG	**H** - Reduce livestock access to stream. **M -** Provide education regarding the impacts of vehicle activity in streams and increase enforcement. **M** - Provide education regarding the impacts of livestock access to streams.		**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **M** - Assess bank erosion (extent and causes) and prioritize sites for restoration.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
LWD	DG	**L -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	DG	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H –** Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**M** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	Poor (DG). Buried chemicals, warm water temperatures, low dissolved oxygen. Causes: Industrial activity, waste wood landfill, stormwater, dairy farm waste, contaminated soils, dioxin & PCPs (superfund site).	**H** - Reduce livestock access and livestock waste inputs to streams. **H -** Develop and implement a stormwater plan that reduces impacts to salmonids. **L -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **L** - Restore wetlands and off-channel habitat.	**M -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Continue water quality monitoring.
Water Quantity	Poor. Low flows due to agriculture, impervious soils (urbanization), increased peak	**H -** Reduce water withdrawals from surface sources. **M -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
	flows.	maturity. **H -**Restore wetlands and off-channel habitat**.**		
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Newaukum Sub-Basin.

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG, Suspect Poor. High road density (4.2 mi/sq mi) and initial culvert inventory lists extremely high number of potential blockages.	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor (DG). Rip-rap, dikes, roads, wetland loss (fill), decline in beaver activity.	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels. **H** - Reduce bank protection.	**H –** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian. **H** - Prevent further diking, rip-rap, and other bank protection.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG). High road densities, landslides caused by roads, high bank erosion and livestock access.	**H**- Decommission roads at risk of landslides, especially side-cast roads. **H** – Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Reduce livestock access to streams. **H** - Increase protection of steep and unstable	**H** - Protect existing good quality spawning habitat. **M** - prevent further degradation of unstable banks.	**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **H** - Inventory, prioritize, and list causes of bank erosion.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		slopes. **H** - Stabilize and revegetate exposed mass wasting sites to reduce surface erosion. **M -** Provide education regarding the impacts of livestock access to streams. **M** - Increase enforcement and provide education regarding the impacts of vehicle activity in streams.		
LWD	Good in upper; DG (likely poor) in lower.	**L -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration). This priority level might change to high after assessment in lower reaches is completed.	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement). **M** - Conduct surveys to determine LWD levels, pool habitat, and riparian conditions in the lower drainage.
Riparian	Poor in lower, mixed in upper.	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer and hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H –** Continue enforcement and revision of current regulations that preserve and enhance riparian	**M** - Assess and prioritize recovery and protection for riparian conditions.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
			regeneration.	
Water Quality	Poor (DG). Warm water temperatures and high turbidity. Causes: riparian loss, sedimentation, livestock.	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to streams. **H** - Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Implement TMDL for water temperature and pH. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Continue to monitor water temperature, dissolved oxygen, pH, and turbidity.
Water Quantity	Poor (DG) in lower; good (DG) in upper. Not meeting base flows, poor hydrological maturity except in upper NF and SF where hm is good. Water withdrawn for City of Chehalis and agriculture.	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce water withdrawals from both surface and ground sources. **H** - Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Continue monitoring stream flows.
Biological Processes	Fair (DG)	**L -** Increase contribution of marine –derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid escapement, distribution, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Stearns Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG, Suspect Poor. High road density (4.9 mi/sq mi) and initial culvert inventory lists extremely high number of potential blockages.	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor (DG). Channelization and floodplain road.	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels. **H** - Reduce bank protection.	**H –** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian. **H** - Prevent further diking, rip-rap, and other bank protection.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG). High road densities and high levels of bank erosion.	**H** – Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** – Reduce livestock access to streams. **M -** Provide education regarding the impacts of livestock access.	**H** - Protect existing good quality spawning habitat.	**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **H** - Inventory, prioritize, and list causes of bank erosion.
LWD	DG (likely poor)	**M -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and	**M** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		This priority level might change to high after assessment in lower reaches is completed.	enforcement.	LWD recruitment potential, and valley confinement). **M** - Conduct surveys to determine LWD levels, pool habitat, and riparian conditions in the lower drainage.
Riparian	Poor	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer and hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	Poor. Low dissolved oxygen from livestock inputs. Poor riparian conditions suggest temperature problems.	**H** - Actions need to address riparian and flow problems. **H** - Reduce livestock access to streams. **H** - Implement TMDL for water temperature and pH. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Continue to monitor water temperature, dissolved oxygen, pH, and turbidity.
Water Quantity	Poor (DG). Low summer flows, poor hydrological maturity.	**H -** Reduce water withdrawals from both surface and ground sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Continue monitoring stream flows.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**		
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid escapement, distribution, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Bunker Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG High road density (4.4 mi/sq.mi)	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data. **H** - Need fish presence assessments
Floodplain Conditions	Fair (DG) Channel incision, scour, roads within floodplain	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H -** Maintain and conserve off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG) Siltation, high road density, high levels of bank erosion, livestock access, vehicle activity	**H** – Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** – Reduce livestock access to streams. **M -** Provide education regarding the impacts of livestock access. **L -** Provide education regarding the		**H -** Inventory roads and assess impacts to salmon and steelhead as well as prioritize restoration actions. **H** - Livestock access and bank erosion information is old and needs updating.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		impacts of vehicle activity in streams and increase enforcement.		
LWD	DG Lack of LWD	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential.	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement) **M** - Assess instream levels of LWD.
Riparian	Poor (DG). Area converted to non-forest, streamside vegetation loss due to logging	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations.	**H** - Assess and prioritize recovery and protection for riparian conditions. Needs more data on riparian conditions
Water Quality	Poor. Low dissolved oxygen caused by livestock access, failing septic systems, fecal coliform (suggesting high BOD loads). Poor riparian conditions suggest temperature problems.	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to streams. **H** - Implement TMDL for water temperature and pH. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Monitor summer water temperatures and dissolved oxygen.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Water Quantity	Poor Low summer flows, irrigation, high peak flows, scour, converted land cover	**H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Install stream flow gage, and monitor stream flow. **H** - Determine actual water usage and water rights.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid distribution, escapement, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

South Fork Chehalis Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG, Suspect Poor. High road density 3.7 in South Fork to 4.5 mi/sq mi in Stillman Creek. Also, large number of potentially-blocking culverts and limited rearing habitat.	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Fair to Good (DG) Rip-rap.	**M** - Reconnect potential off-channel habitat. **M -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels. **H** - Reduce bank protection.	**H –** Maintain, conserve, and prioritize off-channel and side channel habitat and associated riparian. **H** - Prevent further diking, rip-rap, and other bank protection.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG). High road densities, landslides and debris torrents (Stillman), high bank erosion and livestock access.	**H**- Decommission roads at risk of landslides, especially side-cast roads. **H** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Increase protection of steep and	**H** - Protect existing good quality spawning habitat. **M** - Prevent further degradation of human-induced banks instability.	**H -** Inventory roads and assess impacts to salmonids and prioritize restoration actions accordingly. **H** - Inventory, prioritize, and list causes of bank erosion.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		unstable slopes. **H** - Stabilize and revegetate exposed mass wasting sites to reduce surface erosion. **H** – Reduce livestock access to streams. **H**- Reduce human-caused bank erosion. **M -** Provide education regarding the impacts livestock access.		
LWD	Poor (DG)	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential. This priority level might change to high after assessment in lower reaches is completed.	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement). **M** - Conduct surveys to determine LWD levels, pool habitat, and riparian conditions in the lower drainage.
Riparian	Poor	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer and hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Continue enforcement and revision of current regulations that preserve and enhance riparian	**H** - Assess and prioritize recovery and protection for riparian conditions.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
			regeneration.	
Water Quality	Poor (DG). Warm water temperatures, poor riparian, livestock access.	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to streams. **H** - Implement TMDLs for water temperature and pH. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Continue to monitor water temperature, dissolved oxygen, pH, and turbidity. Begin monitoring Lake Creek.
Water Quantity	Poor (DG). Not meeting base flows in the South Fork. Peak flow concerns in Stillman Creek. Poor hydrologic maturity in Lake Creek.	**H -** Reduce water withdrawals from both surface and ground sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** – Monitor stream flows.
Biological Processes	Good (DG)	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid escapement, distribution, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Elk Creek Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. High road density and numerous culverts.	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor (DG) Channel incision, numerous logging roads. .	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, prioritize, and conserve off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor (DG) High road density, side- cast roads, landslides in areas that are geologically sensitive and near stream, debris torrents, bank erosion.	**H** - Decommission roads at risk of landslides, especially side-cast roads. **H** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Increase protection of steep and unstable slopes. **H** - Stabilize and revegetate exposed mass wasting sites to reduce surface erosion. **H** - Reduce livestock access to streams. **M** - Provide education regarding the	**H -** Enforce new forest practice regulations.	**H -** Inventory roads and landslides and assess impacts to salmonids and prioritize restoration actions accordingly.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		impacts of livestock access to streams.		
LWD	Poor in lower (DG). Good (DG) in tributaries	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Poor in lower (DG)	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **H-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	DG. Tree canopy loss.	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to streams. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H -** Monitor water temperature, dissolved oxygen, pH, and turbidity. **H** - Assess culvert sizing.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Water Quantity	Poor (DG). Recent logging likely reduced hydrological maturity, concern about peak flows, water withdrawals.	**H** - Actions need to address sediment, riparian, and flow problems. **H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Install stream flow gage and monitor stream flow. **H** - Assess actual water use and water rights. **H** - Update land cover data (hydrological maturity).
Biological Processes	DG, likely good.	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid escapement, distribution, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Rock Creek (near Pe Ell) Sub-Basin

