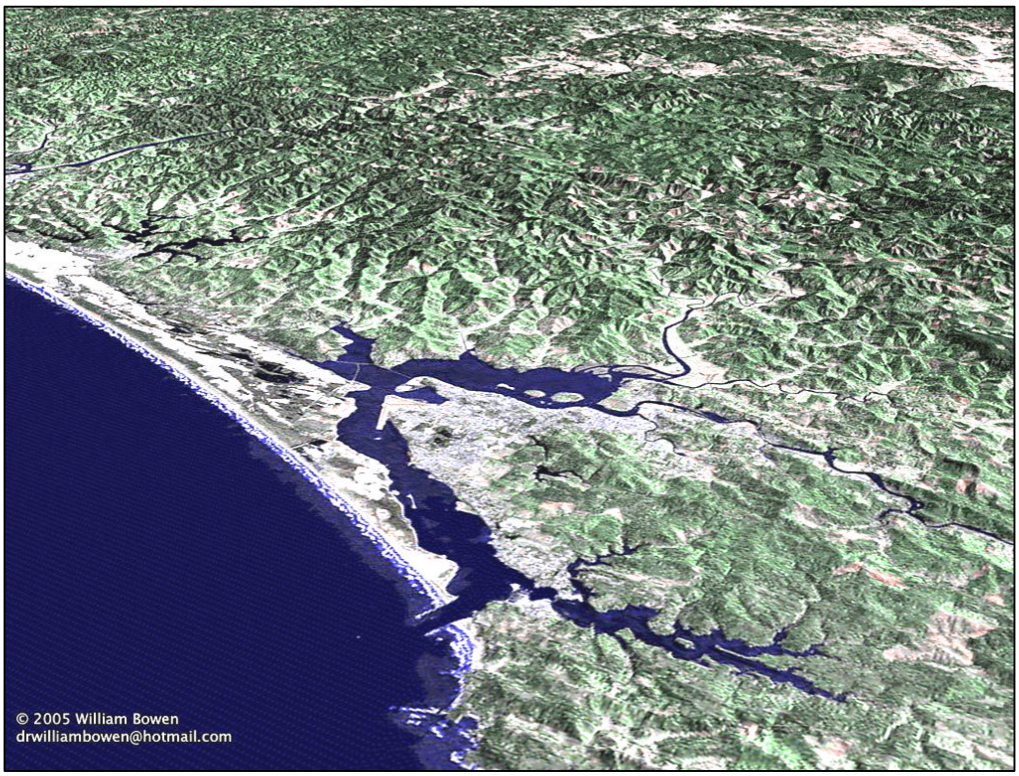
Coos Bay Lowland Assessment and Restoration Plan

2006



Coos Bay

Sea Grant Oregon

Coos Watershed Association
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The **Coos Watershed Association** is a 501(c)(3) non-profit organization whose mission is "to provide a framework to coordinate and implement proven management practices, and test promising new management practices, designed to support environmental integrity and economic stability for communities of the Coos watershed." The Association, founded in 1994, works through a unanimous consensus process to support the goals of the Oregon Plan for Salmon and Watersheds. Our 21 member Board of Director includes representatives from agricultural, small woodland, waterfront industries, fisheries, aquaculture, local government, environmental organizations, industrial timberland managers, and state and Federal land managers.

Acknowledgements

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Acronyms

ACW	Active Channel Width
AUC	Area-Under-the-Curve
BLM	Bureau of Land Management
CFS	Cubic Foot per Second
CHT	Channel Habitat Types
CoosWA	Coos Watershed Association
CSIP	Coastal Salmonid Inventory Project
DEQ	(Oregon) Department of Environmental Quality
ESU	Evolutionarily Significant Unit
GIS	Geographical Information System
NOAA	National Oceanic and Atmospheric Association
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OWEB	Oregon Watershed Enhancement Board
SRS	Stratified Random Sampling

CHAPTER 1
Introduction

Goals

The Coos Bay Lowland Assessment and Restoration Plan is based on condition assessments of lowland tributary streams of the Coos estuary along with input from affected landowners. The overall goal of the project is to develop and a strategically-planned watershed restoration program at the sub-basin level that aims to:

> *Restore and maintain watershed processes that allow for habitat connectivity, sustained populations of anadromous fish, and other ecological functions.*

This document is arranged to provide the following pieces of information. Chapter 1 is an introduction to the development and purpose of the Coos Bay Lowland Assessment and a general description of the Coos Watershed area and its history. Chapter 2 includes a discussion of each of the survey components that were used to inform the assessment and is then broken out into sections containing each sub-basin's assessment data. Chapter 3 includes an introduction to the restoration strategy overall, and is then also broken out into sections pertaining to each sub-basin's restoration opportunities. The sub-basin sections in Chapters 2 and 3 are intended to be independent from the other sub-basins, allowing readers to focus on one sub-basin at a time. Appendices include supplemental information about survey methods, data and notes used in calculations, standards and protocols, and other information useful in understanding watershed conditions.

Assessment and Restoration Plan Process

This assessment process is a unique and important opportunity to engage public and private property owners in the Coos Bay Lowland sub-basins in providing input into the development of a plan to improve water quality and habitat important to many marine and freshwater species, as well as human quality of life. The identification of current watershed conditions, potentials, and priorities will improve chances for successful restoration. The restoration of watershed processes, and habitat connectivity, in particular among freshwater and estuarine habitats, is central to improving salmonid habitat quality, diversity and quantity, thereby increasing the availability of fishery resources in the region. Improved water quality will also benefit the local shellfish growing industry, as well as domestic water uses.

The Lowlands Assessment and Restoration Plan is consistent with, and complements the Oregon Plan for Salmon and Watersheds goals to protect and restore marine resources and recover species under the Endangered Species Act (ESA). The development of the watershed assessment and identification of restoration priorities is consistent with the approaches utilized in the Oregon Watershed Assessment Manual. The Lowlands Assessment Advisory Committee has provided guidance in the process of prioritization, and intensive outreach to Lowland landowners has supplemented the Assessment with a suite of landowner concerns and goals.

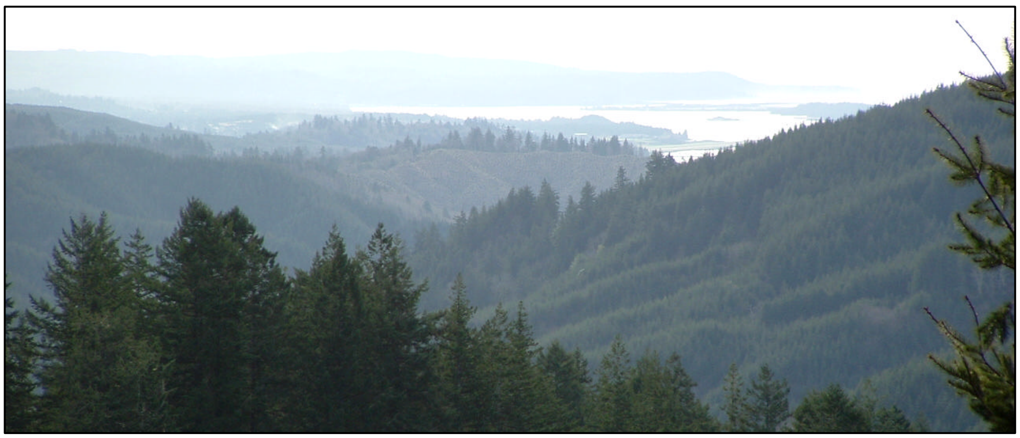


Figure 1-1 Haynes Inlet and Coos Bay from upper Palouse (photo CoosWA)

Physical Setting

Oregon Coast Range

Spanning 200 miles along the Pacific Ocean, the Oregon Coast Range is defined by a 30-40 mile wide swath of moderately high mountains average 1,500 feet in elevation. Slopes and drainage basins are consistently steep through the range, approaching 50° in many localities. Pacific storms buffet the range in the wet, winter months and support thick forests of Douglas fir and hardwood species. The average annual rainfall in the range is over 100 inches per year. Once home to an abundance of trout, salmon, and other fish, rivers and streams in the Coast Range now harbor a small fraction of the original aquatic population.

Geology

The Oregon Coast Range is a belt of uplifted land overlying the subducted Juan de Fuca plate. The land is composed of accreted oceanic sediments - mostly older marine sediments and sands, clays, and muds eroded from ancient mountains to the south and east. Deposited on the ocean floor in a great trough from the Klamath Mountains to Vancouver Island, these sediments were uplifted by the force of colliding continents and eroded once again creating relatively wide river mouths. This regionally extensive marine sandstone and siltstone is commonly referred to as the Tyee formation, and is vulnerable to soil erosion processes. The Lowlands Assessment area lies entirely within the Tyee unit.

Upland topography in the Coast Range consists of convex ridge tops characterized by small soil slips and landslides (Roering et al., 1999). At the base of these steep sideslopes, in unchanneled valleys, soils accumulate and thicken over long periods and become saturated during rainfall events. The combination of thick soil and frequent saturation lends itself to episodic shallow landsliding (Heimsath et al., 2001).

Coos Bay Lowlands

Three Hydrologic Unit Code (HUC) fifth field watersheds drain into the Coos estuary: the Millicoma River, South Fork Coos River, and Coos Bay Lowland tributaries. It is the Coos Bay lowland streams, six in total, that are the focus of this Assessment and Restoration Plan. Figure 1-2

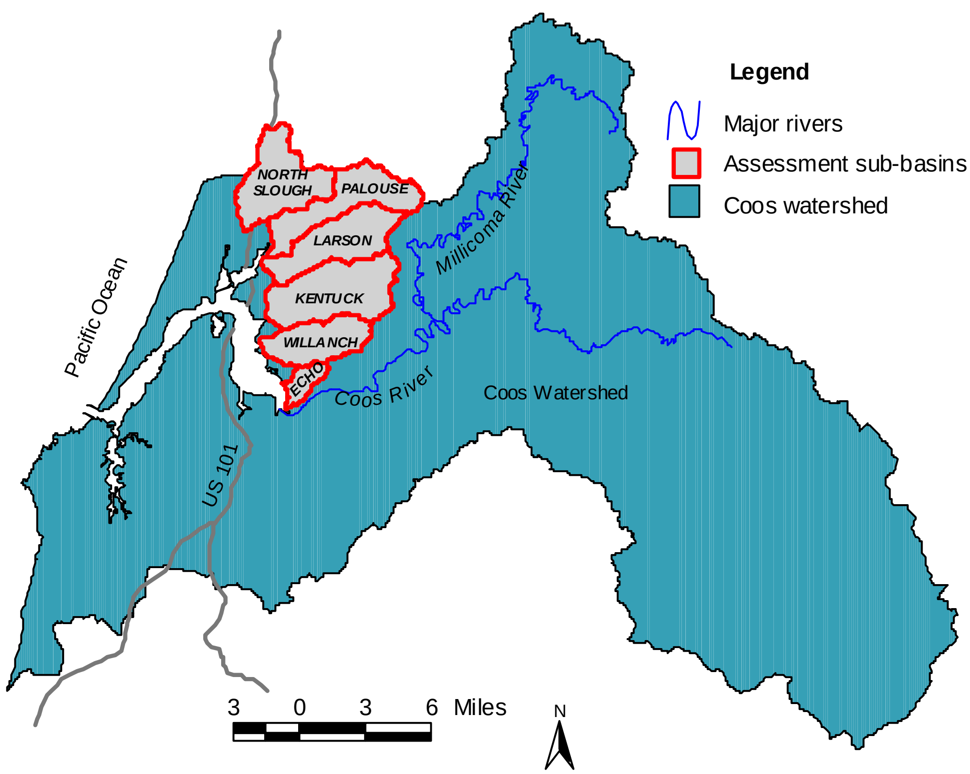


Figure 1-2 Assessment Area

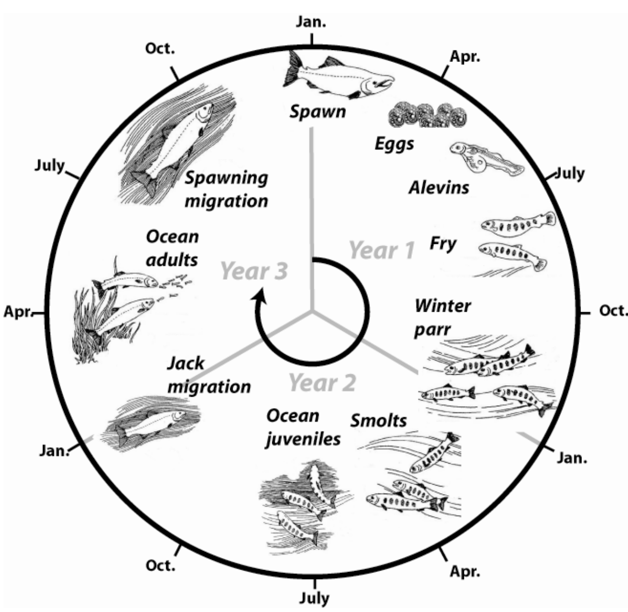
outlines the stream sub-basins in red. The average sub-basin size is 6,415 acres, and the mainstem streams are typically 10 to 25 kilometers in length, drain into either an embayment or tidal slough, and are frequently tide gated. These stream systems have urban or rural residential land uses at their intersection with the estuary, agricultural uses in the valleys upstream, and non-industrial or industrial logging in the hills above their valleys. In their natural state, before settlement, these Lowland streams were sinuous and marshy, and providing highly productive rearing areas for juvenile coho.

Fish

The Coos estuary supports important fishery resources. Five anadromous species of salmon and trout, (i.e., coho, Chinook, steelhead, sea-run cutthroat trout, and chum) Pacific lamprey, and a wide range of coastal species use its various habitats.

This assessment focuses primarily on coho spawning, rearing and migratory habitat conditions and factors influencing those conditions. The coho life history cycle, summarized below and illustrated in Figure 1-3, is a key backdrop to assessment data analysis and planning watershed management.

Figure 1-3 Coho life cycle



Coho smolts typically migrate to sea in the spring of their second year, spend 16-20 months rearing in the ocean, and then return to freshwater in the Fall (October to January) to spawn as three-year-old adults. Egg to smolt survival is typically 2-3%. Coho typically seek small, relatively low-gradient tributary streams for spawning and juvenile rearing. Ideal spawning gravels are generally pea to orange-sized, and maintain cool, clean interstitial spaces for eggs and emerging young. Over-wintering habitat is primarily in off-channel alcoves and beaver ponds where juveniles can find protection from high-velocity flows. In general, coho prefer complex instream structure, i.e. large wood, and shaded streams for rearing.

A returning adult coho may measure more than two feet in length and weigh an average of eight pounds. After the first summer at sea, a small proportion of the males reach early sexual maturity and return that fall as two-year-old "jacks." These jack returns have proven to be a fairly accurate predictor of adult abundance the following year, and serve as a key component for setting ocean coho fishing regulations.

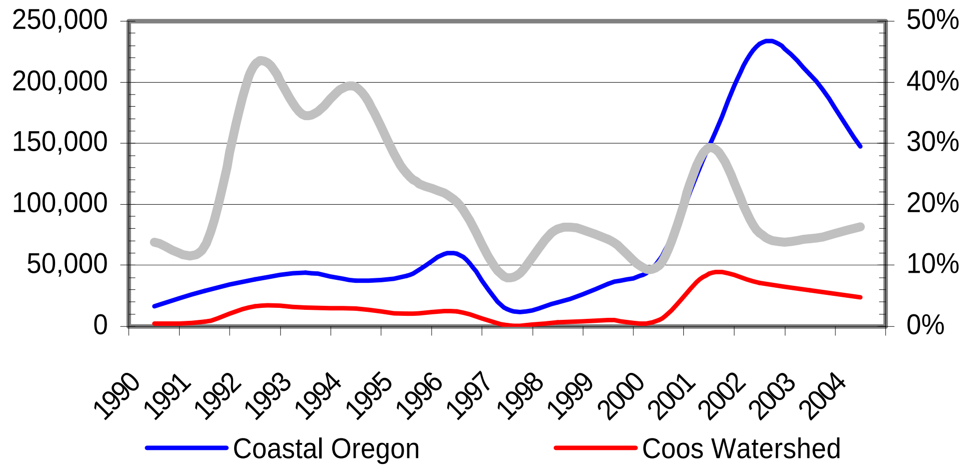


Figure 1-4 Oregon Coastal ESU Wild Coho Spawner Abundance 1990-2004 (ODFW, 2005)

On average about one-fifth (see Figure 1-4), and as much as 43%, of coho salmon on the Oregon Coast Evolutionarily Significant Unit (ESU) pass through the Coos estuary during their coastal migration (ODFW, 2005), and one Lowland tributary stream, Palouse Creek, often has the highest coho spawning densities in Oregon. Although the Oregon Coast coho ESU has been listed in the past as threatened under the Endangered Species Act, it is currently not listed. A factor in the delisting decision was the demonstrated willingness of the state of Oregon and its citizens to implement land management actions that help to rehabilitate freshwater salmon habitat.

In the past, many coastal waterbodies were stocked with hatchery releases to bolster ocean fisheries. Most releases in the Lowland area, ending in the late 1980's to 1990's, were smolts released from small acclimation sites. The later years of hatchery releases were locally founded broodstocks.

Although not directly associated with the Lowland Assessment surveys, CoosWA has installed live fish traps on Larson Creek and, later, Palouse Creek. The purpose of the traps is to study, post tide gate replacement, the productivity of these streams and effects on the coho life cycle. During the 2004 – 2005 season, the Larson trap caught 27 coho, with a final estimate of 273 adults and jacks per kilometer. Estimates of smolt populations, based on 2005 trap data, are 2700 coho, 678 steelhead, and 850 cutthroat.

Wetlands

Wetlands provide many important functions in a watershed, including water quality improvement, flood water attenuation, groundwater recharge and discharge, and fish and wildlife habitat. Wetlands are usually connected to a riparian zone, but sometimes occur in higher elevation areas with no obvious surface connection to a stream.

Water quality is improved by wetlands' ability to trap sediment and contaminants. Dense wetland vegetation acts to decrease rate of flow - allowing sediments to settle. Wetland vegetation can also take up certain nutrients and some toxins, thereby improving downstream water quality. The anaerobic environment of many wetland soils breaks down nitrogen compounds and keeps other compounds in a non-reactive form. However, the ability of a wetland to provide this function is limited.

Wetlands alleviate downstream flooding by storing, intercepting, or delaying surface runoff. Wetlands within the floodplain of a river can hold water that has overtopped river banks. Floodwater desynchronization occurs when wetlands higher in the watershed temporarily store water - reducing peak flows. The most effective wetlands at providing desynchronization are generally located in the middle elevations of the watershed; these wetland locations are far enough away from the receiving water to create delay, but are low enough in the watershed to collect significant amounts of water.

> Note: Floods help shape aquatic habitat by impacting channel morphology, sediment transport and deposition, and adjacent stream vegetation. Habitat quality for fish and other aquatic organisms also is formed by the interaction of these elements.

Wetlands, intimately associated with groundwater, can function to recharge the underlying aquifers. Wetlands are sources of groundwater discharge that may help extend streamflows into the drier summer months.

Wetlands support fish and other wildlife by the functions described above - water quality protection and channel stability, as well as providing habitat themselves. Estuarine wetlands provide important feeding and holding areas for outmigrating salmon smolts (OWAM, 1999).

Both tidally-influenced estuarine wetlands and river-sourced freshwater wetlands occur in and around the Lowlands area. Prior to Euro-American settlement in the 1800's (see Settlement on page 10), the Coos estuary, as shown in Figure 1-5, extended as fingers into the mouths of the six sub-basins covered by the Coos Bay Lowlands Watershed Assessment. Subsequent to settlement, these areas were diked, causeways were built for roads and railroads, and tide gates were installed at the stream mouths to prevent saltwater flooding during high tides while facilitating drainage during low tides. However, it is important to understand the historical extent of wetlands to understand underlying hydrological processes; to work with natural drainage patterns in restoration and infrastructure improvement projects; and to identify potential wetland restoration actions.

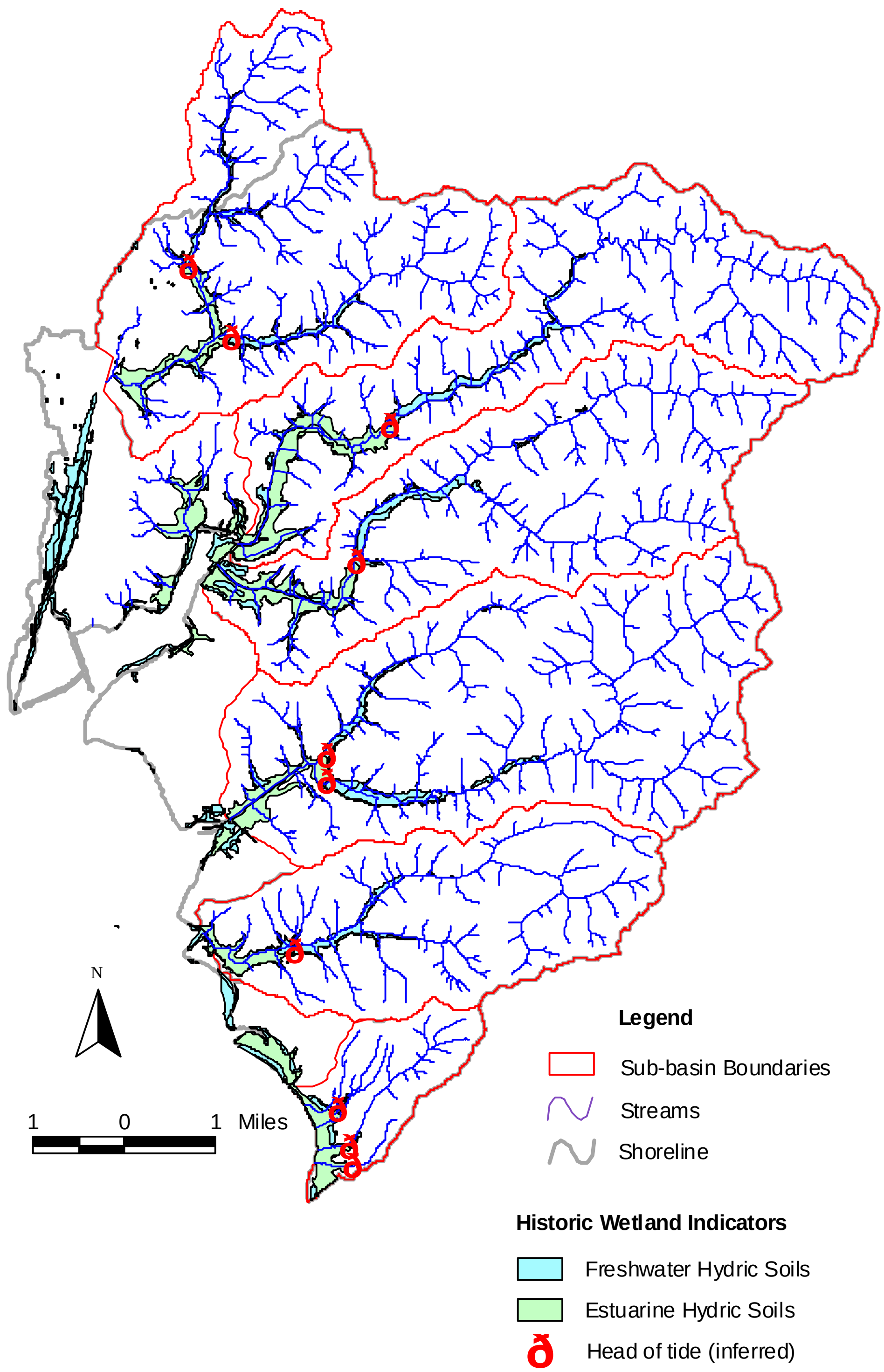


Figure 1-5 Lowland Historic Wetlands And Heads Of Tide

A wetland rehabilitation project is located near the mouth of Larson Creek and smaller wetlands occur at the mouth of Willanch Creek. Other, marine-sourced wetlands, are found on the bay side of the Palouse tide gate, the Kentuck tide gate, along the shore north of Echo Creek, and extensively along North Inlet west of highway 101. See Chapter 3 for more discussion of wetland restoration.

Estuary

The Coos Bay estuary is approximately 13348 acres. It is a drowned river mouth variety, where winter floods discharge high volumes of sediment into and through the estuary. In summer, seawater inflow dominates the estuary due to low streamflow. The Coos Bay estuary is designated as a Deep Draft Development estuary under the Oregon Estuary Classification system.

The bay portion of the estuary is characterized by broad mud flats which are exposed to the air at low tide and flooded by a mix of salt and fresh waters at high tide. Sediments carried from the mountains by the river are deposited in the upper bay and along the edges of main channels, while finer particles of silt and clay drift farther to the edges of the flats near the fringing marshes. Marine sand carried along the ocean front in the "longshore current" is swept into the estuary on incoming tides and may be deposited as far as several miles upstream. Coos Bay has a relatively large bay as part of its estuarine system.

Sloughs, of which the Coos estuary has many, are low-gradient tributaries to the main bay and river channels. They have little freshwater inflow. Tidal flushing may not be as complete as in parts of the estuary that are closer to the ocean or main channel. Generally, sloughs consist of meandering channels that wind through fringing marshes and across mud flats to the main bay. It is these small channels that, when unrestrained, brought the tide up into the marsh and to the edge of the forest. All mainstem streams in the assessment area display slough characteristics near their confluence with the estuary, however altered by land use practices such as tide gates, dredging and diking. In the past these sloughs and streams were generally deeper and navigable by boat.

Estuaries are important for adult salmon, providing the necessary transition and holding areas for the fish before they begin their upstream migration. Estuaries also serve important functions for smolts, especially coho, by providing shelter from high flows while the juveniles prepare for their ocean phase.

Human Impacts

Characterizing pre-European lifestyles and settlement patterns help to understand human impacts to the landscape, and how conditions have changed overtime.

Native Americans

Natives lived in numerous villages along the Coos River and estuary. Apart from marriages, these villages were largely independent of each other. Groups would migrate between more permanent winter homes along the river and estuary, and their seasonal camps farther upriver to follow the migration of salmon and lamprey and to harvest particular plants for food, tools, medicine and clothing. Fish and berries were dried and stored for other seasons of the year. The main staples of the Coos were fish, berries with occasional bear, venison or elk. Before significant trading with Europeans began in the early 1800's, everything the natives used was collected or developed from the local environment (although some trading between regions occurred, e.g. chirt found in the lower Coquille area was sought after for arrowheads).

The Coos tribes were known to be more docile than their neighbors to the north and south, and it was noted that these natives enjoyed a surprising amount of leisure time. Their initial encounters with whites were generally non-combative, however, after the 1856 Rogue River War between the whites and the natives there, all south coast tribes including the Coos, were forced to move to a fort near the mouth of the Umpqua River, and later to Yachats. A small number of Coos eventually moved back to the Coos Bay area either marrying into non-native families, or hiding from authorities with relatives that were married (Douthit, 1999 and CTCLUSI, 2006). In her book of memoirs, Ines Nelson (1978) mentions that Indians were still living in the Haynes (Palouse and Larson Creeks) area until the 1870's.

Settlement

European settlement had begun in the Coos Bay area by 1850, and in 1853 the Coos Bay Commercial Company was formed to promote white settlement of the area. Fueled by commercial interest in resource extraction and the potential for an excellent harbor, Coos Bay flourished rapidly. Initially, coal was the primary draw. The first coal mining in the watershed began in the 1850's and peaked in 1874 with 44, 857 tons shipped to San Francisco that year. The lumber industry, however, immediately surpassed coal mining in importance. Coos Bay lumber began shipments to California as early as 1854 (Case, 1983), and eventually became the world's largest forest products shipper in world. As the port grew, ship building also became a major industry in Coos Bay.

Workers in the mines, forests, mills and ship-building industries fanned out with their families to settle the fertile land surrounding the bay, sloughs and rivers. The Homestead Act of 1862 required settlers to show proof of farming activity in order to hold their homestead claim. As a result, the valleys, fertile with alluvial soil, were quickly cleared and cultivated for myriad crops. Fruit orchards, especially apples, were usually one of the first farming endeavors which laid claim to the land. Other crops included grains, roots, berries, and domestic grasses for pasture. Potatoes, if fields were rotated, were very lucrative, as well as dairies and creameries which flourished along the waterways. All farm products for market were transported by boat to Marshfield and Empire City, and many were shipped by the ton to San Francisco (Nelson, 1978).

Until a railroad was built that connected the Coos Bay area to the Coquille River, in 1893, easier access to the fast-growing markets of Coos Bay gave Coos Bay farmers an advantage over their Coquille counterparts, and resulted in a relatively faster pace of land cultivation. The Coos Bay Lowlands area was especially known for its excellent farms and large amounts of produce shipped to market as a result of much labor and expense to bring these lands into cultivation**.** (Dodge, 1969)

Before the automobile age most transportation in Coos County was by boat. The farmers who lived in the Coos Bay drainage journeyed to town by steamboat or by gasoline launch. Between 1901 and 1930 passenger travel on the Coos River averaged almost 30,000 people per year. Roosevelt Highway was approved in 1921, southwestern Oregon portion completed in 1927. The Roosevelt ferry was put into operation in 1924 for highway traffic across the bay. (Case, 1983)

A fire in 1868 burned 300 thousand acres of forest in much of what is now the Elliot State forest. Many of the old pictures taken during the settlement days in the Lowlands area show tall snags towering over the undergrowth on the hills surrounding the bottom land – indicative of the fires. Besides the fires, most timber in the ridges remained the same until 1951 when it was bought by Weyerhauser Timber Company (Youst, 2003).

Surveyor's notes from 1919 provide some description of the Lowlands vegetation and land uses in the valley bottoms and lower slopes at that time. The bottom land was being drained for cultivation by means of dikes, ditches and tide gates – many still in use today. In many areas the surveyor labels a salt water marsh and adds that it will be "good for cultivation when dyked and drained". Some low-elevation meadows were described as "stumped" indicating tree stumps possibly left as a result of logging, fire, or tree die-off due to hydrologic or tectonic changes. Other area streams were being straightened, especially in the lower valley regions, and occasional relic meanders are shown with dotted lines. Many of the lower slopes are described as "slashed and seeded" – brush cleared for pasture. The notes also indicate problems with the drainage structures, such as a leaking tide gate at the mouth of North Slough Creek, and a break in the dike near the mouth of Willanch Creek, which was also tide gated (Selande and Collier, 1919).

Land Management Impacts

A large proportion of the population settled in what became urban areas surrounding the estuary, sloughs and rivers. These urban areas are largely built on filled estuarine tidal marshes. Urban development has resulted in periodic storm water drainage and sewerage overflows into the estuary, which, combined with failing septic systems and agricultural run-off have caused high levels of fecal coliform bacteria in water. This has affected the use of parts of the estuary for recreation, fishing and oyster cultivation.

Farming and logging practices have affected these basins similar to other Coast Range drainages. Channelization, draining of wetlands, dredging, diking and tide gate placement on low-gradient reaches to create pasture and croplands have eliminated much of the riparian vegetation, decreased channel complexity and productivity, and interrupted the natural cycle of sediment flushing.

In addition, the cumulative effects of upland forestry activities, such as riparian tree removal, soil disturbance, and historical large wood removal have damaged salmonid spawning gravels, decreased stream complexity, increased sediment introductions, and raised water temperatures. Low-gradient reaches are affected by both the adjacent land use practices and the down-stream effects of upland land use practices.

Several waterbodies in the assessment area, mainly in the sloughs and lower reaches of streams, are currently listed by the Oregon Department of Environmental Quality as "water quality limited". The listings are a result of fecal coliform levels exceeding standards for beneficial use. The Oregon DEQ will be completing Total Maximum Daily Loads, and Water Quality Management Plans for the Coos Watershed in 2006.

Other land uses in the Lowland area include a golf course, rock quarries, and wood treatment plants.

Coos Bay Lowland Assessment and Restoration Plan

CHAPTER 2:
SURVEY COMPONENTS

Stream substrate. Image © Wikipedia.

Components Assessed

This assessment is based on scientific data gathered in the field, and background information researched which represents a selection of watershed processes and land management characteristics. This chapter describes the relationship between watershed processes and the components studied.

Land Use

Understanding land use and ownership help to characterize general land management issues and objectives. Land use activities influence the landscape by changing the timing and intensity of natural processes. Residential development, agricultural practices and forest management activities have the potential to significantly change the drainage patterns of water by increasing the amount of impervious surfaces. These issues are farther described in Hydrology, below.

Hydrology

Hydrologic data were used to study major factors within the sub-basin that have an effect on the local water cycle. These factors included precipitation, stream flow, land use and water use. They were used to develop a rating of the risks to altering stream flow. In addition to OWEB WAM hydrology assessment results, we also looked at the Oregon Water Resources Department's water availability and water use allocations within the lowlands.

In 1996, the Oregon Plan for Salmon and Watersheds outlined the Coastal Salmon Restoration Initiative which called for the development of Stream Flow Restoration Priority Areas in which ODFW and OWRD were to assess all Water Availability Basins (WABs) in Oregon based on stream flow and consumptive use issues. Prioritization was based on a combination of biological factors and consumptive water use. ODFW identified areas where flow enhancement was needed to support fish populations. OWRD identified areas where opportunity existed to enhance flow based on consumptive water use, or water right permits.

Aquatic Habitat

Aquatic habitat conditions arise from the interactions between landform and land use. The CoosWA performed aquatic habitat surveys to characterize the status of in-stream salmon habitat features. Distribution and abundance of salmonids within a watershed or sub-basin varies with habitat conditions. Due to the complex life histories of salmon, different features and areas of the stream system are used during different parts of their life cycle. Understanding key aquatic habitat components and their trends is a key step in achieving and maintaining suitable conditions.

Aquatic habitat survey data were used to qualify and quantify current stream conditions. CoosWA surveys were the sole source of information for the aquatic habitat analysis except where otherwise noted. Survey data were compared to ODFW salmonid habitat benchmarks, (more on benchmarks in Appendix A), and resulting analysis will be used to direct and focus habitat restoration efforts. The aquatic habitat survey parameters used in this assessment include unit type, substrate type, pool depth, riffle sediment, large wood, and bank stability (in this assessment bank stability data are presented in the Sediment Sources sections). Channel morphology data were also collected as part of the CoosWA aquatic habitat surveys - see Appendix B.

Aquatic habitat survey areas were split into reaches within each sub-basin and assigned a name. A map of aquatic habitat study reaches is presented for each sub-basin. CoosWA attempted to avoid displaying the data in a way that will make it useable for regulatory purposes by conglomerating data into reaches based on valley and channel form.

Wetlands

Assessment of wetland conditions helps to characterize contributing influences to issues associated with stream-floodplain interaction. Historic estuarine and other hydric soils, along with historic vegetation communities, indicate the extent and nature of pre-settlement wetlands and inland extent of tidal influence. A rough assessment of current wetland conditions provides insight to potential restoration areas. Strategic wetland restoration could help to improve nearby pasture drainage and productivity, while improving water quality and fish habitat.

Sediment Sources

Fine sediment, beyond natural background levels, is detrimental to fish and their habitat in many ways. When substantial erosion occurs spawning gravels become embedded often causing high rates of egg mortality. More than 10-15% fine sediment (silt/organics) reduces the flow of oxygenated water to the eggs (FRS, 2003). In the case of adult salmon, high concentrations of suspended sediment may delay or divert spawning runs (Mortensen et al. 1976). Additionally, as pools collect sediment, depth decreases and solar heating occurs more rapidly. Healthy pool depths provide important thermal, as well as predatory, refuge for salmonids. Aggradation, or raising of the streambed, can influence flow levels, flooding and erosion.

The Sediment Sources component of this assessment evaluated the following four sources of sediment: 1) Bank stability (see aquatic habitat survey methods), in which the percentage of stream bank in each surveyed reach was determined as a being either covered or uncovered, and stable or unstable. 2) Slope stability, in which each sub-basin was evaluated for % of area at risk of slope failure in four risk categories from low to extremely high. 3) Road and landing surveys, in which roads and road drainage features were examined for erosion potential and compared to ODF Best Management Practices. 4) Stream crossing capacity evaluation, in which stream crossing sites were rated for their flow capacity compared to a 50-year event and their risk of failure. Sediment deposition within the stream channel was also reflected in the aquatic habitat analysis.

Slope Stability

Unstable slopes often lead to shallow slope landslides and deep seated soil creeps. It is important to note that landslides are a natural process that is important to streams by recruiting gravel, boulders, and large woody debris in to the stream channel. However, acceleration of this process by human activities can have serious impacts to the aquatic ecosystem. Slope, vegetation, and geology all have direct relationships to the slope stability of an area.

Presence of mature vegetation is important component of stable slopes. "There is some evidence that the removal of trees on steep slopes (greater than 80%) makes an area vulnerable to shallow landslides and can lead to temporary acceleration of the landslide rate. This vulnerability begins when many of the finer roots of the harvested trees become rotten(about 4 years) and ends once the replacement stand has developed a dense root network (about 30 years for wet portions of the state)" (OWEB, 1999). Many of the upland slopes in the Lowlands area are commercial forests on short harvest rotations, most are harvested in 30 or 40 year rotations. Because of this, there may be chronic slope problems from this type of land management. Adhering to Best Management Practices during forest harvesting is important to minimize loss of soil on unstable steep slopes.

Road and Landing Survey

Hydrologic connectivity occurs when road drainage is discharged directly into channels via culvert outflow or drainage ditch relief near stream channels (assumed to be within 100 feet). Either one of these conditions will potentially increase sediment transport volumes and flood stage elevations downstream.

Road surveys were conducted on the lowland tributaries for three primary purposes: (1) to identify fish passage impediments at road stream crossings, (2) to determine the degree of road failure risk, and (3) to identify locations where hydrologic connectivity of road drainage ditches to live stream networks could be altered to filter road sediment before it reaches the stream.

Stream Temperature

Water temperature is commonly used as an indicator of stream health for many reasons. According to the Oregon Department of Environmental Quality, “the purpose of the temperature standard is to protect the beneficial uses of the waters of [Oregon] and to preserve the health of aquatic ecosystems.” (Boyd and Sturdevant 1997) Water temperature affects many aspects of stream health, including dissolved oxygen, productivity, algae and bacteria levels, as well as the physiology and metabolic rates of aquatic organisms.

The stream temperature standard of 64°F (17.8°C) was identified as the maximum acceptable level for general salmon and trout use. The goal of the standard is to maximize the time that cold-water rearing habitat is available for juvenile salmonids and to minimize the warm water stress that can occur when these cold-water fish are exposed to elevated temperatures. This standard for water temperature is not an indicator of the highest levels fish can tolerate, since salmonids commonly live in streams that exceed 64°F. However, physiological and behavioral changes often occur in fish when temperatures approach 70°F. Temperatures above 77°F alone can be directly lethal to fish, but temperatures lower than these also affect their metabolic rates and their ability to reproduce and fight off disease (Oregon DEQ, 2000).

The 7-day maximum is a good method to determine the response of fish to high water temperatures. Water temperature has a cumulative effect on fish health similar to a toxin -- the longer fish are exposed to high temperatures, the lower their chances of survival. Fish can likely endure one day of 75°F water by eating more or moving into cooler areas, but an extended period (multiple days to weeks, depending on the fish) at water temperatures in the mid-70°F or above will cause death due to breakdown of physiological regulation of vital processes (Roberts, 1973; Heath and Hughes, 1973).

There are many factors affecting stream temperatures, both human-caused and naturally-occurring. Human-caused affects can be addressed through restoration actions, and therefore, are discussed here in detail. Water withdrawals reduce in-stream flow and velocity, and both provide more opportunity for solar radiation to increase water temperatures (Oregon DEQ 2000). Tide gates and dams both act as obstructions to the normal flow of a stream, affecting its ability to mix and flow and can strongly affect stream temperature. Because tide gates cause freshwater stagnation and restrict tidal inflow, they tend to increase upstream water temperatures (Giannico and Souder, 2005).

Channel engineering, including straightening, dredging, diking, removal of large wood, rip-rap, and channelizing/culverting affects stream temperature in several ways. These actions decrease the interaction between a stream and its floodplain. It also reduces the ability for groundwater to move into the stream, decreasing the additions of beneficial cooling water. Such channelization increases down-cutting, which lowers the stream surface, again distancing the stream from the floodplain and draining ground water adjacent to the stream that could have a cooling influence. These practices also reduce stream complexity which can change the stream substrate. Large woody debris plays an important role in keeping gravel in streams. Wood removal can cause increased velocities and can wash gravel and cobble downstream leaving bedrock and boulders. Such channel changes can also increase levels of fine silts from erosion and sedimentation can vastly change the streams ability to dissipate heat energy. (Poole and Berman 2001)

Reduction of upland and riparian vegetation is one of the most influencing human-caused effects on stream temperature. Activities that decrease riparian vegetation and canopy cover have been shown to increase the water temperature of adjacent streams (Newton and Zwieniecki, 1996). By reducing the amount of shade on streams, the solar load to the stream is greatly increased. Of the many factors effecting stream temperature, direct solar loading is has the greatest influence on elevating temperatures above natural background levels (Adams and Sullivan, 1989).

Salmonid Distribution

Fish use extents are important to consider when evaluating conditions and planning restoration actions based on salmonid habitat requirements. This assessment includes maps of fish use gathered from Oregon Department of Forestry and the Oregon Department of Fish and Wildlife. These determinations will help inform habitat restoration designed to improve conditions for a specific fish species. The most abundant anadromous fish species in the Assessment area are coho salmon and cutthroat and steelhead trout. Typically, steelhead will utilize higher gradient stream habitat than coho. Above natural anadromous barriers, native cutthroat populations are common. The upper extent of these native cutthroat populations usually defines the end of fish use in these streams.

Limiting Factors Analysis

Ecologists and resource managers have used different theoretical approaches to formulate management plans for watersheds and their fish populations. Some of the early conceptual frameworks include: Limiting Factors Analysis (Reeves et al. 1989, Nickelson 1992) and Watershed Analysis (FEMAT 1993). These were followed in the late 1990s by Ecosystem Diagnosis and Treatment (EDT) (Lestelle et al. 1996), and more recently by Ecosystem Management Decision Support (EMDS) (Reynolds 2002; Reynolds and Hessburg 2005).

This assessment will examine watershed health and determine "bottlenecks" to coho salmon production in the six lowland sub-basins using the Reeves et al. method of Limiting Factor Analysis. The premise of the limiting factors concept is that the upper limit to population size is determined by the habitat resource in least supply. If the amount or quality of that habitat is increased, the population can theoretically grow until constrained by the next most limiting habitat. This process provides carrying capacity estimations for spawning, summer and winter habitats based on aquatic habitat inventories and stream temperature data.

Figure I-3 shows the "bottleneck" to fish production where the limitation occurs (A) during winter before seaward migration of smolts, or (B) during the previous summer. Thus, improvements to habitat should be informed by the fish populations and the habitat carrying capacity of a stream based on specific seasonal needs of rearing fish.

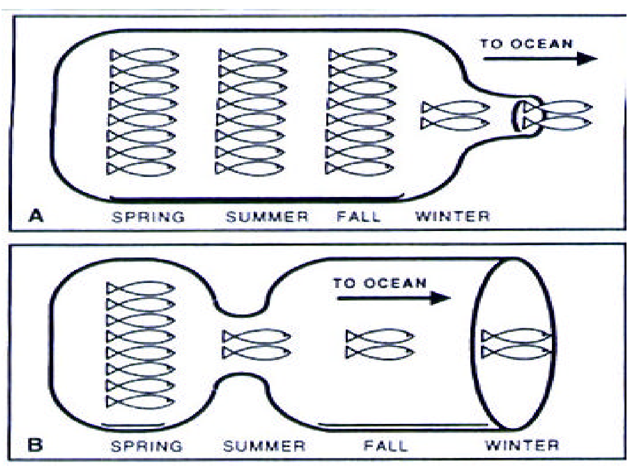


Figure I-3 Bottleneck Concept (Reeves et al., 1991)

Using a biological limiting factors analysis is useful in addressing the habitat needs of a specific species; however, the risk of this approach is that restoration planning would focus on treating the symptoms of watershed problems and not the natural processes that create ideal habitat. In determining limited habitat with this process, CoosWA has found that sediment issues, specifically spawning gravel embeddedness, do not come into play as well as they should. Species specific limiting factors analysis can be useful in helping to prioritize restoration, but should be considered with other information about watershed health, such as intrinsic potential analysis.