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	DG. High road density.	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H** - Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	DG	**H** - Reconnect potential off-channel habitat. **H** - Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, prioritize, and conserve off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory. **H** - Map historic versus current floodplain conditions.
Sediment	Poor (DG) Confined streams with low gradient, landslides due to recent timber harvest in geologically sensitive areas, high road density, high levels of bank erosion.	**H** - Decommission roads at risk of landslides, especially side-cast roads. **H** - Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Increase protection of steep and unstable slopes. **H** - Stabilize and revegetate exposed mass wasting sites to reduce surface erosion.		**H -** Inventory roads and landslides and assess impacts to salmonids and prioritize restoration actions accordingly.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		M - Reduce livestock access to streams. **L -** Provide education regarding the impacts of livestock access and increase enforcement.		
LWD	Poor in lower (DG).	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential (riparian restoration).	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruitment, hydrology, structure size, gradient, LWD recruitment potential, and confinement).
Riparian	Fair (DG)	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **M-** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H** – Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	DG	**H** - Actions need to address sediment, riparian, and flow problems. **M-** Reduce livestock access to streams. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Monitor water temperature, dissolved oxygen, pH, and turbidity.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Water Quantity	Poor (DG) Poor hydrologic maturity, concern about increased peak flows.	**H** - Actions need to address sediment, riparian, and flow problems. **H -** Reduce water withdrawals from both surface and ground sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**M** - Install stream flow gage and monitor stream flow.
Biological Processes	DG	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid escapement, distribution, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Upper Chehalis Sub-Basin (all waters upstream of Pe Ell except Rock Creek)

These are the restoration, preservation, and data gap actions recommended by the Limiting Factors TAG. The actions have been prioritized based upon the Limiting Factors Report coupled with professional judgement.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Fish Passage	Poor (DG) Numerous culverts, high road density, limited rearing habitat.	**H -** Open three or more miles of good quality habitat used by at least one stock of salmon or steelhead. *Exceptions:* include very cost efficient projects addressing unique limiting habitat or benefiting multiple stocks of salmon or steelhead. **H -** Bridges are the preferred structure. If culverts are used, they should be sized to allow full access to all fish species and life history stages.		**H -** Inventory, assess, and prioritize all habitat blockages (culverts, dikes, railroad grades, etc.) for all salmonid life history stages. **H -** Develop a database housed with the lead entity, to contain all blockage data.
Floodplain Conditions	Poor (DG) in all streams but Crim, Thrash, Cinnabar, and the East Fork Chehalis River. Channel incision, rip-rap. .	**H** - Reconnect potential off-channel habitat. **H -** Restoration actions need to increase instream LWD to help address channel incision and flow issues. This includes appropriate riparian restoration to result in better future LWD levels.	**H –** Maintain, prioritize, and conserve off-channel and side channel habitat and associated riparian.	**H -** Inventory impacts and suitable restoration sites for floodplain habitat coincident with the barrier/culvert inventory.
Sediment	Poor High road density, landslides caused by roads, debris torrents, channel instability.	**H** - Decommission roads at risk of landslides, especially side-cast roads. **H** – Correct high impact road sediment delivery problems via push-outs, cross-drains, and sediment traps etc. **H** - Increase protection of steep and unstable slopes. **H** - Stabilize and revegetate exposed mass	**H -** Enforce new forest practice regulations.	**H -** Inventory roads and landslides and assess impacts to salmonids and prioritize restoration actions accordingly.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
		wasting sites to reduce surface erosion. **H** - Reduce livestock access to streams. **M** - Provide education regarding the impacts of livestock access to streams.		
LWD	Poor	**H -** Actions are needed to increase LWD, or similarly functioning natural structures, in appropriate places. This would include anchoring LWD and increasing natural recruitment potential.	**H –** Prevent removal of appropriate pieces of LWD, and other natural structures, within the floodplain through increased education and enforcement.	**H** - Determine appropriateness through inventory or other assessment of LWD, or other natural structure(s), placement. (e.g. gravel recruiting, hydrology, wood or structure size, gradient, near term LWD recruitment potential, and valley confinement).
Riparian	Mixed, but mostly Fair	**H -** Revegetate open riparian areas with native plants including conifers in appropriate places. **M -** Interplant conifer into hardwood riparian areas that were historically conifer areas. **H -** Plant conifer adjacent to and outside existing and limited existing conifer hardwood riparian areas.	**H -** Funds, lands, and easement opportunities should be identified to obtain areas of mid-to late seral stage riparian with priority given to older stands. This is applicable to lands that do not have current protection such as those outside of current forest practice regulations. **H –** Continue enforcement and revision of current regulations that preserve and enhance riparian regeneration.	**H** - Assess and prioritize recovery and protection for riparian conditions.
Water Quality	Poor. Warm water temperatures and loss of riparian canopy.	**H** - Actions need to address sediment, riparian, and flow problems. **H** - Reduce livestock access to streams. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrological maturity. **H** - Restore wetlands and off-channel habitat.	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H -** Monitor water temperature, dissolved oxygen, pH, and turbidity. **H** - Assess culvert sizing.

Limiting Factor	LF Rating	Restoration Actions	Preservation Actions	Data Gap Actions
Water Quantity	DG. Recent logging likely reduced hydrological maturity, concern about peak flows, water withdrawals.	**H** - Actions need to address sediment, riparian, and flow problems. **H -** Reduce water withdrawals from surface sources. **H -** Increase activities that lead to natural recharge of the aquifers and maintain or improve hydrologic maturity. **H -**Restore wetlands and off-channel habitat**.**	**H -** Decrease activities that interfere with the natural recharge of aquifers or degrade hydrological maturity.	**H** - Install stream flow gage and monitor stream flow. **H** - Assess actual water use and water rights. **H** - Update land cover data (hydrological maturity).
Biological Processes	DG, likely good.	**L -** Increase contribution of marine – derived nutrients through increased use of carcasses.		**H -** Increase field surveys for salmonid escapement, distribution, and habitat use by life history stage. **L -** Assess marine-derived nutrient processes.

Secondary Prioritization Attempts

1) The committee considered a second tier prioritization with a goal to focus efforts in areas with healthier, less-degraded habitat. There is community support to maintain healthy stocks and to direct efforts in areas that are not highly degraded because of cost-effectiveness. The committee examined numerous habitat parameters, but most were not usable because the data were not collected throughout the basin. We found three potential habitat categories to pursue: stream flow, road density, and landcover type. These were appealing because they represent broad-level habitat impacts and recovery potential. After developing criteria to rank sub-basins for these three categories, we analyzed the data and found that the effort did not result in a finer-tuned strategy. For road density, no sub-basins ranked "high" and most were rated "low". The stream flow category also had problems. Most sub-basins lacked recent flow information, and for those watersheds that had data, all rated "low". The landcover data resulted in a broader separation between sub-basins, but some of the "low" rated areas are important to fish because they are downstream of large quantities of quality habitat. We were not willing to give these areas a lower prioritization. Details regarding the criteria and scores follow the prioritization table (Appendix Tables 2 and 3). This information may be more valuable during the project ranking process.

For ranking general habitat conditions, we examined road density data, stream flow data, and landuse data, and assigned habitat scores. The lower the score, the more degraded the habitat. The road density data are from Lunetta et al. (1997), to which we applied the NMFS standards of <2 miles of roads/square mile of watershed = score of 6; 2-3 miles/sq. mi. = score of 4; and >3 miles/sq. mi. = score of 2. For stream flow information, if the stream flow exceeded established base flows, the score is 6. If the stream flow met base flows or is unknown, the score is 4. If the stream flow often does not meet base flow or the stream is closed to further water appropriations documented in WAC 173-522, the score is 2. Landuse is rated 6 if it consists of primarily timberlands (greater then or equal to 60% of landcover). If the landuse has 30% or more urban use, the score is 2. All other landuse types (mostly agriculture) are rated 4. Landuse data were obtained from Lunetta et al. (1997), which provides separation of forestland from non-forest lands on a WAU scale. Professional judgement was applied to the non-forest categories to determine if urbanization or agriculture dominated that WAU. If more than one WAU comprised a sub-basin, the results for all WAUs within that sub-basin were averaged for a single sub-basin score. If one WAU included more than one sub-basin, the overall WAU results were assigned to each sub-basin. Appendices 2 and 3 list the data for each of these categories.

2) The committee also examined trends in coho escapement as a tool to more finely develop the strategy. Because coho salmon have a longer freshwater residence time, trends in abundance might be more apparent in this species if there are habitat problems. If a sub-basin had a downward trend in coho returns, it would receive an extra point. This would focus more attention in areas that are experiencing problems. However, only two sub-basins showed a declining trend, and after discussing some of the problems using the data (dependence on fish management actions and data representing a sub-basin were actually collected in a different sub-basin), we decided not to use this approach. In addition, this method conflicts with the above-described approach of prioritizing healthy areas above degraded habitat. However, the results might be useful for another purpose, and are shown in Appendix Table 4.

Appendix Table 1. Stock and "Fish Miles" Data Used to Prioritize Between Sub-Basins.

Stream Complex	Number of Salmon/Steelhead Stocks	Ranking Based upon Number of Stocks	Fish Miles	Ranking Based on Fish Miles
Chehalis Mainstem	7 (sumchin fchin spchin coho chum wsh ssh)	6	118.9 to EF	6
Grays Harbor Estuary	7 (sumchin fchin spchin coho chum wsh ssh)	6	90 sq mi	6
Satsop River and all its tributaries	5 (sumchin fchin coho wsh chum)	6	237.58	6
Wynoochee River and all tribs	5 (fchin coho wsh ssh chum)	6	151.33	6
Humptulips River and all tribs	5 (fchin coho wsh ssh chum)	6	186.68	6
Hoquiam River and tribs	4 (fchin coho wsh chum)	6	78.79	6
Wishkah River and tribs	4 (fchin coho wsh chum)	6	86.63	6
Johns River	4 (fchin coho wsh chum)	6	24.71	4
Elk River	4 (fchin coho wsh chum)	6	11.31	2
Cloquallum Creek and tribs	4 (fchin coho wsh chum)	6	50.3	4
Newman/Vance Creeks	1 (coho)	2	6.6	2
Mox Chehalis and tribs	3 (coho wsh fchin)	4	20.4	4
Workman Creek	0 (coho likely but not doc.)	2	0	2
Delezene Creek	4 (coho wsh chum fchin)	6	8.1	2
Porter Creek and tribs	3 (fchin coho wsh)	4	14.97	2
Gibson Creek	1 (coho)	2	2.06	2
Cedar Creek	2 (coho fchin)	4	18.48	2
Rock/Williams Creeks and tribs	3 (fchin coho wsh)	4	24.39	4
Garrard Creek and tribs	2 (coho wsh)	4	26.74	4
Independence Creek and tribs	1 (coho)	2	11.03	2

Stream Complex	Number of Salmon/Steelhead Stocks	Ranking Based upon Number of Stocks	Fish Miles	Ranking Based on Fish Miles
Lincoln Creek and tribs	2 (coho wsh)	4	36.88	4
Black River and tribs	4 (fchin chum coho wsh)	6	72.32	6
Scatter Creek and tribs	2 (coho wsh)	4	20.01	4
Skookumchuck River and tribs	4 (spchin fchin coho wsh)	6	174.81	6
Salzer Creek	1 (coho)	2	14.41	2
Dillenbaugh Creek	1 (coho)	2	7.78	2
Newaukum River and all tribs	4 (spchin fchin coho wsh)	6	119.06	6
Stearns Creek and tribs	2 (coho wsh)	4	13.23	2
Bunker Creek and tribs	2 (coho wsh)	4	10.72	2
South Fork Chehalis River and all tribs	4 (spchin fchin coho wsh)	6	100.14	6
Elk Creek and all tribs	4 (spchin fchin coho wsh)	6	33.73	4
Rock Creek and tribs	2 (coho wsh)	4	1.94	2
All streams upstream of the confluence of Rock Creek (Upper Chehalis)	4 (spchin fchin coho wsh)	6	48.91	4

Sumchin = summer chinook; spchin = spring chinook; fchin = fall chinook; ssh = summer steelhead trout; wsh = winter steelhead trout.

Data for the number of stocks came from the SASSI report (WDFW and WWTIT 1994) and the Limiting Factors Report (in prep.). Data for fish miles came from the GIS information regarding known salmon and steelhead habitat in the Limiting Factors Report.

Rules for ranking number of stocks: 4-5 stocks = high priority sub-basins (score=6); 2-3 stocks = medium priority sub-basins (score=4); and 1 or less stocks = low priority sub-basins (score=2).

Rules for ranking fish miles:

>70 fish miles = high priority (score=6); 20-69 = medium priority (score=4); < 20 fish miles = low priority (score=2).

Appendix Table 2. Generalized Habitat Conditions: Road Density and Stream Flow.

Stream Complex	Road Density	Draft Ranking Based upon Road Density	Low Flow Conditions	Draft Ranking Based on Low Flows
Chehalis Mainstem	NA	4	Low (base flows not met)	2
Grays Harbor Estuary	NA	4	NA	4
Satsop River and all its tributaries	4.0	2	Low (base flows not met)	2
Wynoochee River and all tribs	2.87	4	Low (base flows not met)	2
Humptulips River and all tribs	2.77	4	DG	4
Hoquiam River and tribs	3.6	2	DG	4
Wishkah River and tribs	3.36	2	DG	4
Johns River	3.88	2	DG	4
Elk River	3.47	2	DG	4
Cloquallum Creek and tribs	4.5	2	Wildcat Creek Closed	2
Newman/Vance Creeks	4.71	2	DG	4
Mox Chehalis and tribs	4.65	2	Closed	2
Workman Creek	4.62	2	DG	4
Delezene Creek	4.62	2	DG	4
Porter Creek and tribs	2.79	4	DG	4
Gibson Creek	2.92	4	DG	4
Cedar Creek	2.92	4	DG	4
Rock/Williams Creeks and tribs	2.72	4	Closed	2
Garrard Creek and tribs	2.72	4	Closed	2
Independence Creek and tribs	3.4	2	DG	4
Lincoln Creek and tribs	3.4	2	Closed	2
Black River and tribs	4.13	2	Closed	2
Scatter Creek and tribs	5.31	2	Closed	2

Stream Complex	Road Density	Draft Ranking Based upon Road Density	Low Flow Conditions	Draft Ranking Based on Low Flows
Skookumchuck River and tribs	4.9	2	Low (base flows not met)	2
Salzer Creek	DG		Closed	2
Dillenbaugh Creek	DG		Closed	2
Newaukum River and all tribs	4.23	2	Low (base flows not met)	2
Stearns Creek and tribs	4.92	2	Closed	2
Bunker Creek and tribs	4.39	2	Closed	2
South Fork Chehalis River and all tribs	4.14	2	Closed	2
Elk Creek and all tribs	4.38	2	DG	4
Rock Creek and tribs	4.8	2	DG	4
All streams upstream of Pe Ell (Upper Chehalis)	6.37	2	DG	4

Road density data from Lunetta et al. (1997). If more than one drainage shared the same road density data, that value was used for both drainages.

Flow ratings resulted from comparison of USGS flow gage data to DOE base flows WAC 173-522. Closed streams are those closed to further water appropriations listed in WAC 173-522.