Intrinsic Potential

Intrinsic potential is a measure of a stream's ability to provide quality habitat for a particular species of fish (Thompson, 2005). Different species have different requirements during their life history stages, i.e., coho prefer low-gradient, slow-moving streams. Understanding the intrinsic potential of particular streams to support salmon populations during historic, pre-settlement conditions is crucial when planning and setting goals for habitat conservation and restoration efforts. While meeting these historic population numbers is largely unrealistic, it is an excellent prioritization tool and aims to increase efficiency of efforts.

A stream's intrinsic potential is estimated based on topography and stream flow data used to produce digital elevation models. When combined with habitat requirements of a particular species life history stages, the model calculates the number of smolt expected to be supported by the stream under natural conditions.

Landowner Input

Local landowners were engaged primarily through a series of 'Coffee Klatch' meetings held in the Lowland area to inform landowners of the surveyed watershed conditions, collect input from landowners to be used in the Assessment as additional resource issues for restoration prioritization, and to enlist landowner participation in watershed restoration efforts. It is understood that implementation of restoration projects is dependant upon the acceptance, understanding and will of landowners. This particular area of the Coos Watershed has a very high proportion of private landowners managing relatively small acreages, and so participation of the community will be essential to successful restoration.

Coos Bay Lowland Assessment and Restoration Plan

Chapter 2:
North Slough Sub-basin Assessment

North Slough pasture wetland area above main stem tide gate. Photo CoosWA, 2006.

North Slough Sub-basin

Introduction

Landform

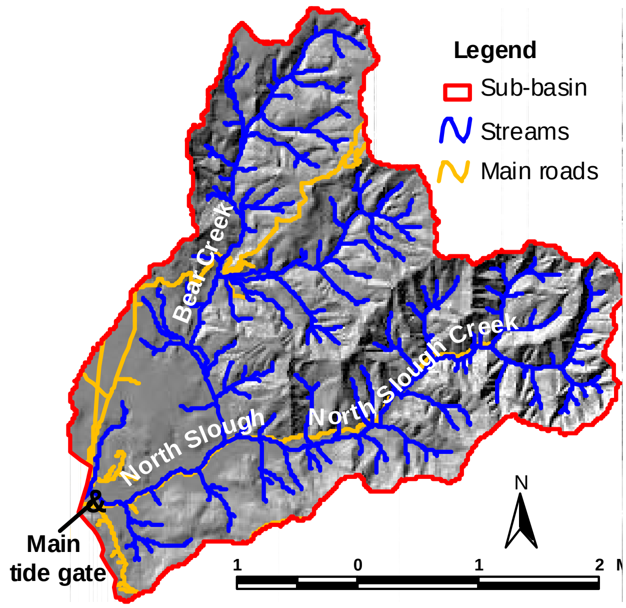


Figure NS-1 General Sub-basin

North Slough is the northern-most sub-basin in the Lowland assessment area. The sub-basin is oriented northeast to southwest (see Figure NS-1), and is a dendritic, or tree-like, fifth order stream system consisting of two main tributaries - Bear Creek and North Slough Creek.

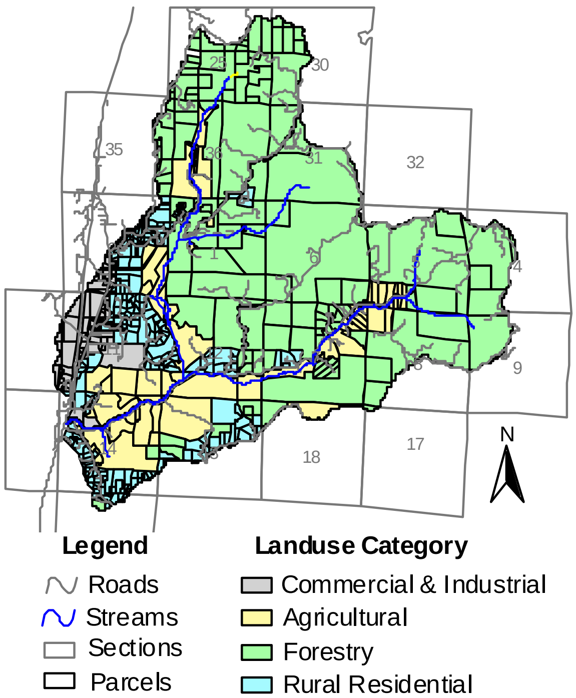
A unique characteristic of North Slough is the 2.6 mile area of tidal estuarine salt marsh below the tide gate. Although this area has been altered by the construction of Highway 101 and a railroad, and has been dredged in the past, it still provides productive estuarine nursery habitats for salmon, trout and other aquatic species.

North Slough, the second largest sub-basin in the assessment area, drains approximately 7,401 acres (11.5 miles^2) including 52 miles of streams - from mainstem to small headwater streams. The mainstem of North Slough is approximately 1.5 miles long from the tide gate at U.S. Highway 101 to the Bear Creek-North Slough Creek confluence. The main channels of Bear Creek and North Slough Creek are approximately 4.6 and 4.3 miles long respectively. The elevation in the basin ranges from 0 to 960 feet above sea level. (OWRD, 2005).

The main types of underlying geology in the North Slough sub-basin are Tyee silt/sandstone (50%), Tuffaceous siltstone/sandstone (24%), Holocene Terrace (10%), and Holocene Alluvial (16%). North Slough differs in its soils from the other sub-basins considered in this assessment. It is the only one dominated by the very soft, highly erosive sandstones of Dune Land-Waldport-Haceta, and Bullards-Bandon-Blacklock soils (Haagen, 1989).

Land Use and Ownership

Figure NS-2
Land Use Distribution



Land use in the North Slough sub-basin (see Figure NS-2 and Table NS-2) is primarily forestry (66%) which is second largest for forestry use in the assessment area. Agricultural use (18%) is largely dedicated to grazing and hay production and found mostly in the bottom land along the mainstems of North Slough Creek and Bear Creek. Rural residential land use is 12% of the area with the majority clustered around the small town of Hauser. Commercial and industrial land use (4%) is located along Highway 101. An industrial wood treatment plant is located near the mouth of North Slough, and another one is west of the tide gate.

Table NS-1 Land Use Area

Land Use	Acres	Percent
Commercial & Industrial	321	4
Agricultural	1287	18
Forestry	4787	66
Rural Residential	875	12
Total	7269[1]	

[1] Note: Totals differ between the county assessors parcel aggregate areas and the sub-basin area. The county assessors database has many duplicate records which were removed based on identical areas, map numbers, and parcel numbers, and may not include area of roads or streams.

Hydrology

Precipitation

Annual precipitation is 67 inches at the lowest elevations in the North Slough sub-basin. Due to the west-facing orientation, rainfall gradually increases as the elevation increases to a maximum of 73 inches, averaging 71 inches for the whole sub-basin (OCS, 2003). The precipitation intensity for a 2-year event is 3.0 inches in 24 hours (OWRD, 2005).

Stream Flow

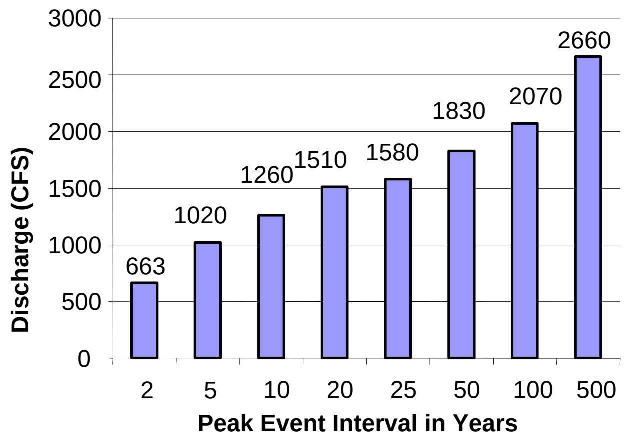


Figure NS-3 Peak Discharge Estimate (OWRD, 2005)

Annual peak stream flow for North Slough was obtained using the Peak Flow Estimation Program (OWRD, 2005). They use hydrologic prediction equations and physical watershed characteristics to estimate peak flows. Figure NS-3 shows the estimated peak discharge at the mouth of North Slough for storm events at two to five hundred year reoccurrence intervals. The bankfull storm event is estimated to be 663 cubic feet per second (CFS). On the other extreme, a maximum discharge of 2660 CFS is estimated for a 500-year storm event.

Table NS-2 Discharge Measurements for 1999, 2003, and 2004.

Location	Year	Date	CFS
Main Tidal	1999	8-Jun	2.89
		8-Jul	2.43
		20-Jul	1.64
		2-Aug	1.34
		16-Aug	1.11
		1-Sep	0.94
Main Valley	2003	18-Aug	0.59
		24-Sep	1.12
Lower Bear Tributary	2004	9-Jun	0.98
Upper Bear Tributary		9-Jun	1.56

Miscellaneous summer flow measurements were collected on North Slough sub-basin during 1999 (OWRD), and in 2003 and 2004 (Coos WA). Table NS-2 shows the summer flow in the sub-basin. In 2003, a measurement was taken in the main valley reach. On August 18, there was a discharge of 0.59 CFS, and on September 24, there was 1.12 CFS at this site. In 2004, two measurements were taken at an upper and a lower location on a tributary to Bear Creek. The Lower Bear Tributary location reported 0.98 CFS, and 1.56 CFS was reported for the Upper site. Based on these measurements, the base summer stream flow for the main tidal section ranges between 0.94 and 2.89 CFS.

Land Use Effects on Hydrology

Land uses, as they affect surface conditions, can be used to make general evaluations of the hydrologic condition of a watershed. Of particular concern is the effect of land uses on peak stream flow, since increases in runoff can contribute to flooding, erosion, and culvert failures. The most important determinant for peak-flow increases is the ability of soils to absorb rainfall.

The impacts from agriculture on hydrology are dependent on the type of cover and management treatments, as well as the characteristics of the soils (OWEB, 1999). We assessed these factors and compared them to the change in runoff from the background condition. This change will be rated as followed: < 0.5 inches, 0.5 to 1.0 inches, and > 1.5 inches.

The main types of hydrologic soil groups (HSG) present in the agriculture lands are, 71% of HSG Class D, 22% of HSG Class B, and only 7% of HSG Class C. The HSG Class D has very slow infiltration rates and high runoff rates. The HSG Class B has moderate infiltration rates and moderate runoff. Agriculture has a greater affect on runoff in areas where soils have a high infiltration rate compared to areas where soils are relatively impermeable in their natural state (USDA 1986). In the North Slough sub-basin, the change in runoff from the background conditions increased by 0.39 inches. Because of this, the potential risk of peak-flow increases is low.

Within the forest use area there are 38.5 total linear miles of forest roads which take up approximately 2.2% of the forested area. The potential risk of significantly increasing peak flows becomes high with when 8% or more of the forested area is roads (OWEB, 1999). Because of this low percentage, the relative potential risk for peak-flow increases in forest use is low in North Slough.

There are approximately 23.25 linear miles of rural roads in the residential area, or 4.2% of the residential area. This percentage ranks the North Slough residential area as a relatively moderate potential risk for peak-flow enhancement.

Water rights

Type of Use	CFS	Acre Feet
Domestic	0.31	21.32
Instream	20.00	0.00
Industrial	0.59	0.00
Agriculture	1.06	0.00
Total	21.96	21.32

Table NS-3 Water Use

There are three main sources of water rights in North Slough: surface water, groundwater, and instream. According to the OWRD, the most senior water right in North Slough was established in 1931 for irrigation use of surface water. Table NS-3 displays the different types of water use in North Slough. The total storage rights, including ponds and reservoirs, are 21.32 acre feet. Total allocated water rights for the entire watershed are 21.96 CFS. The greatest consumptive use is 0.47 CFS in the month of July. The instream rights were established in 1992 and extend 1.34 river miles from the tide gate at Highway 101 to the confluence of North Slough Creek and Bear Creek. The instream water rights were established by ODFW for the purpose of anadromous and resident fish rearing.

Water Availability

Water availability for the mouth of North Slough sub-basin is estimated using the Water Availability Report System (OWRD, 2005). The average of water available is based on the 50 percent exceedance level. The expected flow, shown in Table NS-4, is derived from subtracting the consumptive uses from the estimated natural stream flow. According to this information, North Slough is expected to have low flows of 1.56 CFS in the month of September and average winter flows of 10.96 CFS in February. According to OWRD, the consumptive water use has increased by more than 10% in July to September since 1993, which has had a direct effect on water availability.

Month	Natural Flow	Consumptive Uses	Reserved Instream Flow	Expected Flow (CFS)
Jan	66.50	0.24	20.00	66.26
Feb	71.20	0.24	20.00	70.96
Mar	51.30	0.20	20.00	51.1
Apr	34.30	0.19	20.00	34.11
May	16.70	0.22	16.70	16.48
Jun	8.96	0.35	8.92	8.61
Jul	4.45	0.47	4.40	3.98
Aug	2.33	0.41	2.29	1.92
Sep	1.82	0.26	1.78	1.56
Oct	2.25	0.16	2.21	2.09
Nov	15.80	0.15	15.70	15.65
Dec	55.60	0.22	20.00	35.40

Table NS- 4 Monthly Net Water Available (OWRD, 2005)

Aquatic Habitat

Aquatic habitat surveys were used to evaluate habitat unit type, substrate type, riffle sediment, pool depth, large wood, and bank stability (bank stability is presented in Sediment Sources).

The lowland portion of the North Slough sub-basin is characterized by a wide floodplain crossed by the largely unconstrained channel of North Slough, which is restricted in places by dikes and other structures. In the upper basin, the hill-slope constrained valleys become narrower and V-shaped. Channel gradients are very low throughout the sub-basin (0% to <3% for the first 20 river miles) and, therefore, most reaches are fish accessible. Only the headwater tributaries have steep bedrock cascades that prevent fish passage. See Appendix A for specific channel morphology metrics.

Aquatic habitat surveys were conducted on most of the North Slough Creek's mainstem, portions of two small tributaries to North Slough Creek, and portions of a tributary to Bear Creek. The aquatic habitat study reach locations are shown in Figure NS-4. These reach names will be used to describe locations within the North Slough sub-basin throughout this assessment.

Figure NS-4 Aquatic Habitat Study Reaches

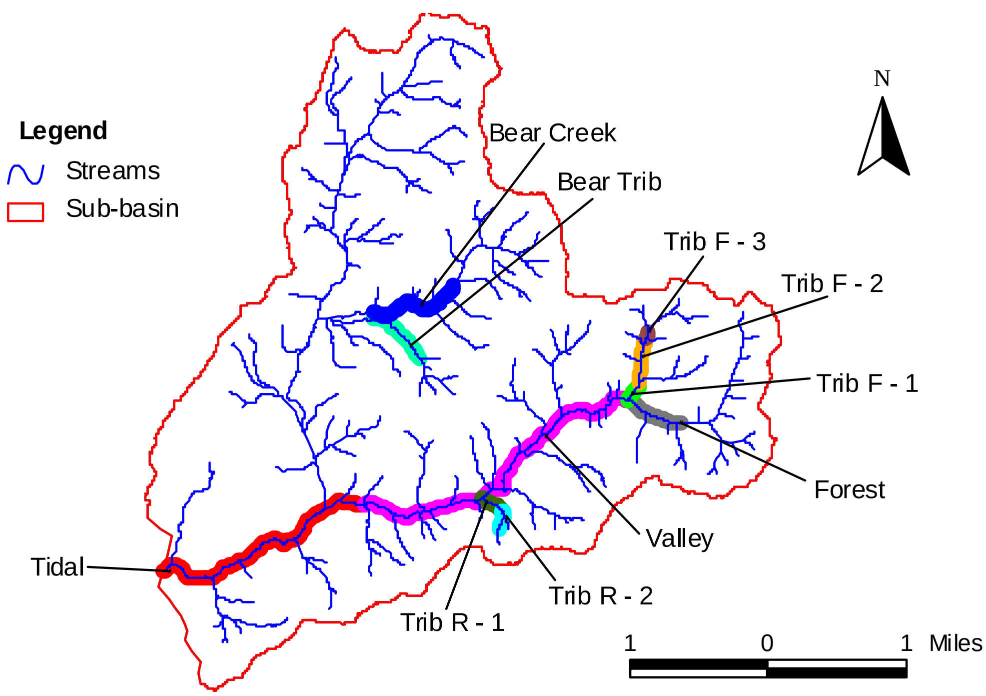


Figure NS-5, unit types, shows the percentage of unit types within each reach surveyed. A moderate portion of North Slough is considered tidal slough or tidal glide (green). Tidal glides are very similar to small estuarine channels, as described by the Oregon Watershed Assessment Manual. Riffles increase in the tributary reaches and higher on the mainstem. Trib R-1 has a large amount of dry units.

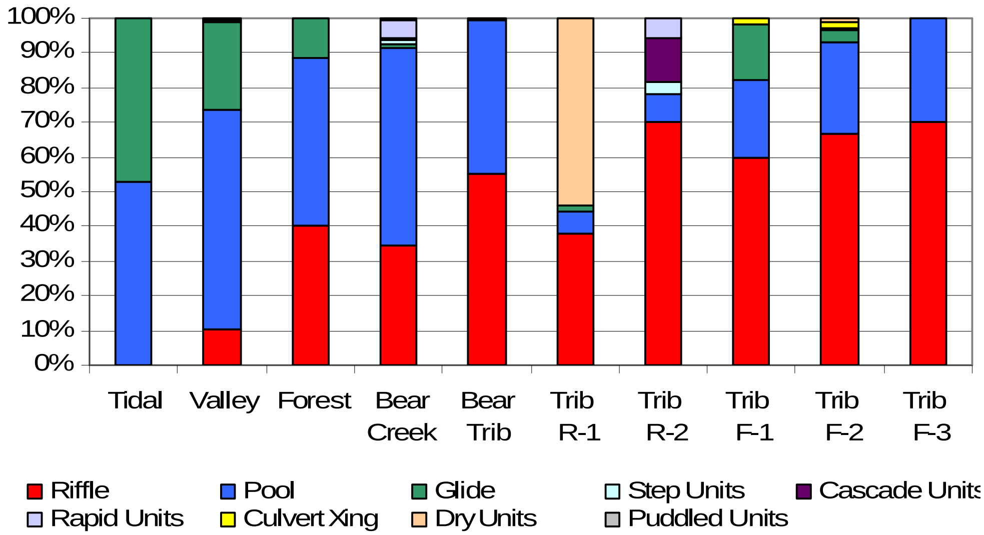


Figure NS-5 Unit Types

Figure NS-6, substrate types, shows the percentage of each substrate within the reaches. These typically correspond with the unit types. This sub-basin contains high percentages of silt and sand, especially in the mainstem reaches and increasing to more than 60% in the Tidal reach. Conversely, the proportion of gravel increases in the tributary reaches.

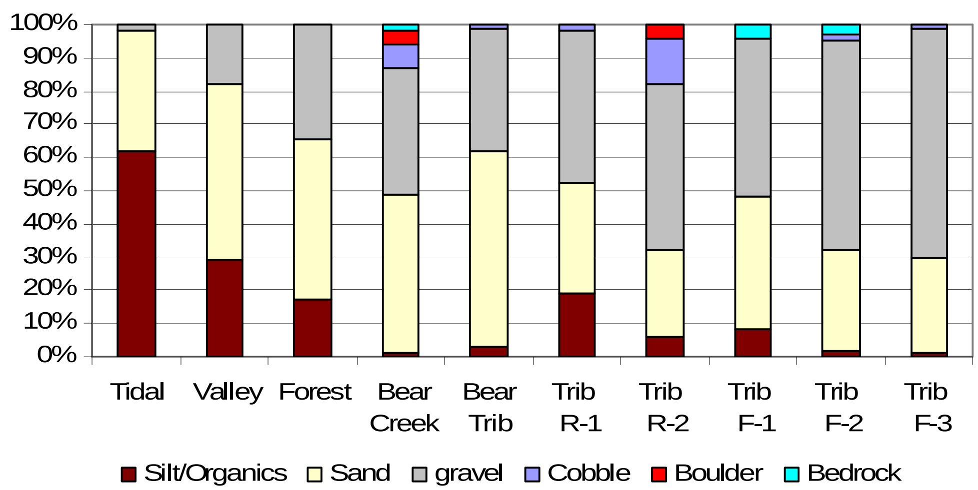
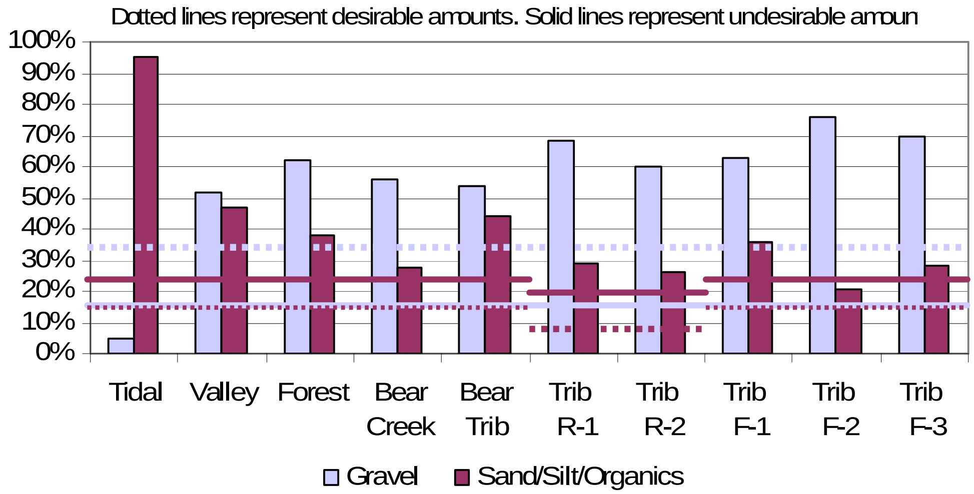


Figure NS-6 Substrate Types

Figure NS-7, riffle sediment, shows that the North Slough sub-basin contains a desirable amount of gravel in all reaches except the Tidal reach, which has only 5% of gravel and extremely high amounts of fine sediment. All other reaches have very high amounts of gravel, however, fine sediment also exceeds undesirable levels in all reaches except Trib F-2.

Figure NS- 7 Riffle Sediment



As shown in Figure NS-8, average pool depths and residual average pool depths for this sub-basin are intermediary throughout most of the reaches - falling below the desirable benchmark. The Valley reach has very good pool depths, while the Tidal reach has significant pool area, but the depths are undesirable given the channel size. Trib F-1 has good pool depths.

Figure NS- 8 Pool Depths

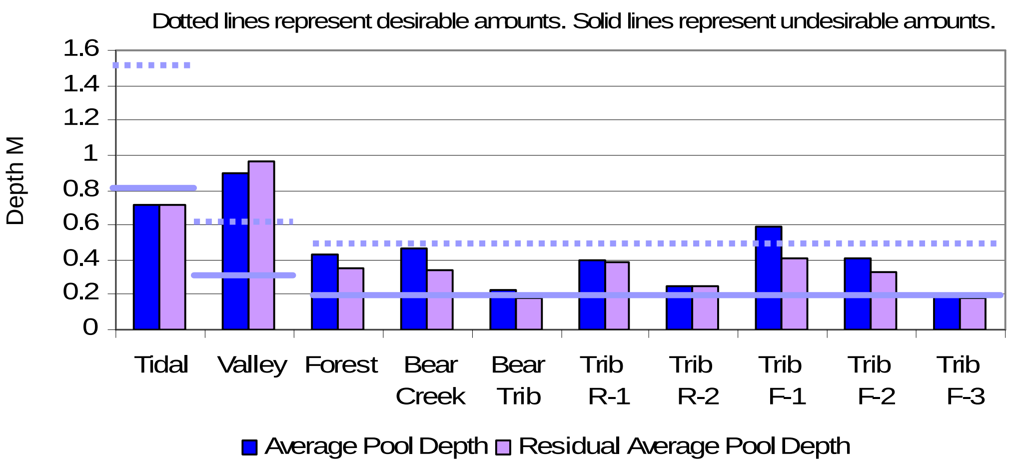


Figure NS-9 shows the amount of large wood per 100 meters of primary channel, including number of pieces, volume, and number of key pieces (key pieces are greater than 60 centimeters in diameter and over 10 meters long). According to the surveys, only Tributary F, Reach 3 had desirable amounts of wood volume. All other reaches were found to contain less than desirable amounts of wood in all categories.

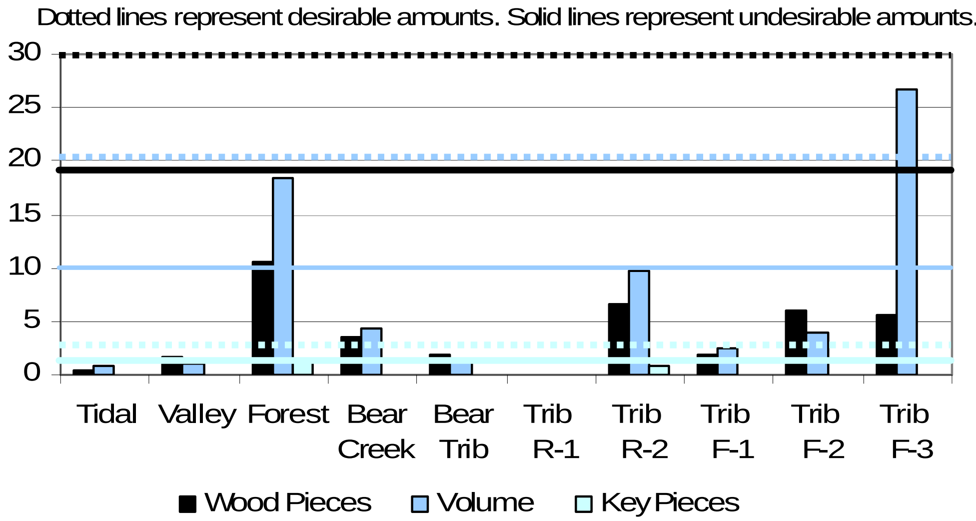


Figure NS-9
Large Wood

Wetlands

Historic, current and potentially restored wetlands in the North Slough sub-basin are shown in Figure W-10. The current (2005) wetland extent, determined by CoosWA using aerial photography analysis, is land presently dominated by wetland vegetation and not showing signs of recent agricultural production. In most cases, however, 'current wetland' is not a properly functioning wetland and is included in the area of potential wetland restoration. The area considered current wetland is 32% of the historic wetland extent in this sub-basin. Historic wetland extents are based on soil type and plant characteristics. Sixty-six percent (337 acres) of the historic wetlands in this sub-basin are described in the National Wetland Inventory as 'emergent', meaning they were dominated by rooted herbaceous plants, or 'forested' and are seasonally flooded. It is the seasonally flooded areas, not currently functioning as wetland, that CoosWA recommends for restoration consideration as these areas are often more difficult to manage for crop production. Wetland restoration is discussed in more depth in Chapter 3, and National Wetland Inventory categories are provided in Appendix A.

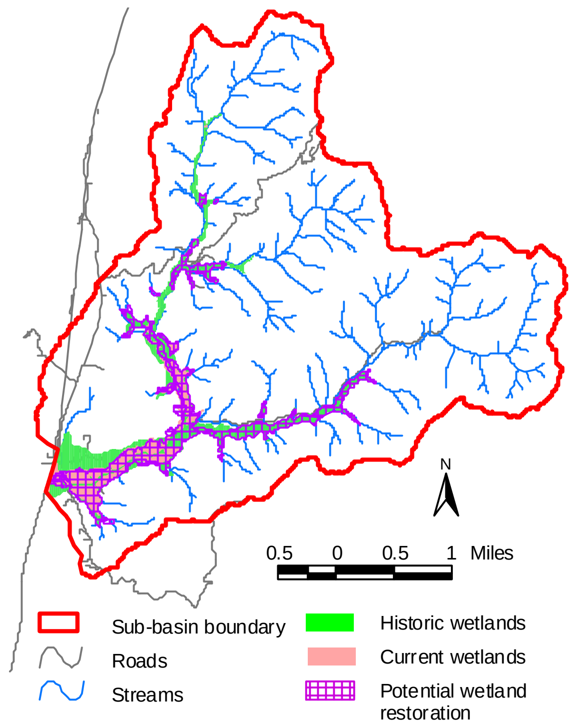


Figure NS-10 Wetlands

Table NS-5 Wetland Areas

Wetland Type	Acres
Historic wetlands	508
Current wetlands	165
Potential wetland restoration	344

Sediment Sources

Sediment sources considered in this assessment include unstable stream banks, unstable slopes, erosion associated with roads, and stream crossing road fill risk of failure.

Bank Stability

Bank stability surveys are conducted as part of the aquatic habitat surveys. Figure NS-11 shows the bank stability ratings for each aquatic habitat reach. The North Slough bank stability survey indicates that most of the stream system has fair bank stability, however, Bear creek and its main tributary both have over 20% unstable banks. Most covered unstable banks are dominated by Reed canarygrass (*Phalaris arundinacea*).

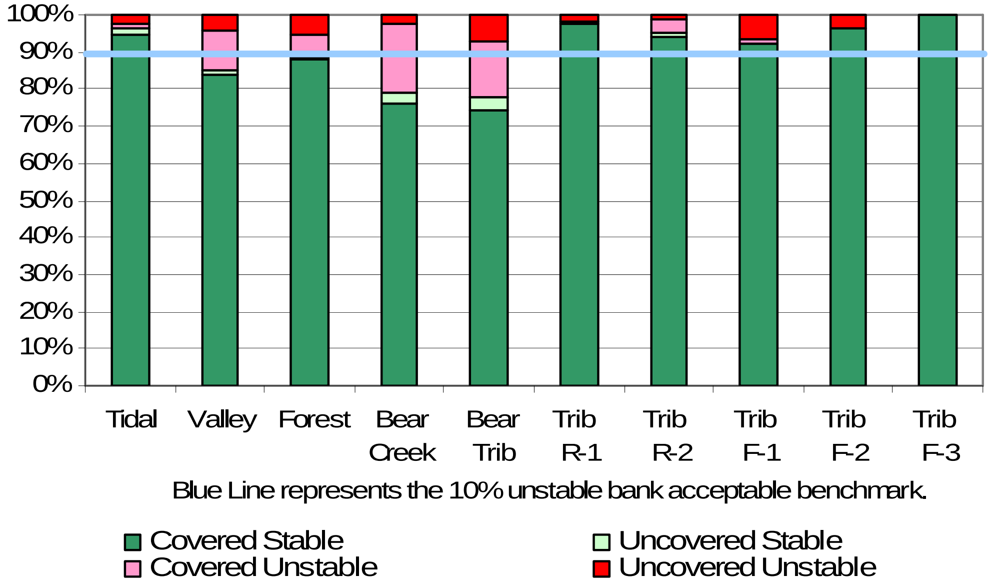


Figure NS-11 Bank Stability

Slope Stability

The slope analysis, shown in Figure NS-12, determined that 89.9% of the area in the sub-basin is in the low risk category for landslide potential, 8.7% is at moderate risk, 0.8% is at high risk, and 0.6% is at

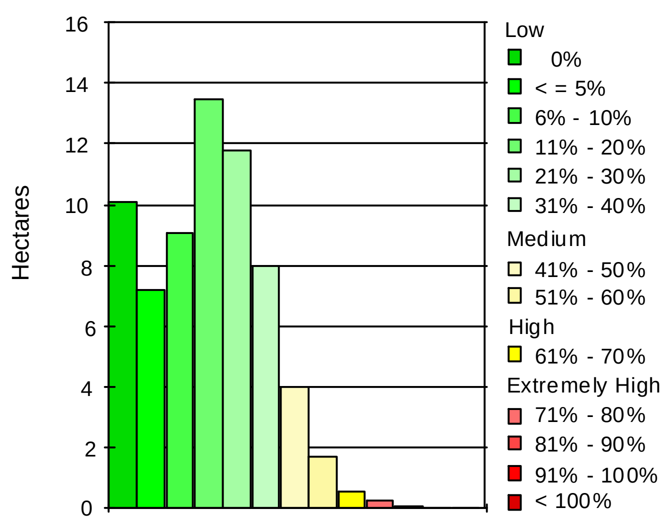


Figure NS-12 Slope Stability

extremely high risk. The most unstable slopes are located in the headwaters of North Slough Creek, in the highest elevations at the eastern end of the sub-basin. The highest slopes are found in areas of Tyee silt/sandstone, which means that there is high potential for slope failure in these areas.

Road-Related Erosion

The North Slough sub-basin road and landing survey was conducted between January 2001 and August 2004. The survey was divided into two groups - county roads and private roads. The county survey started at the junction of North Bay Road and North Way Lane and ended at the 3.9 mile marker on North Way Lane. The Shutters Landing Lane county road system included another 3.9 miles of roads. All private roads were surveyed where landowner permission was granted.

Table NS-7 provides a summary of the data collected. Thirty-two miles of road were surveyed in the North Slough sub-basin. The average number of drainage sites per mile was 7.4. A total of 52 stream crossings, 78 ditch relief culverts, 110 ditch outs, four potential landslides and five road surface sites were surveyed.

Table NS-7 Road and Landing Survey Results

Site Type	Sites	Contributing Ditches	Ditch Lengths(ft)
Stream Crossing	52	71	Avg. 387 Min. 40 Max. 1900
Ditch Relief	78	95	Avg. 352 Min. 40 Max. 1110
Ditch Out	110	127	Avg. 413 Min. 70 Max. 1600
Potential Landslide	4	6	Avg. 576 Min. 100 Max. 2200
Ponding/Gullied Road Surface	5	4	Avg. 231 Min. 116 Max. 220
Totals	244	303	

Stream Crossing Drainage Evaluation

The 53 stream crossing culverts studied in the road and landing survey were also ranked for their ability to properly drain the area upstream during a 50-year peak rain event (see Table NS-8 below). Twenty-two, or 41.5% of the stream crossings in this survey area were undersized for the 50-year peak flow and at risk of washing out.

At-risk culverts were ranked in Table NS-8 for failure risk based on the amount that a 50-year rainfall event would exceed the stream crossing's capacity. Undersized stream crossings were listed according to the amount of road fill that would deliver to the stream if the crossing washed out. Knowing the delivery potential of an undersized crossing is another critical component in prioritizing stream crossing upgrades.

Table NS-8 Stream Crossing Failure Risk and Fill Volume

50-Year Rainfall Fill Failure Risk	Fill Volume Size Class									
	Minimal		Small		Medium		Large		Very Large	
	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3
Low	1	5	1	21	1	91	1	125	-	-
Moderate	-	-	1	39	-	-	2	177	-	-
High	-	-	3	56	1	62	2	522	-	-
Very High	-	-	5	119	1	75	2	336	1	2133

Failure Risk, Low = 76% - 100%; Moderate = 51% - 75%; High = 26% - 50%; Very High = 0% - 25%
Fill Volumes, Minimal = $\leq$ 10 $yds.^3$; Small = 10 - 50 $yds.^3$; Medium = 51 - 100 $yds.^3$; Large = 101 - 500 $yds.^3$; and Very Large = > 500 $yds.^3$.

In the North Slough sub-basin, nine of the 22 at-risk culverts ranked Very High risk for potential failure. If all Very High risk crossings failed 2,663 $yards^3$ of fill would be delivered to the stream. Most of this fill is related to a single stream crossing site. Six sites ranked High risk, potentially releasing 640 $yards^3$, three ranked Moderate risk, potentially releasing 216 $yards^3$ of fill, and four ranked Low risk, potentially releasing 242 $yards^3$ of fill downstream. These stream crossings contain a total of 3,811 $yards^3$ of fill that could be deposited downstream as sediment during a 50-year rain event.

Stream Temperatures

Water temperature recorders were placed at eight different sites during the two years of study. Two sites were replicated in both years, while the six other sites were unique to one year or the other. Two units were placed on the North Slough Creek mainstem, one slightly upstream of the tide gate and one in the mid-valley, just below the confluence of the tributary. Two units in 2004 were also placed on Bear Creek near the Hauser Substation. Bear Creek enters the mainstem near Saint Dennis-Road.

Table NS-9 Temperature Summary and Exceedance of Standards

Site	Year	7-Day averages			Days >64°F	Days >70°F	Hours >64°F	Hours >70°F
		Max.	Min.	Daily D T				
Site 1	2003	64.9	56.5	8.4	19	0	64.0	0.0
Site 2	2003	66.2	60.3	6.0	38	0	278.5	0.0
Site 3	2003	71.5	59.2	12.4	68	16	578.0	47.0
Site 4	2003	69.7	60.2	9.5	64	4	605.0	9.0
	2004	66.6	60.8	5.8	40	0	269.0	0.0
Site 5	2003	73.8	64.6	9.3	76	26	933.0	61.5
Site 6	2003	76.7	66.3	10.3	102	59	1693.0	458.0
	2004	78.9	69.0	9.9	99	65	1892.0	589.0
Trib-Upper	2004	64.7	57.0	7.7	19	0	80.0	0.0
Trib Lower	2004	65.4	56.5	8.9	27	0	87.5	0.0

Table NS-9, above, shows the 7-day average maximum and minimum temperatures, and the number of days and hours spent exceeding 64 and 70°F for each temperature logging site in the North Slough sub-basin. Exceedance of standards is shown in Figure NS-13, below. The data indicate that during the hottest 7-day period of the season, the average minimum temperature never dropped below 64°F. All sites on North Slough in 2003 and 2004 exceeded the state standard for 7-day maximum temperatures of 64°F.

Figure NS-13 7-Day Moving Averages of Daily Maximum Temperatures

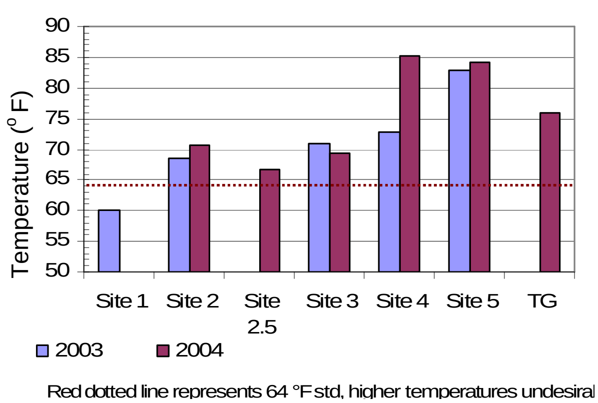


Figure NS-13 illustrates the temperature trends within the sub-basin using 7-day average maximums, and colors them according to salmonid suitability. The map shows the temperature trends over the length of the stream, displaying the temperature increases from 55°F at the headwaters to 76.7°F near the mouth in 2003. The Bear Creek Tributary data is from 2004. On North Slough Creek in 2003, the average daily high water temperature downstream from the Upper site to the mouth increased 0.52°F per 1000 ft. This represents the difference between the average daily highs at the uppermost mainstem site (Site 1), and Site 6, near the tide gate. The change in temperature between the individual sites for 2003 was less than 1°F per 1000 ft for all segments except between Sites 3 and 4, where the stream temperature changed -13.35 °F per 1000 ft, meaning temperatures actually decreased in this segment. Based on the data, the tributary would appear to be a cooling influence, but the temperature logging site is over 2 miles up the tributary. Without a temperature unit measuring the tributary shortly before it meets the mainstem, as well as a site just upstream of the confluence on the mainstem, it is not possible to draw exact conclusions on the influence of the tributary on mainstem water temperature. Unit placement was largely dictated by landowner permissions for access.

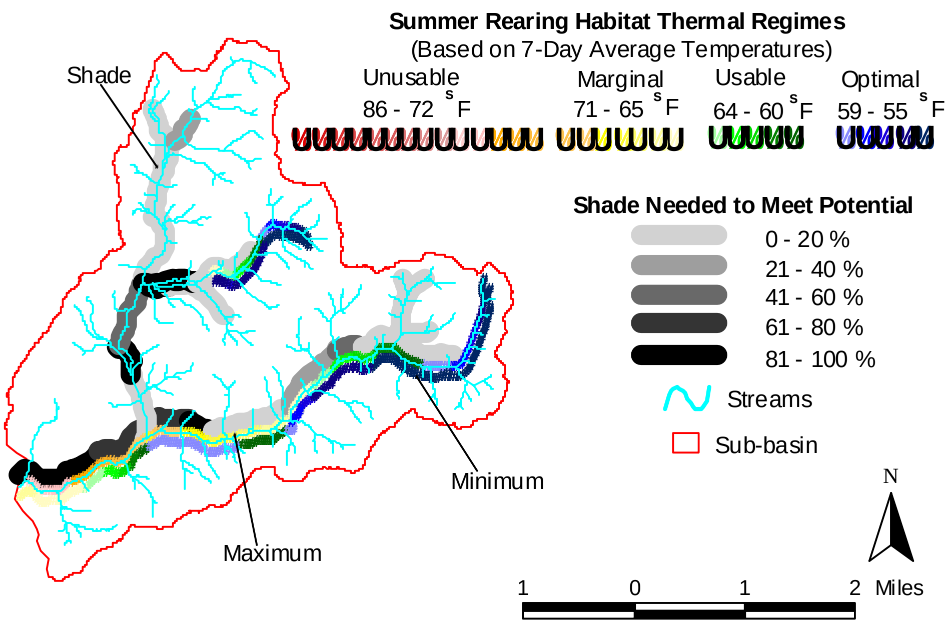


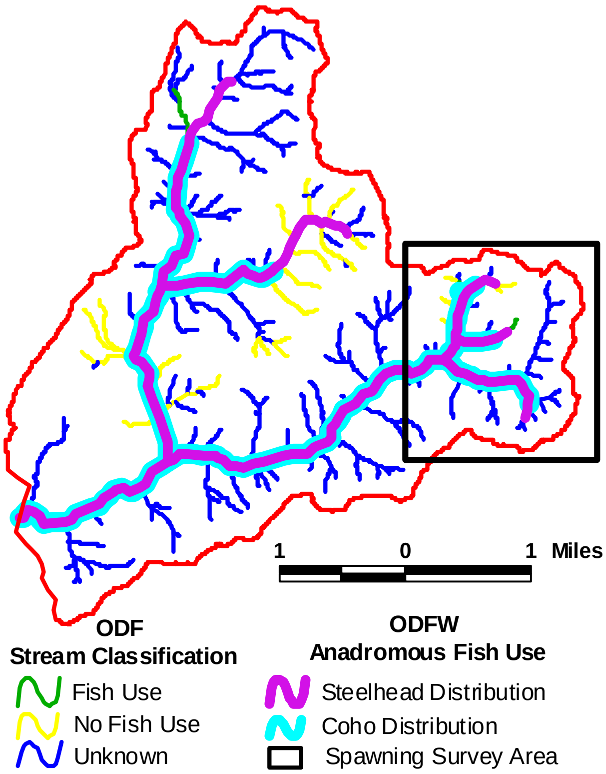
Figure NS-14 Temperature Trends and Riparian Shade Conditions

Riparian Shade

The difference between current and potential shade is shown in Figure NS-14, above, and is expressed as shade needed to meet potential. Current and potential shade values in the North Slough sub-basin are 89% and 98%, respectively, in the upper-most, steep canyon areas. The upper valley area has 61% and 98% respectively, and the lower valley currently has only 18% compared to the potential of 87%. North Slough creek's current lower valley shade is the lowest of the six sub-basins.

Salmonid Distribution

Figure NS-15 Salmonid Distribution



Coho and winter steelhead distribution, according to ODFW, is shown in Figure NS-15. Oregon Department of Forestry (ODF) classifies general fish use streams including cutthroat trout (green line is hidden under the steelhead and coho lines). The spawning survey area is enlarged below in Figure NS-15. There is little historical information on the fish usage in the basin.

Natural fish barriers in the basin are due to the steep gradient of the channel in the headwater reaches. In most cases, these barriers consist of shallow water flows over steep bedrock cascades. Three artificial fish passage barriers at stream crossings were fixed in the summer of 2004 by Coos WA, when two culverts were removed indefinitely and another one was replaced to improve fish passage. There is also a dam on the Bear Creek tributary, which has a fish ladder, but blocks juvenile fish passage.

Stocking Records

Records show that there were three releases of juvenile salmonids into North Slough Creek since 1978. In 1981, 12,000 coho fry were released, and in 1982 and 1984, steelhead fry were released (see Table NS-10).