Rankings are as follows: High (Good) = 6; Medium = 4; Low (Poor) = 2.

Road density data standards: High = <2 miles road/sq. mi watershed; Medium = 2-3 mi/sq. mi; Low = >3 mi/sq.mi

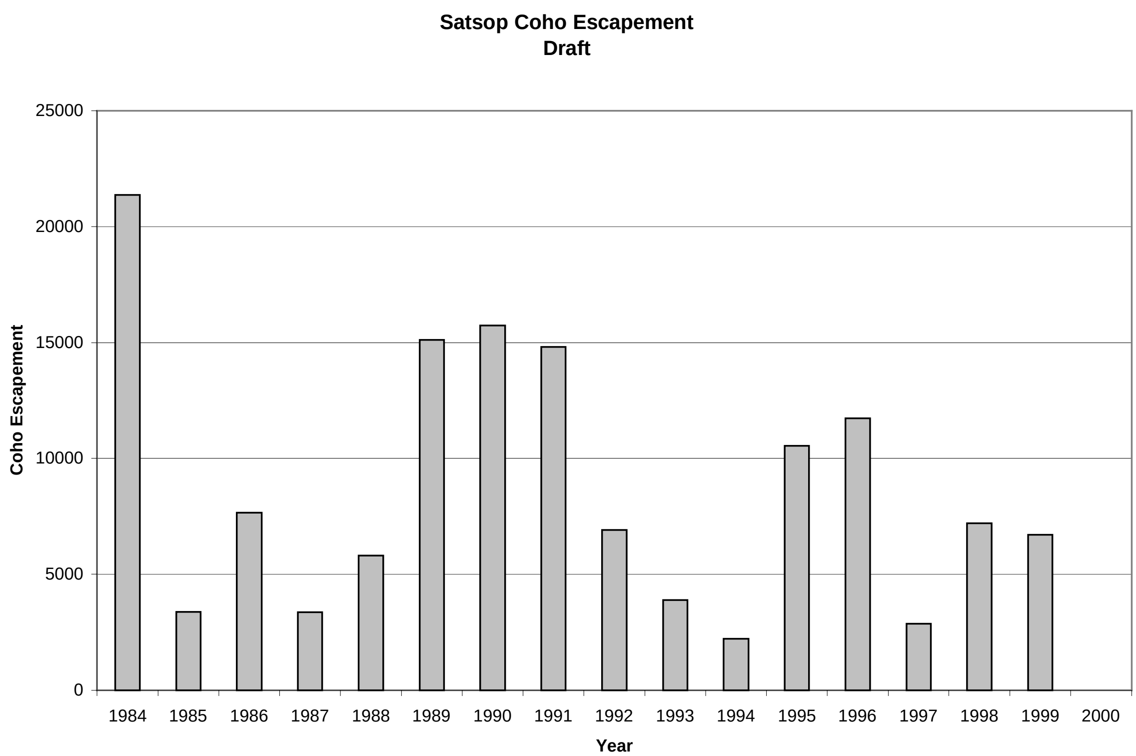
Stream flow data standards: High = exceeds flow; Medium = meets flow or data gap (DG); Low = does not meet flow.

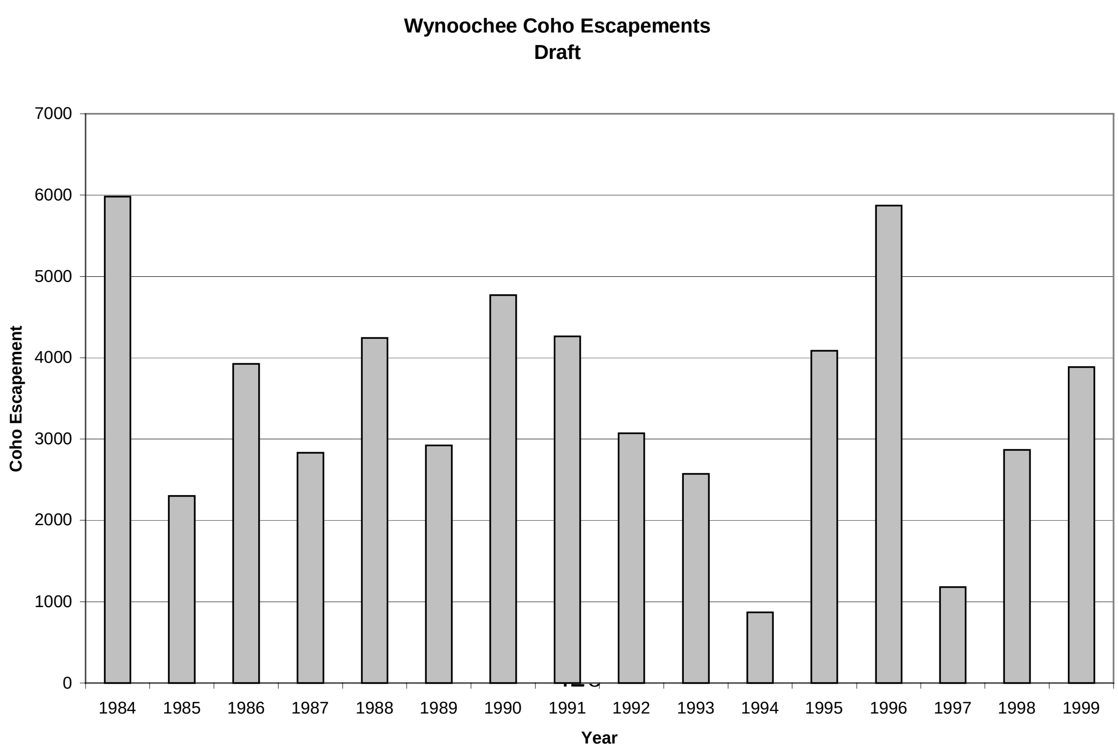
Appendix Table 3. Landcover ratings by WAU in the Chehalis Drainage (data from Lunetta et al. 1997).