Table NS-10 Stocking Records

Creek	Species	Year	# of Juveniles Released
North Slough	Coho	1981	12,000
North Slough	Steelhead	1982	16,150
North Slough	Steelhead	1984	13,925
			42,075

Spawning surveys conducted in 1986 and 1987 by ODFW indicate a small coho escapement and a large Chinook escapement. However, no chinook spawners were observed during the recent spawning surveys, and the channel characteristics in this area are not typical of chinook habitat. The 1980's Chinook runs likely reflect hatchery influence and not natural fish populations.

Spawning Surveys

Coos WA conducted coho spawning surveys from 2002 to 2004 in upper North Slough Creek and a tributary to North Slough Creek (see Figure NS-16).

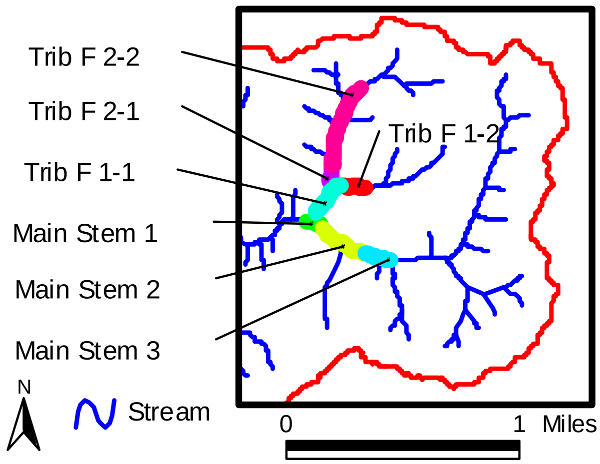


Figure NS-16 Coho Spawning Survey Area

In 2002, the mainstem reaches 1 to 3 (see Figure NS-17) were surveyed. Of these reaches, Main Stem 3 had a significantly higher spawning density (837 coho AUC/Km, see Table NS-11) than the downstream reaches. The high number of spawning coho per square meter of gravel (3.1 m^2 gravel per female) indicates that spawning habitat may be limited in this sub-basin. The high spawning density resulted in superimposition of redds (Coos WA surveyors notes).

In 2003 and 2004, spawning surveys were conducted on Trib F. In 2003 the peak count of coho was 64 for all four reaches combined. Trib F 2-1 had the highest spawning density with 359 coho AUC/km. In this reach only 2.6 m^2 of gravel was available per female. In 2004 a peak count of 89 spawning coho was observed in Tributary F. The highest

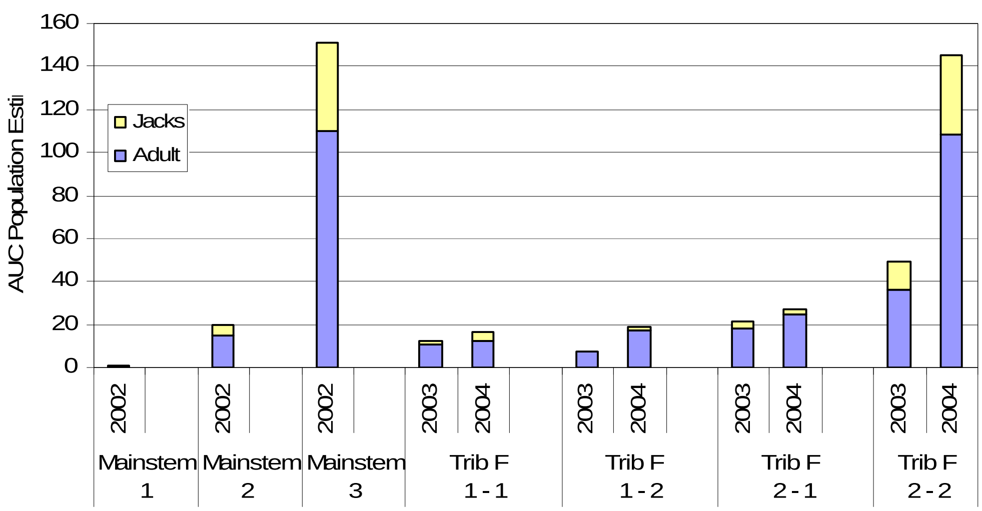


Figure NS-17 Coho Spawning Survey AUC Population Estimate

spawning density in 2004 was 454 AUC/km found in Trib F 2-1. Although there were more total spawning coho in Trib F 2-2, the short length of Trib F 2-1 resulted in the high spawning density in this reach.

Historic records from ODFW indicate peak spawning counts in 1987 of five adult coho (live and dead) and eight chinook. Peak counts in 1985 were one chinook and 26 adult coho. The historic data are not a reliable measure of suitable habitat based on fish productivity, however, because the stream was hatchery-influenced at the time. According to ODFW data sources, the last stocking of coho was in 1981, of 12,000 emergent fry from a hatch box (see Table NS-10, above). Conversely, during the 2002 survey, only one coho was observed with a clipped adipose fin, which was probably a stray from a nearby hatchery.

The 2002 - 2004 surveys show a high density of spawning fish in a limited amount of suitable habitat (see Table NS-11). Aquatic habitat inventory surveys indicate less gravel, fewer riffles and more sand/silt/organics in the Main Stem reaches 1-3 than in Tributary F. Although the quality of habitat in Tributary F is below ODFW habitat benchmarks in all criteria except total wood volume, it supports a large population of spawning coho.

Table NS-11 Spawning Density

Reach		Year	Total AUC/ Km	Gravel m^2	Gravel m^2/ female
Main Stem	1	2002	6	0	0
	2	2002	61	16	2
	3	2002	837	84	2
Tributary F	1 - 1	2003	87	16	3
		2004	118	105	18
	1 - 2	2003	46	72	21
		2004	119	52	4
	2 - 1	2003	359	24	3
		2004	454	71	6
	2 - 2	2003	74	112	6
		2004	217	229	4

From 2003 to 2004, the number of spawning coho observed in all Tributary F reaches increased by 135%. Fish passage and habitat projects were implemented during the summer of 2004 between these spawning seasons. These projects included the removal of a perched culvert that had impeded passage to reach 2-2, and the replacement of a culvert that impeded passage to reach 1-2. Enhancement projects also included a riparian road decommission and large wood placement along Tributary reaches 2-1 and 2-2. After these projects, the AUC per kilometer in all reaches of Tributary F increased, especially above culverts in the upper reaches. These projects improved access to spawning habitat, and the large wood should, over time, capture gravel suitable for spawning and help scour pools for juvenile rearing.

Intrinsic Potential for Coho Smolt Production

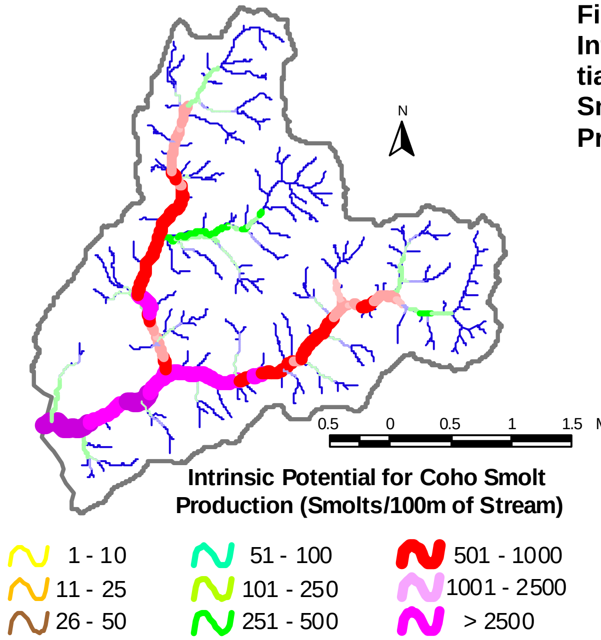


Figure NS-18 Intrinsic Potential For Coho Smolt Production

The intrinsic potential for streams in the Lowlands area to produce coho smolts was estimated based on digital elevation models, channel widths, known natural barriers and coho life histories. The values indicate the number of coho smolts supported by historic, pre-settlement stream conditions. Intrinsic potential for the North Slough sub-basin, shown in Figure NS-18, indicates that the lower mainstem reaches have very high potential – more than 2500 smolts per 100 meters of stream in many areas of the tidal reaches. Potential in the upper mainstem and tributaries drops off abruptly. This pattern reflects the coho preference of lower-gradient, slow moving streams. Many of the first and second order streams, the thin blue lines, indicate zero intrinsic potential due to gradients above 20% and known natural migration barriers. Total intrinsic potential for smolt production this sub-basin is 140,438 smolts. Intrinsic potential for adult coho returns under low ocean survival rates (1%) is 1,404, and under high ocean survival rates (10%) is 14,044 fish.

While restoring coho smolt populations to these levels is unlikely given current land uses and infrastructure, understanding intrinsic potential for a particular stream will help to inform restoration efforts and to set realistic coho population goals.

Coho Habitat Limiting Factors

The limiting factors analysis (based on Reeves et al., 1989), shown in Table NS-12, indicates that spring, summer and winter rearing habitats are all limited given the potential summer population. However, summer habitat was found to be the bottleneck to coho smolt production. The current usable summer rearing habitat is 22% of the area needed to support potential populations. The reduction in usable area is primarily due to high temperatures making the Tidal reach unfit for salmonids (see note below). If the temperatures were low enough that coho could utilize all summer habitat, winter rearing habitat would be the limiting factor. According to this analysis, spawning area, based on spawning gravel estimates taken during coho spawning surveys, was more than sufficient for potential populations.

Table NS-12 Limiting Factors to Coho Populations

North Slough Habitat Component	Potential Summer Population	Area/ Survival Factor	Area Needed (M^2)	Current Usable Area (M^2)	Smolt Factor	Smolts Produced
Spawning	31,168	0.006	187	441	95.5	42,116
Spring Rearing	31,168	0.3	9,350	7,637	1.7	12,983
Summer Rearing	31,168	0.6	18,701	4,058	0.9	3,653
Winter Rearing	31,168	0.4	12,467	4,285	1.2	5,142

[Note: The Tidal reach was over 25°C for 7 days in 2003, and 6 days in 2004. It also was over the minimum daily temperature of 22°C for 3 days. This reach was removed from the Useable Area because of the multiple days over 25°C. Even if the coho juveniles could survive the high temperatures, they would need large amounts of easily available food (which are not expected to be there) in order to survive for very long (Giannaco 2005).]

Resource Issues

As is the case with most streams in the assessment area, water elevations in the inlet scour pool above the tide gate are influenced by the tide gate's operation – rising when the gate is closed during high tides, and falling when the gate opens at low tide. Leakage through the gate allows brackish water to enter the inlet scour pool during high tides, and which also increases the water elevation of the pool behind the tide gate.

Low elevation streams in the North Slough sub-basin have been managed primarily for agriculture. Consequently, dredging, straightening, removal of woody material and diking have occurred widely on the system. Because of the low gradient of the stream and because of the tide gate, the lower reaches of North Slough Creek do not adequately flush sediment. Therefore, the need for dredging to reduce flooding is an ongoing management issue. During the high flows of the winter, and often into spring, much of the bottom land is inundated.

Landowner Concerns and Desired Future Conditions

At a community meeting, or Coffee Klatch, held in May of 2005, residents of North Slough expressed what they would like to see in the future of the North Slough area. Their visions include forming a new drainage district to manage drainage maintenance activities and form collaborative permit applications. Residents also would like to see minimal development, drier pastures, paved roads, restored streams, abundant wildlife, and bigger trees.

Figure NS-19 Landowner Concerns

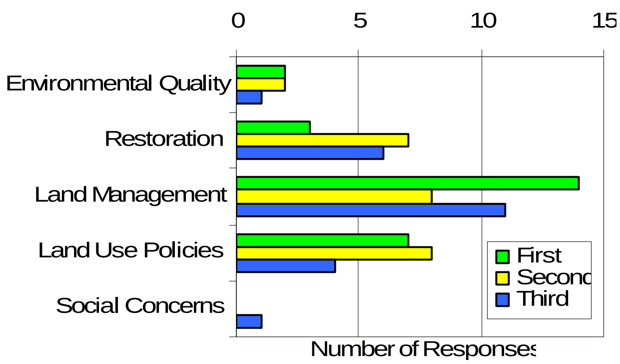


Figure NS-19 shows landowners' top three concerns in the North Slough sub-basin identified during meetings with landowners on May 19, 2005. Land management issues such as maintenance of culverts, tide gates, and county roads, and land use policies such as the difficult dredging permit process are priority concerns.

Coos Bay Lowland Assessment and Restoration Plan

Chapter 2:
Palouse Creek Sub-basin Assessment

Palouse Creek tidal reach during winter flood. Photo CoosWA, 2006.

Palouse Creek Sub-basin

Introduction

Landform

The Palouse sub-basin is long, narrow and oriented northeast to southwest. Palouse Slough (see Figure P-1) enters the northern-most tip of Coos Bay at the top of Haynes Inlet. The head of Palouse Slough is tide-gated, draining into a network of tidal and high salt marshes along the bay near the mouth.

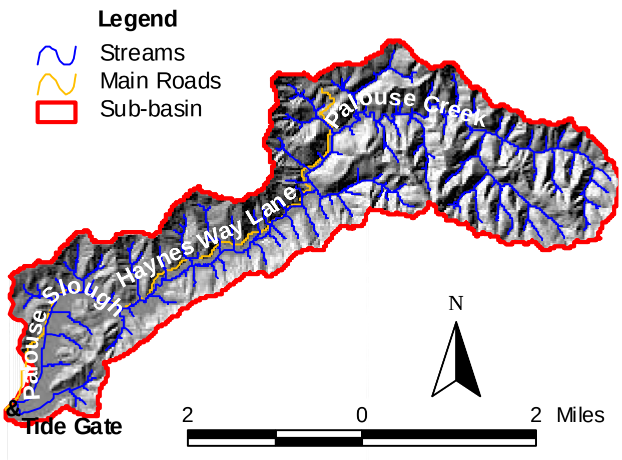


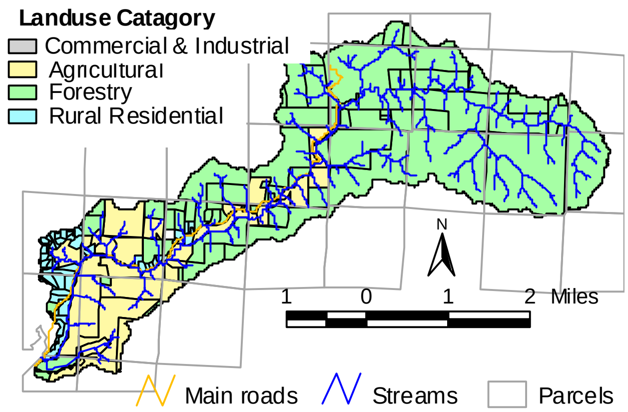
Figure P-1 General Sub-basin

The Palouse stream system forms a dendritic, fourth order system. The drainage area of the sub-basin is approximately 6,954 acres (10.9 miles^2), and is the fourth largest sub-basin in the assessment area. There are approximately 48.5 total river miles of streams within the Palouse sub-basin including every stream from mainstems to very small intermittent headwater streams. From the tide gate at North Bay Drive the Palouse mainstem is approximately 9.1 miles in length. The elevation in the basin ranges from 0 to 1,520 feet above sea level (OWRD, 2005).

The main types of underlying geology in the Palouse sub-basin are Tyee silt/sandstone (97%), with Tuffaceous siltstone/sandstone (3%). Compared to all of the other sub-basins in the assessment area, Palouse has the second largest amount of Tyee silt/sandstone, which is prone to natural landslides. The following three general soil types are weathered into the sandstone geology: Dune land-Waldport-Heceta, which is both excessively drained and poorly drained, Templeton-Salander, which is well drained and loamy, and Milbury-Bohannon-Umpcoos, which is moderately deep, gravely and loamy. (Haagen, 1989)

Landuse and Ownership

Figure P-2 Landuse Distribution



The long valley and the tidal reaches of the Palouse watershed are managed for agriculture, while the uplands are dominated by forestry operations (see Figure P-2). Landuse includes 73% forestry, both private industrial and small woodland owners (see Table P-1). Four percent of the sub-basin is in rural residential dwellings, largely clustered along the bay and spotted along Palouse creek. Agricultural lands comprise 23% of the basin and are primarily used for grazing and hay cropping.

Table P-1 Landuse Area (Coos County Assessor, 2004)

Landuse	Acres	Percent
Agricultural	1,557	23
Forestry	5,021	73
Rural Residential	297	4
Unclassified	10	0
Total	6,885[2]	

The headwaters of Palouse Creek are located in the Elliot State Forest, and are currently managed as one of the Elliot State Forest's "long rotation basins".

[2] Note: Totals differ between the county assessors parcel aggregate areas and the sub-basin area. The county assessors database has many duplicate records which were removed based on identical areas, map numbers, and parcel numbers, and may not include area of roads or streams.

Hydrology

Precipitation

Annual precipitation is 69 inches at the lowest elevations in the Palouse sub-basin. Due to the west facing orientation, rainfall gradually increases as the elevation increases to a maximum of 75 inches, averaging 71 inches for the whole sub-basin (OCS, 2003). The precipitation intensity for a 2-year event is 3.0 inches in 24-hours (OWRD, 2005).

Stream flow

Annual peak stream flow for Palouse Creek was obtained using the Peak Flow Estimation Program (OWRD, 2005). They use hydrologic prediction equations and physical watershed characteristics to estimate peak flows. Figure P-3 shows the estimated discharge at the mouth of Palouse creek for storm events at two to five hundred year reoccurrence intervals. The bankfull storm event is estimated to be 668 cfs. On the other extreme, a maximum discharge of 2,690 cfs is estimated for a 500-year storm event in Palouse Creek.

Miscellaneous summer flow measurements were collected on Palouse Creek in 1998 to 2001 (OWRD), and 2003, 2004 (Coos WA). Table P-2 shows the summer flows on Palouse creek at various locations from 1998 to 2004. The lowest summer flows recorded were in 2000, at the

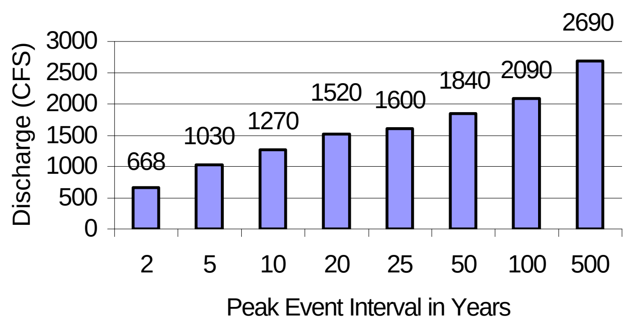


Figure P-3 Peak Event Interval in Years

Table P-2 Discharge Measurements 1998-2001 and 2003, 2004

Location	Year	Date	CFS
Lower Tidal	1998	3-Aug	3.13
Lower Tidal	1999	29-Jun	2.89
		1-Jul	5.27
		20-Jul	1.97
		2-Aug	1.77
		16-Aug	1.79
		1-Sep	1.17
Lower Valley	2000	22-Aug	1.09
		29-Aug	0.74
		20-Sep	0.54
		19-Oct	7.44
Lower Valley	2001	11-Jul	2.2
		15-Aug	0.96
		12-Sep	0.67
		11-Oct	7.93
Lower Valley	2003	2-Jul	1.72
		24-Sep	1.39
Upper Valley - Site 1	2004	8-Jun	9.94
Upper Valley - Site 2		8-Jun	22.1
Middle Valley		8-Jun	20.0
Lower Tidal		17-Jun	5.29
Upper Valley - Site 2		26-Aug	1.98

Lower Valley site, with a discharge of 0.54 cfs. The highest summer flow was recorded in 2004, at the Upper Valley site 2, with a discharge of 22.1 cfs. From these measurements, the Lower Tidal site has a base summer stream flow of between 1.17 to 5.27 cfs, and for the Lower Valley site there was a summer stream flow range of 0.54 to 2.2 cfs.

Landuse Effects on Hydrology

Landuses, as they affect surface conditions, can be used to make general evaluations of the hydrologic condition of a watershed. Of particular concern is the effect of land uses on peak stream flow, since increases in runoff can contribute to flooding, erosion and culvert failures. The most important determinant for peak-flow increases is the ability of soils to absorb rainfall.

The impacts from agriculture on hydrology are dependent on the type of cover and management treatments, as well as the characteristics of the soils (OWEB, 1999). We assessed these factors and compared them to the change in runoff from the background condition. This change will be rated as followed: < 0.5 inches, 0.5 to 1.0 inches, and > 1.5 inches.

The main types of hydrologic soil groups (HSG) present in the agriculture lands in Palouse were, 80% of HSG Class D, and 20% of HSG Class B. The HSG Class D has very slow infiltration rates and high runoff rates. The HSG Class B has moderate infiltration rates and moderate runoff. Agriculture has a greater affect on runoff in areas where soils have a high infiltration rate compared to areas where soils are relatively impermeable in their natural state (USDA, 1986). In the Palouse Sub-basin, the change in runoff from the background conditions increased by 0.39 inches. Because of this, the potential risk of peak-flow increases from agricultural uses was low.

Forest and Rural land use are assessed by their percentage of area that is comprised of roads. They were rated as: low < 4%, medium 4% - 8%, and high > 8%.

Within the forest use area there are 23.1 linear miles of forest roads, which take up approximately 1.0 percent of the forested area. Because of the low percentage, the relative potential risk for peak-flow increase is low in the Palouse forest use area.

There are approximately 23.2 linear miles of rural roads in the residential and industrial area, 4.2 percent of the total area. This percentage ranks the Palouse residential area as a having a moderate potential risk for elevated peak-flows based on impervious surfaces.

Overall, Palouse sub-basin's potential risks of peak-flow increase from land use impacts are low.

Water rights

Table P-3 Types Of Water Use In Palouse Creek

Type of Use	CFS	Ac-ft
Domestic	0.04	0.00
Instream	26.00	0.00
Fire protection	0.01	0.13
Irrigation	0.11	0.00
Wildlife	0.00	31.60
Livestock	0.01	0.00
Total	26.13	31.73

There are three main sources of water rights in Palouse Creek: surface water, groundwater, and instream. The most senior water right was established in 1968 for domestic use of surface water. Table P-3 displays the different types of water use in Palouse Creek. The total storage rights, including ponds and reservoirs, are 31.73 acre feet for wildlife and fire protection. All allocated water rights for the entire watershed are 26.13 cfs, and 31.73 acre feet. The total consumptive use is 0.07 cfs. The in-stream rights were established in 1990, and extend 5.5 river miles from the tide gate at North Bay Drive to the largest tributary. A maximum instream water right of 26.00 cfs was established for the purpose of providing optimum stream flow for fish migration, spawning and juvenile rearing of anadromous and resident fish, and supporting aquatic life.

Water Availability

Water availability for the mouth of Palouse sub-basin is estimated using the Water Availability Report System (OWRD, 2005). The average water available is based on the 50 percent annual exceedance level. The water availability, shown in Table P-4, is derived from subtracting the consumptive uses from the estimated natural stream flow. Palouse Creek has very little allocation of stream flows for consumptive uses.

Table P-4 Monthly Net Water Available (OWRD, 2005)

Month	Natural Flow	Consumptive Uses	Reserved Instream Flow	Expected Flow (cfs)
Jan	59.10	0.00	26.00	59.1
Feb	63.40	0.00	26.00	63.4
Mar	46.50	0.00	26.00	46.5
Apr	32.30	0.00	26.00	32.3
May	16.60	0.01	16.60	16.59
Jun	8.32	0.02	10.00	8.3
Jul	3.94	0.03	3.85	3.91
Aug	2.01	0.01	2.00	2.0
Sep	1.57	0.00	2.00	1.57
Oct	1.96	0.00	15.00	1.95
Nov	14.00	0.00	15.00	14.0
Dec	49.40	0.00	26.00	49.4

However, based on natural flow conditions, the stream has expected net flows of 1.57 cfs in September and 2 cfs or less from August through October. The consumptive water use has not increased by more than 10% since 1993 (OWRD, 2005).

Aquatic Habitat

Aquatic habitat features addressed in this assessment include distribution of unit types, stream substrate, riffle sediment, pool depths, large wood, and bank stability (bank stability is presented in Sediment Sources).

The Palouse sub-basin aquatic habitat survey starts at the tide gate and extends 14.6 kilometers (secondary and primary channel) to a 5-meter-high bedrock falls that block anadromous fish passage.

Aquatic habitat study reaches are shown in Figure P-4. The tidal reaches of the stream were surveyed in the summer of 2003, and the dredging project of 2004 may have significantly changed some of the habitat in the tidal reaches of the survey. These reach names will be used to describe locations within the Palouse sub-basin throughout this assessment.

Figure P-4 Aquatic Habitat Study Reaches

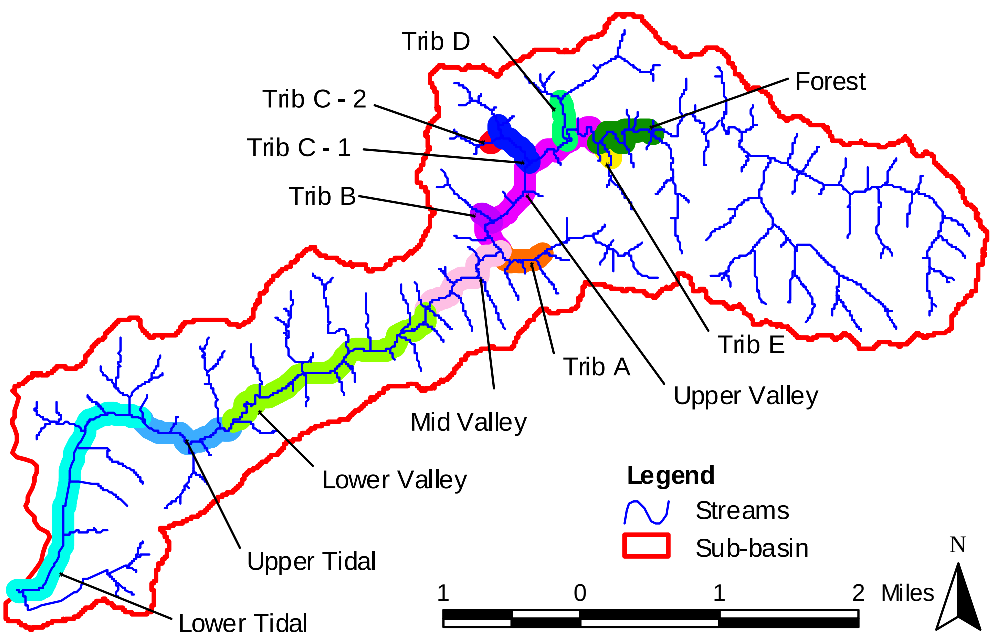


Figure P-5 shows the percentage of unit types in each reach. Both Tidal reaches are almost all (99.5%) tidal glides. The Lower Valley reach has a high number of glides, but is less tidally influenced. The remaining mainstem reaches contain a high number of pools. Tributary C was mostly dry during the summer habitat survey..

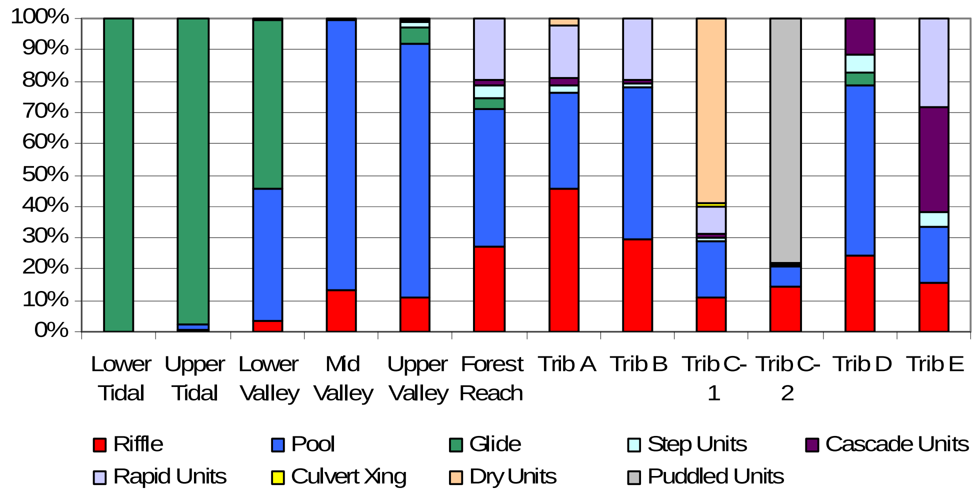


Figure P-5 Unit Types

Figure P-6 shows the substrate types per reach. Almost all reaches had a very high sand percentage, and the upper reaches had high amounts of gravel. As is typical in the lowlands, the lower reaches contain high amounts of silt/organics due to the very low gradient of the stream.

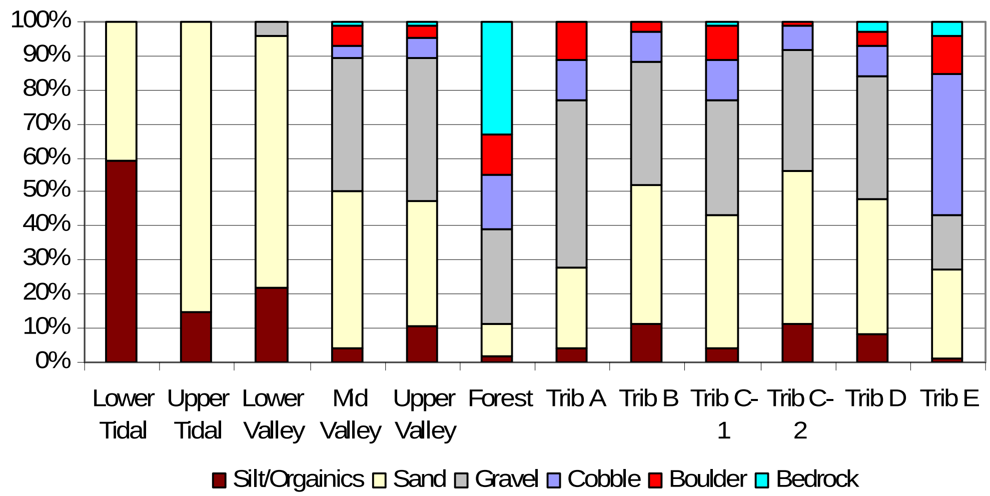


Figure P-6 Substrate Types

Based on an analysis of riffle sediment, Figure P-7, Palouse creek had high gravel content throughout all the reaches except for the Tidal reaches, which have no gravel. The graph lacks data for riffle analysis in the Lower Tidal reach because there were no riffles within that reach. The amount of sand/silt/organics is above desirable levels in all reaches except in the Upper Valley, Forest, Trib A, and Trib C-1. Undesirable levels of sand/silt/organics are found in the Upper Tidal (100%), Lower Valley, and Mid Valley reaches where the land use is largely agricultural and the stream gradient is very low. Those three reaches also have unstable banks along the stream. All the tributary reaches have above desirable amounts of gravel, with Trib A also having very low, desirable levels of riffle fines. All the other tributaries have undesirable levels of fine sediment making them less suitable for spawning.

Figure P-7 Riffle Sediment

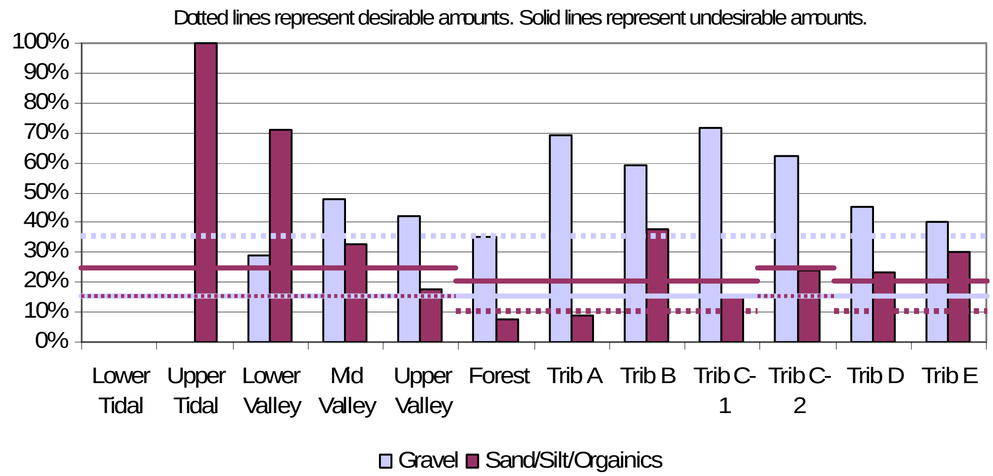


Figure P-8, below, shows that the average pool depth is far less than desirable levels in the Lower Tidal reach. This reach is routinely dredged and has only three small pools. Dredging creates a more uniform streambed that generally lacks complexity. In the lower mainstem, deeper pools are considered desirable, they stay cooler and provide more habitat for juvenile rearing. Reaches having above desirable levels for average pool depths were the Upper Tidal, Lower Valley, Mid Valley, and Upper Valley reaches. Trib B is missing benchmark lines due to a lack of active channel dimension data, although it is assumed to be at the same levels as in Trib A and C.

Figure P-8 Pool Depth

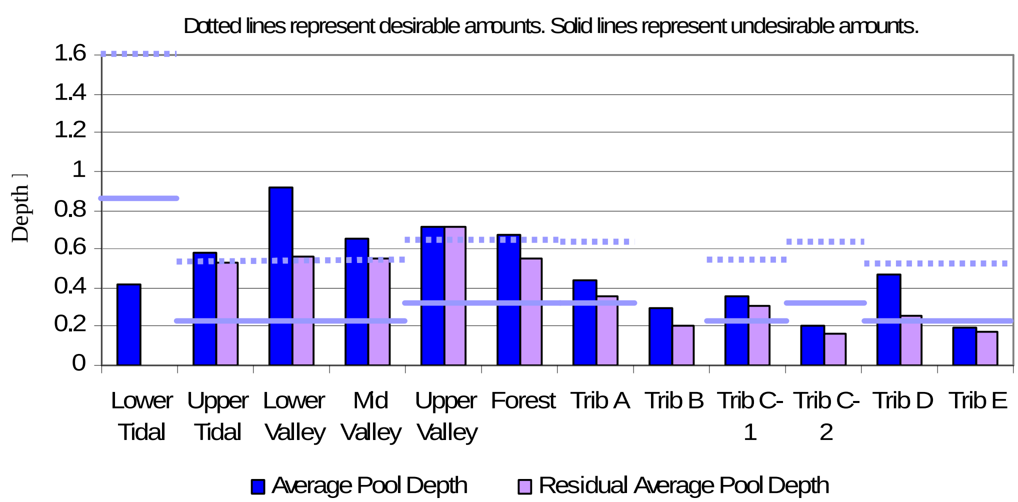


Figure P-9 shows the Palouse sub-basin large wood analysis. None of the reaches were shown to have optimal amounts of large wood. The two lowest reaches have no large wood - partially because of routine stream dredging, but also because glides tend to be low in woody debris (see ODFW AHI protocol). The volume of woody debris for the upper two mainstem reaches and Trib E comes closer to optimal levels.

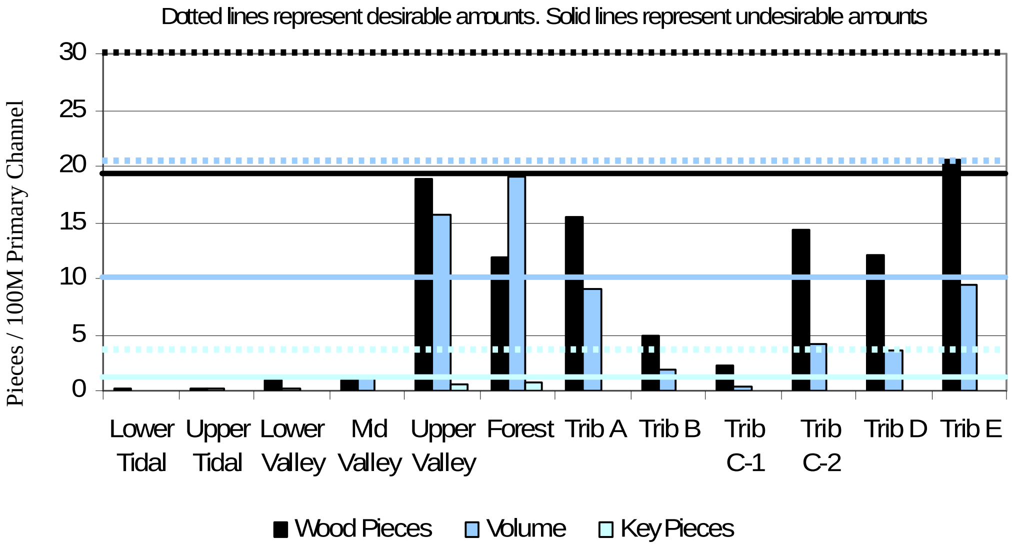


Figure P-9
Large Wood

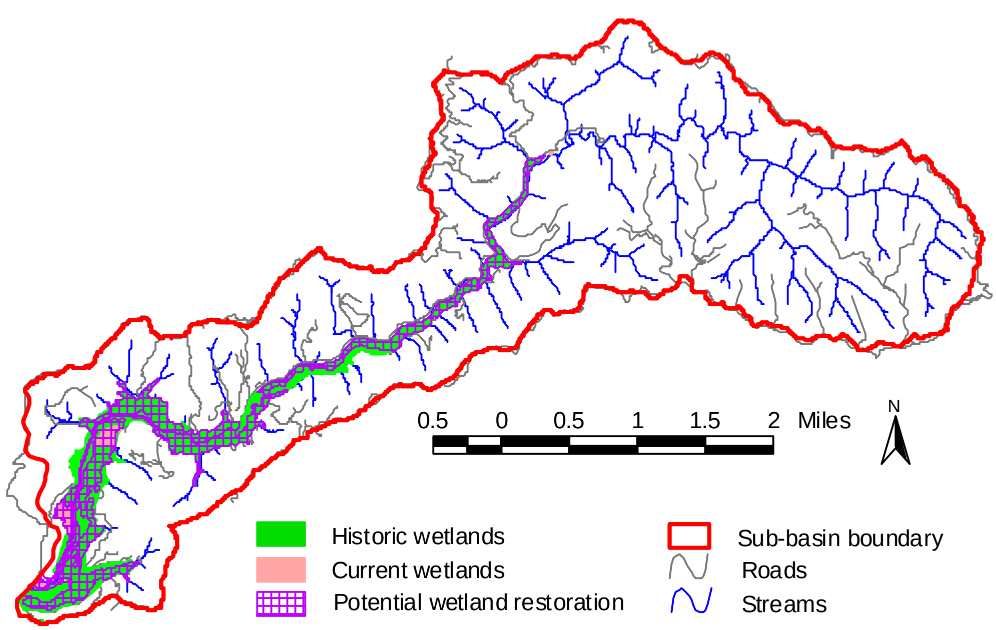
Wetlands

Historic, current and potentially restored wetlands in the Palouse sub-basin are shown in Figure P-10 and Table P-5. The current (2005) wetland extent, determined by CoosWA using aerial photography analysis, is land presently dominated by wetland vegetation and not showing signs of recent agricultural production. In most cases, however, 'current wetland' is not a properly functioning wetland and is included in the area of potential wetland restoration. The area considered current wetland is only 5% of the historic wetland extent in this sub-basin. Historic wetland extents are based on soil type and plant characteristics. Seventy-five percent (415 acres) of the historic wetlands in this sub-basin are described in the National Wetland Inventory as seasonally flooded or unconsolidated river bed. It is primarily the seasonally-flooded areas, not currently functioning as wetland, that CoosWA recommends for restoration consideration as these areas are often more difficult to manage for crop production. Wetland restoration is discussed in more depth in Chapter 3, and National Wetland Inventory categories are provided in Appendix A.

Table P-5 Wetland Areas

Wetland Type	Acres
Historic wetlands	555
Current wetlands	30
Potential wetland restoration	415

Figure P-10 Wetlands



Sediment Sources

Sediment sources considered in this assessment include unstable stream banks, unstable slopes, erosion associated with roads, and stream crossings with road fill at risk of failure.

Bank Stability

Bank stability surveys were conducted as part of the aquatic habitat surveys. Figure P-10 shows the bank stability ratings for each aquatic habitat reach. Bank stability surveys indicated that the first two reaches of Palouse Creek had excellent bank stability. In the Lower Valley Reach, 18.3% of the banks were unstable. Unacceptable banks are on the Mid Valley, Upper Valley, Trib A and Trib C- 1.

Figure P-10 Bank Stability

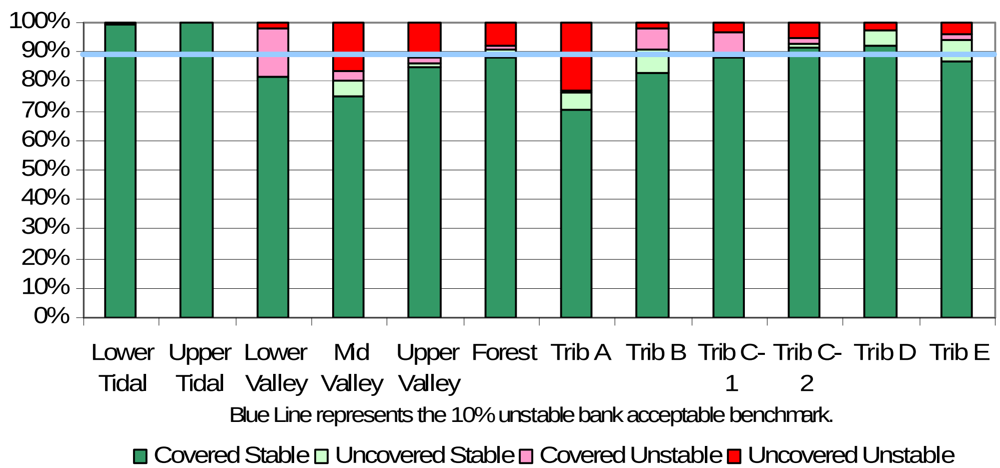
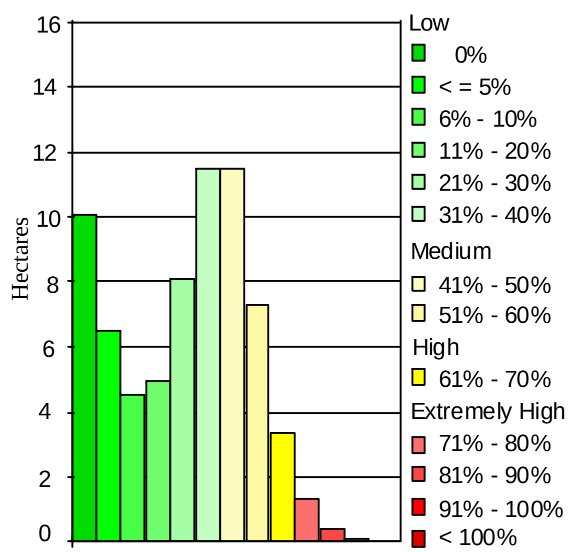


Figure P-11 Slope Stability Risk Classifications



Slope Stability

The slope stability analysis, shown in Figure P-11, determined that 65.6% of the area is in the low risk category for landslide potential, and approximately 26.9% is at moderate risk. High risk is 4.9% of the area and extremely high risk is 2.6% of the area. High and extremely high risk areas total 7.5% of the Palouse sub-basin. The most unstable slopes are located in the headwaters of Palouse Creek in the Elliot State Forest, located in the upper headwaters of the stream.

Road-Related Erosion

Palouse Creek road and landing survey was conducted between February 2001 and October 2004. The survey was divided into two groups, county roads and private roads. The county road survey started at the junction of North Bay Drive and Haynes Way Lane and ended at the 5.5 mile marker on the county road. All private roads were surveyed where landowner permission was granted. Table P-5, below, provides a brief summary of data collected.

Table P-5 Road and Landing Survey Results

Site Type	Number of Sites	Number of Ditches	Existing Ditch Lengths (ft)
Stream Crossing	61	94	Avg. 309 Min. 20 Max. 2130
Ditch Relief	104	133	Avg. 422 Min. 25 Max. 1960
Ditch Out	33	53	Avg. 415 Min. 10 Max. 1500
Potential Landslide	6	4	Avg. 685 Min. 80 Max. 1390
Ponding/ Gullied Road Surface	4	7	Avg. 325 Min. 30 Max. 490
Totals	208	291	

A total of 23.5 miles of road were surveyed in the Palouse sub-basin. The average number of drainage sites per mile was 8.9. Within the Palouse road and landing survey, there were 61 stream crossings, 104 ditch relief culverts, 33 ditch outs, 6 potential landslides and 4 road surface sites. See Discussion and Restoration Opportunities for recommended drainage feature upgrades.