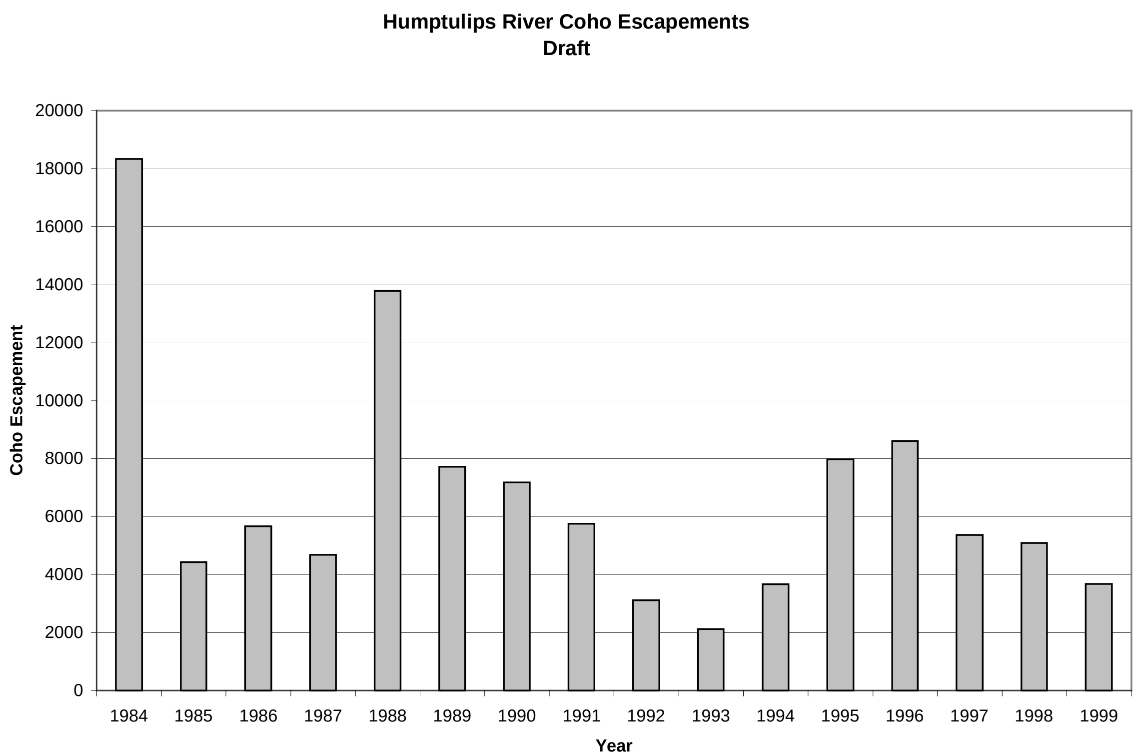
WAU	% Late Seral	% Mid Seral	% Early Seral	Total % Forest	>60% Forest	% Non-Forest	<10% Non-Forest	<30% Non-Forest	>30% Non-Forest
WYNOOCHEE, UPPER	44.55	12.87	3.49	60.91	High	0.21			
SATSOP, WF	15.30	32.41	2.55	50.26		0.63	Medium		
SATSOP, MF	13.87	24.23	2.90	41.00		0.50	Medium		
SATSOP, EF	40.05	11.19	0.54	51.78		0.83	Medium		
CLOQUALLUM	10.52	15.58	1.60	27.70		7.59	Medium		
MOX CHEHALIS	1.98	21.11	4.77	27.86		17.38		Medium	
DELEZENE	4.66	21.37	0.76	26.79		11.09		Medium	
ELMA	5.37	5.24	0.99	11.60		39.64			Low
SATSOP	11.78	18.52	2.25	32.55		9.04	Medium		
MONTESANO	0.16	3.77	0.00	3.93		65.83			Low
WYNOOCHEE RIVER	8.91	36.54	0.85	46.30		6.55	Medium		
JOHNS RIVER	3.91	59.16	0.77	63.84	High	6.90			
OCEAN SHORES COASTAL	0.00	0.27	0.00	0.27		78.35			Low
TULIPS	1.24	35.15	2.38	38.77		6.24	Medium		
HUMPTULIPS, MIDDLE	4.23	28.17	1.58	33.98		3.84	Medium		
WISHKAH, LOWER	2.87	18.66	0.78	22.31		12.01		Medium	
RANEY CREEK	4.95	31.85	1.04	37.84		2.71	Medium		
HOQUIAM, EF	8.39	26.22	0.94	35.55		3.45	Medium		
HOQUIAM, WF-MF	7.95	25.94	1.40	35.29		6.70	Medium		
STEVENS CREEK	14.03	30.12	2.06	46.21		2.13	Medium		
HUMPTULIPS, WF	42.36	26.99	1.15	70.50	High	0.00			
HUMPTULIPS, EF	44.32	19.62	1.08	65.02	High	0.00			
ABERDEEN WATERSHED	10.85	52.29	0.51	63.65	High	0.00			
ELK RIVER	2.75	48.25	1.34	52.34		14.63		Medium	
WADDEL CREEK	0.07	39.29	6.52	45.88		17.17		Medium	
BLACK RIVER	0.00	16.50	7.80	24.30		29.69		Medium	
SCATTER CREEK	0.00	13.21	3.05	16.26		48.05			Low
SKOOKUMCHUCK,LOW	0.00	20.54	5.14	25.68		25.40		Medium	
HANAFORD	0.00	20.64	2.14	22.78		17.61		Medium	

WAU	% Late Seral	% Mid Seral	% Early Seral	Total % Forest	>60% Forest	% Non-Forest	<10% Non-Forest	<30% Non-Forest	>30% Non-Forest
SKOOKUMCHUCK, UP	0.00	60.67	9.66	70.33	High	0.10			
NEWAUKUM, UPPER NF	0.00	47.52	9.10	56.62		9.84	Medium		
NEWAUKUM, UPPER SF	0.00	52.37	11.60	63.97	High	1.25			
NEWAUKUM, MF	0.05	13.07	5.60	18.72		22.81		Medium	
NEWAUKUM, LOWER NF	0.00	12.33	1.77	14.10		40.73			Low
SCAMMON-STEARNS	0.02	13.65	5.44	19.11		37.99			Low
CURTIS	0.04	25.72	12.79	38.55		14.53		Medium	
CHEHALIS, SF	0.00	41.25	19.03	60.28	High	10.14			
STILLMAN CREEK	0.00	55.53	18.37	73.90	High	3.80			
CHEHALIS HEADWATERS	0.00	45.59	18.49	64.08	High	0.32			
ROCK-JONES	0.00	25.51	10.92	36.43		11.47		Medium	
ELK CREEK	3.39	49.70	16.13	69.22	High	1.09			
BUNKER CREEK	0.00	35.47	8.89	44.36		6.75	Medium		
LINCOLN CREEK	0.00	24.77	11.56	36.33		15.78		Medium	
GARRARD CREEK	3.37	29.73	6.57	39.67		13.56		Medium	
CEDAR CREEK	0.03	55.43	5.09	60.55	High	9.40			
PORTER CREEK	0.00	60.37	7.30	67.67	High	6.51			

Appendix Table 4. Coho salmon escapement trends (data from WDFW, Montesano, WA).