Stream Crossing Drainage Evaluation

The 61 stream crossing culverts studied in the road and landing survey were ranked for their ability to properly drain the area upstream during a fifty-year rain event (see Table P-6). Thirty-four (55.7%) of the stream crossings in this survey are considered at risk for improper drainage or failure because they are undersized.

At-risk culverts are ranked in Table P-6 based on the percentage of associated drainage area they can properly drain during a 50-year rainfall event. The number of culverts in each failure risk level (left column) is listed according to the associated road fill volume size class. It is important to consider both failure risk and fill volume in prioritizing treatment sites for stream crossing upgrades.

Table P-6 At-risk Stream Crossing Evaluation

50-Yr. Rainfall Fill Failure Risk	Fill Volume Size Class									
	Minimal		Small		Medium		Large		Very Large	
	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3
Low	-	-	1	14	1	66	1	200	-	-
Moderate	-	-	1	38	-	-	1	214	-	-
High	-	-	5	138	1	55	1	154	-	-
Very High	3	13	15	427	4	352	-	-	-	-

Failure Risk: Low = 76% - 100%; Moderate = 51% - 75%; High = 26% - 50%; Very High = 0% - 25%
Fill Volumes: Minimal = ≤ 10 $yds.^3$; Small = 10 - 50 $yds.^3$; Medium = 51 - 100 $yds.^3$; Large = 101 - 500 $yds.^3$; and Very Large = > 500 $yds.^3$.

In the Palouse sub-basin, of the 34 culverts that had capacities that were lower than the 50 year peak flow, 22 ranked as having very high risk of failure, potentially delivering 792 yds^3 of fill. Seven were ranked as having high risk, potentially releasing 347 yds^3 of fill. Two ranked moderate, potentially releasing 252 yds^3 of fill. Three of them ranked low risk, potentially releasing 280 yds^3. There is a total of 1,671 yds^3 of fill at these 34 at-risk culverts.

Stream Temperatures

Five temperature logging units were placed in Palouse creek in 2003. They were distributed from the upper forested region, site 1, to the wide-channel Tidal reaches slightly upstream of the mouth, site 5. In 2004, seven temperature units were placed on Palouse creek, but the site 1 temperature recorder was lost under a collapsed bank. All of the 2004 units coincided with the 2003 locations, and two new locations were added(see Table P-7). One of these new units was placed on the upstream side of the tide gate (TG) to monitor temperatures at the stream mouth.

Table P-7 Temperature Summary and Exceedance of Standards

Site	Year	7-Day Averages Max.	7-Day Averages Min.	7-Day Averages Daily D T	Days >64 °F	Days >70 °F	Hours >64 °F	Hours >70 °F
Site 1	2003	60.1	58.9	1.2	0	0	0.0	0.0
Site 2	2003	68.5	60.4	8.1	48	2	402.5	16.0
	2004	70.7	63.1	7.6	62	16	787.5	56.0
Site 2.5	2004	66.8	62.9	3.8	40	0	291.0	0.0
Site 3	2003	71.0	62.2	8.7	64	12	638.5	39.0
	2004	69.4	63.3	6.1	67	1	761.5	3.0
Site 4	2003	72.7	62.0	10.7	97	24	1401.0	266.0
	2004	85.3	81.6	3.7	93	82	2020.5	1696.5
Site 5	2003	82.7	67.2	15.5	80	72	1688.0	1108.0
	2004	84.2	78.0	6.3	106	89	2249.0	1845.5
TG	2004	75.9	71.8	4.1	110	65	2300.0	769.0

Table P-7 shows the 7-day average maximum and minimum temperatures, and the number of days and hours each site exceeded 64 and 70°F. Exceedance of standards is shown in Figure P-12, below. The data indicate that all 2003 sites in Palouse except Site 1, registered days over both 64°F and 70°F. The sites lower in the system recorded a much higher number of days over the standard, as expected. In 2004, all sites on Palouse registered days over 64°F; and all but Site 2.5 recorded days over 70°F. In both years, all of the 7-day average maximums on Palouse exceeded the 64°F standard, except for Site 1 in 2003. The 7-day average minimums of Site 5 in 2003, and Sites 4, 5 and the tide gate in 2004 were also above the 64 °F standard. This means that during the hottest 7 day period of the season, the average minimum temperature never dropped below 64°F. This site also indicated temperatures af-

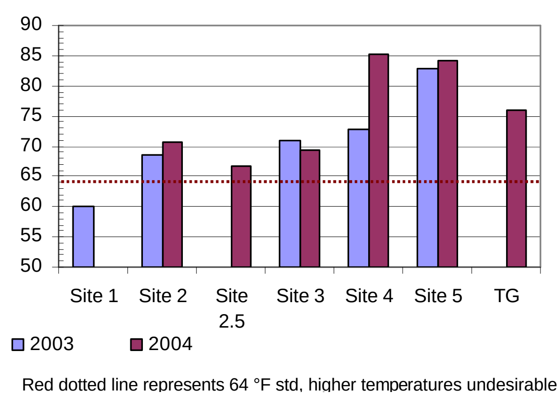
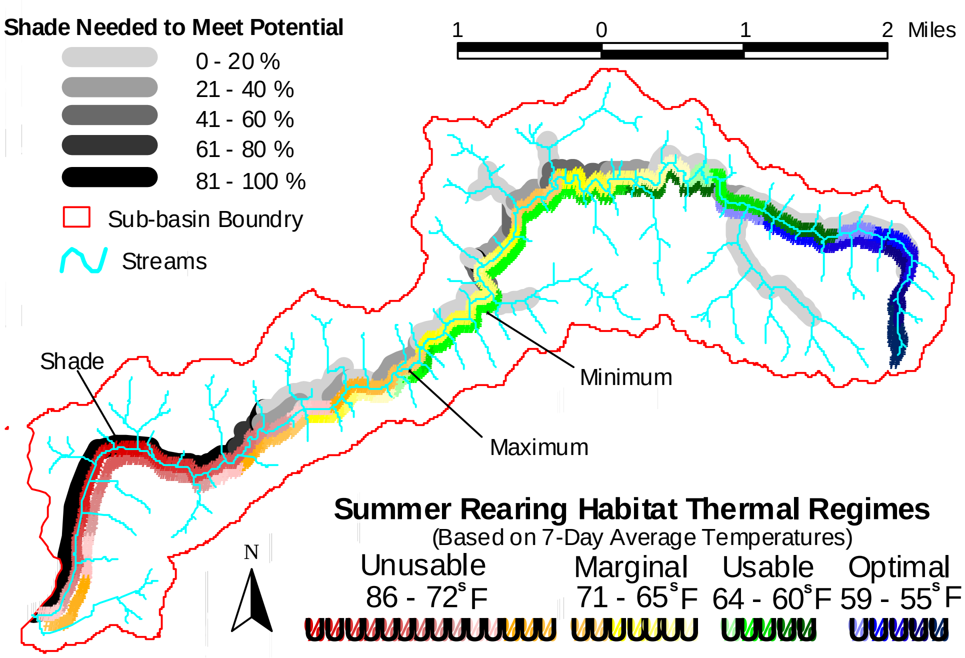


Figure P-12 7-Day Moving Averages of Daily Maximum Temperatures

fected by cooler tidal water leaking back into the stream.

Figure P-13, below, illustrates the temperature trends within the sub-basin using 7-day average maximums, and colors them according to suitability as rearing habitat for juvenile coho salmon. The map shows that temperature over the length of the stream increases from 55°F at the headwaters to 84°F in the lowlands, and then is cooled by tidal influence to 76°F at the tide gate in 2004. Overall in 2004 there was a significant warming trend. The overall 2004 temperature increase on Palouse Creek going downstream was 0.48°F per 1000 ft from the upper unit (Site 2) to the tide gate. In the two uppermost segments, from sites 2 to 2.5, and 2.5 to 3, the difference between the average daily highs was less than 1°F per 1000 ft. Further downstream, from site 3 to site 4, the average daily high increases by 3.92°F per 1000 ft. From site 4 to the tide gate (site 5), the average daily high water temperature decreases 0.17°F per 1000 ft. Only approximately the uppermost 4 miles of stream are usable habitat during the hottest part of the summer. Tributaries likely offer significant thermal refuge, but were not monitored.

Figure P-13 Temperature Trends and Riparian Shad Condition



Riparian Shade

The difference between current and potential shade, shown in Figure P-13 above, is expressed as shade needed to meet potential. The darker riparian areas on the map have the least amount of current shade. Current and potential shade values in the Palouse sub-basin are 84% and 95%, respectively, in the upper-most, steep canyon areas. The upper valley has 57% and94% respectively, in the upper valley area and the lower valley has only 30% and 92% respectively.

Salmonid Distribution

Coho and winter steelhead distribution, according to ODFW, is shown in Figure P-14. Chinook and chum salmon also use the Palouse system for spawning and rearing, but populations are significantly smaller than coho. Anadromous fish distribution is restricted 11.7 kilometers from the tide gate by a 3 meter bedrock falls. Four large upper tributaries provide an additional 2 kilometers of critical spawning and rearing habitat for salmonid species. Above the bedrock falls, extending 4.8 kilometers on the mainstem channel, there are significant native cutthroat trout populations (see green line) (ODF). Chinook, chum, steelhead, cutthroat, and coho are observed as far as the end of our survey area. The spawning survey area is enlarged below in Figure P-15.

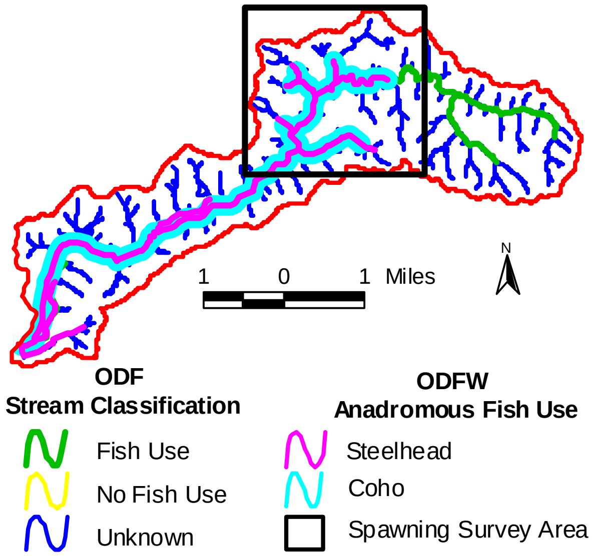


Figure P-14 Salmonid Distribution

A wide variety of amphibian and non-salmonid fish species are also observed in the Palouse sub-basin. These species include, but are not limited to cottids, brook lamprey, Pacific lamprey, stickleback, Pacific giant salamander, Dunn's salamander, roughskin newt, tailed frogs, red-legged frog, Pacific treefrog, and foothill yellow-legged frog (Coos WA 2005).

Stocking Records

Palouse creek was stocked with steelhead and coho between 1980 and 1991 (see Table P-8). In all, there were nearly 100,000 steelhead released during this period, with a single release of 9,600 coho in 1990. Palouse creek has been stocked with more steelhead than any other

Table P-8 Stocking Records

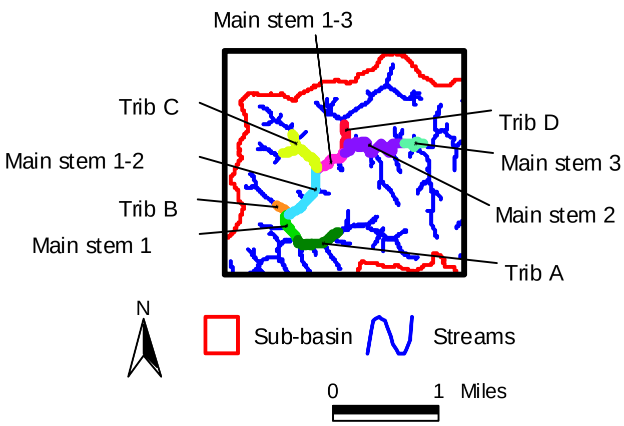
Creek	Species	Year	Juveniles Released
Palouse	Steelhead	1980	12,539
Palouse	Steelhead	1981	12,490
Palouse	Steelhead	1982	10,232
Palouse	Steelhead	1983	11,879
Palouse	Steelhead	1984	7,470
Palouse	Steelhead	1985	7,522
Palouse	Steelhead	1986	7,437
Palouse	Steelhead	1987	7,381
Palouse	Steelhead	1988	7,508
Palouse	Steelhead	1989	4,878
Palouse	Steelhead	1990	5,020
Palouse	Coho	1990	9,618
Palouse	Steelhead	1991	5,005
			108,979

stream in the assessment area. Stockings were conducted every year from 1980 to 1991. According to ODFW, few fish if any have been stocked in Palouse creek since 1991.

Spawning Surveys

During the winter of 2003 and 2004, the Coos WA and ODFW partnered to survey all major coho spawning reaches in the Palouse basin in order to assess the total coho escapement population. Reach locations are shown in Figure P-15. The Coos WA surveyed mainstem reaches 1-1, 1-2, 1-3, and all tributary reaches (see Figure P-15 below). The ODFW surveyed the mainstem reaches 2 and 3.

Figure P-15 Coho Spawning Survey Reaches



Palouse creek consistently has had one of the highest densities of spawning coho of streams on the coast of Oregon. In 2003, an estimated 1,914 coho returned to the spawning grounds and in 2004 total coho escapement is estimated at 1,837 fish. However, the population estimates in mainstem reaches 2 and 3 may be biased because Coos WA and ODFW surveys were conducted at different times. This is because fish may have moved to other reaches and been counted again by the other surveyors. Based on surveys, spawning primarily occurs in the uppermost 4.4 km of mainstem and 2 km of small upper valley tributaries streams (see fish population data below).

Because of the limited length of spawning habitat and high numbers of spawners, Palouse creek had high spawner densities. Table P-9, below, which compared fish counts with amount of available spawning gravel likely overstates the spawning usage in the mainstem segments 1-1 through 1-3. Although many fish are counted in these segments, they were primarily observed holding in pools prior to spawning in the upper reaches. The gradient in this segment is very low and has high sand and silt content in the spawning gravel. The high spawner densities in the small side tributaries were also notable.

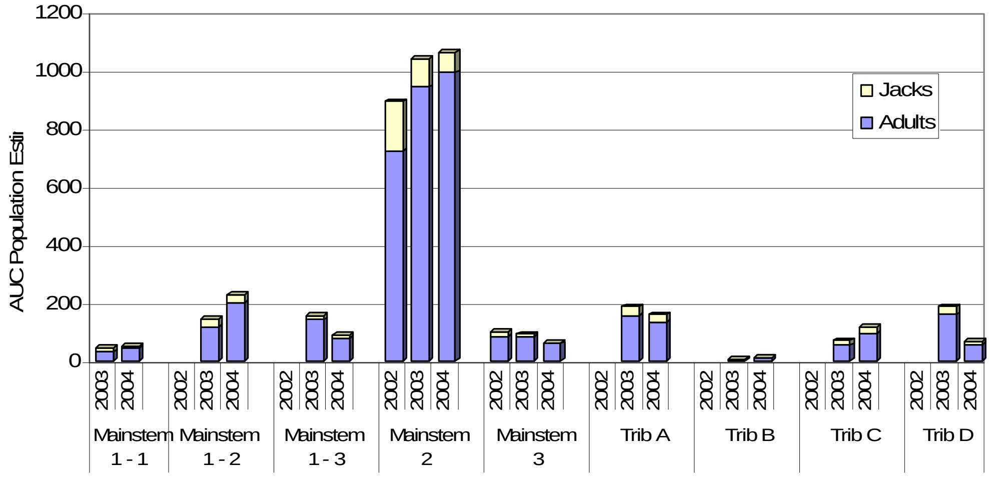


Figure P-16 Coho AUC Population Estimate

Coho are not the only anadromous fish observed during the spawning surveys on Palouse Creek. A small run of Winter Chinook have been noted in the mainstem. Numerous resident trout, as well as Sea-run cutthroat trout, were seen in many survey reaches. In 2004, a pair of chum salmon were observed spawning in mainstem reach 1-3. Near the upper end of the Coho run, steelhead were observed in the mainstem survey reaches. No predation was observed in Palouse Creek, but scavenging of carcasses by large birds and mammals was common in the tributary reaches.

In terms of coho productivity, the mainstem reaches had 326.7 AUC/km for 2003, and in 2004 there was 330.7 AUC/km. The tributaries produced 222.3 AUC/km in 2003 and 174.1 AUC/km in 2004. The decrease in AUC/km on the tributaries is probably due to the paucity of significant rainfall events in the 2004 season. This only allowed occasional access to tributary habitat. The most productive reach in Palouse Creek was mainstem 2, at 708/km in 2003. There were culvert passage issues at Tributary B and C which is reflected in the

Table P-9 Spawning Densities

Reach		YEAR	Estimated AUC/Km	Gravel (m^2)	Gravel (m^2)/ Female
Main Stem	1 - 1	2003	92	30	2.0
		2004	108	292	13.9
	1 - 2	2003	315	132	2.2
		2004	389	347	3.5
	1 - 3	2003	338	54	0.8
		2004	192	232	6.0
	2	2002	558	No Data	No Data
		2003	708	No Data	No Data
		2004	665	No Data	No Data
	3	2002	278	No Data	No Data
		2003	254	No Data	No Data
		2004	174	No Data	No Data
Tributary	A	2003	238	426	5.5
		2004	203	375	5.6
	B	2003	69	48	24.0
		2004	102	69	15.4
	C	2003	92	294	11.3
		2004	157	319	6.8
	D	2003	583	157	2.1
		2004	212	156	5.5

low fish counts in the upper reaches of these tributaries. The gravel per female was high on tributaries B and C, compared to estimated gravel use of 5.85 m^2 per female (Sandercoch, 1991) indicating that there was available spawning habitat that is not being utilized. In most other segments, spawning gravel was fully utilized. Gravel estimates were not available for reaches 2 and 3.

Intrinsic Potential for Coho Smolt Production

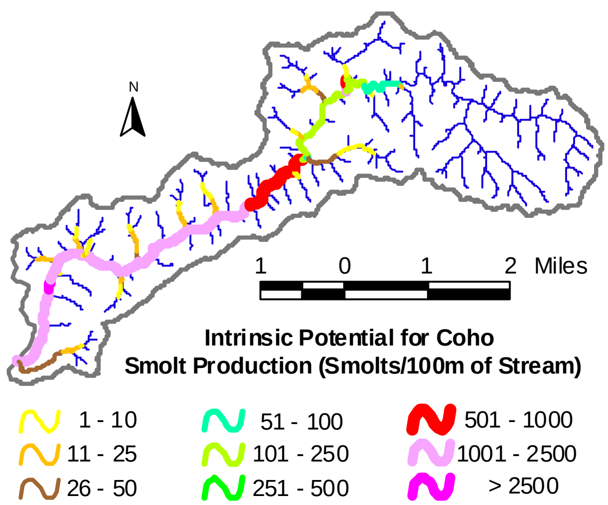


Figure P-17 Intrinsic Potential For Coho Smolt Production

The intrinsic potential for streams in the Lowlands area to produce coho smolts was estimated based on digital elevation models, active channel and valley widths, known natural barriers and coho life histories. The values indicate the number of coho smolts supported by historic, pre-settlement stream conditions. Intrinsic potential for the Palouse sub-basin, shown in Figure P-17, indicates that Palouse Creek has the highest intrinsic potential in its tidal and lower valley reaches – from 1001 to 2500 smolts per 100 meters of stream. This pattern reflects the coho preference for wider active channel and valley widths. The thin blue lines, streams, indicate zero intrinsic potential due to gradients above 20% and known natural migration barriers. Understanding intrinsic potential for a particular stream will help guide restoration efforts in setting realistic coho population goals. Total intrinsic potential for smolt production this sub-basin is 141,756 smolts. Intrinsic potential for adult coho returns under low ocean survival rates (1%) is 1,418, and under high ocean survival rates (10%) is 14,044 fish.

While restoring coho smolt populations to these levels is unlikely given current land uses and infrastructure, understanding intrinsic potential for a particular stream will help to inform restoration efforts and to set realistic coho population goals.

Coho Habitat Limiting Factors

The Limiting Factors analysis (based on Reeves et al., 1989), shown in Table P-10 below, indicated that summer and winter rearing habitats were bottlenecks to coho production. Summer rearing habitat was only 25% of the area needed, and winter habitat was 39% of the area needed to support potential smolt populations produced from currently available spawning gravel. The summer bottleneck was due to excessively high temperatures which eliminated reaches[3] from the current usable area. If there were no temperature limitations within the sub-basin, winter rearing habitat would be the next limiting factor. Palouse Creek was found to have limited connectivity with its flood plain and limited off-channel habitat, which greatly limits its winter usable area. The pool behind the tide gate may provide additional winter rearing habitat, but the use level of this area has not been determined. Current spawning area is more than sufficient for potential populations.

Table P-10 Limiting Factors to Coho Populations

Palouse Habitat Component	Potential Summer Population	Area/ Survival Factor	Area Needed (M^2)	Current Usable Area (M^2)	Smolt Factor	Smolts Produced
Spawning	50,486	0.006	303	1,141	95.5	108,966
Spring Rearing	50,486	0.3	15,146	34,426	1.7	58,524
Summer Rearing	50,486	0.6	30,292	7,676	0.9	6,908
Winter Rearing	50,486	0.4	20,194	7,849	1.2	9,419

Resource Issues

Early settlement

A wildfire burned through much of Haynes Inlet in 1867, and again in 1883, leaving large snags and early-succession stands of alder in many places. The land along the slough and Palouse creek was settled in the 1880s and by 1890s most bottom land was claimed. By 1909, the lower

[3] The Lower Tidal reach was removed from the Useable Area because that reach had severe high temperatures. There were 3 temperature sensing devices in this reach. One had 63 days with a minimum temperature >22°C with over 40 consecutive days and 27 consecutive days over a max of 25°C. Another had 53 days with the minimum >22°C with over 40 consecutive days and 49 days (21 consecutive) of over 25°C. The third temperature monitoring station also detected warm temperatures, but with less detrimental temperatures than the others.

stream reaches were straightened, hand-dredging began, and culverts with iron lids, early tide gates, were installed. In 1910, Julius Larson invented a dredge boat to deepen and widen the sloughs for better navigation. A dike was constructed along Palouse in the 1920s, and in 1924 a road along the dike was built. Principle transportation of dairy products went from boat to trucks in 1926. In her book, Ines Nelson recalls many family swimming holes along the slough and stream. (Nelson, 1978)

Contemporary Issues

Past impacts to the stream include large wood removal in both the forested and valley segments of the channel. Dredging and channeling of the stream in the valley bottoms, diking in the lower reaches, and road construction has had ongoing impacts on the drainage of the lowland area. The main channel was last dredged in the summer of 2003 (after Coos WA conducted surveys), but is still far below its original capacity. Removal of riparian vegetation and tidal exclusion have also changed the natural conditions of the Palouse sub-basin.

The main tide gate is suspended from a concrete tide box with two large, top-hinged, wooden doors. The tide gate creates a large, slackwater pool immediately upstream which has caused the hydrologic and sediment transport mechanisms in the lower Palouse system to be highly altered. Because sediment deposits in this area more closely resemble a reservoir than a connected estuary, the tidal part of the channel has seriously aggraded. The tide gate may have direct effects on fish populations related to fish passage as well as creating thermal and salinity gradient conditions that fish would not have experienced historically.

Like other sub-basins in the area, the Palouse sub-basin key resource issues are related to sediment transport through the lower reaches. Sediment accretion in the lower reaches since the placement of the tide gate has caused significant changes to channel dimensions. As a result of the channel filling with sediment, flooding of roads and driveways has become a major problem for local residents.

Landowner Concerns and Desired Future Conditions

At a Palouse sub-basin Coffee Klatch meeting held 0n May 12, 2005, landowner expressed their concerns about watershed issues. According to a number of local

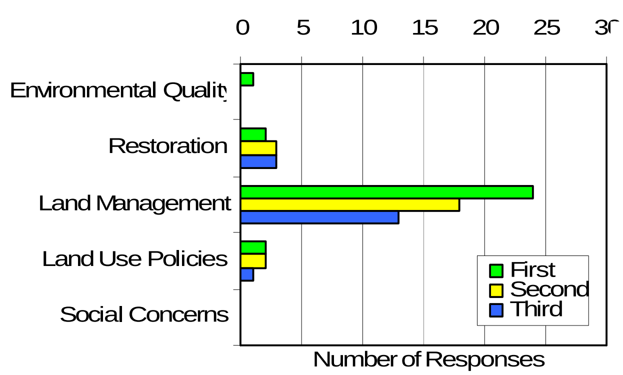


Figure P-18 Landowner Concerns

landowners, drainage of the bottom land has become much worse since the main tide gate was replaced in 1988, and especially bad in the last five years. A large storm event in 1982 was also recalled by landowners as having a sudden and lasting effect on the sub-basin by transporting large amounts of sediment from the uplands. Land commonly used for grazing and hay production now remains wet most of the year, and is becoming inundated with wetland associated plants such as “tussocks” *(Juncus sp.)*. Land management concerns (see Fig. P-18) expressed by landowners in the Palouse Creek sub-basin were heavily dominated by the problem of poor drainage.

Private landowners in the Palouse Creek watershed expressed their primary desired future condition for the area as regaining drainage on currently wet pasture land for hay and grazing purposes. This goal of “reclaiming the land” was generally a top priority concern for the majority of Palouse Creek Coffee Klatch attendees. Landowners expressed the need for ongoing proper maintenance of culverts, especially under county roads, and tide gate “fixes”. Landowners also expressed the desire to better understand whose responsibility it is to maintain these drainage structures, and the proper process of implementing maintenance activities. Other future desires include continued availability of irrigation water, restoration of fish passage, and keeping the pastoral, undeveloped feel of the area.

Coos Bay Lowland Assessment and Restoration Plan

Chapter 2:
Larson Creek Sub-basin Assessment


Larson Creek tidal reach from tide gate. Photo CoosWA, 2006.

Larson Creek Sub-basin

Introduction

Landform

The Larson sub-basin (see Figure L-1) is long, narrow and orientated northeast to southwest. Larson Slough, the head of which is tide-gated, drains into the north end of Coos Bay through Haynes Inlet and there are tidal and high salt marsh areas near the mouth. Sullivan Creek, Larson's main tributary, flows into the mainstem about midway up the sub-basin.

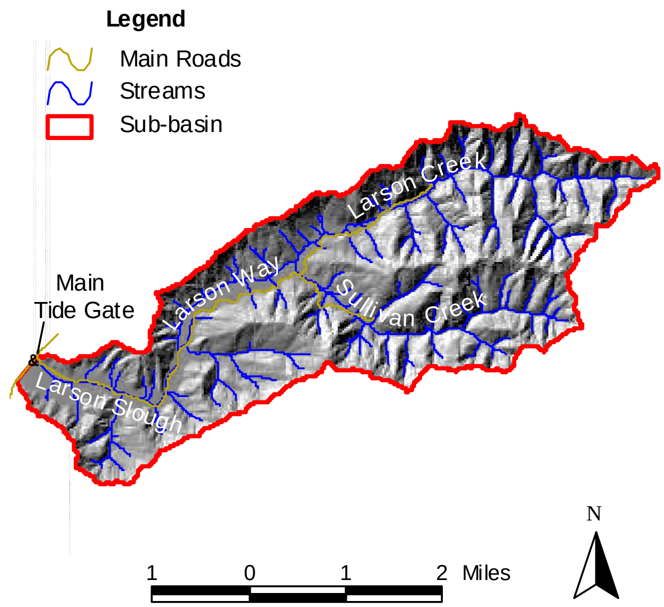


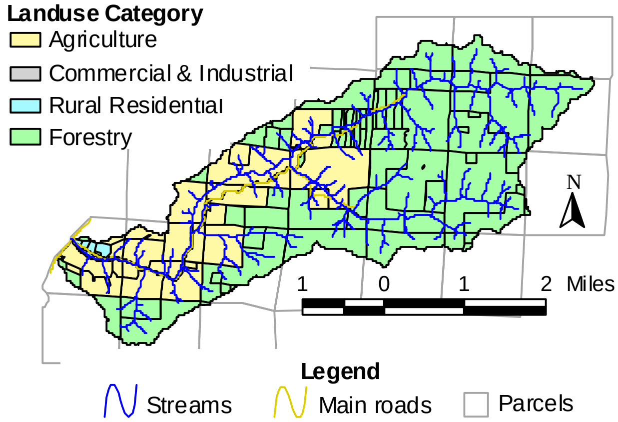
Figure L-1 General Sub-basin

Both Larson and Sullivan Creeks are dendritic river systems. Larson Creek is a fourth order stream, while Sullivan is a third order stream. The drainage area of the sub-basin is approximately 6944 acres (10.85 miles^2), which is the third largest in the lowlands assessment area. The total river miles of streams within the Larson watershed is approximately 47.2 miles, including every section of stream from mainstems to very small intermittent headwater streams. From the tide gate at North Bay Drive, the Larson mainstem is approximately 8 miles long, and Sullivan Creek mainstem is 3.4 miles long. The elevation in the basin ranges from 0 to 1383 feet above sea level (OWRD, 2005).

Larson is the only sub-basin in the assessment area whose underlying geology is composed entirely of Tyee silt/sandstone, which forms an erosive, landslide-formed topography. Weathered into this are the following three general soil types. Dune land-Waldport-Heceta, which is common to dune areas with Waldport being excessively drained, while the Heceta is poorly drained, Templeton-Salander, common to the lowland area, which is well drained and loamy, and Milbury-Bohannon-Umpcoos, found in the uplands, which is moderately deep and shallow, gravely and loamy (Haagen, 1989).

Landuse and Ownership

Figure L-2 Landuse Distribution



Landuse in the Larson sub-basin (see Figure L-2) is 69% forestry, which covers most of the uplands and head waters. Larson contains the highest percentage, 31%, of agricultural lands within the assessment area. These spread across the lowlands of the Larson mainstem and slough, and are mainly dedicated to grazing and hay crops for dairy and cattle operations. Rural residential land use, located near the mouth of the slough, is very minimal, and there is virtually no commercial or industrial land use present in the sub-basin (see Table L-1).

Table L-1 Landuse Area (Coos County Assessor, 2004)

Landuse	Acres	Percent
Agriculture	2,146	31
Forestry	4,845	69
Rural Residential	34	<1
Commercial & Industrial	-	
Total	7,025[4]	

[4] Note: Totals differ between the county assessors parcel aggregate areas and the sub-basin area. The county assessors database has many duplicate records which were removed based on identical areas, map numbers, and parcel numbers, and may not include area of roads or streams.

Hydrology

Precipitation

Annual precipitation is 69 inches in the lowest elevation in the Larson sub-basin. Due to the west facing orientation, rainfall gradually increases as the elevation increases to a maximum of 73 inches, averaging 71 inches for the whole sub-basin (OCS, 2003). The precipitation intensity for a 2-year 24-hour event is 3.01 inches (OWRD, 2005).

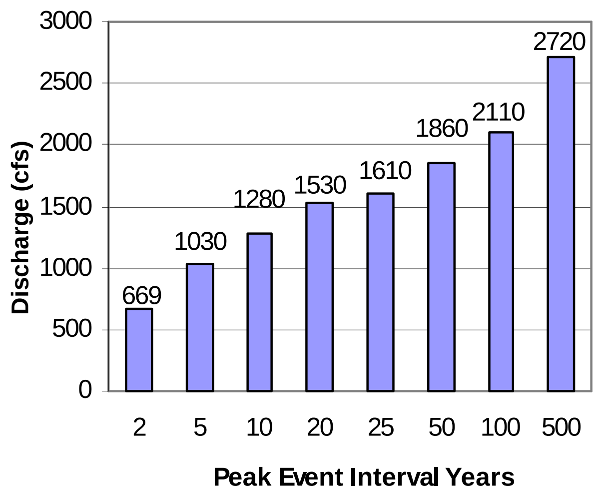


Figure L-3 Annual Peak Discharge Estimates

Stream flow

Annual peak stream flow (Figure L-3) was obtained from the Peak Flow Estimation Program (OWRD, 2005). They use hydrologic prediction equations and physical watershed characteristics to estimate peak flows. Table L-2 shows the estimated discharge at the mouth of Larson Creek for storm events at two to five hundred year reoccurrence intervals. The bankfull storm event is estimated to be 669 cfs. On the other extreme, a maximum discharge of 2720 cfs is estimated for a 500-year storm event in Larson Creek.

Miscellaneous summer flow measurements were collected on Larson Creek in 1998 to 2002 (OWRD), and in 2003 (Coos WA). Table L-2 shows the summer flows on Larson

Table L-2. Discharge Measurements (1998–2003)

Location	Year	Date	CFS
Winter 1	1998	1-Jun	37.0
		1-Jul	11.00
		3-Aug	2.20
		1-Sep	1.20
Winter 1	1999	29-Jun	5.32
		19-Jul	1.70
		2-Aug	1.35
		16-Aug	1.31
Winter 2	2000	21-Aug	2.01
		29-Aug	0.69
		20-Sep	0.37
		19-Oct	4.64
Winter 2	2001	17-Sep	1.19
		22-Jul	1.34
Winter 2	2002	11-Oct	8.47
		2-Jul	1.26
Main 4	2003	18-Aug	0.14
		24-Sep	0.20
Winter 1		18-Aug	0.70
Sullivan 1		29-Aug	0.71

Creek at Winter 1 and at Winter 2 site from 1998 to 2003. In 2003, measurements were taken at the Main 4, Winter 1, and at the Sullivan 1. The lowest flow was taken at the Main 4 site (0.14 cfs), however this site is in a much smaller section of stream than the other sites. Based on these measurements the base summer stream flow for the Winter 1 site ranges between 1.20 and 11.00 cfs. At the Winter 2 site the stream flow ranges from 0.69 and 2.01 cfs. A high flow of 37.00 cfs was taken at the Winter 2 site in June 1998.

Land Use Effects on Hydrology

Land uses, as they affect surface conditions, can be used to make general evaluations of the hydrologic condition of a watershed. Of particular concern is the effect of land uses on peak stream flow, since increases in runoff can contribute to flooding, erosion, and culvert failures. The most important determinant for peakflow increases is the ability of soils to absorb rainfall.

The main types of hydrologic soil groups (HSG) present in the agriculture lands are, 61% of HSG Class D, and 39% of HSG Class B. The HSG Class D has very slow infiltration rates and high runoff rates. The HSG Class B has moderate infiltration rates and moderate runoff. Agriculture has a greater affect on runoff in areas where soils have a high infiltration rate compared to areas where soils are relatively impermeable in their natural state (USDA, 1986). Because of the soils, potential risk of peak-flow increases is moderate in the Larson sub-basin.

Within the forest land use area, there are 36.75 linear miles of forest roads. These roads take up approximately 2.0 percent of the forested area. If the percentage of forest area rises above 8 percent, the potential risk of increasing peak-flow moves to high (OWEB, 1999). Because of the low percentage, the relative potential risk for peak-flow enhancement is low.

There are approximately 7.62 linear miles of rural roads in the Larson Creek. Of this area, there is 5 percent area in roads. This percentage ranks Larson Creek residential and area as a relatively moderate potential risk for peak-flow enhancement.

Included within the rural road area, there are some impervious surfaces, but no urban roads. Because of the small amount of impervious surfaces, the potential risk for peak-flow enhancement from urban roads is low.

Overall, Larson sub-basin's potential risks of peak-flow increase from land use impacts are low to moderate.

Water rights

There are three main sources of water rights in Larson Creek: surface water, groundwater, and instream. The most senior water right in was established in 1924 for domestic use of surface water. Table L-3 displays the different types of water use in Larson Creek. There are no storage rights for Larson sub-basin. Total water rights for the entire sub-basin are 43.92 cfs. The total consumptive use is 1.51 cfs. The instream rights extend 4.0 river miles from the tide gate at North Bay Drive to the Sullivan Creek tributary. Sullivan Creek instream rights extend for 3.5 miles. However, there are no instream rights for Larson Creek above the confluence of Sullivan Creek. A maximum instream water right of 40.00 cfs was established for the purpose of providing optimum stream flow for migration, spawning and juvenile rearing of anadromous and resident fish, and supporting aquatic life. Of the 40.00 cfs maximum reserved instream flow, 14.00 cfs is for Sullivan Creek.

Type of Use	CFS	Ac-ft
Domestic	0.17	0.00
Irrigation	3.08	0.00
Instream	40.00	0.00
Livestock	0.67	0.00
Total	43.92	0.00

Table L-3 Maximum Water Use

Water Availability

Water availability for the mouth of Larson sub-basin is estimated using the Water Availability Report System (OWRD, 2005). The average water available is based on the 50% annual exceedance level. The expected Flow, shown in Table L-4 for Larson Creek and Table L-5 for Sullivan Creek, was derived by subtracting the consumptive uses from the estimated natural stream flow. In Larson sub-basin, has less than 2 cfs of expected stream flow for the months of August through October. However, in Larson Creek, the consumptive water use has not increased by more than 10% since 1993 (OWRD, 2005).

Month	Natural Flow	Consumptive Uses	Reserved Instream Flow	Expected Flow (cfs)
Jan	55.50	0.16	26.00	55.34
Feb	59.70	0.18	26.00	59.52
Mar	43.90	0.10	26.00	43.8
Apr	30.60	0.05	26.00	30.55
May	15.90	0.06	15.90	15.84
Jun	7.90	0.12	10.00	7.78
Jul	3.81	0.21	3.70	3.6
Aug	1.98	0.14	2.00	1.84
Sep	1.57	0.06	2.00	1.51
Oct	1.89	0.01	15.00	1.88
Nov	12.80	0.01	15.00	12.79
Dec	46.10	0.12	26.00	45.98

Table L-4 Larson Creek Monthly Net Water Available (OWRD, 2005)

Table L-5 Sullivan Creek Monthly Net Water Available (OWRD, 2005)

Month	Natural Flow	Consumptive Uses	Reserved Instream Flow	Expected Flow (cfs)
Jan	14.70	0.00	14.00	14.70
Feb	15.90	0.00	14.00	15.90
Mar	11.80	0.00	11.80	11.8
Apr	8.22	0.00	8.22	8.22
May	4.28	0.02	4.28	4.26
Jun	2.05	0.06	2.06	2.0
Jul	0.91	0.10	0.93	.81
Aug	0.44	0.08	0.45	.36
Sep	0.33	0.03	0.34	.3
Oct	0.40	0.00	0.41	.4
Nov	3.09	0.00	3.12	3.09
Dec	12.00	0.00	12.00	12.0

In Sullivan Creek, the natural stream flows become very low in the summer months of July through October, dropping below 1 cfs for the entire period. With consumptive uses, Sullivan Creek is expected to reach 0.3 cfs low summer flows in the month of September. Also, the consumptive water use has increased in Sullivan Creek by more than 10% since 1993 (OWRD, 2005)

Aquatic Habitat

Aquatic habitat surveys addressed in this assessment include unit type, substrate type, riffle sediment, pool depth, large wood, and bank stability (bank stability is presented in Sediment Sources).

Larson's stream reaches extend upstream constrained by terraces in a low gradient, broad valley. Farther upstream the channel becomes constrained by hillslopes and the valley becomes narrower and steeper. See Appendix A for specific channel morphology metrics.

The Larson sub-basin aquatic habitat survey is a combination of 2001 survey data from ODFW covering reaches Main 5, Main 6, and all three Sullivan reaches. Coos WA performed aquatic habitat surveys on reaches Winter 1 and Winter 2 in the winter 2000, and Main 3 and Main 4 in 2003. The first reach on the Larson aquatic habitat survey starts approximately one kilometer above the tide gate. A moderate portion of the lower mainstem and lower Sullivan Creek were not surveyed because of landowner denials. Aquatic habitat survey reaches are shown in Figure L-4. These reach names will be used to describe locations within the Larson sub-basin throughout this assessment.

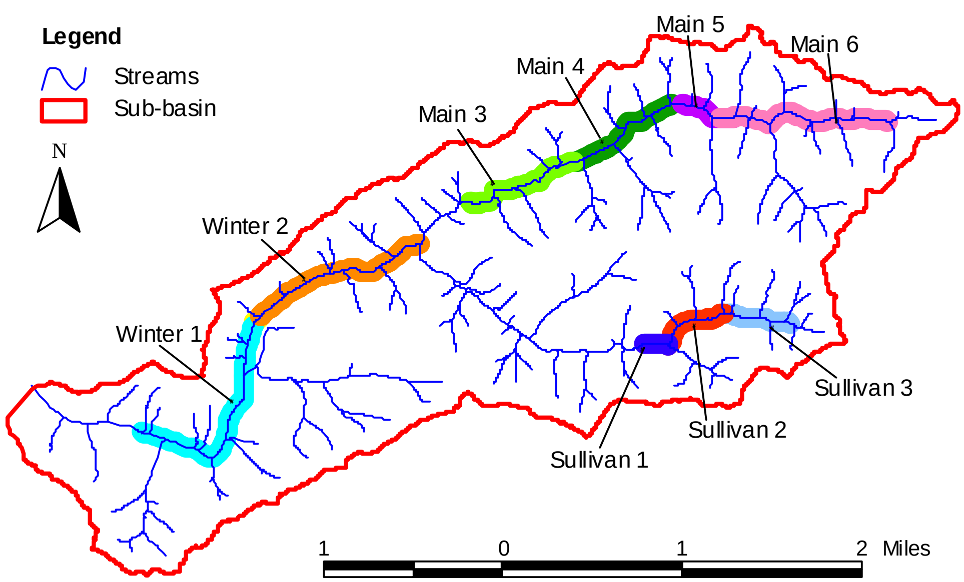


Figure L-4 Aquatic Habitat Study Reaches

Figure L-5, unit types, shows the percentage of unit area per unit type for each of the surveyed reaches. The mainstem reaches are dominated by pools, riffles and glides with rapids in the upper reaches and Sullivan Creek. Small amounts of dry units are spotted in the upper mainstem and upper Sullivan.

Figure L-5
Unit Types

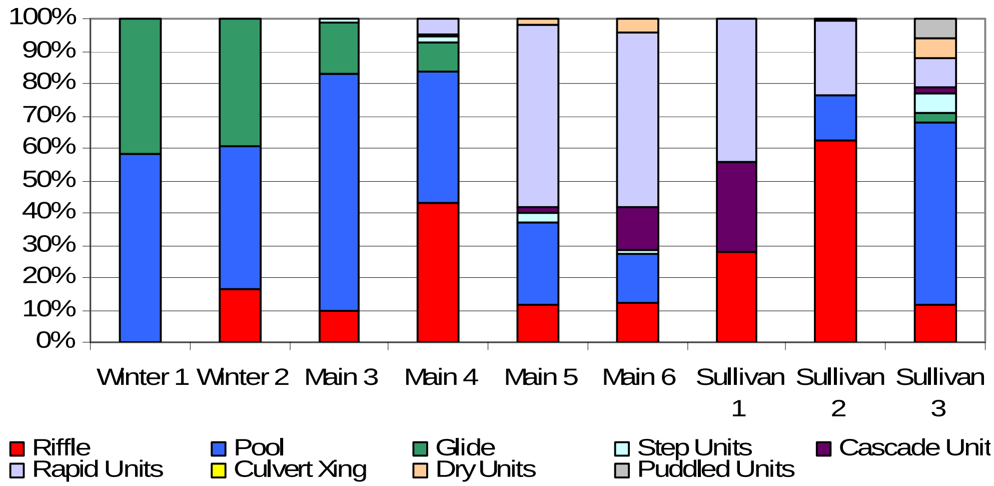


Figure L-6, substrate types, shows the percent of substrate types found in each reach. The upper mainstem and Sullivan reaches have more cobble, boulders, and bedrock. Sullivan 3 has a high amount of silt/organics likely being caught in the large pool area shown in Figure L-5. The lower reaches, less varied in substrate types, are dominitated by sand, gravel and relatively smaller amounts of silt/organics.

Figure L-6
Substrate Types

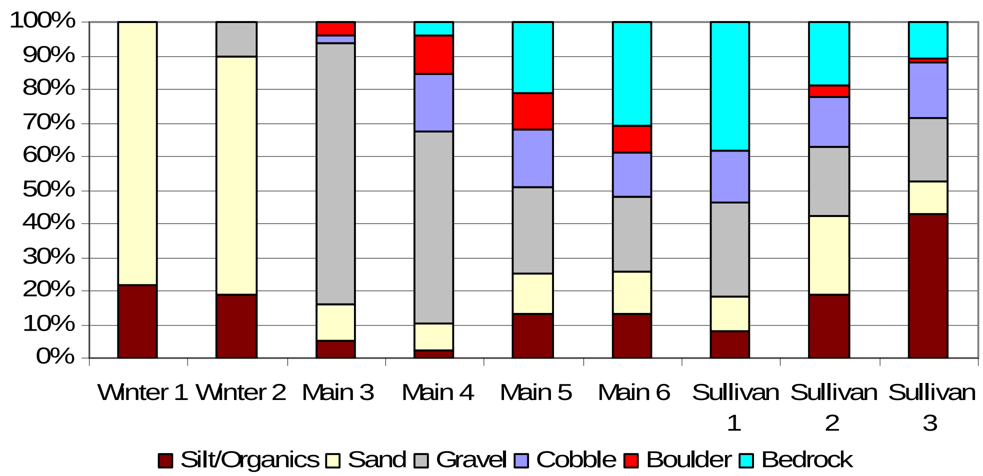


Figure L-7, riffle sediment, shows that most reaches, except Winter 1 which didn't have any riffles, have good amounts of gravel. Main 3, and to a lesser degree Main 4, have extremely high amounts of gravel and little fine sediment – making them excellent for spawning. Winter 2, however, has extremely embedded gravel

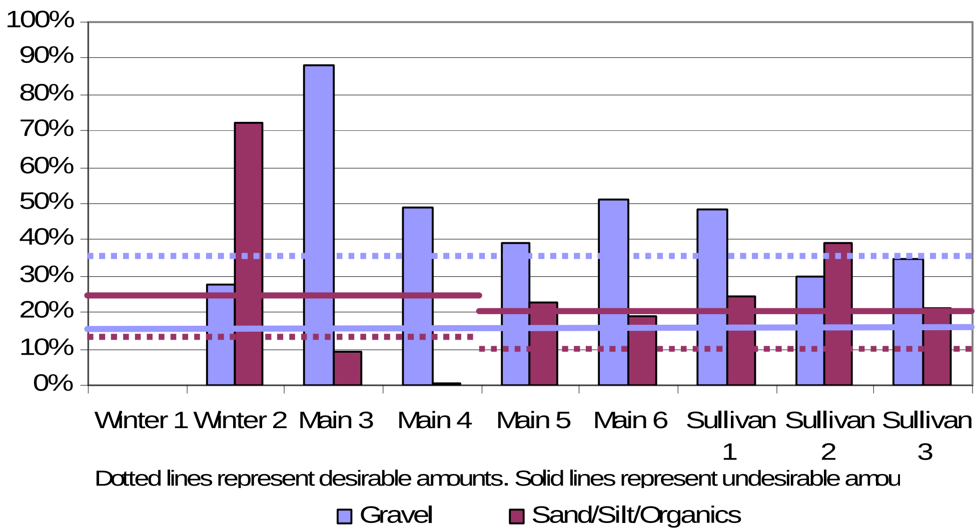


Figure L-7 Riffle Sediment

Figure L-8, pool depth, shows that only Main 3, 5 and 6 and Sullivan 2 and 3 had good pool and residual pool depths. Pool depth was not applicable for Sullivan 1 because there were no pools within that reach. Average residual pool depths were not available for three reaches. Winter 1 and Winter 2 had extremely deep pools.

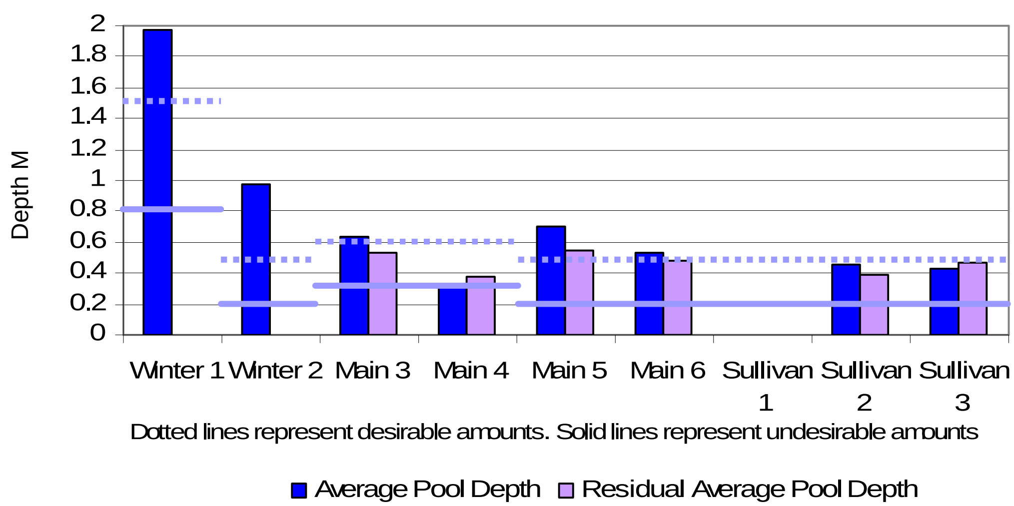
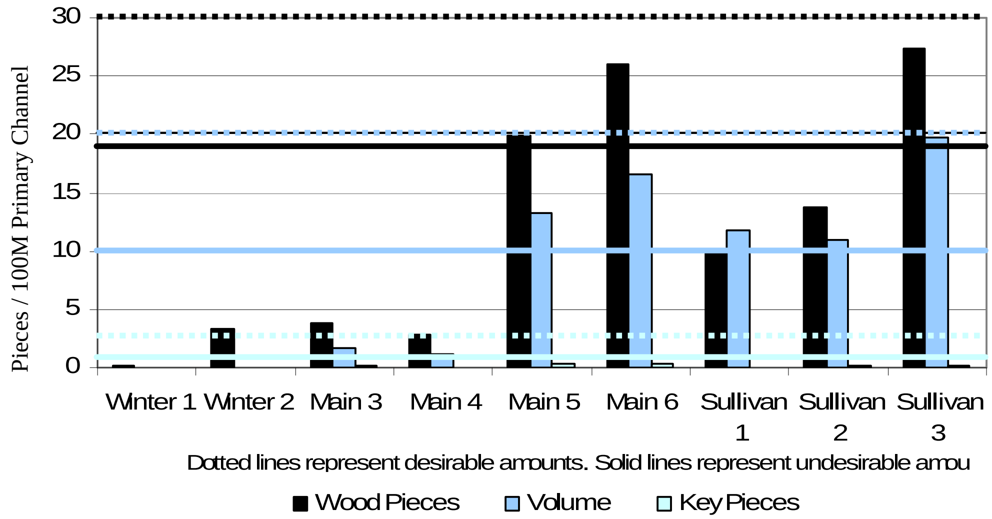


Figure L-8 Pool Depth

Figure L-9, large wood, shows that large wood increases drastically in the upper mainstem and Sullivan reaches, yet wood pieces and volume in these upper areas are still not to desirable levels. Sullivan 3 has the best amount of large wood. Key pieces of wood are very low to none in all reaches.

Figure L-9
Large Wood



Wetlands

Historic, current and potentially restored wetlands in the Larson sub-basin are shown in Figure L-10 and Table L-6. The current (2005) wetland extent, determined by CoosWA using aerial photography analysis, is land presently dominated by wetland vegetation and not showing signs of recent agricultural production. 'Current wetland' is not necessarily properly functioning wetland and is often included in the area of potential wetland restoration. In this sub-basin, current wetland is only 8% of the historic wetland extent. Historic wetland extents are based on soil type and plant characteristics. Wetlands considered to have good potential for restoration comprise 60% of the historic wetland extent in this sub-basin. These are areas not currently functioning as wetland, are often more difficult to manage for crop production due to drainage issues, and are described in the National Wetland Inventory as being seasonally flooded. Wetland restoration is discussed in more depth in Chapter 3, and National Wetland Inventory categories are provided in Appendix A.

Table L-6 Wetland Areas

Wetland Type	Acres
Historic wetlands	587
Current wetlands	46
Potential wetland restoration	350

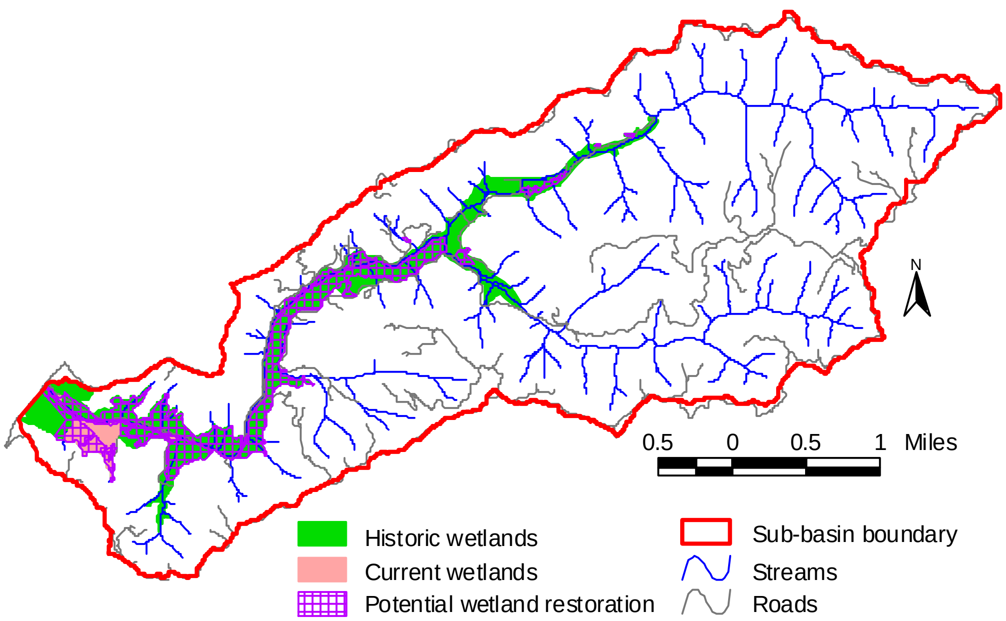


Figure L-10 Wetlands

Sediment Sources

Sediment sources considered in this assessment include unstable stream banks, unstable slopes, erosion associated with roads, and stream crossings with road fill at risk of failure.

Bank Stability

Bank stability surveys are now conducted as part of the aquatic habitat surveys, however, this was not routine until after 2000 and ODFW surveys do not include bank stability. Therefore, only reach Main 3 and Main 4 were surveyed for bank stability. Figure L-11 shows the bank stability ratings for each aquatic habitat reach. In the Larson sub-basin, only two reaches were surveyed for bank stability. In each reach, nearly 15% of the bank area was uncovered unstable and another 5% uncovered stable.

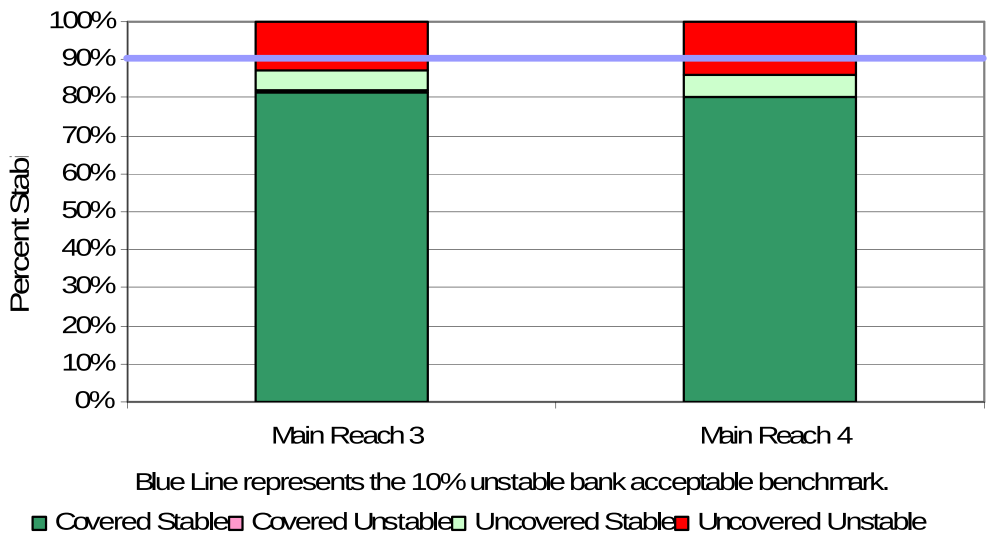


Figure L-11 Bank Stability

Slope Stability

The slope analysis, shown in Figure L-12, determined that the area in the low risk category for landslide potential is approximately 66.4%, the moderate risk area is 25.9%, the high risk area is 5%, and the extremely high risk area is 2.7%. The data show that the Larson sub-basin has a total of 7.7% in the high and very high risk range. The most un-

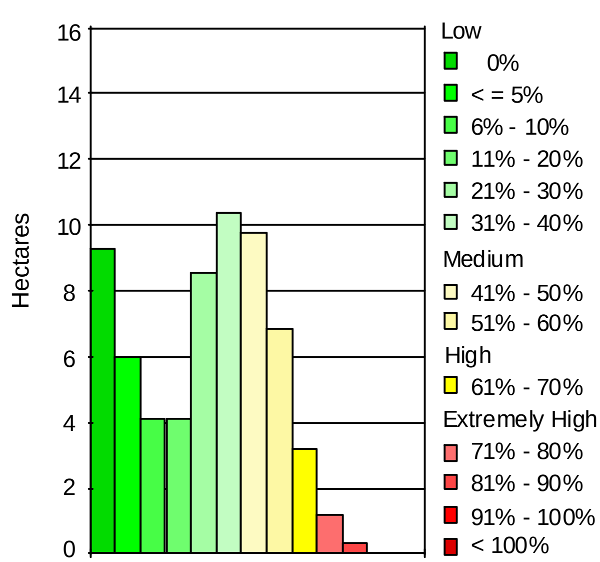


Figure L-12 Slope Stability Risk Classifications

stable slopes are located in the headwaters of Larson and Sullivan Creek, in the highest elevations of the most eastern part of the sub-basin.

Road-Related Erosion

Larson Creek road and landing survey was conducted between February 2001 and October 2004. The survey was divided into two groups, county roads and private roads. The county survey started at the junction of North Bay Drive and Larson Lane and ended at the 5.4 mile marker on the county road. All private roads were surveyed where landowner permission was granted. Table L-7 provides a brief summary of the data collected.

Table P-7 Road and Landing Survey Results

Site Type	Number of Sites	Number of Ditches	Existing Ditch Lengths (ft)
Stream Crossing	51	75	Avg. 401 Min.30 Max.2270
Ditch Relief	82	112	Avg. 416 Min. 50 Max. 1600
Ditch Out	51	76	Avg. 472 Min. 70 Max. 1350
Potential Landslide	1	1	Avg. 80 Min. 80 Max. 80
Ponding/ Gullied Road Surface	1	2	Avg. 220 Min. 140 Max. 300
Totals	186	266	

A total of 29.4 miles of road were surveyed. The average number of drainage sites per mile was 6.3. Within the Larson survey, there were 51 stream crossings, 82 ditch relief culverts, 51 ditch outs, one potential landslide and one ponding road surface site. See Discussion and Restoration Opportunities for recommended drainage feature upgrades.

Stream Crossing Drainage Evaluation

The 51 stream crossing culverts addressed in the road and landing survey were ranked for their ability to drain the area upstream during a 50-year rain event (see Table L-8). Eighteen (35.3%) of the stream crossings in this survey are considered at risk for improper drainage or failure because they are undersized.

At-risk culverts are further ranked in Table L-8 based on the percentage of associated drainage area they can properly drain during a 50-year rainfall event. The number of culverts in each failure risk level (left column) spread across the table depending on the associated fill volume size class. It is important to consider both failure risk and fill volume since it is the fill that becomes the sediment source upon failure of the crossing.

Table L-8 At-risk Stream Crossing Evaluation and Fill Volume

50-Yr. Rainfall Fill Failure Risk	Fill Volume Size Class									
	Minimal		Small		Medium		Large		Very Large	
	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3
Low	-	-	2	61	1	87	1	204	-	-
Moderate	-	-	1	44	-	-	1	157	-	-
High	-	-	2	58	-	-	3	632	-	-
Very High	-	-	5	161	1	97	1	156	-	-

Failure Risk, Low = 76% - 100%; Moderate = 51% - 75%; High = 26% - 50%; Very High = 0% - 25%
Fill Volumes, Minimal = ≤ 10 $yds.^3$; Small = 10 - 50 $yds.^3$; Medium = 51 - 100 $yds.^3$; Large = 101 - 500 $yds.^3$; and Very Large = > 500 $yds.^3$.

In the Larson sub-basin, seven of the 18 culverts ranked as having very high risk of failure, potentially releasing 414 yd^3 of fill. Five of them ranked as having high risk, potentially releasing 690 yd^3 of fill. Two of them ranked as having moderate risk, potentially releasing 201 yd^3 of fill, and four of them ranked as having low risk, potentially releasing 352 yd^3. There is a total of 1657 yds^3 of fill at these 18 at-risk culverts.

Stream Temperatures

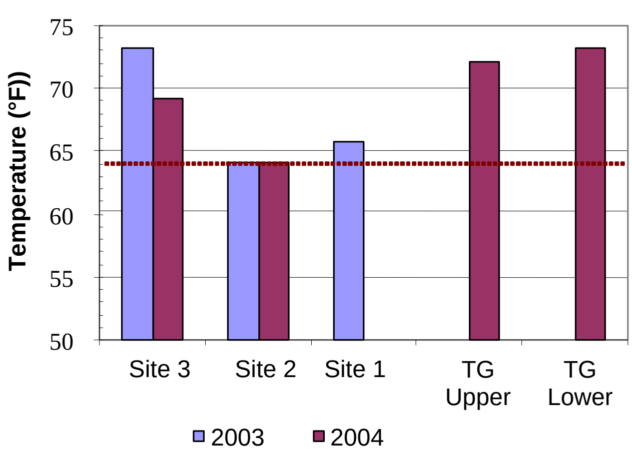
Three temperature logging units were placed in the upper and middle reaches in Larson Creek in 2003. Six temperature loggers were placed in Larson Creek in 2004 (two in the same locations as 2003). Four of these were successfully retrieved, one was lost during high flows (anchor was recovered), and the other was not found. Two of the sites were at the tide gate, one above the gate, and one just below the mouth in the bay. These sites can be used to evaluate temperature differences between the bay and the backwater pool of the tide gate. The other two sites were in the wooded upper reaches of the valley. Sullivan Creek enters Larson mid-way up the valley, but was not monitored due to landowner permission issues.

Table L-9 Temperature Summary and Exceedance of Standards

Site	Year	7-Day averages			Days >64°F	Days >70°F	Hours >64°F	Hours >70°F
		Max.	Min.	Daily ? T				
Site 3	2003	73.2	58.5	14.7	83	35	374.5	71.0
	2004	69.2	59.7	9.5	59	3	184.5	6.0
Site 2	2003	64.1	58.5	5.6	7	0	18.5	0.0
	2004	64.1	60.0	4.0	8	1	12.5	4.5
Site 1	2003	65.8	59.2	6.6	18	0	102.0	0.0
TG Upper	2004	72.1	70.0	2.1	94	27	2110.0	317.0
TG Lower	2004	73.2	70.4	2.9	98	38	2184.0	457.5

Table L-9 shows the 7-day average maximum and minimum temperatures, and the number of days and hours spent exceeding 64 and 70 °F for each temperature logging site on Larson Creek. Exceedance of standards is shown in Figure L-12, below. The data indicate that in 2003, all sites in Larson Creek were above 64 °F, but only site 3 reached temperatures over 70. In 2004 all temperature loggers registered maximum temperatures over both 64 and some over 70 °F. The sites with elevated temperatures during the longest period of time were the ones on either side of the tide gate.

Figure L-13 7-Day Moving Averages of Daily Maximum Temperatures



Red dotted line represents 64 °F std, higher temperatures undesirable

Figure L-13, below, illustrates the temperature trends within the sub-basin using 7-day average maximums, and colors them according to salmonid suitability. The map shows that temperature increases from 55 °F at the headwaters to 72 °F at the tide gate in

2004. In 2003, the Larson Creek overall downstream change in temperature from the uppermost site (3) to the mouth was 0.905 °F per 1000 ft. The average daily high temperature change slightly decreased going from the most upstream site (3) to the next downstream site (2). The 2004 average overall downstream change in temperature from the most upstream site (3) to the lower tide gate site was 0.242 °F per 1000 ft. In both years the average daily high water temperature decreased slightly between site 3 and site 2 likely due to the fact that site 2 was in a meter-deep, shaded pool that was quite cold.

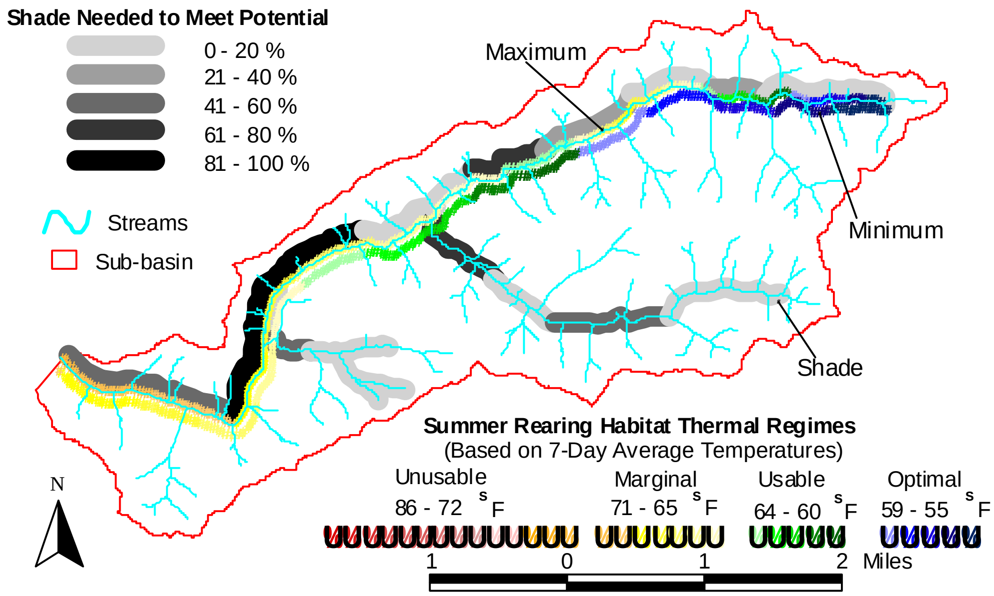


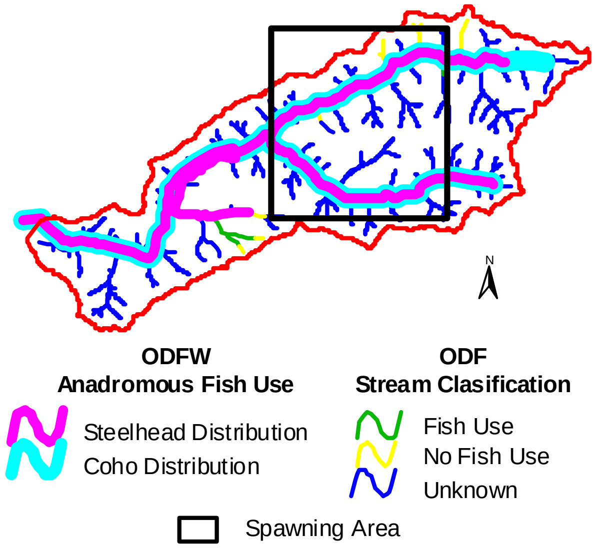
Figure L-14 Temperature Trends and Riparian Shade Condition

Riparian Shade

The difference between current and potential shade is shown in Figure L-14, above, and is expressed as shade needed to meet potential. The darker riparian areas on the map have the least amount of current shade. Current and potential shade values in the Larson sub-basin are 80% and 97%, respectively, in the upper-most, steep canyon areas. The upper valley has 51% and 91% respectively, and the lower valley area has 50% and 93% respectively.

Salmonid Distribution

Figure L-15 Salmonid Distribution



Coho, fall Chinook, winter steelhead, and chum salmon are present in the Larson sub-basin. Figure L-15 shows the distribution of steelhead and coho according to ODFW. However, based on the high stream gradients in the upper reaches of these streams, the coho extent is likely exaggerated. Oregon Department of Forestry (ODF) classifies general fish use streams including cutthroat trout (green line is hidden under the steelhead and coho lines). The spawning survey area is enlarged below in Figure L-16.

Other fish and amphibian species observed in Larson Creek, based on incidental catch at the fish traps, include cottids, brook lamprey, Pacific lamprey, stickleback, Pacific Giant salamander, Dunn's salamander, Roughskin newt, tailed frogs, Red-legged frog, Pacific tree frog, and Foothill Yellow-legged frog (CWA 2005).

Stocking Records

Larson Creek and its major tributaries have been stocked throughout the 1980's with both steelhead and coho juveniles (see Table L-10). Both smolt and fry juveniles were distributed into the Larson sub-basin, with the majority of the stocked fish being released by the use of hatchboxes. From 1980-1989 nearly 120,000 juvenile salmonids were released into the sub-basin, with 90% of them being steelhead. The largest fish release of any species reported in the lowlands

Table P-10 Stocking Records

Creek	Species	Year	Juveniles Released
Larson Slough	Steelhead	1980	12,542
Larson Slough	Steelhead	1981	29,719
Larson Cr.	Steelhead	1982	10,229
Larson Cr.	Steelhead	1983	11,928
Larson Cr.	Steelhead	1984	7,496
Larson Cr.	Steelhead	1985	7,444
Larson Cr.	Steelhead	1986	7,500
Larson Cr.	Steelhead	1987	7,625
Larson Cr.	Steelhead	1988	7,530
Larson Cr.	Steelhead	1989	5,155
Sullivan Cr.	Coho	1989	9,928
			117,096

assessment area was conducted in Larson slough in 1981 when almost 30,000 juvenile steelhead were released in the lower reaches of the stream. The only stocking other than steelhead was in 1987 when almost 10,000 juvenile coho were released into Sullivan Creek. According to ODFW, in the last five to ten years very few fish if any have been stocked into the Larson sub-basin.

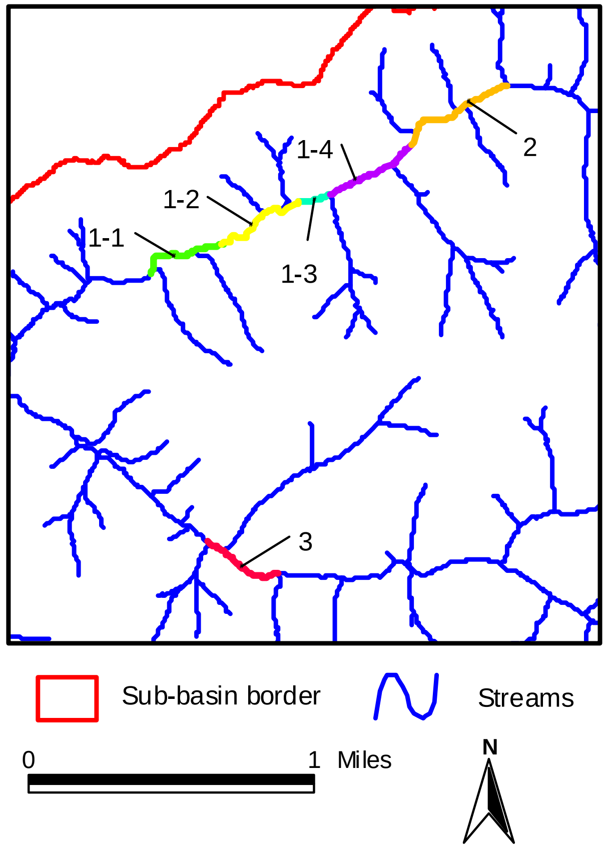


Figure L-16 Coho Spawning Survey Reaches

Spawning Surveys

Coho spawning surveys were preformed on the mainstem of Larson Creek (see Figure L-16), for reaches 1-1 through reach 2, in 2002 - 2004 by the Coos WA. A section of Sullivan Creek (reach 3) was surveyed in 2001 by ODFW, and in 2004 by the Coos WA.

Larson Creek consistently has had the second highest number of spawning coho in the assessment area, and in recent years, the population has been increasing. In 2002, there was a total of 406 coho surveyed in the Larson reaches, in 2003, there were 598 coho (AUC), and in 2004 there were 757 coho (AUC). This was an 86% increase in returning coho spawners in the Larson Creek mainstem reaches, from 2002 to 2004.

Table L-11 Spawning Density

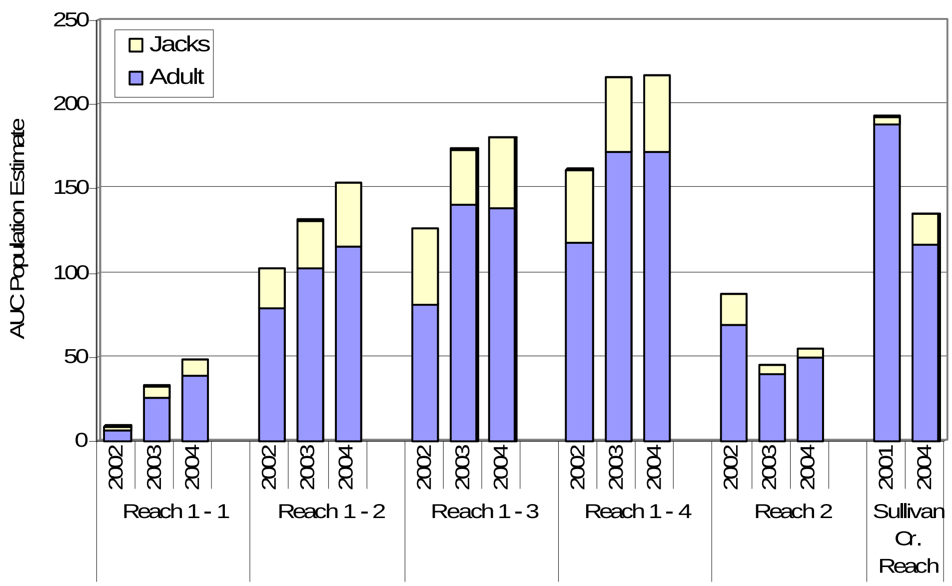
Reach	YEAR	Total AUC/Km	Gravel (m^2)	Gravel (m^2)/ Female
1-1	2002	21	612	136.0
	2003	75	422	32.5
	2004	110	430	22.6
1-2	2002	251	446	11.2
	2003	319	318	6.2
	2004	372	388	6.7
1-3	2002	434	540	13.3
	2003	596	424	6.1
	2004	621	366	5.3
1-4	2002	378	477	8.1
	2003	505	709	8.2
	2004	503	287	3.4
2	2002	167	76	2.2
	2003	87	239	12.0
	2004	106	189	7.6
3	2001	139	No Data	No Data
	2004	126	121	2.1

Examining the density of spawning coho by reach (see Table L-11 and Figure L-17) indicates which parts of the stream are preferentially selected by the fish and whether the existing habitat is being fully utilized. Reaches 1-3 and 1-4 consistently had the most spawning coho/km. In 2004, the year with the highest number of spawners, there were only 5.3 and 3.4 m^2 of suitable spawning gravel available per female. It has been estimated that 11.7 m^2 is needed for each spawning pair to avoid displacing eggs deposited by other pairs (Sandercoch, 1991). According to this estimate, most of the spawning habitat in the Larson sub-basin was fully seeded each survey year.

In Sullivan Creek, there were 192 coho (AUC) in 2001, and 135 coho (AUC) in 2004. The 2004 gravel per female data show that the spawning habitat on Sullivan Creek is highly utilized.

Other anadromous fish have been observed during the spawning surveys on Larson Creek. In 2002, a pair of chum were observed spawning in reach 1-3. Also, in 2004 one chum carcass was recovered in reach 1-4. Steelhead and cutthroat trout were observed in both Larson and Sullivan Creeks.

Figure L-17 Coho-Spawning AUC Population Estimates



Intrinsic Potential for Coho Smolt Production

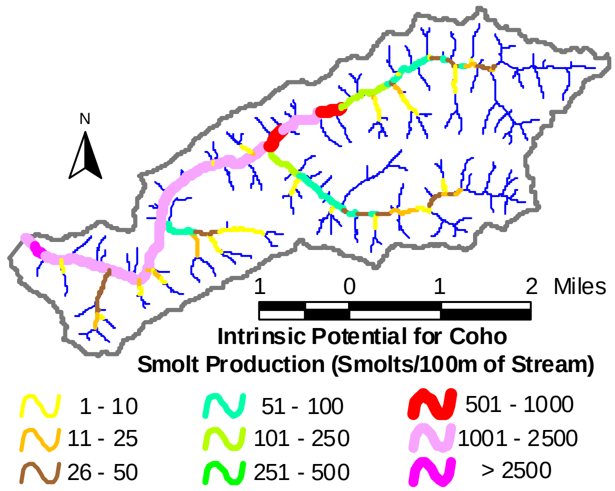


Figure L-18 Intrinsic Potential for Coho Smolt Production

The intrinsic potential for streams in the Lowlands area to produce coho smolts was estimated based on digital elevation models, active channel and valley widths, known natural barriers and coho life histories. The values indicate the number of coho smolts supported by historic, pre-settlement stream conditions. Intrinsic potential for the Larson sub-basin, shown in Figure L-18, indicates that the Larson sub-basin has the highest intrinsic potential in its mainstem reaches – from 1001 to 2500 smolts per 100 meters of stream. Intrinsic potential increases even more in a small area just upstream from the mouth, and decreases dramatically in the side tributaries. This pattern reflects the coho preference for wider active channel and valley widths. The thin blue lines, streams, indicate zero intrinsic potential due to gradients above 20% and known natural migration barriers. Understanding intrinsic potential for a particular stream will help guide restoration efforts in setting realistic coho population goals. Total intrinsic potential for smolt production this sub-basin is 125,867 smolts. Intrinsic potential for adult coho returns under low ocean survival rates (1%) is 1,259, and under high ocean survival rates (10%) is 12,587 fish.

While restoring coho smolt populations to these levels is unlikely given current land uses and infrastructure, understanding intrinsic potential for a particular stream will help to inform restoration efforts and to set realistic coho population goals.

Coho Habitat Limiting Factors

The limiting factors analysis (based on Reeves et al., 1989), shown in Table L-12, below, indicates that both summer and winter rearing habitats are in short supply for coho juveniles. Current useable area of winter rearing habitat, the most severe bottleneck to smolt production, is only 10% of the area needed to support smolt populations potentially produced from currently available spawning gravel. Winter rearing habitat, however, is not clearly understood in this sub-basin as quite often when flows (and velocity) increase the stream has greater connectivity with the majority of its flood plain (visual observations by Coos WA staff). The usable summer habitat is approximately 50% of the area needed to support the potential coho population. Summer temperatures were within acceptable parameters for salmonid survival. Current spawning area is more than sufficient for potential populations.

Larson Habitat Component	Potential Summer Population	Area/ Survival Factor	Area Needed (M^2)	Current Usable Area (M^2)	Smolt Factor	Smolts Produced
Spawning	43,539	0.006	261	2,337	95.5	22,3184
Spring Rearing	43,539	0.3	13,062	12,509	1.7	21,266
Summer Rearing	43,539	0.6	26,123	12,509	0.9	11,258
Winter Rearing	43,539	0.4	17,416	1670	1.2	2,004

Table L-12 Limiting Factors to Coho Populations

Resource Issues

Larson Creek's tide gate was replaced in 2001 to improve fish passage. The older, failing top-hinge tide gate on Larson was replaced with a side-hinge gate that opens with much less hydraulic head differential to open (Giannico et al 2005). The lowering of the invert elevation has also likely increased sediment transport through the tide gate. Monitoring of the gate, however, has indicated that some of the changes made are not necessarily beneficial. For instance, even though the water velocities are much lower for the new gate, the drainage is so efficient that the period that the gate is open is significantly reduced. Another consequence of unknown ramifications is the filling of the large backwater tide gate pool. "diking of tidal marshes, and loss of shallow subtidal and deep channel habitats through sedimentation have significantly reduced the biological productivity of many estuaries." (Pacific 1994)

Landowner Concerns and Desired Future Conditions

Private landowners in the Larson sub-basin expressed concerns regarding land management in the area at a Coffee

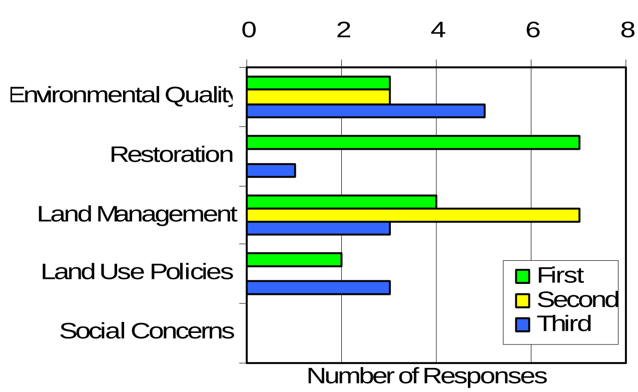


Figure L-19 Landowner Concerns

Klatch meeting on April 26, 2005. Like other sub-basins in the lowland area, many of the attending landowners in Larson are concerned about drainage of the bottom land. Many once-productive grazing lands now remain wet to the point of supporting wetland vegetation over pasture. Larson slough was last dredged in 1967, and since then a lot of silt has built up in the lower watershed due to upland logging practices, the 1996 landslides, and unstable stream banks. Landowners are concerned about sediment causing blockage of agricultural ditches and culverts, and the permit process that often delays maintenance of these structures.

Landowners in Larson also expressed concerned for stream bank conditions and several meeting attendees were very supportive of riparian restoration efforts by the Coos WA. As in other sub-basins, concerns over sediment introduction from stream-side roads were also raised.

As shown in Figure L-19, landowners' concerns spread more evenly across the spectrum of categories, with the exception of social concerns, than in other sub-basins. Landowners here were also worried about the threat of new development spurred by the 2004 Oregon Measure 37, and coal-bed methane wells. Several meeting attendees expressed concern over the heavy use of fertilizers and herbicides by the timber industry in the area.

Apart from improved drainage, landowners attending the Larson Coffee Klatch agreed they would like to see little change in the area for the future. Positive changes would be reduced flooding, a healthier ecosystem including free-roaming wildlife, stabilization of the stream channel, and improved logging practices.

Coos Bay Lowland Assessment and Restoration Plan

Chapter 2:
Kentuck Creek Sub-Basin Assessment

Kentuck Creek tidal reach from the tide gate. Photo CoosWA,2006.

Kentuck Creek Sub-basin

Introduction

Landform

The Kentuck sub-basin is oriented east to west, and enters the north end of Coos Bay through Kentuck Inlet. The stream system is made up of two major tributaries, Kentuck and Mettman creeks (see Figure K-1). These streams converge in the lowlands to form Kentuck Slough which drains into the Bay through a tide gate. There are tidal and high salt marshes near the mouth.

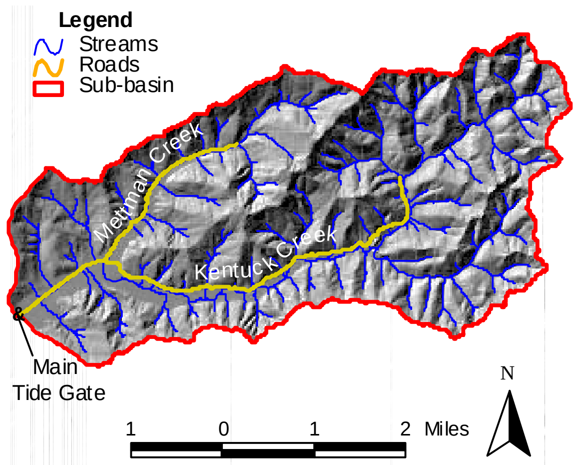


Figure K-1 General Sub-basin

Kentuck and Mettman creeks are both dendritic river systems. Kentuck Creek is a forth order stream system, and Mettman is a third order system. The drainage area of the sub-basin is approximately 10637 acres (16.62 miles^{2}), which is the largest in the lowlands assessment area. The total river miles of streams within Kentuck is approximately 59.28 miles, including every section of stream from mainstems to very small intermittent and perennial headwater streams. From the tide gate at East Bay Drive, Kentuck mainstem is approximately 8.1 miles long, and Mettman Creek mainstem is 3.4 miles long. The elevation in the basin ranges from 0 to 1334 feet above sea level (OWRD,2005).

The main type of underlying geology in the Kentuck sub-basin is the Tyee silt/sandstone (76%). Other types include Tuffaceous siltstone/sandstone (11%), and Siletz River Volcanic (13%). Due to the type of these parent materials, a fair amount of the area in this sub-basin is prone to landslides. Soils in the Kentuck sub-basin consist of the following three general types. The Templeton-Salander soil type, most common in the lowlands area, is well-drained and loamy. Steeper areas in the uplands are characterized by the Preacher-Bohannon type which is deep, gravely to loamy and prone to erosion. The headwaters of Kentuck are on the Milbury-Bohannon-Umpcoos type that is moderately deep and shallow, gravelly to loamy (Haagen, 1989).

Isolated basalt deposits are found in some headwater areas of Kentuck, which have been used as rock sources for over 50 years.

Landuse and Ownership

Landuse in the Kentuck sub-basin (see Figure K-2 and Table K-1)) is dominated by forestry, which covers 81% of the area. Forests are managed by both private industrial and small woodlot owners. Agricultural use is confined to the bottom lands along the main tributaries, and comprises 11% of the area. Most agricultural land is managed for grazing, hay production and small hobby farms. Rural residential use is spotted along the mainstem and lower valley. The Kentuck golf course is located along Kentuck slough, comprising 1.5% of recreational use. Two large rock quarries are located along Kentuck creek.

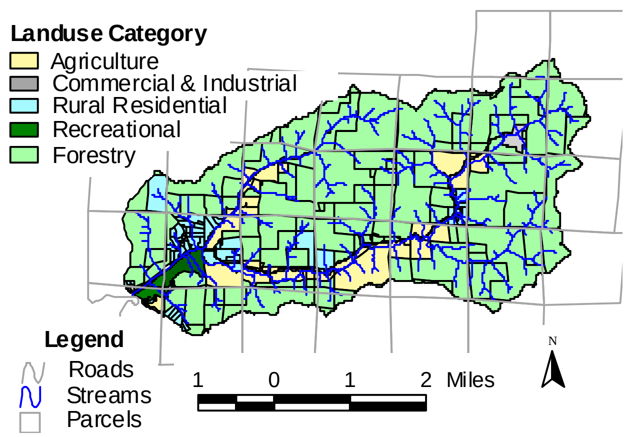


Figure K-2 Landuse Distribution

Table K-1 Landuse

Landuse	Acres	Percent
Agricultural	972	11
Forestry	7207	81
Rural Residential	557	6
Commercial & Industrial	48	0.5
Recreational	134	1.5
Total	8918	

Hydrology

Precipitation

Annual precipitation is 67 inches in the lowest elevations in the Kentuck sub-basin. Due to the west facing orientation, rainfall gradually increases as the elevation increases to a maximum of 73 inches, averaging 70 inches for the whole sub-basin (OCS, 2003). The precipitation intensity for a 2-year 24-hour event is 2.95 inches (OWRD, 2005).

Stream flow

Annual peak stream flow was obtained using the Peak Flow Estimation Program (OWRD, 2005). They use hydrologic prediction equations and physical watershed characteristics to estimate peak flows. Figure K-3 shows the estimated discharge at the mouth of Kentuck creek for storm events for two to five hundred year reoccurrence intervals. The bankfull flow event is estimated to be 864 cfs. On the other extreme, a maximum discharge of 3540 cfs is estimated for a 500-year storm event in Kentuck Creek.