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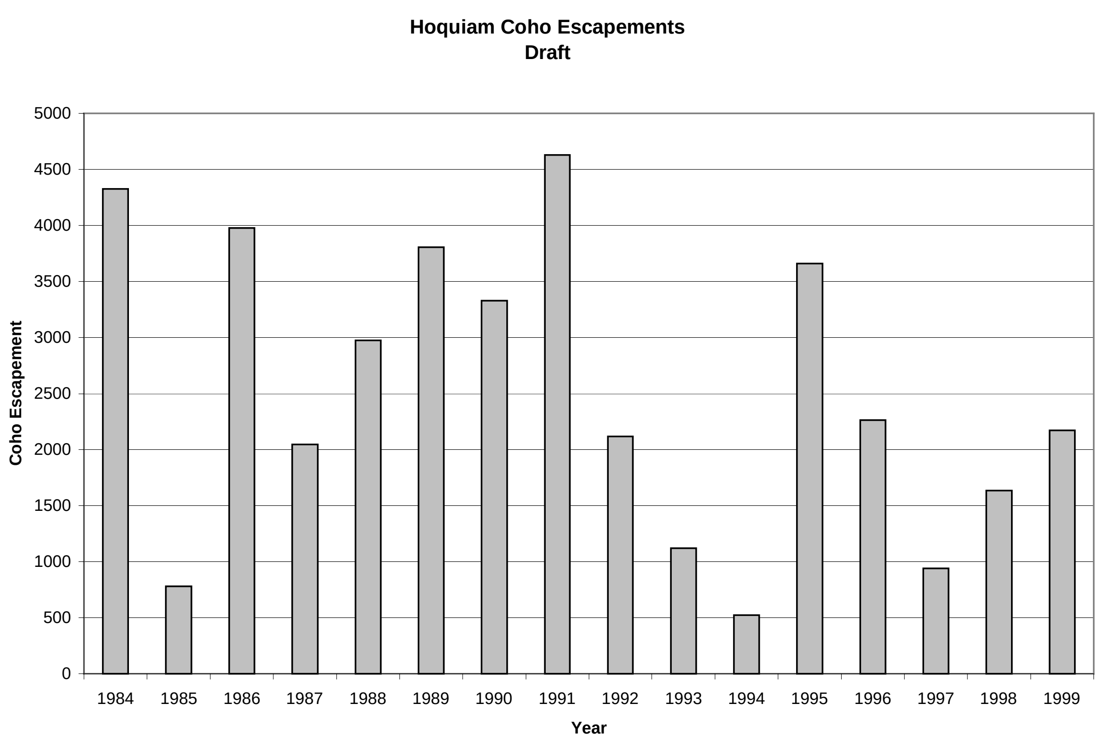
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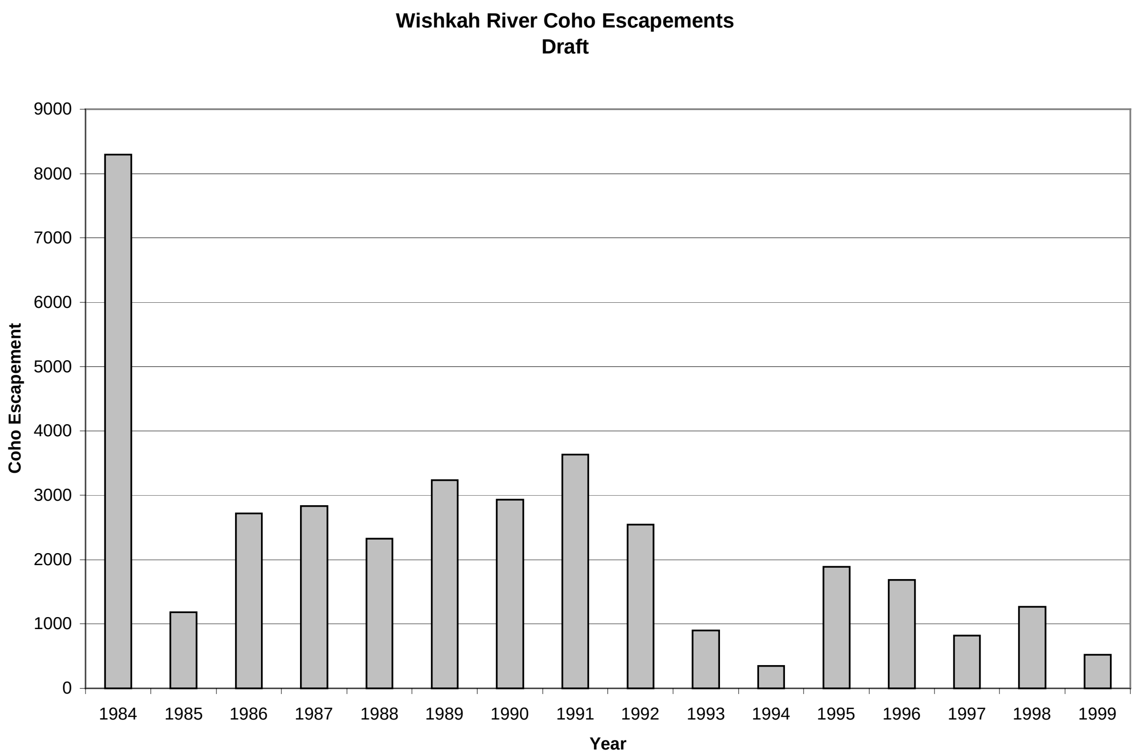
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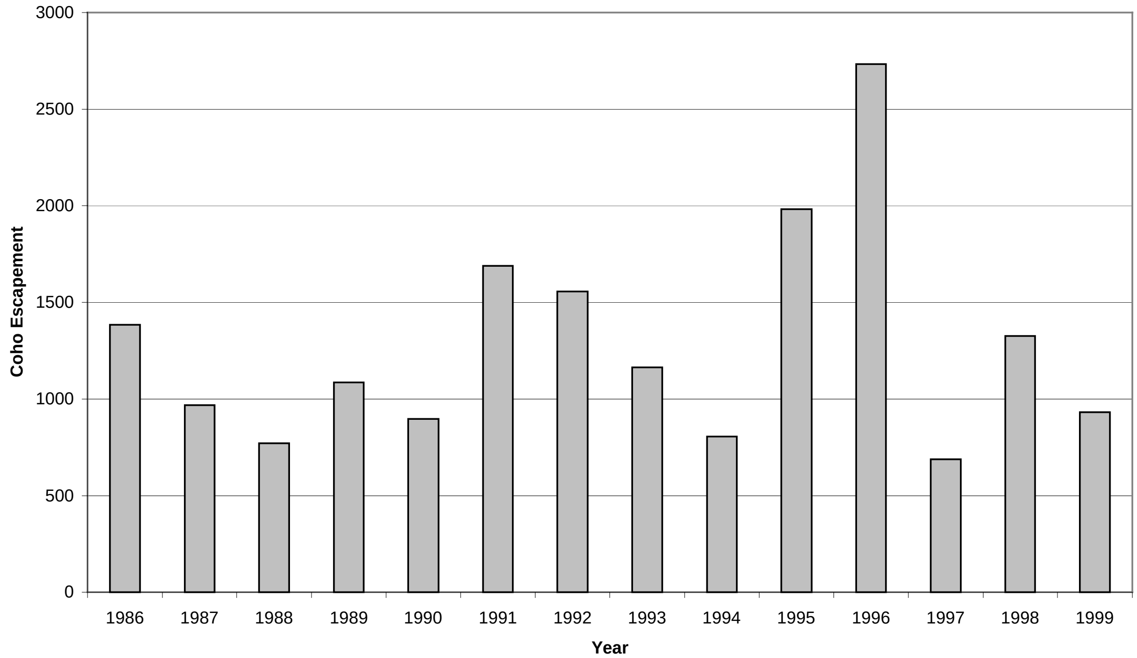
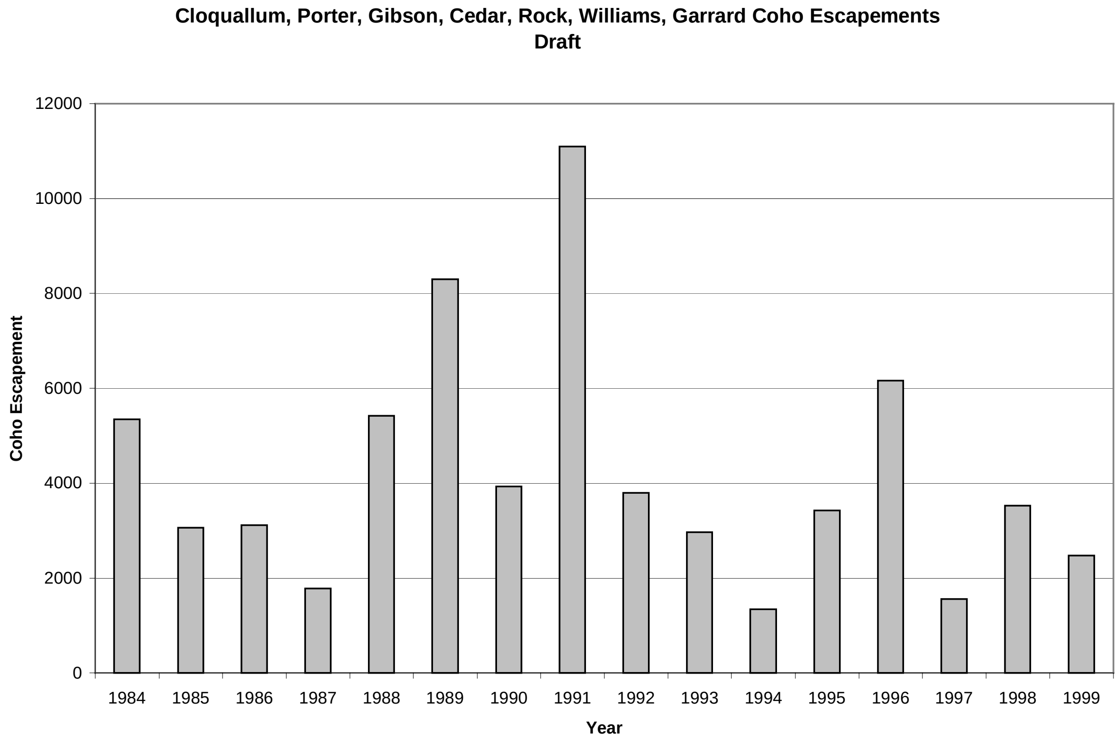
Johns/Elk Rivers Coho Escapements
Draft