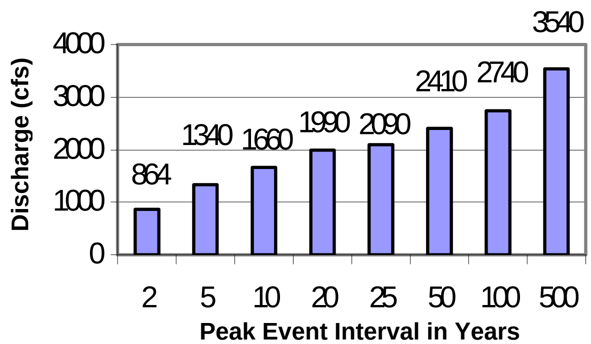


Figure K-3 Annual Peak Discharge Estimates (OWRD, 2005)

No data for summer flow measurements were available for Kentuck and Mettman Creeks.

Land Use Effects on Hydrology

Land uses, as they affect ground surface conditions, can be used to make general evaluations of the hydrologic condition of a watershed. Of particular concern is the effect of land uses on peak stream flow, since increases in runoff can contribute to flooding, erosion, and culvert failures. The most important determinant for peakflow increases is the ability of soils to absorb rainfall.

The impacts from agriculture on hydrology are dependent on the type of cover and management treatments, as well as the characteristics of the soils (OWEB, 1999). We assessed these factors and compared them to the change in runoff from the background condition. This change will be rated as followed: < 0.5 inches, 0.5 to 1.0 inches, and > 1.5 inches.

The main types of hydrologic soil groups (HSG) present in the agriculture lands are, 61% of HSG Class D, and 39% of HSG Class B. The HSG

Class D has very slow infiltration rates and high runoff rates. The HSG B has moderate infiltration rates and moderate runoff. Agriculture has a greater affect on runoff in areas where soils have a high infiltration rate compared to areas where soils are relatively impermeable in their natural state (USDA, 1986). In the Kentuck sub-basin, the change in runoff from the background conditions increased by 0.52 inches. Because of this, the potential risk of peak-flow increases is moderate.

Forest and Rural land use will be assessed by their percentage of area that is comprised of roads. They will be rated as: low < 4%, medium 4% - 8%, and high > 8%.

Within the forest use area, there are 81.25 linear miles of forest roads, the largest of the assessment area. These roads take up approximately 3.3 percent of the forested area. Because of the low percentage present, relative potential risk for peak-flow enhancement is low in the Kentuck sub-basin.

There are approximately 15.24 linear miles of rural roads in the Kentuck Creek. Of this area, there is 5 percent area in roads. This percentage ranks Kentuck Creek residential and industrial area as a relatively moderate potential risk for peak-flow enhancement.

Overall, Kentuck sub-basin's potential risk of peak-flow increases from land use impacts is low to moderate.

Water rights

There are three main types of water rights in Kentuck sub-basin: surface water, groundwater, and instream. The most senior water right in was established in 1927 for domestic and livestock use of surface water. Table K-2 lists the different types of water use in the Kentuck sub-basin, and their potential maximum water use. The storage rights for Kentuck sub-basin are 2.64 acre feet for irrigation use. Total allocated water rights for the entire sub-basin are 47.82 cubic feet per second. The total consumptive use is 1.16 cfs. Both Kentuck and Mettman creek instream rights were established in 1992. Mettman Creek rights extend 3.3 miles up Mettman Creek. Kentuck Creek instream rights extend from the confluence of Mettman creek up Kentuck Creek for 4.9 miles. However, there are no instream rights from the tide gate to the confluence of Mettman Creek. The instream water rights were established for migration, spawning, egg incubation, fry emergence, juvenile rearing (12 cfs) on Mettman creek, and fish life (34 cfs) on Kentuck Creek.

Table K-2 Water Use

Type of Use	CFS	Ac-ft
Domestic	0.42	0.00
Irrigation	1.40	2.64
Instream	46.00	0.00
Total	47.82	2.64

Water Availability

Water availability for the Kentuck sub-basin is estimated using the Water Availability Report System (OWRD, 2005). The average water available is based on the 50% annual exceedance level. The expected flow was derived by subtracting the consumptive uses from the estimated natural stream flow and is shown in Table K-3 for Kentuck creek above and Table K-4 for Mettman creek below. In the months of July to October, there is between 1.05 and 2.56 cfs of expected flows in Kentuck Creek. During this low flow period, there is between .02 and .34 cfs of consumptive use. In Kentuck creek the consumptive water use has increased by more than 10% since 1993.

Month	Natural Flow	Consumptive Uses	Reserved Instream Flow	Expected Flow (cfs)
Jan	43.50	0.01	34.00	43.49
Feb	47.00	0.01	34.00	46.99
Mar	34.40	0.01	34.00	34.39
Apr	23.80	0.02	23.80	23.78
May	12.10	0.08	12.10	12.02
Jun	6.06	0.22	6.02	5.84
Jul	2.90	0.34	2.85	2.56
Aug	1.50	0.28	1.46	1.22
Sep	1.17	0.12	1.14	1.05
Oct	1.38	0.02	1.34	1.36
Nov	9.46	0.01	9.34	9.45
Dec	35.80	0.01	34.00	35.79

Table K-3 Kentuck Creek Monthly Net Water Available (OWRD, 2005)

In Mettman Creek, the instream flow is equal to the natural flow for the months March to June and in December. The predicted natural flow patterns of the stream create very low flow summer conditions with less than 1 cfs from July through October. There is very little consumptive use on Mettman creek and the consumptive use has not increased by more than 10% since 1993.

Month	Natural Flow	Consumptive Uses	Reserved Instream Flow	Expected Flow (cfs)
Jan	14.20	0.00	12.00	14.2
Feb	15.40	0.00	12.00	15.4
Mar	11.30	0.00	11.30	11.3
Apr	7.58	0.00	7.58	7.58
May	3.76	0.00	3.76	3.76
Jun	2.01	0.01	1.98	2.0
Jul	0.99	0.01	0.96	0.98
Aug	0.51	0.01	0.49	0.5
Sep	0.40	0.00	0.37	0.4
Oct	0.47	0.00	0.44	0.47
Nov	3.08	0.00	3.00	3.08
Dec	11.50	0.00	11.50	11.5

Table K-4 Mettman Creek Monthly Net Water Available (OWRD, 2005)

Aquatic Habitat

Aquatic habitat surveys addressed in this assessment include unit type, substrate type, riffle sediment, pool depth, large wood, and bank stability (bank stability is presented in Sediment Sources).

The Tidal reach, Kentuck Slough, lies in a large, low-gradient floodplain and is constrained by Kentuck Way Lane on the north and a dike on the south. As the mainstem reaches progress upstream they are constrained by the dike, then by terraces, and then by hillslopes in a narrow, moderate, v-shaped valley. Mettman creek is also constrained by hillslopes in a narrow, moderate v-shaped valley. See Appendix A for specific channel morphology metrics.

The Kentuck aquatic habitat survey starts near the mouth of Kentuck Slough at the tide gate. Aquatic habitat survey reaches are shown in Figure K-4. These reach names will be used to describe locations within the Kentuck sub-basin throughout this assessment.

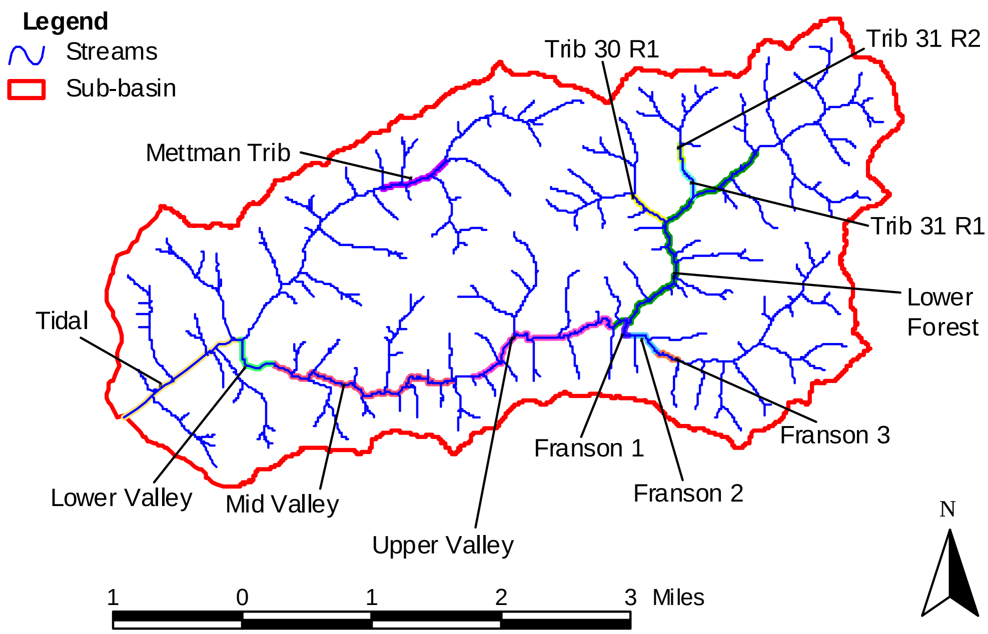


Figure K-4 Aquatic Habitat Study Reaches

In Figure K-5, unit types, the Mettman Trib reach has a very diverse group of unit types, including a large percentage of step units, rapid units, and cascade units. Tributary 30, Reach 1, also has a high percentage of cascade units, culvert crossings, step units, and rapid over boulders. In Franson Creek, Reach 3 has 47% of the units are rapid or step units.

Figure K-5
Unit Types

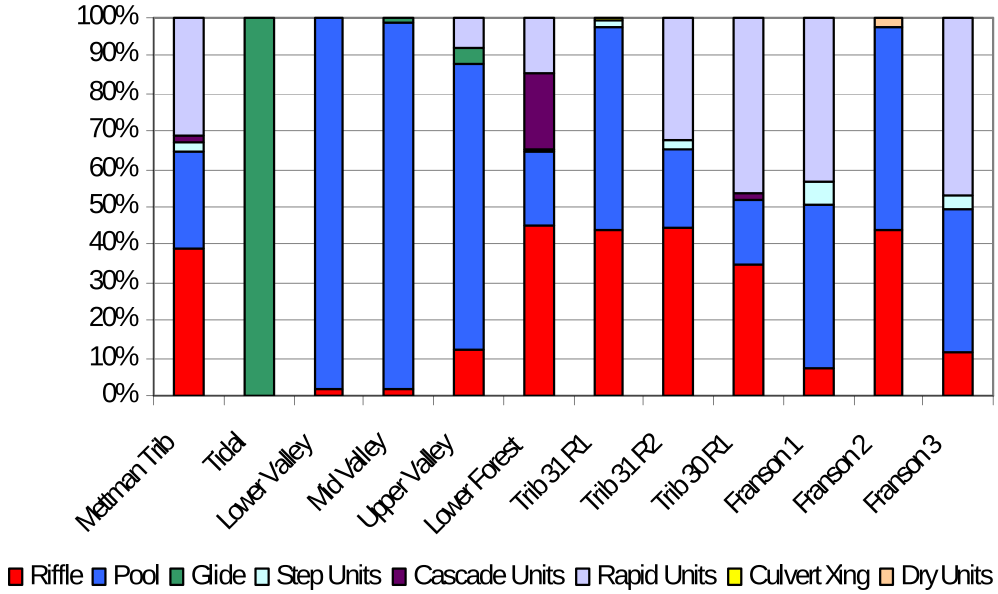
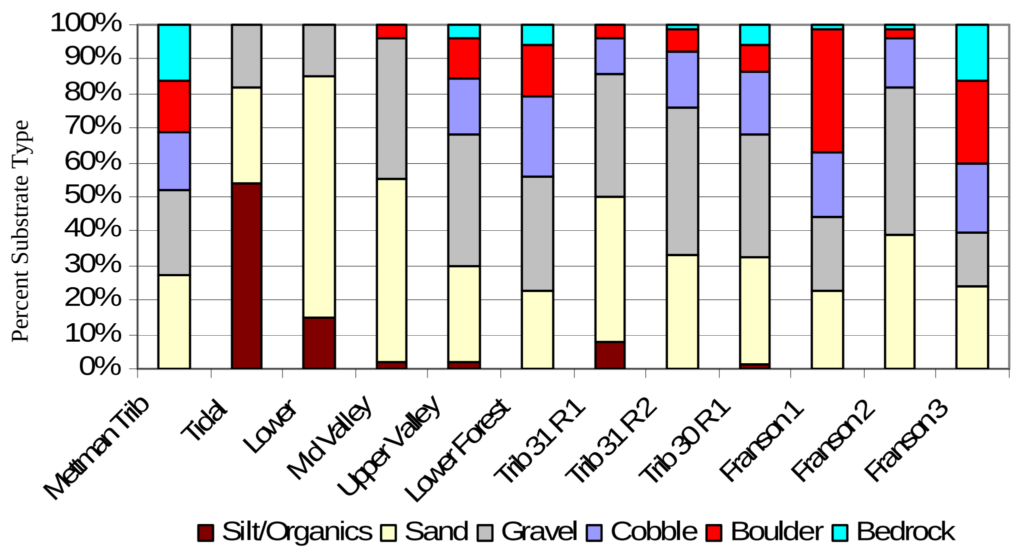


Figure K-6 illustrates the substrate type for each reach. The substrate types correspond with the unit types. Higher gradient reaches tend to have more cobble, boulders, and bedrock; lower tidal areas tend to have higher sand/silt/organic substrates.

Figure K-6
Substrate Types



In figure K-7, riffle sediment, there is no data for the Main Tidal reach because there were no riffles to analyze. All other reaches had excellent levels of gravel and poor levels of fine sediments. The Upper Valley and Lower Forest, as well as three other tributary reaches, have fine sediment levels below the unacceptable levels. The Lower Valley reach has a very high level of fine sediment in the riffles.

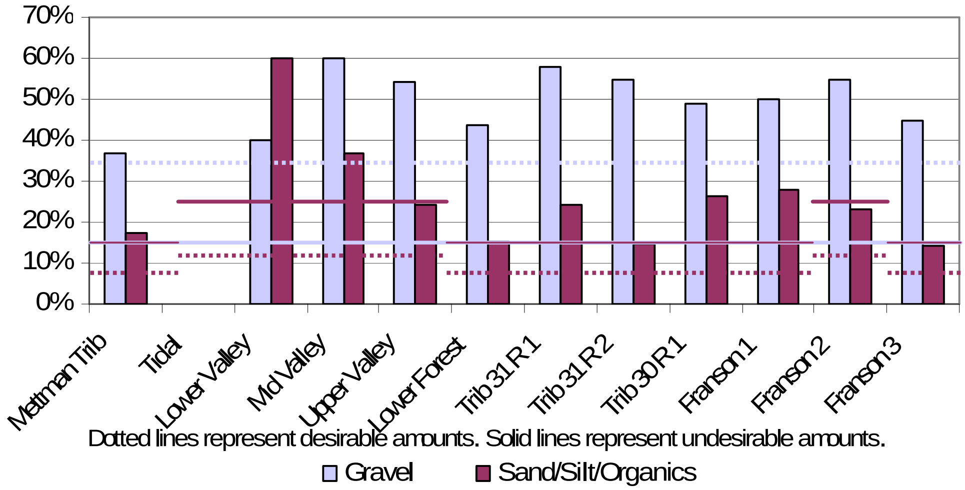


Figure K-7 Riffle Sediment

The average residual pool depths are shown in Figure K-8. The Tidal reach does not have any data because it did not have any pool units. The best depths, according to the ODFW benchmarks, were in all reaches but the Mettman, Tributary 31, Reach 2, Tributary 30, and the Franson Reaches. Deep pools are used by young salmonids for rearing habitat.

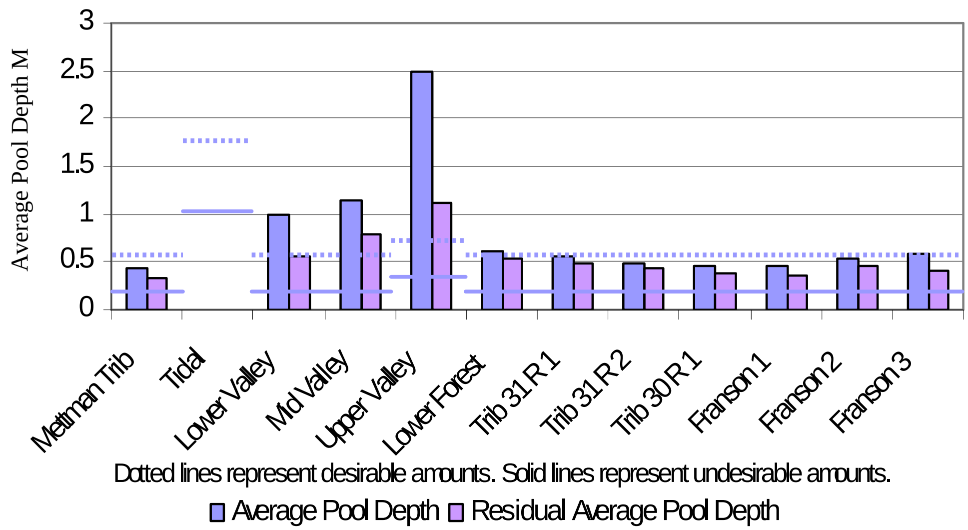
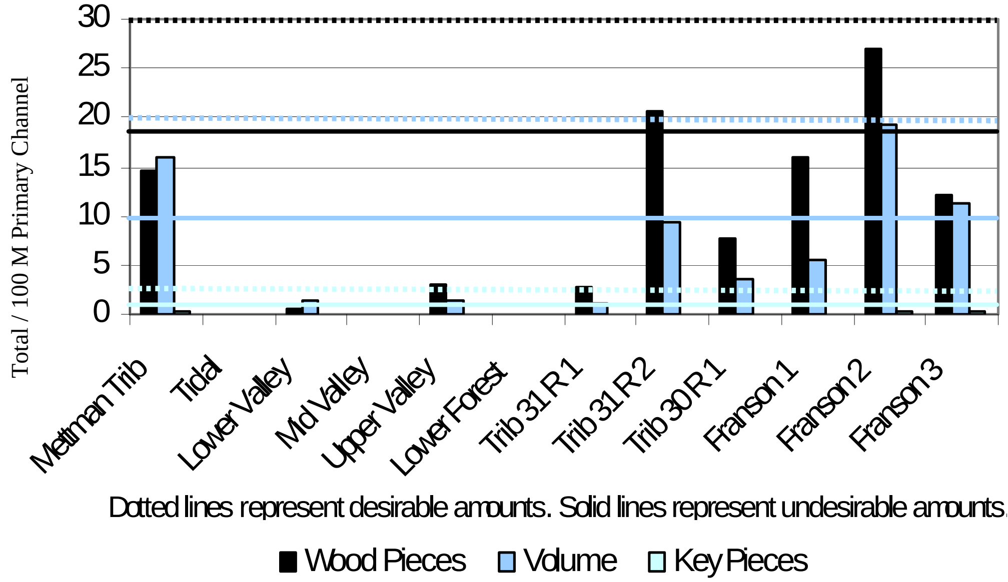


Figure K-8 Pool Depth

As seen in Figure K-9, the mainstem area (Tidal through Lower Forest) has little to no large wood. None of the reaches surveyed in the Kentuck sub-basin contain even the minimum benchmark levels for key pieces of large wood.

Figure K-9 Large Wood



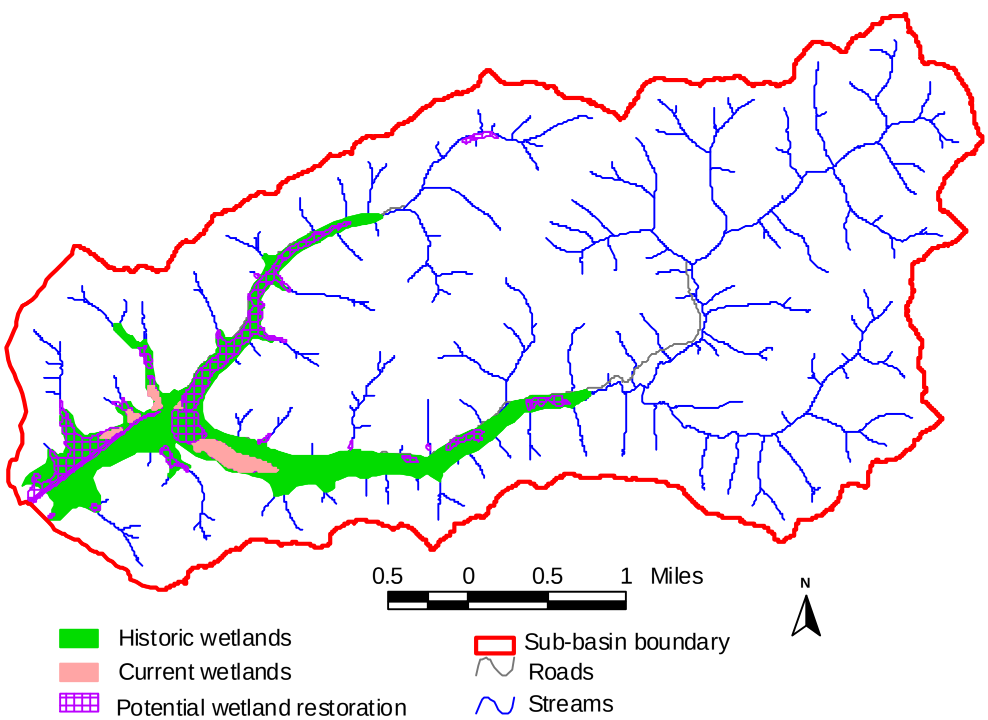
Wetlands

Historic, current and potentially restored wetlands in the Kentuck sub-basin are shown in Figure K-10 and Table K-5. The current (2005) wetland extent, determined by CoosWA using aerial photography analysis, is land presently dominated by wetland vegetation and not showing signs of recent agricultural production. In most cases, however, 'current wetland' is not a properly functioning wetland and is included in the area of potential wetland restoration. The area considered current wetland is only 6% of the historic wetland extent in this sub-basin. Historic wetland extents are based on soil type and plant characteristics. Twenty-nine percent (174 acres) of the historic wetlands in this sub-basin are described in the National Wetland Inventory as 'emergent', meaning they were dominated by rooted herbaceous plants, and are seasonally flooded. It is primarily the emergent seasonally-flooded areas, not currently functioning as wetland, that CoosWA recommends for restoration consideration as these areas are often more difficult to manage for crop production. Wetland restoration is discussed in more depth in Chapter 3, and National Wetland Inventory categories are provided in Appendix A.

Table K-5
Wetland Areas

Wetland Type	Acres
Historic wetlands	608
Current wetlands	37
Potential wetland restoration	185

Figure E-10
Wetlands



Sediment Sources

Sediment sources considered in this assessment include unstable stream banks, unstable slopes, erosion associated with roads, and stream crossings with road fill at risk of failure.

Bank Stability

Bank stability surveys are conducted as part of the aquatic habitat surveys. Figure K-11 shows the bank stability survey results for each aquatic habitat reach. The data indicate a very high percentage of covered/unstable banks, especially along the mainstem of Kentuck creek. This area is largely managed for grazing and riparian cover is grass. The Tidal, Mettman Trib, and Franson reaches have the most stable banks, however these are barely within the acceptable benchmark range.

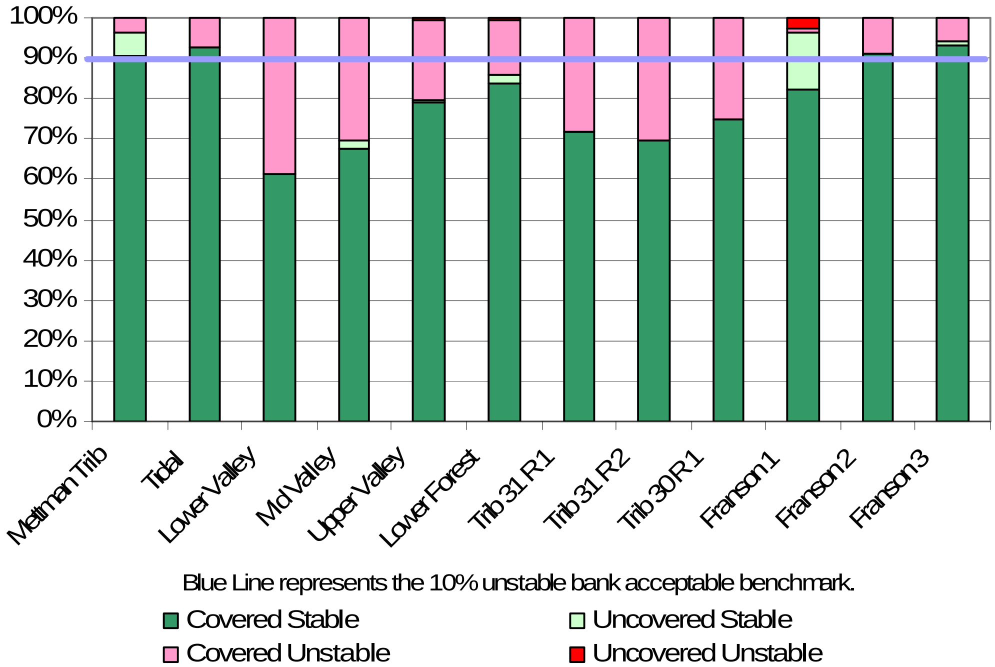


Figure K-11 Bank Stability

Slope Stability

The slope analysis, shown in Figure K-12, indicates that 72.4% of the land area in the Kentuck sub-basin is at low risk for landslide potential, 22.1% is at medium risk, 3.5% is at high risk, and 2.1% is at extremely high risk. The most unstable slopes are located in the headwaters of Kentuck creek, in the highest elevations of the most eastern part of the sub-basin. The steepest slopes are found in areas of Tyee silt/sandstone, which means that there is high potential for slope failure in these areas.

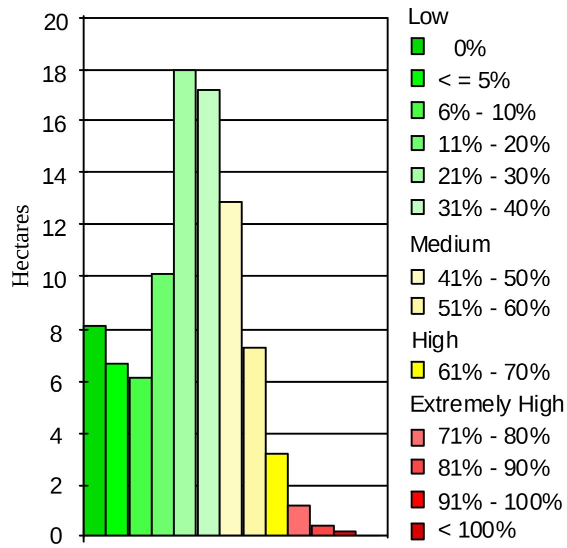


Figure K-12 Slope Stability Risk Classifications

Road-Related Erosion

The Kentuck sub-basin has the most complex road system in the Lowlands area, and many roads are used by both the quarries and the large logging companies.

The Kentuck sub-basin road and landing survey was conducted between March 2001 and March 2005. The survey was divided into two groups, county roads and private roads. The county survey started at the junction of East Bay Drive and Kentuck Way Lane and ended at the junction with the Gould Quarry Road. Mettman Creek Road was included in the county survey. All private roads were surveyed where landowner permission was granted.

Table K-6 Road and Landing Survey Results

Site Type	Number of Sites	Number of Ditches	Existing Ditch Lengths(ft)
Stream Crossing	99	127	Avg. 470 Min. 50 Max. 3030
Ditch Relief	140	172	Avg. 382 Min. 50 Max. 1840
Ditch Out	68	88	Avg. 464 Min. 70 Max. 2530
Potential Landslide	7	9	Avg. 119 Min 50 Max 350.
Gullied Road Surface	2	2	Avg. 395 Min. 230 Max. 830
Totals	330	398	

A total of 47.9 miles of road were surveyed in the

Kentuck sub-basin. The average number of drainage feature sites per mile was 7.6. Table K-6, above, provides a summary of the data collected. Within the Kentuck survey, there were 99 stream crossings, 140 ditch relief culverts, 68 ditch outs, seven potential landslides and two gullied road surface sites. Treatment recommendations are presented later in Discussion and Restoration Opportunities.

Stream Crossing Drainage Evaluation

The 99 stream crossing culverts studied in the road and landing survey were also ranked for their ability to properly drain the area upstream during a 50-year rain event. Of those 99 stream crossings, 42 (42.4%) were evaluated as at risk of failure during a 50-year rain event.

Table K-7 At-risk Stream Crossing Evaluation

50-Yr. Rainfall Fill Failure Risk	Fill Volume Size Class									
	Minimal		Small		Medium		Large		Very Large	
	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3
Low	-	-	4	138	-	-	5	1481	-	-
Moderate	1	0	2	84	1	75	3	603	-	-
High	1	0	5	165.5	1	54	3	720	-	-
Very High	1	8	4	98.5	5	401	6	1402	-	-

Failure Risk, Low = 76% - 100%; Moderate = 51% - 75%; High = 26% - 50%; Very High = 0% - 25%
Fill Volumes, Minimal = $\leq$ 10 yds.^{3}; Small = 10 - 50 yds.^{3}; Medium = 51 - 100 yds.^{3}; Large = 101 - 500 yds.^{3}; and Very Large = > 500 yds.^{3}.

At-risk culverts are ranked in Table K-7 for failure risk based on the percentage of associated drainage area they can properly drain during a 50-year rain event. The number of culverts in each failure risk level (left column) spread across the table depending on the associated fill volume size class. It is important to consider both failure risk and fill volume since it is the fill that becomes a major sediment source upon failure of the crossing.

These 42 stream crossing sites contain a total of 5230 yards^3 of fill. Sixteen of these ranked as having very high risk of failure, potentially releasing 1909.5 yards^3 of fill. Ten of them ranked as having high risk of failure, potentially releasing 939.5 yards^3. Seven ranked as having moderate risk, potentially releasing 762 yards^3 of fill, and nine ranked as having low risk, potentially releasing 1619 yards^3 of fill as sediment downstream.

Stream Temperatures

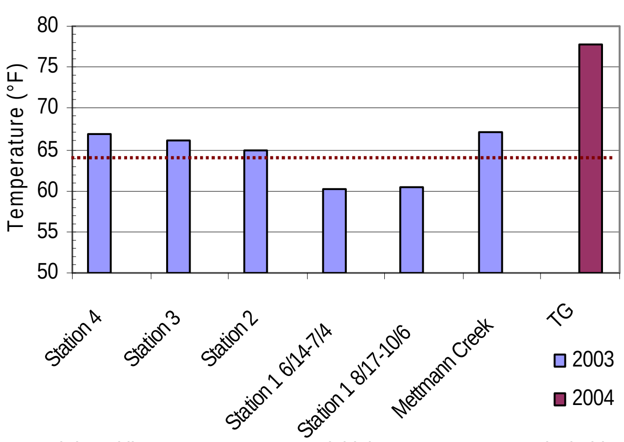
Kentuck creek is located south of Larson creek. The basin is accessed by Kentuck Way and flows into the bay though a tide gate under East Bay Drive. Approximately 2 kilometers upstream, Mettman creek enters Kentuck Slough. In 2003 four temperature loggers were placed on Kentuck creek and one on the Mettman tributary. One temperature logger was located on Mettman creek in 2004, but it disappeared by mid-summer. Two units were located on Kentuck itself in 2004, one upstream in the mid-valley which was stripped off its rebar stake by high flows, and the other was located just upstream of the tide gate.

Table K-8 Temperature Summary and Exceedance of Standards

Site	Year	7-Day averages Max.	Min.	Daily ? T	Days >64°F	Days >70°F	Hours >64°F	Hours >70°F
Site 4	2003	67.0	62.4	4.6	59	0	558.5	0.0
Site 3	2003	66.1	59.5	6.6	44	0	273.5	0.0
Site 2	2003	64.8	56.2	8.6	17	0	69.5	0.0
Site 1 (6/14-7/4)	2003	60.1	53.8	6.3	0	0	0.0	0.0
Site 1 (8/17-10/6)	2003	60.4	55.4	5.0	0	0	0.0	0.0
Trib	2003	67.1	57.1	9.9	48	0	243.5	0.0
Tide gate	2004	77.9	69.5	8.4	110	72	2153.0	778.0

Table K-8 shows the 7-day average maximum and minimum temperatures, and the number of days and hours spent exceeding 64 and 70 °F for each temperature logging site in the Kentuck sub-basin. Exceedance of standards is shown in Figure K-13. The data indicate that in 2003, all of the sites except Site 1 exceeded the 64 °F standard, but none exceeded 70 °F. In 2004, the 7-day average maximum temperature at the tide gate did exceed 70 °F, and the 7-day average minimum exceeded 64 °F. This means that during the hottest 7 day period of the season, the average daily minimum temperature remained above 64 °F.

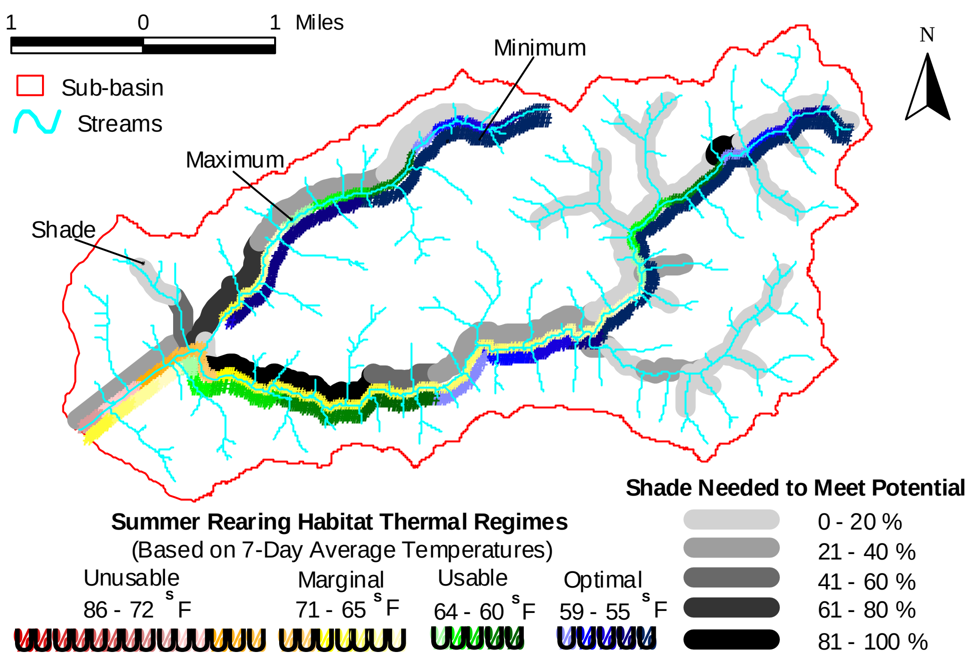
Figure K-13 7-Day Moving Averages of Daily Maximum Temperatures



Red dotted line represents 64 °F std, higher temperatures undesirable

Figure K-14, below, illustrates the temperature trends within the sub-basin using 7-day average maximums, and colors them according to salmonid usability. The map shows that temperature over the length of the stream increases from 55 °F at the headwaters to 78 °F at the tide gate (tide gate data are from 2004). The 2003 overall downstream change in temperature from Site 1 to Site 4, the lowest downstream site was -0.102 °F per 1000 ft, meaning the temperatures actually decreased at the mouth. This can be attributed to the tidal cooling effects due to the tide gate.

Figure K-14 Temperature Trends and Riparian Shade Condition

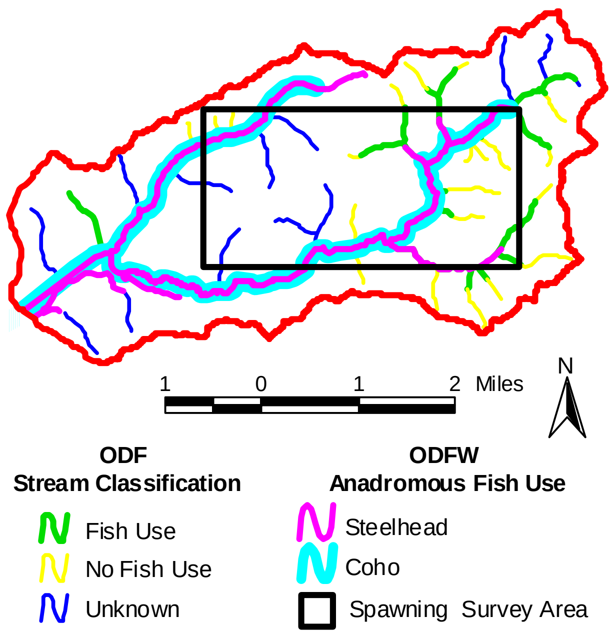


Riparian Shade

The difference between current and potential shade is shown in Figure K-14, above, and is expressed as shade needed to meet potential. The darker riparian areas on the map have the least amount of current shade. Current and potential shade values in the Kentuck sub-basin are 89% and 98% respectively, in the upper-most, steep canyon areas. The upper valley has 78% and 96% respectively, and the lower valley area has only 30% and 86% respectively.

Salmonid Distribution

Figure K-15 Salmonid Distribution



Coho and winter steelhead distribution, according to ODFW, is shown in Figure NS-15. Kentuck Slough is also used by fall chinook. Oregon Department of Forestry (ODF) classifies general fish use streams including cutthroat trout (green line is hidden under the steelhead and coho lines). The spawning survey area is enlarged below in Figure K-16.

Stocking Records

The Kentuck sub-basin has only a few records of juvenile hatchery releases. One of these being earlier, in 1958, when 5,050 coho fry were released directly into Kentuck Slough. In 1981 Mettman Creek was stocked with 12,000 coho, and the following year there was another release of 11,250 Steelhead into Mettman. (See Table K-8).

Table K-8 Stocking Records

Creek	Species	Year	# of Juveniles Released
Kentuck Slough	Coho	1958	5,050
Mettman Cr.	Coho	1981	12,000
Mettman Cr.	Steelhead	1982	11,250
			28,300

Spawning Surveys

Spawning surveys were conducted on Kentuck creek by ODFW in 2001 and by Coos WA in 2002. Coos WA also conducted spawning surveys on Mettman creek in 2003. Two existing ODFW survey reaches on Kentuck were each divided into four smaller reachs. The Mettman Creek Survey was divided into a reach 2-1 on the mainstem, and 3-1 on a tributary to Mettman Creek (see Figure K-16 below).

The lower reaches (1-1 through 1-4) in Kentuck Creek are low gradient with steep constraining terraces. The quantity of gravel is high however, its quality is poor. Gravel is mixed with large cobble and boulders and is imbedded with fines. The upper reaches in Kentuck Creek have a higher gradient, with more riffle and less pool area. Reaches 2-1 and 2-2 have little spawning gravel, but the habitat is highly utilized (See Table K-9). In the upper end of the reach the substrate contains more boulders and large cobbles, and spawning beds are more embedded with fines. The stream is highly constrained, and there is little in the way of pools or complex habitat.

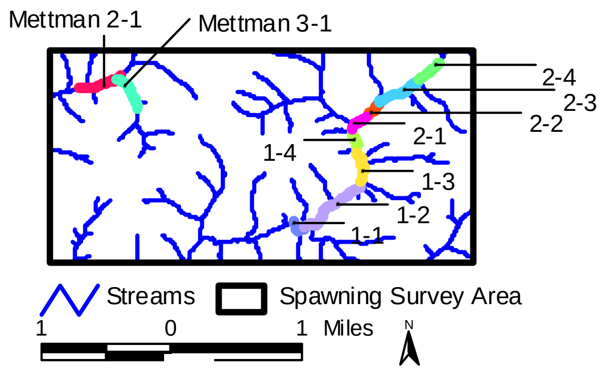


Figure K-16 Spawning Survey Reaches

The 2001 total adult coho AUCs were 131 on the lower reaches 1-1 through 1-4 and 75 on reaches 2-1 through 2-4. These compare to 2002 AUCs of 116 for the lower reaches and 62 on the upper reaches. Figure K-17 below shows the total estimated number of spawners per reach for Kentuck in 2002 and Mettman in 2003.

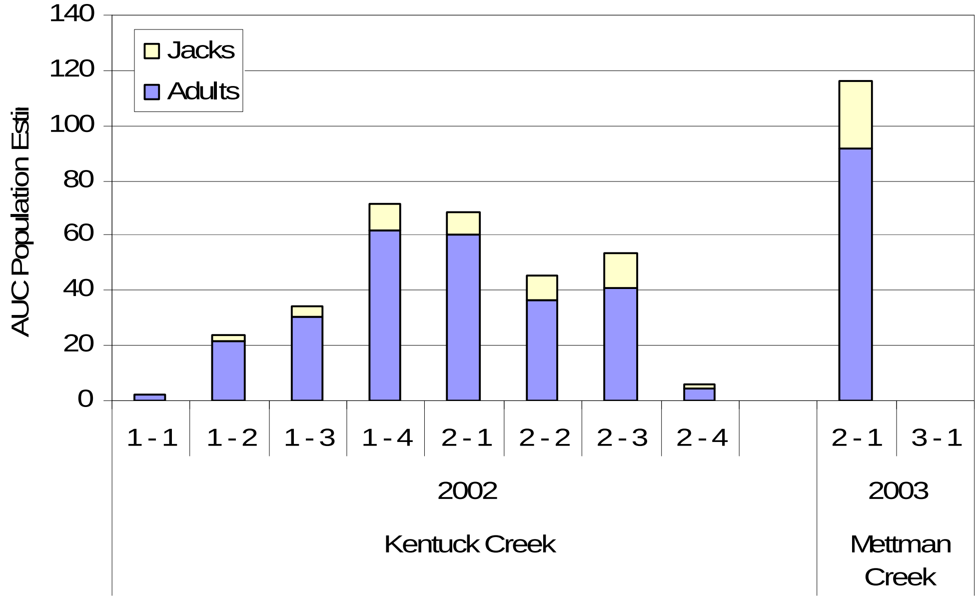
Table K-9 Spawning Density

	Reach	YEAR	Total AUC/Km	Gravel (m^2)	Gravel (m^2)/ Female
Kentuck	1 - 1	2002	29	52	52.0
	1 - 2	2002	42	390	35.5
	1 - 3	2002	68	160	10.3
	1 - 4	2002	189	413	13.3
	2 - 1	2002	381	130.5	4.4
	2 - 2	2002	167	217	6.5
	2 - 3	2002	96	194	9.5
	2 - 4	2002	18	14	5.6
Mettman	2 - 1	2003	315	144	3.1
	3 - 1	2003	0	24	0.0

In terms of coho spawner densities, the lower reaches had a coho AUC/Km of 77, and the upper reaches had a coho AUC/Km of 110. In the lower reaches there is 71.5 m^2 available gravel per female, and 7.9 m^2 gravel per female in the upper reaches. The data indicate that the habitat in the upper reaches is preferentially selected over the lower reach(see Gravel (M^2)/ Female in Table K-9).

Mettman Creek mainstem provides good coho spawning habitat. In reach 2-1, there was a large amount of gravel and many pools. The adult coho AUC/km was 248, with a jack coho AUC/km of 67. Only one steelhead was observed in this reach (see Table K-9).

Figure K-17 Spawning Survey AUC Coho Population Estimate



On the tributary reach 3-1 the spawning habitat is much poorer. It has a higher gradient with less holding pools and low quantity gravel. No fish or redds were observed in this reach during the 2003 spawning season.

Overall, productivity was fair for Mettman creek mainstem (315 AUC/Km). However, with only 3.1 m^2 of gravel per female in reach 2-1, the available habitat was highly utilized.

In order to better understand the fish trends in this sub-basin, more data should be collected on both of these creeks. It would also be useful to do surveys on more of the tributaries in order to identify all available coho habitat.

Intrinsic Potential for Coho Smolt Production

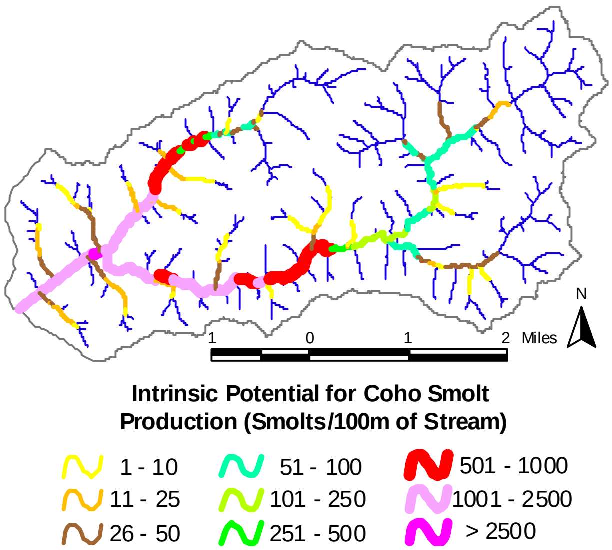


Figure K-18 Intrinsic Potential for Coho Smolt Production

The intrinsic potential for streams in the Lowlands area to produce coho smolts was estimated based on digital elevation models, active channel and valley widths, known natural barriers and coho life histories. The values indicate the number of coho smolts supported by historic, pre-settlement stream conditions. Intrinsic potential for the Kentuck sub-basin, shown in Figure K-18, indicates that the Kentuck sub-basin has the highest intrinsic potential in its lower mainstem and main tributary reaches – from 1001 to 2500 smolts per 100 meters of stream. Intrinsic potential decreases dramatically in the side tributaries. This pattern reflects the coho preference for wider active channel and valley widths. The thin blue lines, streams, indicate zero intrinsic potential due to gradients above 20% and known natural migration barriers. Understanding intrinsic potential for a particular stream will help guide restoration efforts in setting realistic coho population goals. Total intrinsic potential for smolt production this sub-basin is 135,417 smolts. Intrinsic potential for adult coho returns under low ocean survival rates (1%) is 1,354, and under high ocean survival rates (10%) is 13,542 fish.

While restoring coho smolt populations to these levels is unlikely given current land uses and infrastructure, understanding intrinsic potential for a particular stream will help to inform restoration efforts and to set realistic coho population goals.

Coho Habitat Limiting Factors

The limiting factors analysis (based on Reeves et al., 1989), shown in Table K-10 below, indicated that summer rearing habitat is the most limiting factor to coho smolt production at only 23% of the area needed to support potential populations. The Tidal reach was removed from the summer rearing current usable area due to sustained temperatures above 77°F (25°C) that made this reach unfit for salmonids during the hottest months. Winter habitat was limited by lack of refugia from high flows. Current spawning area is more than sufficient for potential populations.

Table K-10 Limiting Factors to Coho Populations

Kentuck Habitat Component	Potential Summer Population	Area/ Survival Factor	Area Needed (M^2)	Current Usable Area (M^2)	Smolt Factor	Smolts Produced
Spawning	83,484	0.006	501	2,063	95.5	197,017
Spring Rearing	83,484	0.3	25,045	11,575	1.7	46,560
Summer Rearing	83,484	0.6	50,091	11,575	0.9	24,650
Winter Rearing	83,484	0.4	33,394	18,254	1.2	21,905

Resource Issues

The Kentuck stream system is affected by the introduction of upland sediment that is then stored in the lower reaches since it can not be flushed out due to the low gradient and the tide gate at the mouth of Kentuck Slough that is does not function properly. With the cessation of tidal flushing, flocculated clays have been allowed to accumulate in the immediate area of the Kentuck lowlands. Between 1939 and 1961, the marsh at the mouth of Kentuck Slough doubled in size, and is still growing. (Beaulieu, 1975) The main sources of sediment include upland logging operations, unstable stream banks, and rock quarry spoils.

Kentuck has two large rock quarries along the mainstem; during high precipitation fine sediments from these quarries contribute to the stream system. There is also a holding pond downstream from Franson creek that is supposed to help catch and filter fine sediment. During high flow events this pond becomes a secondary channel.

Isolated basalt outcroppings near the headwaters serve as sources for rock quarries operating in the Kentuck sub-basin. Quarry operators deposit unusable rock spoils in the area, and in some cases require NPDES permits for stormwater discharge. The Kentuck area has been known historically for mineral deposits, and in 1906 experienced as small “gold rush” (Youst, 2003).

Landowner Concerns and Desired Future Conditions

Landowners in the Kentuck sub-basin expressed concerns about land management issues in the area at a Coffee Klatch meeting on April 21, 2005. Ten percent of the landowners contacted attended the meeting. As shown in Figure K-19, the majority of concerns were for environmental issues, which included restoration of fish habitat and passage, restoration of wildlife populations and local ecosystems, and water quality and quantity. Land management concerns were, again, based around drainage issues such as culvert and ditch maintenance. Other concerns within this sub-basin included, in the land management category- control of noxious weeds, and problems with beavers. Landowners in the Kentuck area, more than the other sub-basins, also expressed a number of social concerns including the need for educating the public about land use regulation and issues affecting the watershed, such as riparian management and non-native versus native vegetation. Other social concerns included negative effects of trespassing ATV’s, and garbage dumping.

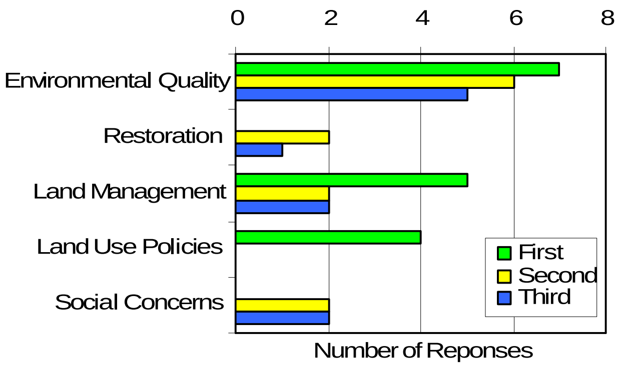


Figure K-19 Landowner Concerns

Residents at the Kentuck Coffee Klatch agreed that they would generally want the area to stay the same in the future. However, positive changes would include more robust fish populations, stream restoration, ditches restored to streams, and improved drainage.

Coos Bay Lowland Assessment and Restoration Plan

Chapter 2:
Willanch Creek Sub-basin Assessment

Willanch Creek upstream from the tide gate. Photo CoosWA, 2006.

Willanch Creek Sub-basin

Introduction

Landform

The Willanch sub-basin, shown in Figure W-1, is the second smallest stream system in the assessment area. Located south of Kentuck, it is oriented east to west, and drains into Coos Bay. Willanch Slough also empties into Coos Bay through a tide gate and there is a high salt marsh area near its mouth. Willanch Creek's main tributary is Johnson Creek which converges from the south approximately 3.5 miles upstream from the mouth.

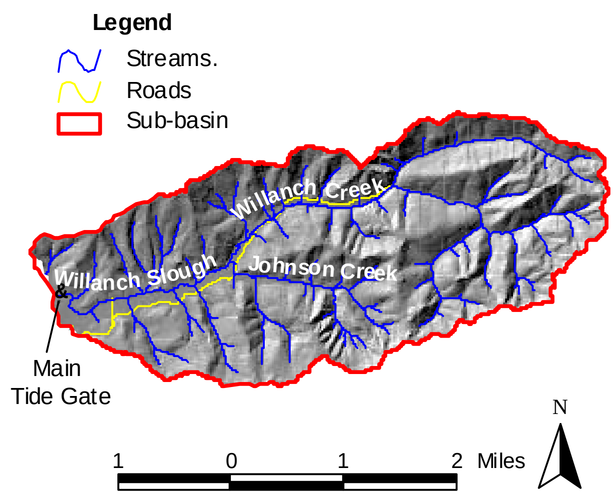


Figure W-1 General Sub-basin

Willanch sub-basin is a dendritic, forth order stream system. The drainage area of Willanch is approximately 5369 acres (8.39 miles^2), which is the second smallest in the assessment area. The total length of streams within the Willanch sub-basin is approximately 33.8 miles, this including mainstems to very small intermittent headwater streams. From the tide gate at East Bay Drive, Willanch mainstem is approximately 6 miles in length. The elevation in the basin ranges from 0 to 1209 feet above sea level. (OWRD, 2005)

Underlying geology of the Willanch sub-basin consists of the Tyee silt/sandstone (43%), Tuffaceous siltstone/sandstone (38%), and Siletz River Volcanic (19%). General soil types, weathered into this sandstone geology, are Templeton-Salander, which is well drained and loamy, and Preacher-Bohannon, which is deep, steep, gravelly and loamy. (Haagen, 1989)

Landuse and Ownership

Forestry is the dominate landuse in the Willanch sub-basin, comprising 76% of the area. The forest lands are managed by both small woodlot owners and larger, private industrial timber operators, which dominate the headwater areas of Willanch Creek and its tributaries (see Figure W-3 and Table W-1). Agricultural landuse, primarily for grazing and hay cropping, makes up 20% of the area and is concentrated in the lower-gradient bottom lands. Rural residential land use is 4% of the area and is largely clustered around the small community of Cooston and along the bay.

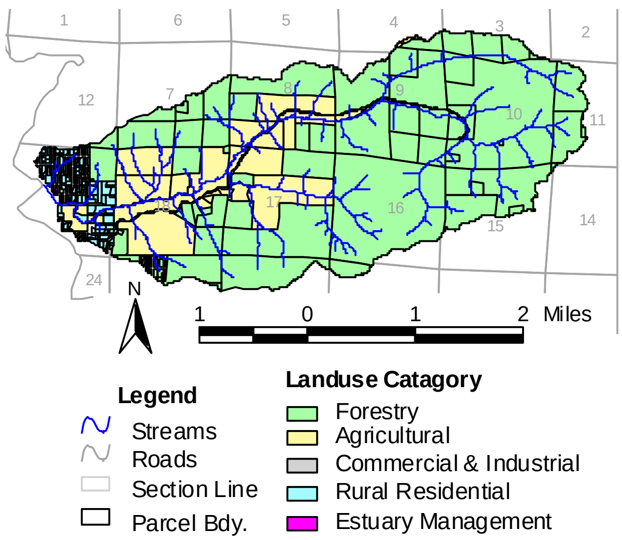


Figure W-3 Landuse Distribution

Landuse	Acres	Percent
Agriculture	998	20
Forestry	3745	76
Rural Residential	179	4
CBEMP	5	<1
Unclassified	0.5	<1
Total	4,927[5]	

Table W-1 Landuse Area

[5] Note: Totals differ between the county assessors parcel aggregate areas and the sub-basin area. The county assessors database has many duplicate records which were removed based on identical areas, map numbers, and parcel numbers, and may not include area of roads or streams.

Hydrology

Precipitation

Annual precipitation is 65 inches at the lowest elevations in the Palouse sub-basin. Due to the west facing orientation, rainfall gradually increases as the elevation increases to a maximum of 69 inches, averaging 67 inches for the whole sub-basin (OCS, 2003). The precipitation intensity for a 2-year 24-hour event is 2.86 inches. OWRD, 2005)

Stream flow

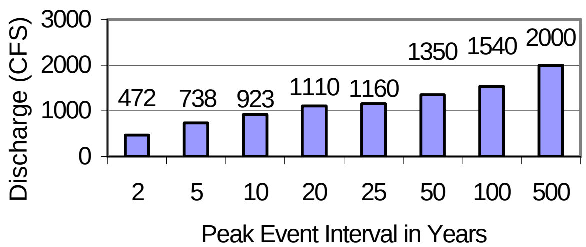


Figure W-3 Peak Discharge Estimates (OWRD, 2005)

Annual peak stream flow for Willanch creek was obtained using Peak Flow Estimation Program (OWRD, 2005). They use hydrologic prediction equations and physical watershed characteristics to estimate peak flows. Figure W-3 shows the estimated discharge at the mouth of Willanch creek for storm events at two to five hundred year reoccurrence intervals. The bankfull storm event is estimated to be 472 cfs. On the other extreme, a maximum discharge of 2000 cfs is estimated for a 500-year storm event in Willanch Creek.

Miscellaneous summer flow measurements were collected on Willanch Creek in 2000 to 2004 (CoosWa). Table W-2 shows the summer flows on Willanch Creek at various locations during this time. The highest flow was collected on June 15, 2004 at the Tidal site, with a discharge of 9.89 cfs. The lowest flow was collected on August 11, 2003 at the Lower Valley site, with a discharge of 0.69 cfs. Based on these measurements the base summer stream flow range is between 0.88 and 9.89 cfs.

Table W-2 Discharge Measurements

Location	Year	Date	CFS
Lower Valley	2000	7-Aug	1.75
	2001	10-Jul	2.5
	2002	22-Jul	1.48
Lower Forest	2003	11-Aug	0.88
		25-Sep	0.74
Lower Valley		11-Aug	0.69
		27-Jun	6.05
		25-Sep	2.3
Tidal	2004	15-Jun	9.89
Upper Valley (Upper Part)		10-Jun	5.49
Upper Valley (Upper Part)		4-Aug	1.61
Lower Valley		15-Jun	5.54
		5-Aug	1.98
Upper Valley (Lower Part)		10-Jun	6.05
Upper Valley (Lower Part)		10-Jun	5.25
		4-Aug	1.73
		5-Aug	1.92
Right Fork 1		4-Aug	1.38
Lower Forest		10-Jun	1.54
Right Fork 1		10-Jun	4.17

Landuse Effects on Hydrology

Landuses, as they affect surface conditions, can be used to make general evaluations of the hydrologic condition of a watershed. Of particular concern is the effect of land uses on peak stream flow, since increases in runoff can contribute to flooding, erosion, and culvert failures. The most important determinant for peakflow increases is the ability of soils to absorb rainfall.

The main types of hydrologic soil groups (HSG) present in the agriculture lands are, 77% of HSG Class D, and 23% of HSG Class B. The HSG Class D has very slow infiltration rates and high runoff rates. The HSG Class B has moderate infiltration rates and moderate runoff. Agriculture has a greater affect on runoff in areas where soils have a high infiltration rate compared to areas where soils are relatively impermeable in their natural state (USDA 1986). Because of the soils, the potential risk of peak-flow enhancement is low in the Willanch sub-basin.

Within the forest use area there are 38.43 linear miles of forest roads. These roads take up approximately 3.3 percent of the forested area. If the percentage of forest area rises above 8 percent, the potential risk of increasing peak-flow moves to high (OWEB, 1999). Because of this low percentage, the relative potential risk for peak-flow enhancement is low in Willanch Creek.

There are approximately 9.13 linear miles of rural roads in the residential and industrial area, which comprise 3.9%. This percentage ranks the Willanch residential and industrial area as a relatively low potential risk for peak-flow enhancement.

Included within the rural road area, there are some impervious surfaces, but no urban roads. Because of the small amount of impervious surfaces, the potential risk for peak-flow enhancement from urban roads is low.

Overall, Willanch sub-basin's potential risks of peak-flow increase from landuse impacts are low.

Water rights

There are three main sources of water rights in Willanch Creek, surface water, groundwater, and instream. The most senior water right in was established in 1932 for irrigation use of surface water. Table W-3 displays thedifferent types of water use in Willanch Creek. The total storage rights including ponds and reservoirs are 2.30 acre feet, for wildlife use. Total water rights for the entire watershed are 93.78 cfs. The total consumptive use is 1.49 cfs. The instream rights were established in 1993, and extend 4.1 river miles from Coos Bay to the end of the county road. A maximum instream water right of 92.2 cfs was established for the purpose of providing optimum stream flow for migration, spawning and juvenile rearing of anadromous and resident fish

Table W-3 Maximum Water Use

Type of Use	CFS	Ac-ft
Domestic	0.08	0.00
Irrigation	1.49	0.00
Instream	92.2	0.00
Livestock	0.01	0.00
Wildlife	0.00	2.30
Total	93.78	2.30

Water Availability

Water availability for the mouth of Willanch sub-basin is estimated using the Water Availability Report System (OWRD, 2005). The average water available is based on the 50% annual exceedance level. The expected flow, shown in Table W-4, was derived by subtracting the consumptive uses from the estimated natural stream flow. Willanch creek has a three month period from July to September when the stream flows are critically low (.76 to 1.1 cfs) and has from .16 o .43 cfs of consumptive use during the low-flow period. Also, the consumptive water use has increased by more than 10% since 1993 and is the largest increase of all of the lowlands area.

Table W-4 Estimated Net Water Available (OWRD, 2005)

Month	Natural Flow	Consumptive Uses	Instream Flow	Expected Flow (cfs)
Jan	35.60	0.02	26.00	35.58
Feb	38.60	0.02	26.00	38.58
Mar	28.10	0.02	26.00	28.08
Apr	9.65	0.03	9.65	9.62
May	5.24	0.11	5.25	5.13
Jun	2.66	0.28	2.67	2.38
Jul	1.43	0.43	1.43	1.0
Aug	1.11	0.35	1.12	.76
Sep	1.26	0.16	1.27	1.1
Oct	7.84	0.03	7.85	7.81
Nov	7.84	0.02	7.86	7.82
Dec	29.10	0.02	26.00	29.08

Aquatic Habitat

Aquatic habitat surveys addressed in this assessment include unit type, substrate type, riffle sediment, pool depth, large wood, and bank stability (bank stability is presented in Sediment Sources on page 12).

The Tidal reach is in a low gradient, small flood plain with a wide valley floor. As the reaches progress upstream the channel becomes moderately confined, and the valley gradually changes from moderate to steep and narrow. See Appendix A for specific channel morphology metrics.

Aquatic habitat study reaches are shown below in Figure W-4. These reach names will be used to describe locations within the Willanch sub-basin throughout this assessment. Data from 2001, 2003, and 2004 were combined to run consecutively from the mouth to the upper reaches.

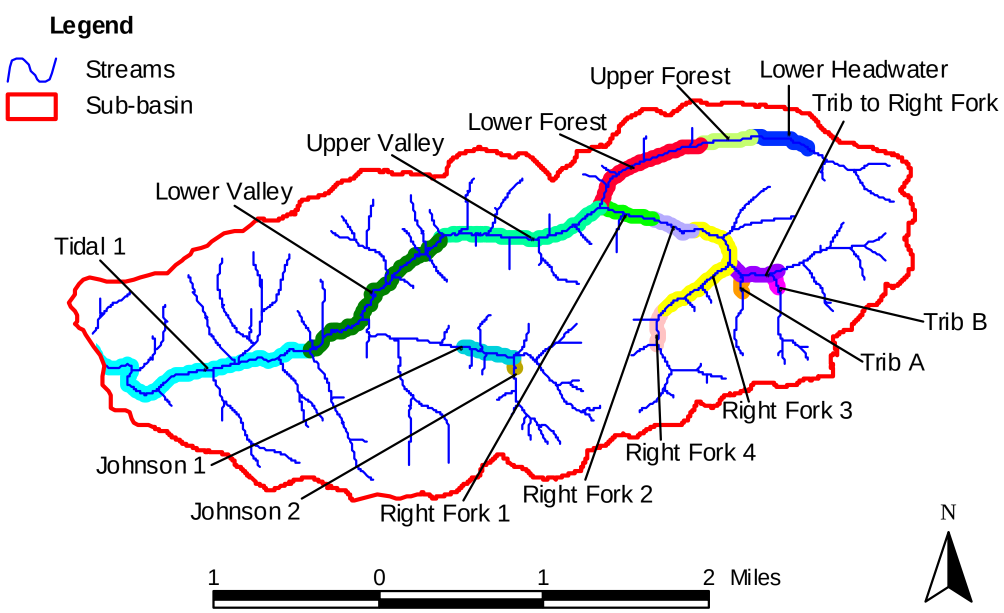


Figure W-4 Aquatic Habitat Study Reaches

Figure W-5, below, shows the percent of unit types for each reach. The habitat quality benchmark set by ODFW is that pools should comprise 35% of the habitat in reaches with less than 4% gradient and an active channel width (ACW) of less than 12 meters. (Moore, 1997) The only reaches in this basin that reach this benchmark are Tidal, both Valley reaches, Right Fork Reach 2, and Right Fork Reach 4.

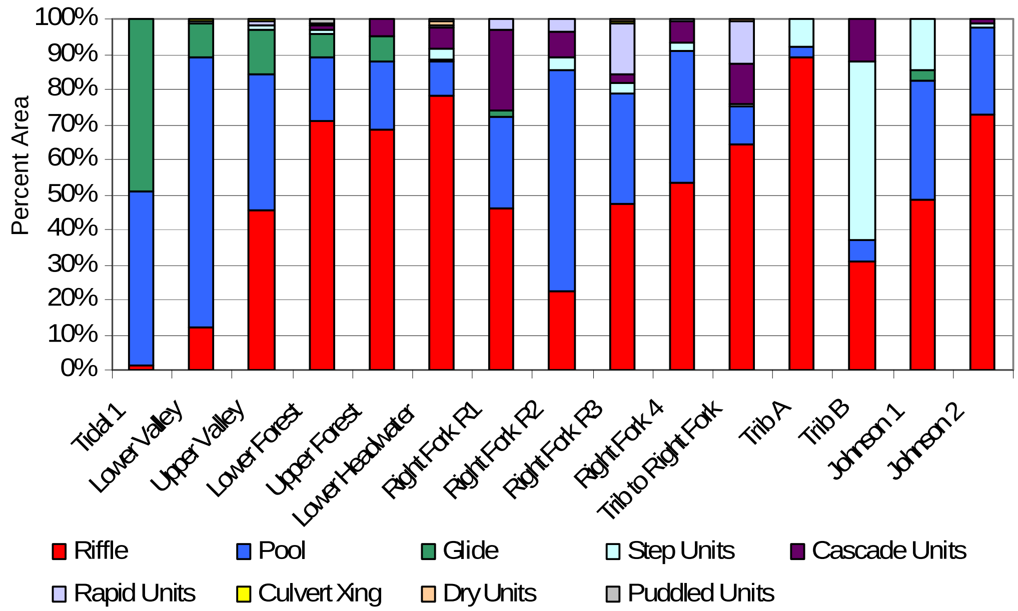


Figure W-5 Unit Types

Figure W-6, below, shows average percentage of substrate for each reach. Higher gradient reaches tend to have more cobble, boulders, and bedrock. Lower tidal areas tend to have higher sand/silt/organic substrates.

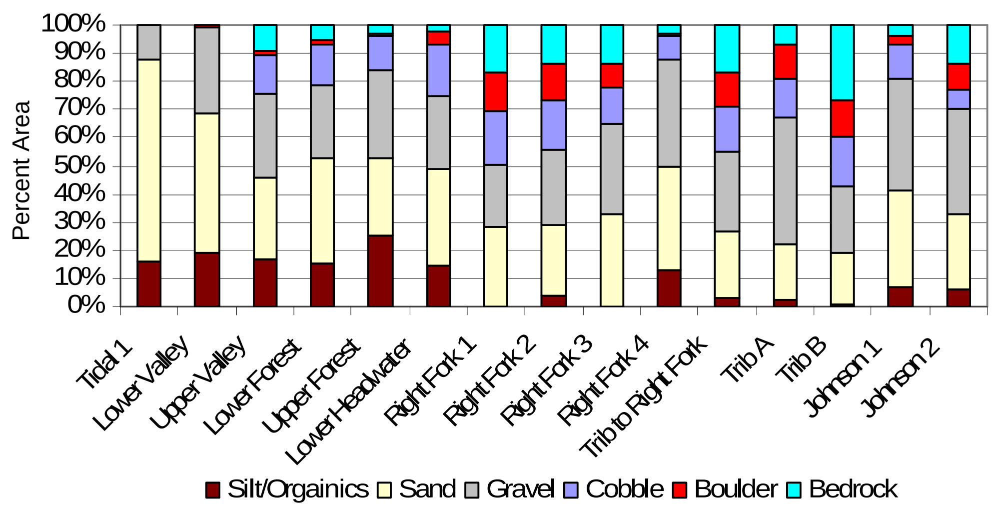


Figure W-6 Substrate Types

Figure W-7, below, shows that riffles in all but the Lower Forest and the Lower Headwaters have excellent levels of gravel, while all reaches have less than desirable amounts of fine sediment.

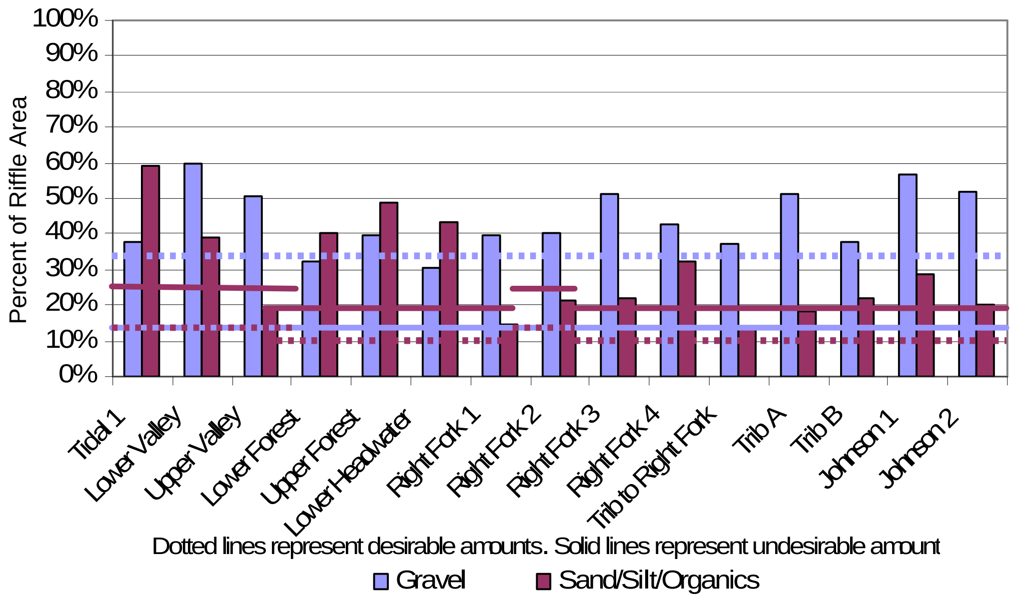


Figure W-7 Riffle Sediment

Figure W-8, below, shows that all the reaches are below the ODFW desirable benchmark for residual average depth. The entire basin, except the Right Fork, Reach 2, is considered to be a small channel—this reach is an anomaly attributed to either surveyor error or an unusual landform.

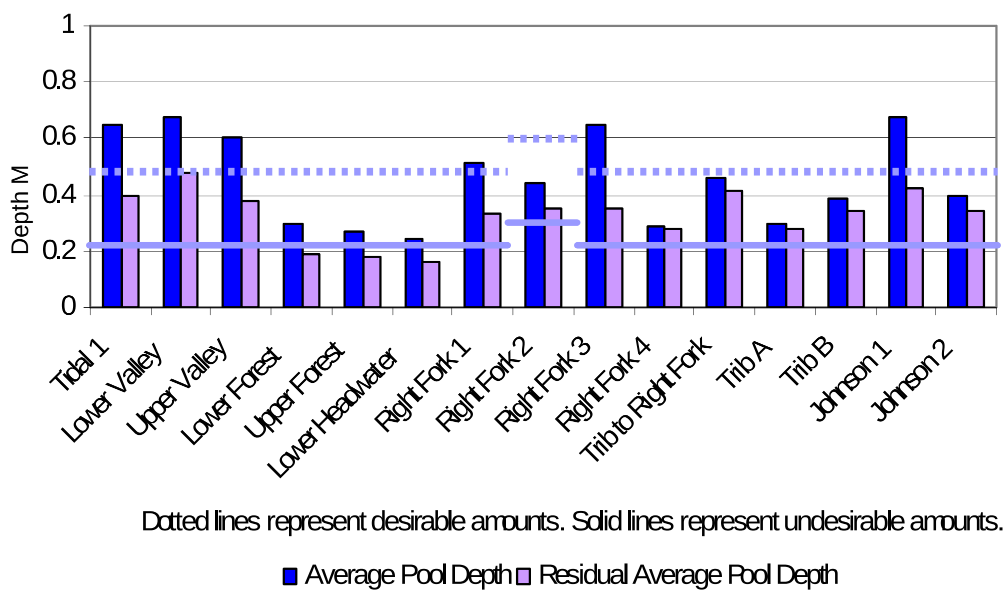


Figure W-8 Pool Depth

As shown in Figure W-9, below, none of the mainstem reaches have desirable amounts of large wood. Only three of the fifteen reaches have desirable levels of wood pieces and volume; none of the reaches has desirable amounts of key pieces

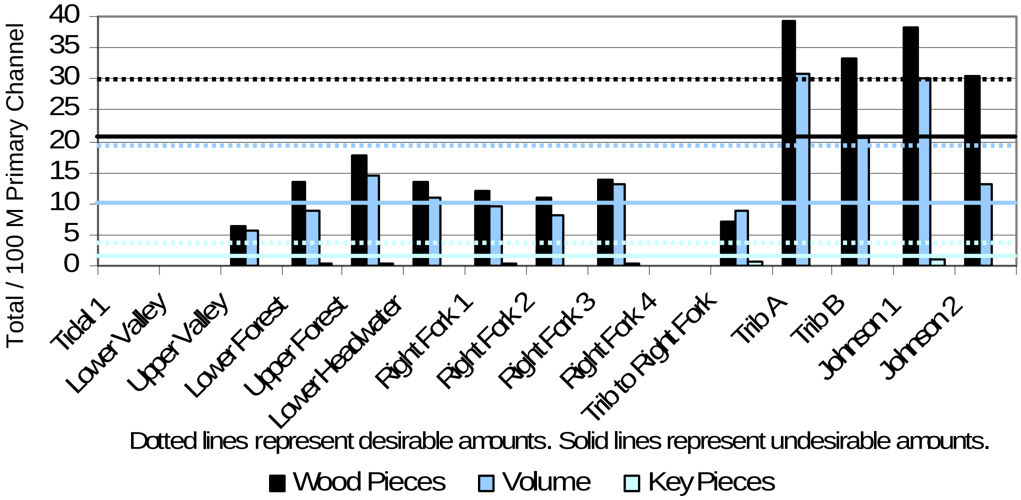


Figure W-9 Large Wood

Wetlands

Historic, current and potentially restored wetlands in the Willanch sub-basin are shown in Figure W-10. The current (2005) wetland extent, determined by CoosWA using aerial photography analysis, is land presently dominated by wetland vegetation and not showing signs of recent agricultural production. In most cases, however, 'current wetland' is not a properly functioning wetland and is included in the area of potential wetland restoration. The area considered current wetland is 7% of the historic wetland extent in this sub-basin. Historic wetland extents are based on soil type and plant characteristics. Thirty-three percent (85 acres) of the historic wetlands in this sub-basin are described in the National Wetland Inventory as 'emergent', meaning they were dominated by rooted herbaceous plants, and are seasonally flooded. It is the emergent seasonally flooded areas, not currently functioning as wetland, that CoosWA recommends for restoration consideration as these areas are often more difficult to manage for crop production. Wetland restoration is discussed in more depth in Chapter 3, and National Wetland Inventory categories are provided in Appendix A.

Table W-5
Wetland Areas

Wetland Type	Acres
Historic wetlands	256
Current wetlands	17
Potential wetland restoration	86

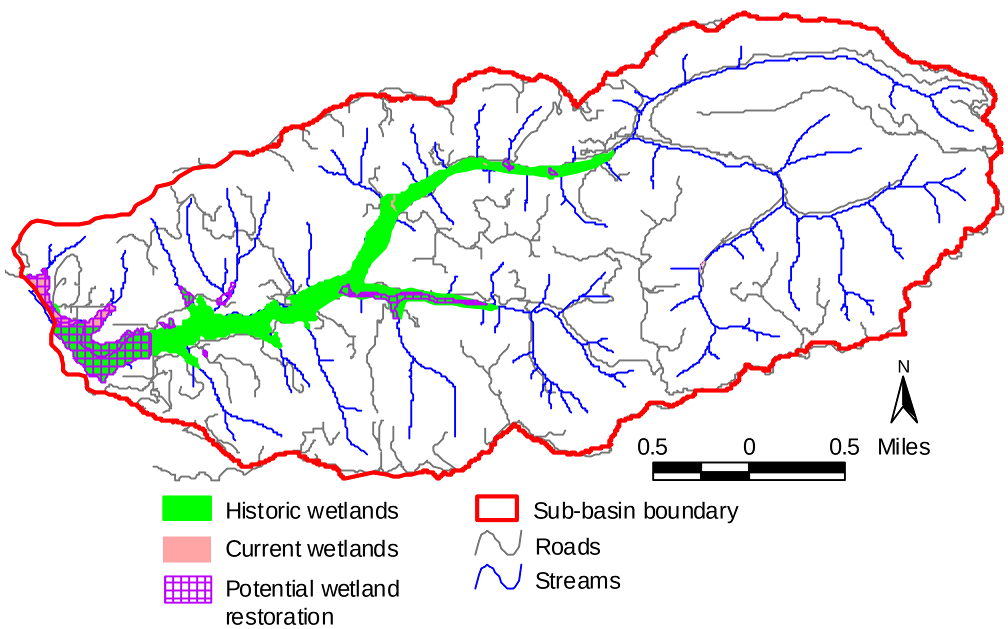


Figure W-10
Wetlands

Sediment Sources

Sediment sources considered in this assessment include unstable stream banks, unstable slopes, erosion associated with roads, and stream crossings with road fill at risk of failure.

Bank Stability

Bank stability surveys are conducted as part of the aquatic habitat surveys. Figure W-11 shows the bank stability ratings for each aquatic habitat reach. Of the reaches surveyed for bank stability in the Willanch sub-basin, four were unacceptable with a range of 19.2% to 25% unstable banks. Figure W-10 shows missing data because bank stability data was not available for three reaches.

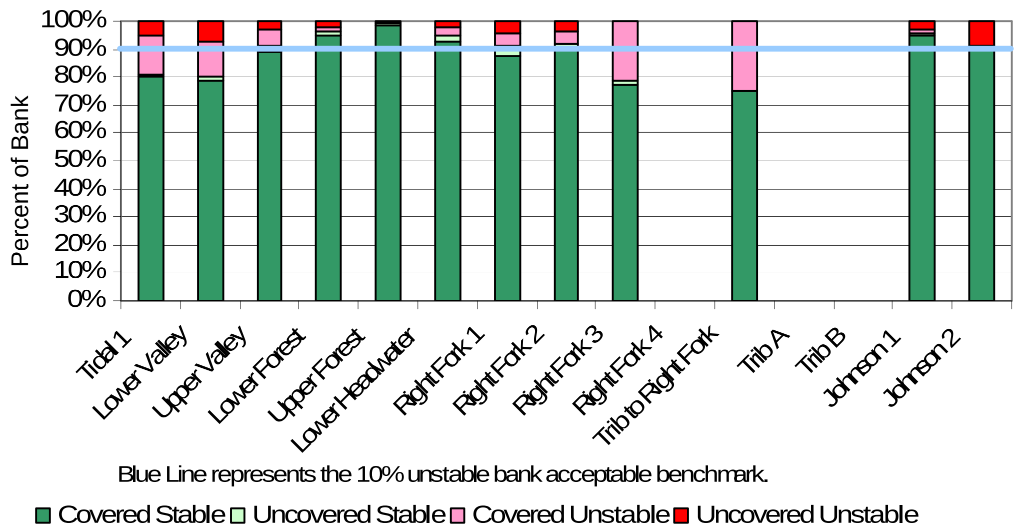


Figure W-11
Bank Stability

Slope Stability

The slope stability analysis, see Figure W-12, shows the area in the low risk category for landslide potential is approximately 85.9%, the moderate risk is 11.9%, high risk is 1.4%, and the extremely high risk is 0.08%. Based on the data, Willanch sub-basin has a relatively low amount of area in the medium to extremely high risk range (13.38%). The

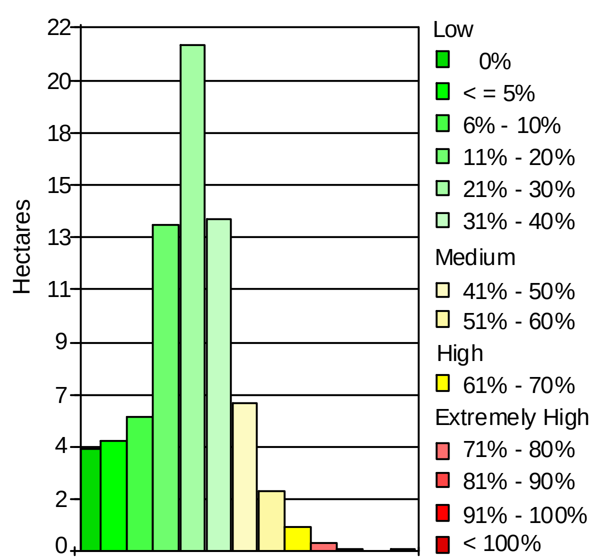


Figure W-12
Slope Stability Risk Classifications

most unstable slopes are located in the headwaters of Willanch Creek, in the highest elevations of this sub-basin. The highest slopes are found in areas of Tyee silt/sandstone, which means that there is high potential for slope failure in these areas.

Road-Related Erosion

Table W-6 Road and Landing Survey Results

Site Type	Number of Sites	Number of Ditches	Existing Ditch Lengths (ft)
Stream Crossing	88	99	Avg. 314 Min. 10 Max.1150
Ditch Relief	73	85	Avg. 315 Min. 50 Max 1000
Abandoned Road	1	2	Avg. 1450 Min. 1450 Max. 1450
Totals	162	186	

The Willanch Creek road and landing survey was conducted between April 2001 and July 2004. The survey was divided into two groups, county roads and private roads. The county survey started at the junction of East Bay Drive and Willanch Way and ended at the junction with the Weyerhaeuser 0240 road. All private roads were surveyed where landowner permission was granted. Table W-6 provides a brief summary of the data collected.

A total of 25 miles of road were surveyed in the Willanch sub-basin, including 3.65 miles of county roads and 21.3 miles of private roads. The average number of drainage sites per mile on county roads is 10.8 and 4.2 per mile on private roads. One reason for the different density is the ridge roads are on private lands and they do not need as many drainage features as the midslope or valley locations.

Within the survey there were 88 stream crossings, 73 ditch relief culverts and one gullied road surface site (see Table W-6). There were no future landslide sites found. See Discussion and Restoration Opportunities for recommended drainage feature upgrades.

Stream Crossing Drainage Evaluation

The 88 stream crossing sites studied in the road and landing survey were also evaluated for their ability to drain the area upstream during a 50-year peak rain event. Of those 88 sites, 27, or 31%, are at risk of failing during such an event.

At-risk culverts are ranked in Table W-7 for failure risk based on the percentage of associated drainage area they can properly drain during a 50-year rain event. The number of culverts in each failure risk level (left column) spread across the table depending on the associated fill volume size class. It is important to consider both failure risk and fill volume since it is the fill that becomes a major sediment source upon failure of the crossing.

Table W-7 At-Risk Stream Crossing Evaluation

50-Yr. Rainfall Fill Failure Risk	Fill Volume Size Class									
	Minimal		Small		Medium		Large		Very Large	
	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3
Low	-	-	2	51	-	-	2	655	1	649
Moderate	-	-	1	48	-	-	-	-	-	-
High	-	-	1	14	1	72	3	503	-	-
Very High	5	0	5	155	1	71	5	721	-	-

Failure Risk, Low = 76% - 100%; Moderate = 51% - 75%; High = 26% - 50%; Very High = 0% - 25%
Fill Volumes, Minimal = $\leq$ 10 yds.^{3}; Small = 10 - 50 yds.^{3}; Medium = 51 - 100 yds.^{3}; Large = 101 - 500 yds.^{3}; and Very Large = > 500 yds.^{3}.

There is a total of 2939 yards^3 of fill at these 27 at-risk culverts. Sixteen of the 27 at risk culverts ranked as having very high risk of failure, potentially releasing 947 yards^3 of fill. Five ranked as having high risk of failure, potentially releasing 589 yards^3 of fill. One site ranked as having moderate risk of failure, potentially releasing 48 yards^3 of fill. Five of them ranked as having low risk of failure, potentially releasing 1355 yards^3 of fill downstream.

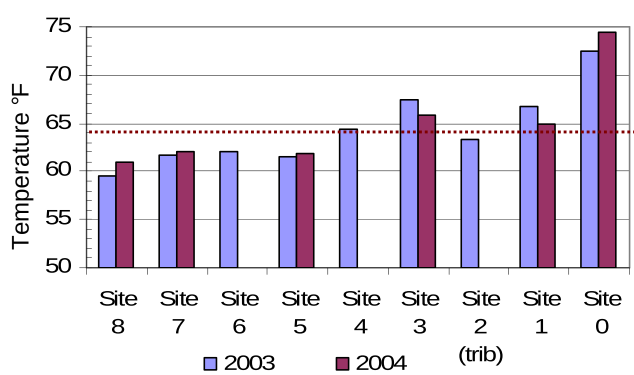
Stream Temperatures

Eight temperature gauging sites were located within the Willanch sub-basin, including a forested upland tributary site on the upper right fork of the mainstem. Data at Site 2, on the wooded upper valley, were lost due to equipment failure. Willanch stream temperatures have been monitored at various sites since 1997 and several of these locations were still used in 2004, offering a good comparison of temperature trends over the years.

Table W-8 Temperature Summary and Exceedance of Standards

Site	Year	7-Day averages			Days	Days	Hours	Hours
		Max.	Min.	Daily ? T	>64°F	>70°F	>64°F	>70°F
Site 8	2003	59.5	54.2	5.3	0	0	0.0	0.0
Site 7	2003	61.7	55.2	6.5	0	0	0.0	0.0
	2004	62.1	56.5	5.5	0	0	0.0	0.0
Site 6	2003	62.0	55.4	6.6	0	0	0.0	0.0
Site 5	2003	61.5	55.8	5.7	0	0	0.0	0.0
	2004	61.9	57.3	4.6	0	0	0.0	0.0
Site 4	2003	64.5	56.4	8.0	10	0	29.0	0.0
Site 3	2003	67.4	56.6	10.9	46	0	215.5	0.0
	2004	65.7	59.2	6.5	25	0	142.0	0.0
Site 2	2003	63.3	55.8	7.5				
Site 1	2003	66.6	57.4	9.3	38	0	193.0	0.0
	2004	64.9	59.3	5.7	19	0	94.5	0.0
Site 0	2003	72.5	56.3	16.2	58	14	275.5	41.0
	2004	74.5	59.8	14.7	43	13	230.0	29.5
Upper L Fork	2004	60.0	55.8	4.2	0	0	0.0	0.0
Upper R Fork	2004	61.5	56.6	4.9	0	0	0.0	0.0

Table W-8 shows the 7-day average maximum and minimum temperatures, and the number of days and hours spent exceeding 64 and 70 °F for each temperature logging site in the Willanch sub-basin. Exceedance of standards is shown in Figure W-13, below. The data indicate that during 2003 and 2004, only the lower sites on Willanch creek logged any days exceeding the 64 °F standard, and only the unit near the mouth recorded any days above 70 °F.

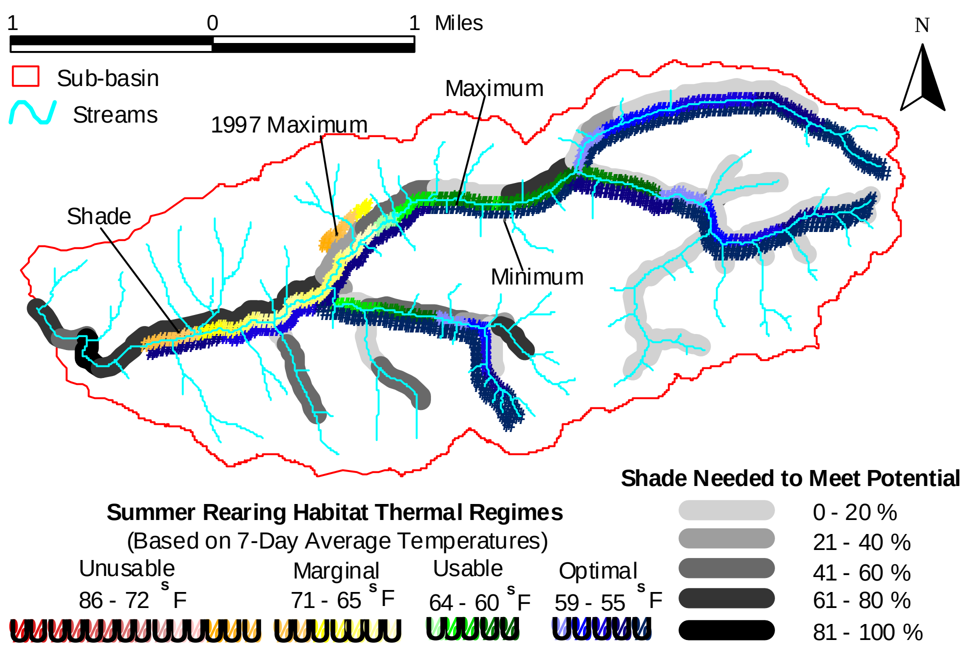


Red dotted line represents 64 °F std, higher temperatures undesirable

Figure W-13 7-Day Moving Averages of Daily Maximum Temperatures

Figure W-14, below, illustrates the temperature trends within the sub-basin using 7-day average maximums, and colors them according to salmonid suitability. The map shows that temperatures increase from 55 °F at the headwaters to 74.5 °F in the lowlands just above the tide gate in 2004. The lower tributary data are from 2003. Temperatures on Willanch were first recorded in 1997, and displaying these data along-side the recent data shows a cooling trend over the years. In 1997 the temperature increased from 55 °F at the headwaters to 69 °F in the middle segments of the stream where a riparian planting project was installed that year. In 2003, that same station recorded a 7-day average maximum of 64.5 °F, and the stream does not reach 69 °F until it enters the lowest section.