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Coho Escapement
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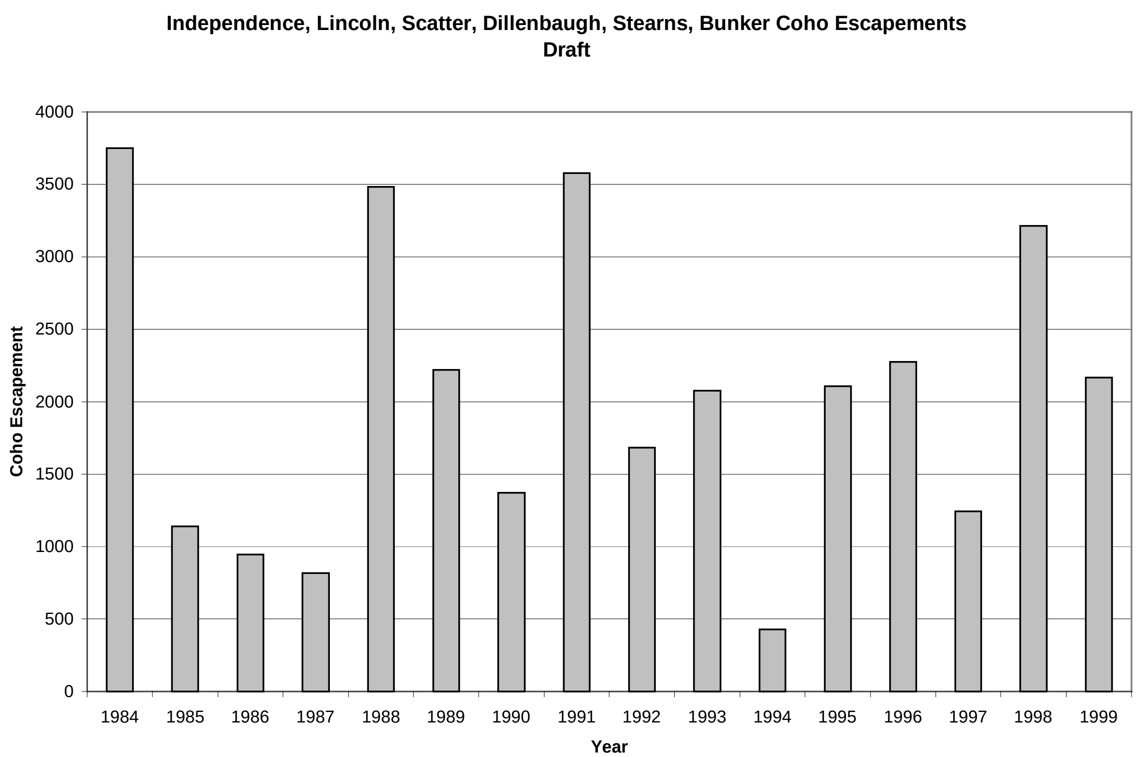
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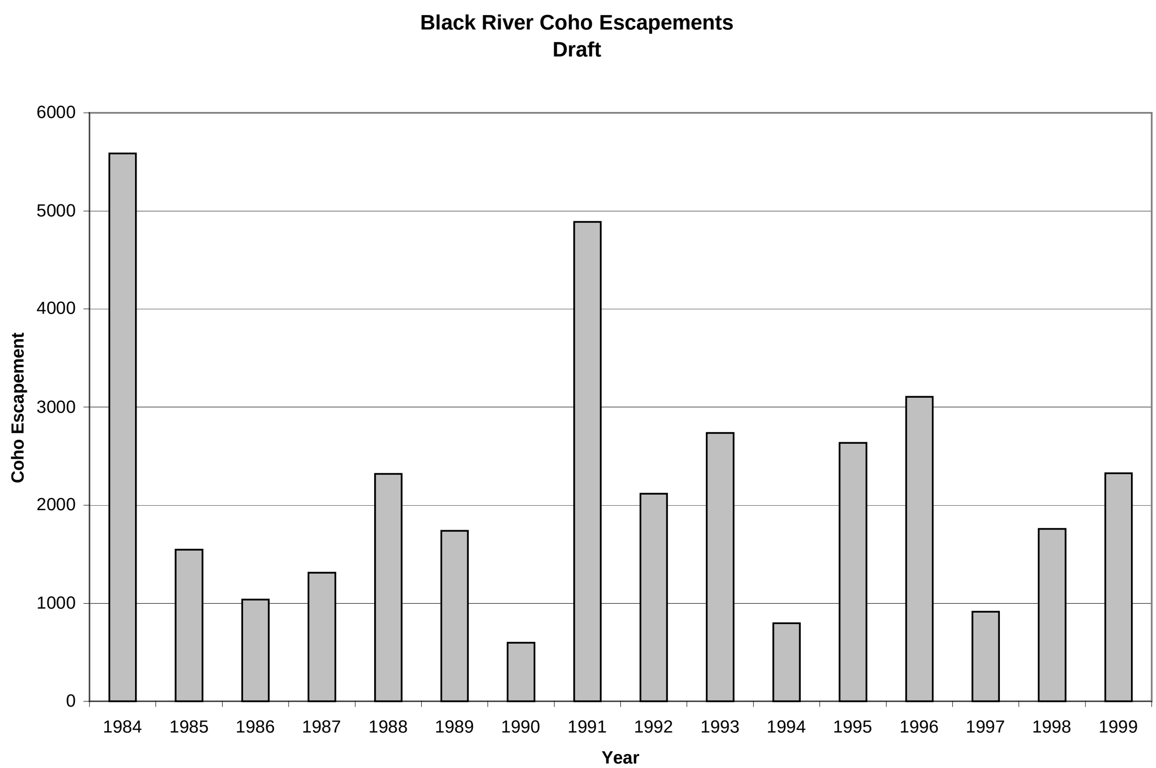
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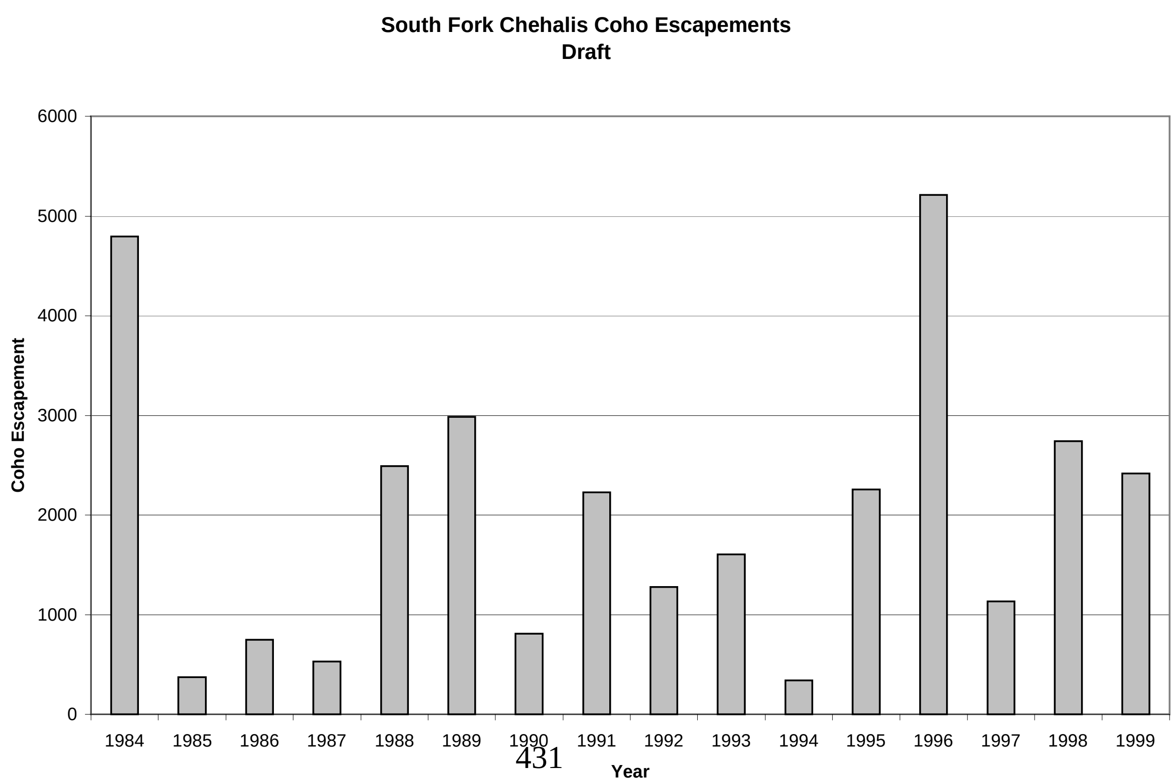
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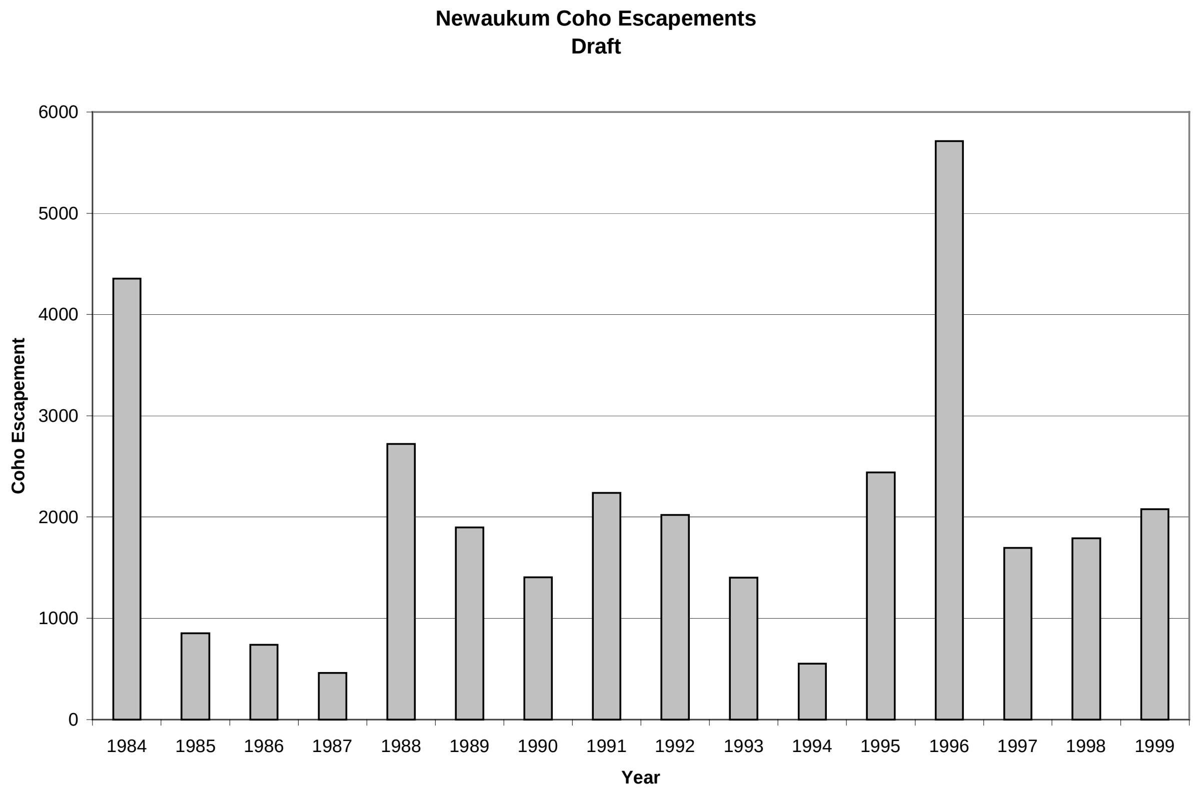
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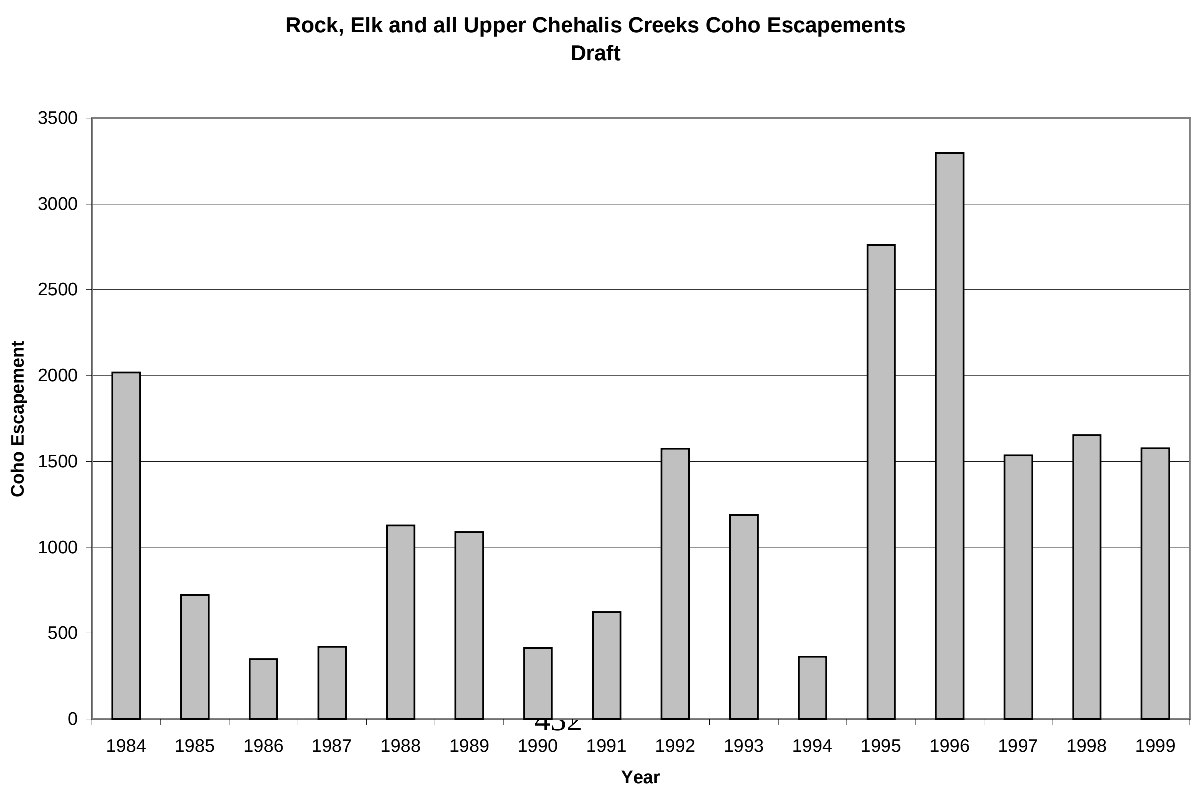
Rock, Elk and all Upper Chehalis Creeks Coho Escapements
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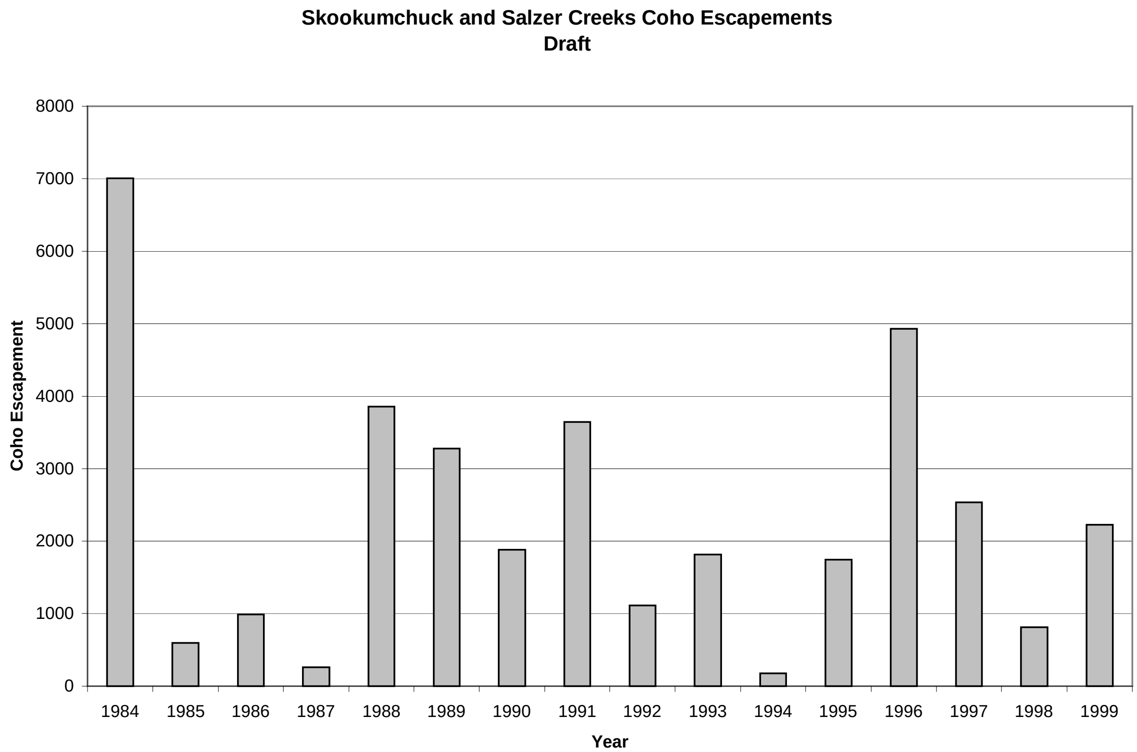
Skookumchuck and Salzer Creeks Coho Escapements
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