Figure W-14 Temperature Trends and Riparian Shade Condition



Riparian Shade

The difference between current and potential shade is shown in Figure W-14, above, and is expressed as shade needed to meet potential. The darker riparian areas on the map have the least amount of current shade. Current and potential shade values in the Willanch sub-basin are 82% and 97%, respectively, in the upper-most, steep canyon areas. The upper valley has 42% and 92% respectively, and the lower valley area has 35% and 92% respectively. Willanch's current upper valley shade is the lowest in the assessment area.

Salmonid Distribution

Coho and winter steelhead distribution, according to ODFW, is shown in Figure W-15. Oregon Department of Forestry (ODF) classifies general fish use streams including cutthroat trout (green line is hidden under the steelhead and coho lines). The spawning survey area is enlarged below in Figure W-16.

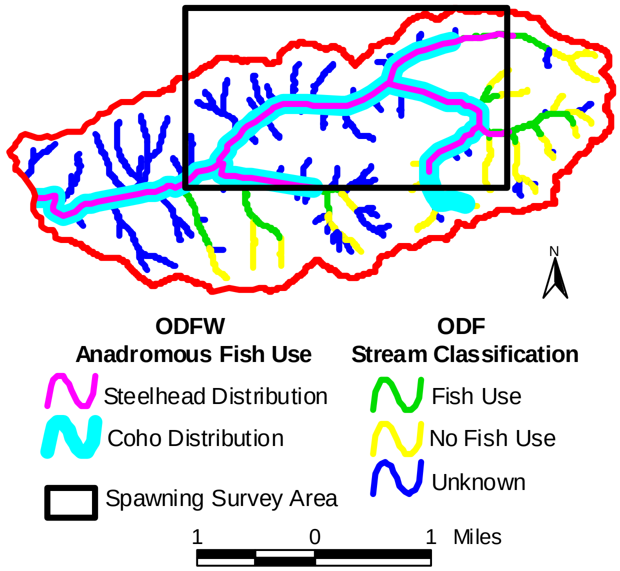


Figure W-15 Salmonid Distribution

Stocking Records

There were only a few releases of hatchery stocks into the Willanch system (see Table W-9). These consisted of releases of both coho and cutthroat into Willanch Creek and one of its major tributaries, Johnson creek. The Willanch mainstem was stocked in 1983 and 1990. In these two years almost 23,000 juvenile coho fry were placed into hatchboxes, until they were released. The only other stocking was conducted between 1947 and 1948. This release is the oldest record of hatchery releases into the lowlands assessment area. There were a total of 3,942 juvenile cutthroats placed into Johnson creek. In all almost 27,000 juvenile fish were released into the Willanch sub-basin.

Table W-9 Stocking Records

Creek	Species	Year	Juveniles Released
Willanch	Coho	1983	1,000
Willanch	Coho	1990	21,699
Johnson Cr. (trib to Willanch)	Cutthroat	1947-1948	3,942
			26,641

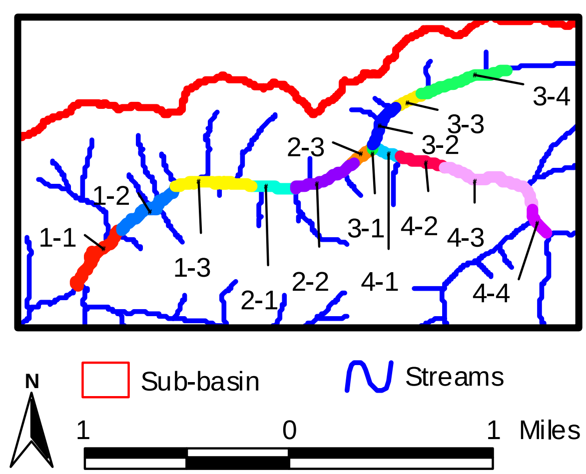


Figure W-16 Spawning Survey Area

Spawning Surveys

On Willanch Creek, coho spawning surveys were conducted by the Coos WA from 2002 to 2004. In 2002, the survey was conducted on reaches 2-1 through 3-3 (see Figure W-15 above).

In 2003 the spawning survey included the same two reaches and included a third reach, immediately downstream, with three segments (3-1, 3-2, 3-3). In 2004, another reach was added with four segments (4-1, 4-2, 4-3, 4-4), upstream from the other reaches, on the right tributary. However in 2004, segment 1-1 was not repeated due to poor spawning habitat, and low counts of fish in the previous survey years. Also, another segment (3-4) was added to reach three. Spawning population estimates are shown in Figures W-17 and W-18 below.

Although the culvert was not a complete passage barrier, it was definitely an impediment. The long riffles in segment two and three had relatively little productive spawning habitat. In segment 3-4 there was only a fair amount of fish counted.

Figure W-17 Lower Willanch Spawning Survey AUC Population Estimate

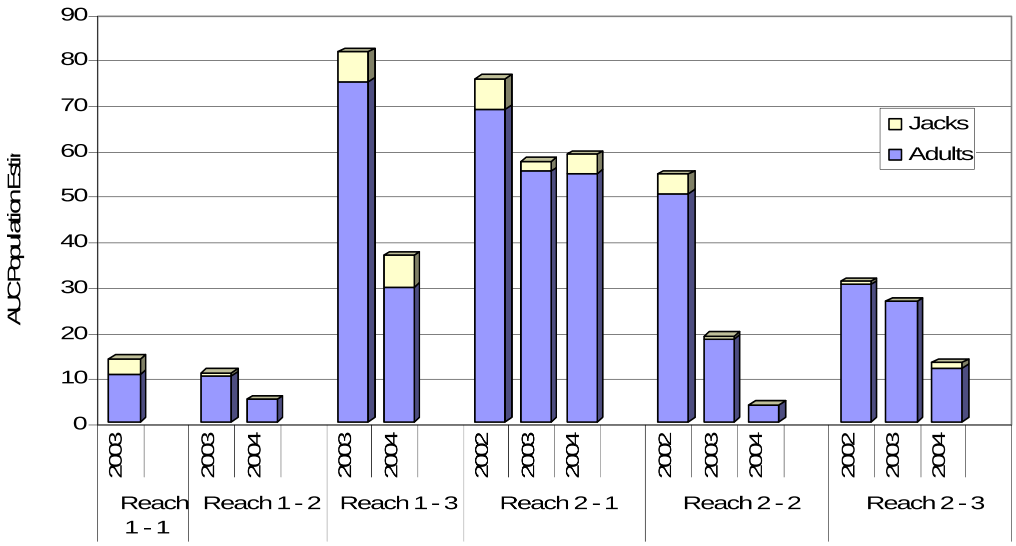
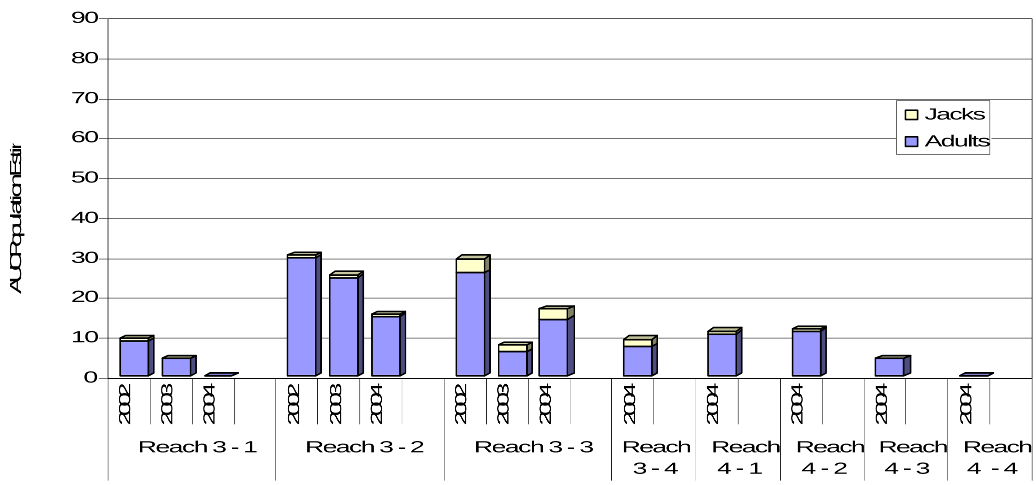


Figure W-18 Upper Willanch Spawning Survey AUC Population Estimate



During the high flow events of the winter of 2002, an undersized culvert on the upper end of segment 2-2 became blocked, and became a migration barrier to coho. High stream velocities resulting from the culvert failure resulted in scouring of redds and substrate downstream, exposing bedrock. The Coos WA and Menasha Forest Products removed the culvert during the summer of 2003 in order to remove the passage barrier. The stream crossing was rebuilt with a bridge in 2004.

Table W-10 Spawning Density

Reach	YEAR	Total AUC/Km	Gravel (m^2)	Gravel (m^2)/ Female
1 - 1	2003	14	20	4.0
1 - 2	2003	20	95	19.0
	2004	9	231	92.4
1 - 3	2003	138	358	9.7
	2004	62	419	27.9
2 - 1	2002	261	118	3.5
	2003	198	314	11.4
	2004	203	231	8.6
2 - 2	2002	126	53	2.1
	2003	44	103	11.4
	2004	9	182	91.0
2 - 3	2002	249	41	2.7
	2003	147	46	3.5
	2004	72	49	8.2
3 - 1	2002	314	8	2.0
	2003	143	12	6.0
	2004	0	9	0.0
3 - 2	2002	104	67	4.5
	2003	87	147	12.3
	2004	53	134	19.1
3 - 3	2002	95	60	4.6
	2003	25	92	30.7
	2004	54	79	11.3
3 - 4	2004	30	48	13.7
4 - 1	2004	47	65	13.1
4 - 2	2004	29	133	22.2
4 - 3	2004	5	50	25.2
4 - 4	2004	0	17	0.0

The Coos Watershed has invested considerably in the restoration of Willanch Creek, including fish passage and riparian restoration efforts. In the summer of 2004, projects were implemented, including stream crossing upgrades, wood placement, and road decommissioning. There were three bridges put in, one where the culvert was removed from the upper segment of 2-2 in 2003, and two on the main county road that were fish passage impediments. There was also large wood placement in segments 2-3, 3-1, 3-2, 3-3, and 4-1, and an abandoned streamside road was decommissioned.

Each year that the stream was surveyed, the highest densities of fish were observed reaches 2-1 through 3-1 (see Table W-10). The spawning population The 2002 surveys had 314 AUC/Km; in 2003 there were 198 AUC/Km, and 203 AUC/Km in 2004. Also, the greatest change in the amount of gravel per female was recorded in 1-2 and 2-2. These reaches also had a decrease in the number of AUC/Km. This may be due to better accessibility to more desirable fish habitat in other areas of the stream.

During the Coho spawning surveys, there were also other types of anadromous fish observed. Sea-Run Cutthroat trout were noted in the lower reaches on a number of surveys. Chinook and steelhead were observed at the very top of reach 2. Also, steelhead were counted in segments 1-3, 2-1 and 2-2. They were not observed spawning, and were most likely migrating through these segments.

Intrinsic Potential for Coho Smolt Production

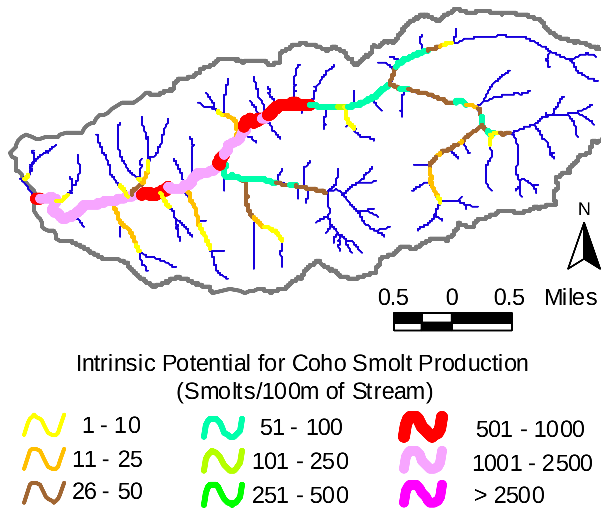


Figure W-19 Intrinsic Potential For Coho Smolt Production

The intrinsic potential for streams in the Lowlands area to produce coho smolts was estimated based on digital elevation models, channel widths, known natural barriers and coho life histories. The values indicate the number of coho smolts supported by historic, pre-settlement stream conditions. Intrinsic potential for the Willanch sub-basin, shown in Figure W-19, indicates that the lower mainstem reaches have higher potential, up to 2500 smolts per 100 meters of stream, while potential in the upper mainstem and tributaries drops off abruptly. This pattern reflects the coho preference of lower-gradient, slow moving streams. Many of the first and second order streams, the thin blue lines, indicate zero intrinsic potential due to gradients above 20% and known natural migration barriers. Total intrinsic potential for smolt production this sub-basin is 61,622 smolts. Intrinsic potential for adult coho returns under low ocean survival rates (1%) is 616, and under high ocean survival rates (10%) is 6,162 fish.

While restoring coho smolt populations to these levels is unlikely given current land uses and infrastructure, understanding intrinsic potential for a particular stream will help to inform restoration efforts and to set realistic coho population goals.

Habitat Limiting Factors to Coho

The limiting factors analysis (based on Reeves et al., 1989) calculates potential smolt populations based on current, surveyed stream conditions (rather than digital elevation models used for calculating intrinsic potential). The limiting factors analysis shown in Table W-11, below, indicated that both winter and summer rearing habitats were limiting coho productivity. Current useable area of winter rearing habitat was only 42% of the area needed to support potential populations. The current useable area of summer rearing habitat was 48% of what was needed to support potential coho populations. Summer temperatures were within acceptable parameters for salmonid survival. Current spawning area is more than sufficient for potential populations.

Table W-11 Limiting Factors To Coho Populations

Willanch Habitat Component	Potential Summer Population	Area/ Survival Factor	Area Needed (M^2)	Current Usable Area(M^2)	Smolt Factor	Smolts Produced
Spawning	23,272	0.006	140	1,638	95.5	156,429
Spring Rearing	23,272	0.3	6,982	6,682	1.7	11,360
Summer Rearing	23,272	0.6	13,963	6,682	0.9	6,014
Winter Rearing	23,272	0.4	9,309	3,947	1.2	4,737

Resource Issues

Although watershed improvements have been made in places within Willanch, the sub-basin is affected by many of the same resource issues found in the other lowland sub-basins. Sediment introduced from logging operations, and unstable stream banks is stored in the lowland reaches and does not flush out as it would in natural conditions due to the low gradient and the tide gate at the mouth of the system. The present tide gate is in need of repair, and the mainstem dike is not functioning properly. The first tide gate was installed in the Willanch area in 1945 or 1948.

Maintaining bottom land for pasture remains high on land management priorities and therefore, landowners are faced with issues of saltwater intrusion, drainage problems and the need for land use permits to perform maintenance on drainage structures.

Landowner Concerns and Desired Future Conditions

Landowners in the Willanch sub-basin expressed their concerns about land management issues at a Coffee Klatch meeting on April 14, 2005. Nineteen

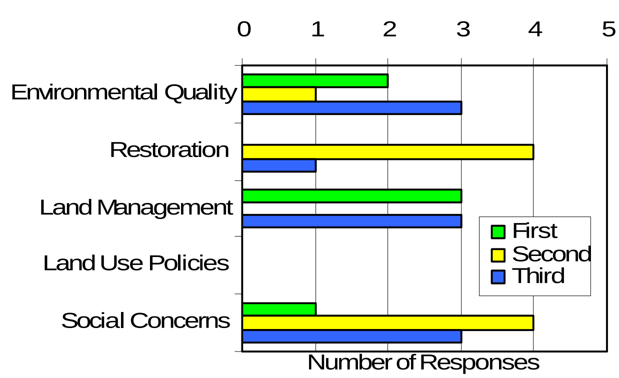


Figure W-20 Landowner Concerns

percent of landowners contacted attended the meeting. As shown in Figure W-20 above, social concerns were much higher here than in other sub-basins. The top social concern was the problem of garbage dumping, which, landowners agreed had decreased over the last year since certain roads had been closed to the public. Other concerns expressed included control of blackberries and beaver.

In the future, landowners in the Willanch sub-basin would like to see more-productive pasture land, healthy fish populations, improved logging practices, and better maintenance of drainage structures.

Several Coffee Klatch attendees had personally participated in the draining of the Willanch area in the 1940’s and 50’s. They had seen farm productivity on the land improve greatly, and then dwindle in recent years.

Coos Bay Lowland Assessment and Restoration Plan

Chapter 2:
Echo Creek Sub-basin Assessment


Echo Creek upstream from the mouth. Photo CoosWA, 2006.

Echo Creek Sub-basin

Introduction

Landform

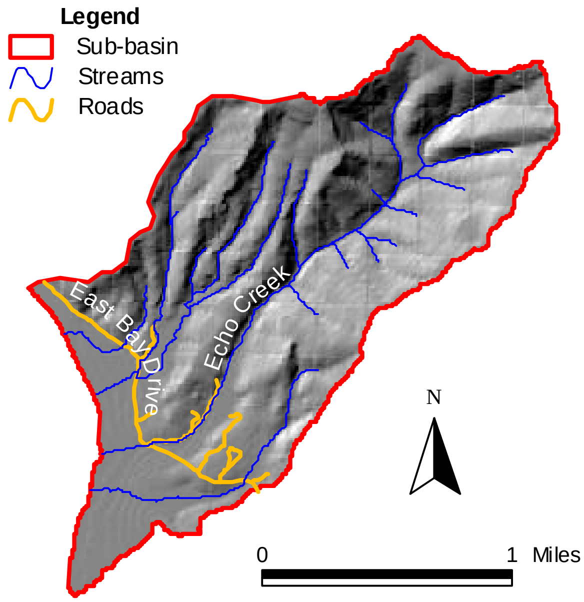


Figure E-1 General Sub-basin

The Echo sub-basin (see Figure E-1) is the southern-most, smallest system in the assessment area. It consists of four streams that empty directly into the Cooston Channel, which runs along the eastern side of the Coos estuary mud flats. The Echo sub-basin is bordered on the south by the South Fork Coos River, which converges with the bay at the southern tip of the sub-basin. Tidal marshes extend along the bay north of the mouth of Echo Creek.

The Echo sub-basin is a dendritic, third order stream system. The drainage area is approximately 1184 acres (1.85 miles^2), which is the smallest in the lowlands assessment area. The total river miles of streams within the Echo Watershed is approximately 10.6 miles. The Echo Creek mainstem is approximately 4.49 miles in length. The elevation in the basin ranges from 0 to 903 feet above sea level, which is the lowest in the area (OWRD, 2005).

The main type of underlying geology in the Echo sub-basin is the Tuffaceous siltstone/sandstone (87%). Other types include Tyee silt/sandstone (9%), and Holocene Alluvial (4%). Compared to all of the other sub-basin in the lowlands, Echo has the lowest amount of the Tyee siltstone/sandstone. Weathered into this underlying geology are the following three general soil types. The Coquille-Nestucca-Langlois soil is found on the near-shore areas along the Bay and Coos River. This soil drains somewhat poorly, is silty and clayey, and common to flood plains. The Templeton-Salander soil type, most common in the lowlands area, is well-drained and loamy. Steeper areas in the uplands are characterized by the Preacher-Bohannon type which is deep, gravely to loamy and prone to erosion. (Haagen, 1989)

Landuse and Ownership

Landuse distribution in the Larson sub-basin is shown in Figure E-2. Forest use covers 81% of the area and is primarily managed by large timber operators. Agricultural use, just over 7%, and rural residential use, 11.8%, are clustered along the estuary and main roads. Area of land use categories are shown in Table E-1. The estuary management area is designated under the Coos Bay Estuary Management Plan as agricultural land that may also be used for dredged material disposal or mitigation, and the adjacent channel may be used for subtidal log storage.

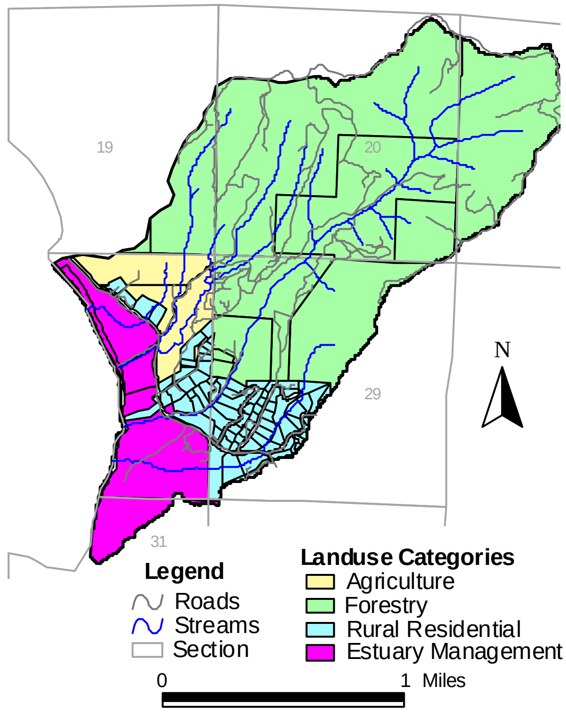


Figure E-2 Landuse Distribution

Table E-1 Landuse Area

Landuse	Acres	Percent
Agriculture	86	7.3
Forestry	958	80.9
Rural Residential	140	11.8
Unclassified	<1	0.02
Total	1184	

Hydrology

Precipitation

Annual precipitation is 65 inches at the lowest elevation s in the Echo sub-basin. Due to the west facing orientation, rainfall gradually increases as the elevation increases to a maximum of 67 inches, but averaging 65 inches for the whole sub-basin (OCS, 2003). The precipitation intensity for a 2-year 24-hour event is 2.8 inches. (OWRD, 2005)

Stream flow

Annual peak stream flow was obtained using the Peak flow estimation program (OWRD, 2005). They use hydrologic prediction equations and physical watershed characteristics to estimate peak flows. Figure E-3 shows the estimated discharge at the mouth of Echo Creek for storm events for two to five hundred year reoccurrence intervals. These values are for 1.11 sq. miles of the Echo sub-basin. The bankfull event is estimated to be 69 cfs. On the other extreme, a maximum discharge of 310 cfs is estimated for a 500-year storm event in Echo Creek.

Figure E-3 Annual Peak Discharge Estimates (OWRD, 2005)

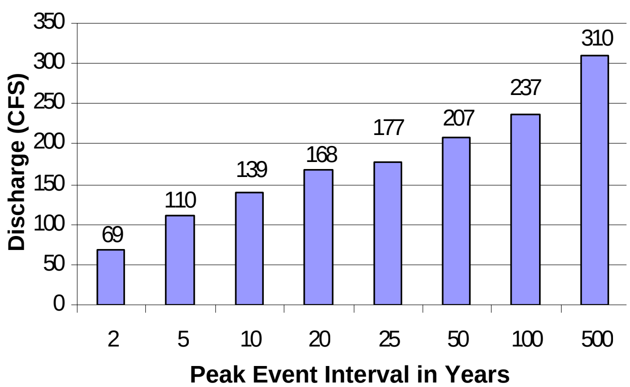


Table E-2 Discharge Measurements 2004

Location	Date	CFS
Valley	16-Jun	0.63
Upper Forest	17-Jun	0.35
Valley	18-Aug	0.24

Miscellaneous summer flow measurements were collected for Echo Creek in 2004 (CoosWA). Table E-2 shows the summer flow on Echo Creek at two different sites in 2004. The lowest flow recorded was taken with a flume at the Valley site (0.24 cfs). Based on these measurements the base summer stream flow ranges between 0.63 and 0.24 cfs.

Landuse Effects on Hydrology

Land uses, as they affect ground surface conditions, can be used to make general evaluations of the hydrologic condition of a watershed. Of particular concern is the effect of land uses on peak stream flow, since increases in runoff can contribute to flooding, erosion, and culvert failures. The most important determinant for peakflow increases is the ability of soils to absorb rainfall.

The impacts from agriculture on hydrology are dependent on the type of cover and management treatments, as well as the characteristics of the soils (OWEB, 1999). We assessed these factors and compared them to the change in runoff from the background condition. This change will be rated as followed: < 0.5 inches, 0.5 to 1.0 inches, and > 1.5 inches.

All of the area in Echo sub-basin is made up of the hydrologic soil group (HSG) Class D. The HSG Class D has very slow infiltration rates and high runoff rates. Agriculture has a greater affect on runoff in areas where soils have a high infiltration rate compared to areas where soils are relatively impermeable in their natural state (USDA, 1986). In the Echo sub-basin, the change in runoff from the background conditions increased by 0.27 inches. Because of this, the potential risk of peak-flow increases is low.

Forest and Rural land use will be assessed by their percentage of area that is comprised of roads. They will be rated as: low < 4%, medium 4% - 8%, and high > 8%.

Within the forest use area, there are 11.46 linear miles of forest roads. These roads take up approximately 3.4 percent of the forested area. If the percentage of forest area rises above 8 percent, the potential risk of increasing peak-flow moves to high (OWEB, 1999). Because of this low percentage, relative potential risk for peak-flow increases is low.

There are approximately 2.84 linear miles of rural roads in the residential, or 4.2 percent. This percentage ranks the Echo residential area as a relatively moderate potential risk for peak-flow increases.

Overall, Echo sub-basin's potential risks of peak-flow increases from land use impacts are low.

Water rights

There are two types of water rights in Echo Creek, domestic and irrigation. The most senior water right in was established in 1956 for domestic use. There are no storage rights in Echo sub-basin. Total allocated water rights for the entire watershed are 0.225 cubic feet per second. The water rights for domestic use are 0.21 cfs, and .015 cfs for irrigation. There are no instream rights for Echo Creek and the unnamed tributaries within the sub-basin.

Water Availability

For the Echo sub-basin, water availability is estimated using the Water Availability Report System (OWRD, 2005). The average water available is based on the 50% annual exceedance level. The water availability is derived from the estimated natural stream flow shown in Table E-3 below. There is no time of the year in which the allocated rights exceed estimated natural stream flow. Also, the consumptive water use has not increased by more than 10% since 1993.

Table E-3 Monthly Net Water Available (OWRD, 2005)

Month	Natural Flow	Consumptive Uses	Instream Flow	Net Water Available (cfs)
Jan	4.80	0.00	0.00	4.80
Feb	5.25	0.00	0.00	5.25
Mar	3.80	0.00	0.00	3.80
Apr	2.41	0.00	0.00	2.41
May	1.11	0.00	0.00	1.11
Jun	0.65	0.00	0.00	0.65
Jul	0.33	0.00	0.00	0.33
Aug	0.17	0.00	0.00	0.17
Sep	0.12	0.00	0.00	0.12
Oct	0.15	0.00	0.00	0.15
Nov	0.98	0.00	0.00	0.98
Dec	3.82	0.00	0.00	3.82

Aquatic Habitat

Aquatic habitat surveys addressed in this assessment include unit type, substrate type, riffle sediment, pool depth, large wood, and bank stability (bank stability is presented in Sediment Sources).

Echo Creek flows out of Echo valley, which is moderately steep, and narrow. The upper reaches are confined by hillslopes which then transition to alluvial fan and finally a small, low-gradient flood plain with constraining terraces. The Beaver Pond is a large wetland area and some surveys were unable to be done there due to lack of visibility. Echo Creek has a tide gate at the mouth and smaller gates on the lower tributaries and other streams in the sub-basin. See Appendix A for specific channel morphology metrics.

The Echo Creek aquatic habitat survey, which is on Echo Creek only, starts at the tide gate at the mouth of the stream. Aquatic habitat survey reaches are shown in Figure E-4. These reach names will be used to describe locations within the Echo sub-basin throughout this assessment.

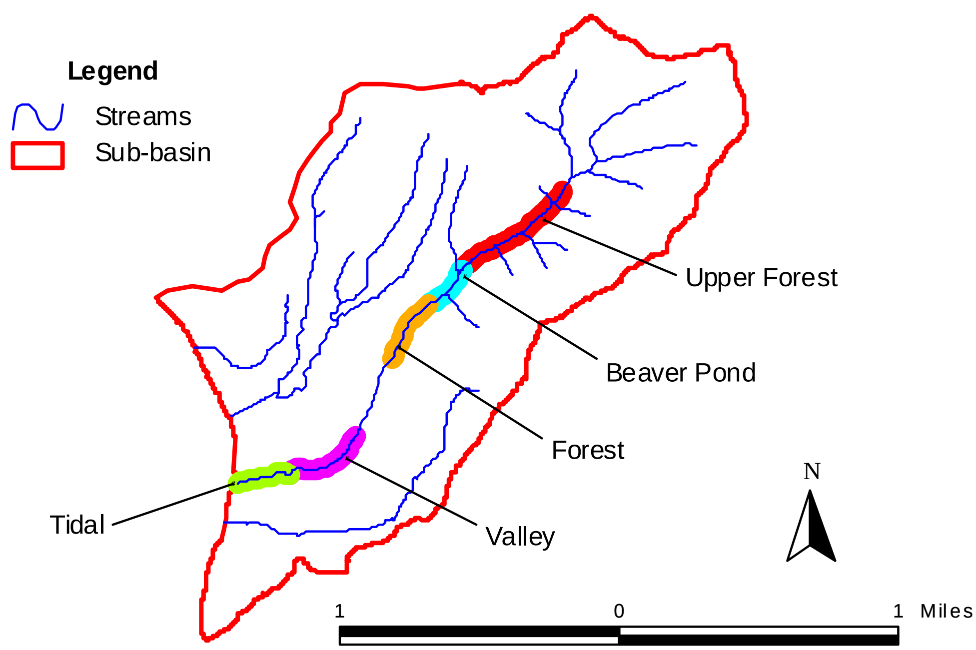


Figure E-4 Aquatic Habitat Study Reaches

Figure E-5 shows the percentage of unit area per unit type for each of the five reaches surveyed. The Echo reaches are characterized by pools with increasing riffles further up the valley except for the Beaver Pond reach.

Figure E-5
Unit Types

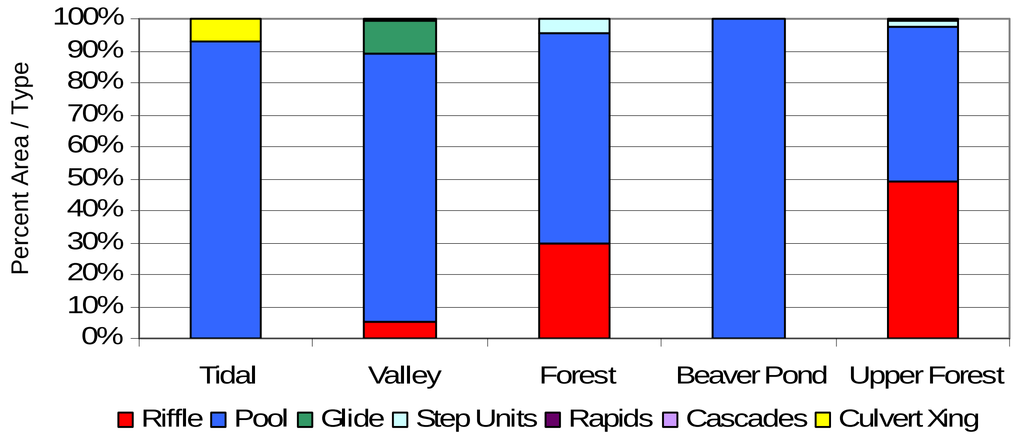


Figure E-6 shows the percent of the different substrate types per reach. These correspond with the unit types. The boulders in the Tidal reach were placed there previously as an attempt to riprap around the culverts and tide gate. It has been dredged to maintain drainage. The Beaver Pond reach may be acting as catch basin for sediment.

Figure E-6
Substrate
Types

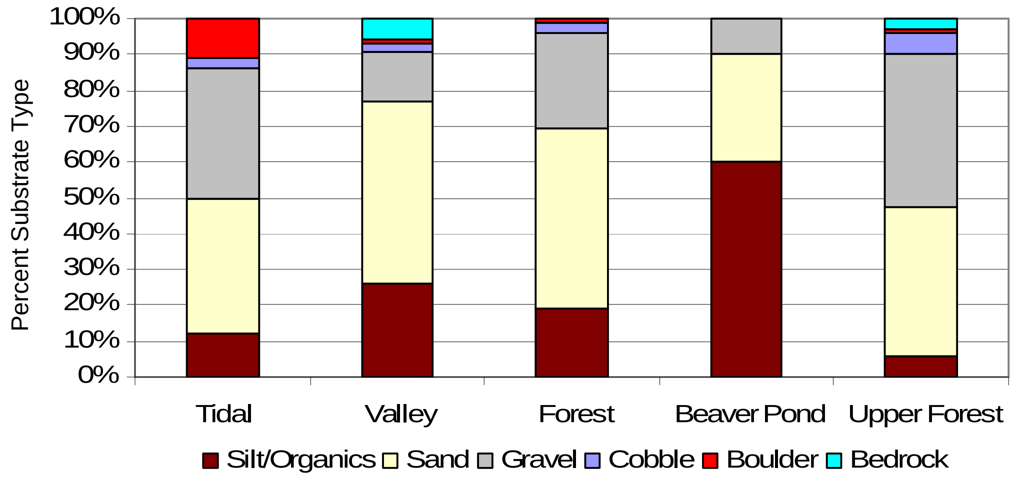


Figure E-7, riffle sediment, analysis for those reaches containing riffle units. (There weren't any riffles for the Tidal and Beaver Pond reaches.) Each of these reaches contains very high amounts of gravel, however, the fine sediment levels are highly undesirable.

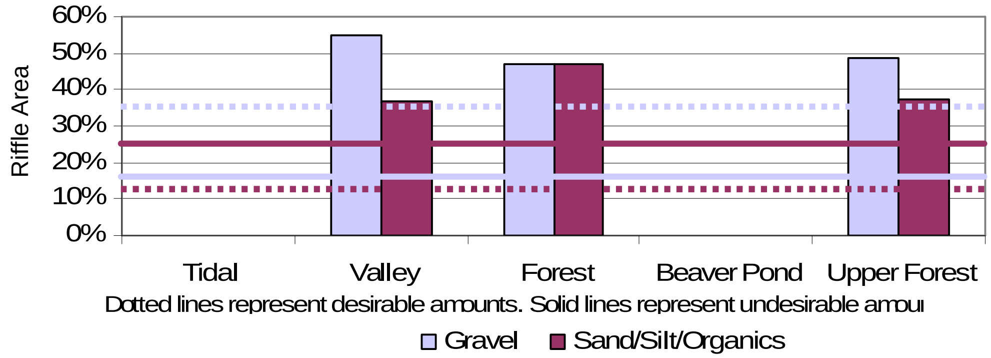


Figure E-7 Riffle Sediment

Figure E-8 shows average pool depths. None of the reaches had pool depths below the undesirable benchmark, however, the Tidal reach has very poor residual pool depths. Residual pool depth was not surveyed in the Beaver Pond reach due to its overall depth.

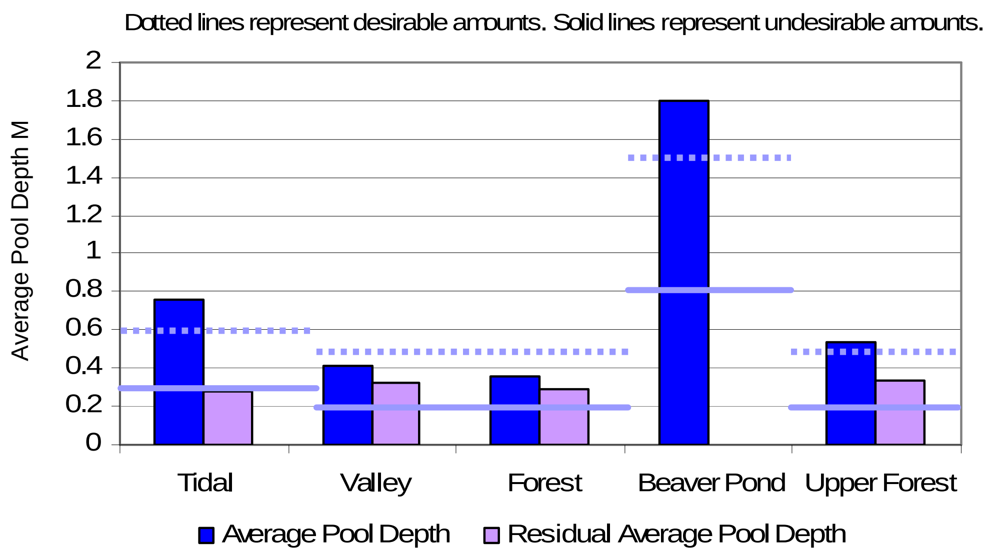
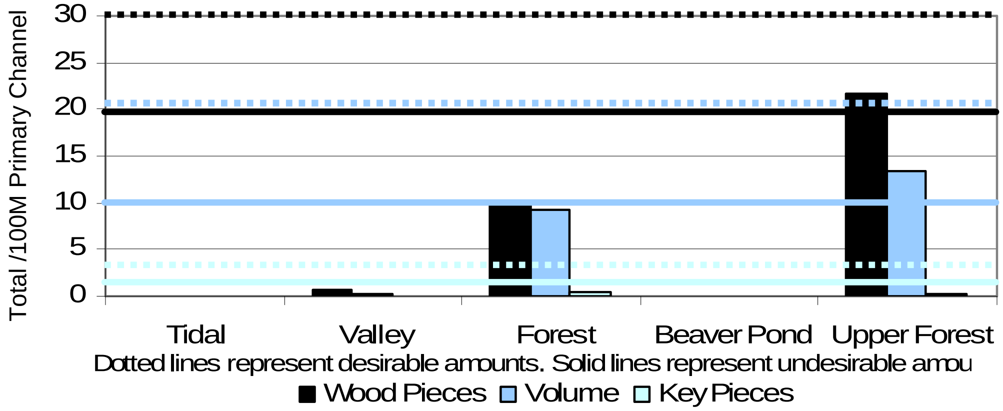


Figure E-8 Pool Depth

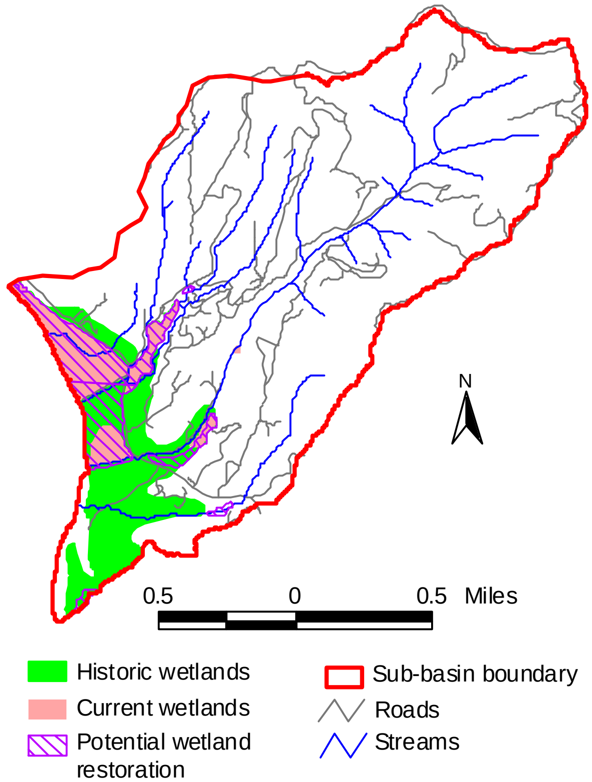
Figure E-9 describes the large wood analysis. The Tidal and Valley reaches had little to no large wood, and the Forest and Upper Forest reaches, had some wood but below desirable levels. Large wood was not visible in the Beaver Pond reach, but approximately one third of its surface is covered with live trees growing in the pond.

Figure E-9
Large Wood



Wetlands

Figure E-10
Wetlands



Historic, current and potentially restored wetlands in the Echo sub-basin are shown in Figure E-10 and Table E-4. The current (2005) wetland extent, determined by CoosWA using aerial photography analysis, is land presently dominated by wetland vegetation and not showing signs of recent agricultural production. In most cases, however, 'current wetland' is not a properly functioning wetland and is included in the area of potential wetland restoration. The area considered current wetland is 31% of the historic wetland extent in this sub-basin. Historic wetland extents are based on soil type and plant characteristics. Forty-one percent (80 acres) of the historic wetlands in this sub-basin are described in the National Wetland Inventory as 'emergent', meaning they were dominated by rooted herbaceous plants, and are seasonally flooded. It is the emergent seasonally flooded areas, not currently functioning as wetland, that CoosWA recommends for restoration consideration as these areas are often more difficult to manage for crop production. Wetland restoration is discussed in more depth in Chapter 3, and National Wetland Inventory categories are provided in Appendix A.

Table E-4
Wetland Areas

Wetland Type	Acres
Historic wetlands	194
Current wetlands	60
Potential wetland restoration	83

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Sediment Sources

Sediment sources considered in this assessment include unstable stream banks, unstable slopes, erosion associated with roads, and stream crossings with road fill at risk of failure.

Bank Stability

Bank stability surveys are conducted as part of the aquatic habitat surveys. Figure E-11 shows the bank stability ratings for each aquatic habitat reach. The Valley, Forest and Upper Forest reaches have more than the acceptable amount of unstable banks, while the Beaver Pond reach has all covered, stable banks.

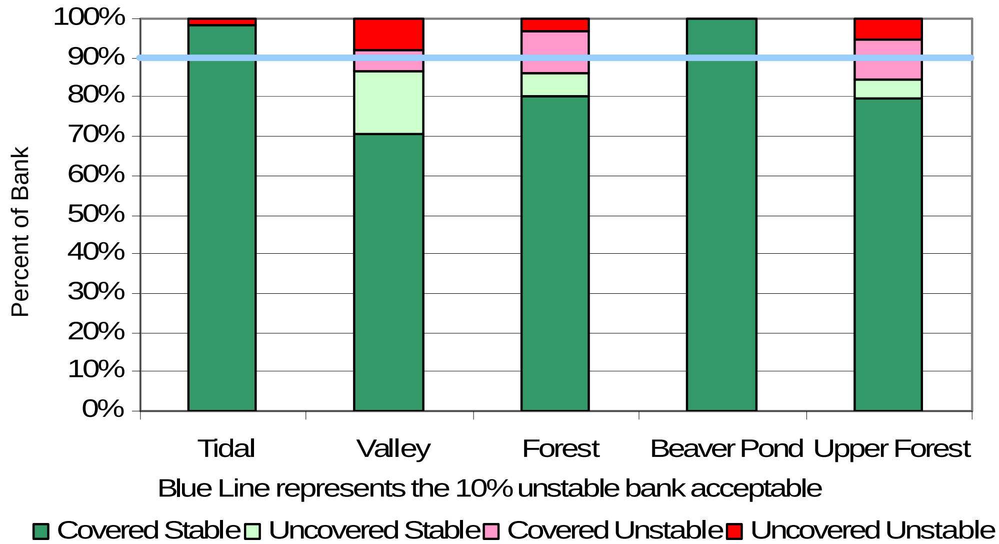


Figure E-11
Bank Stability

Slope Stability

The slope stability analysis (see Figure E-12) shows the amount of sub-basin area within each landslide potential risk classification. According to the analysis, 72.6% of the sub-basin is in the low risk category, 21.1% is at moderate risk, and 3.8% is at high risk. The most unstable slopes are located in the headwaters of Echo Creek, in the highest eleva-

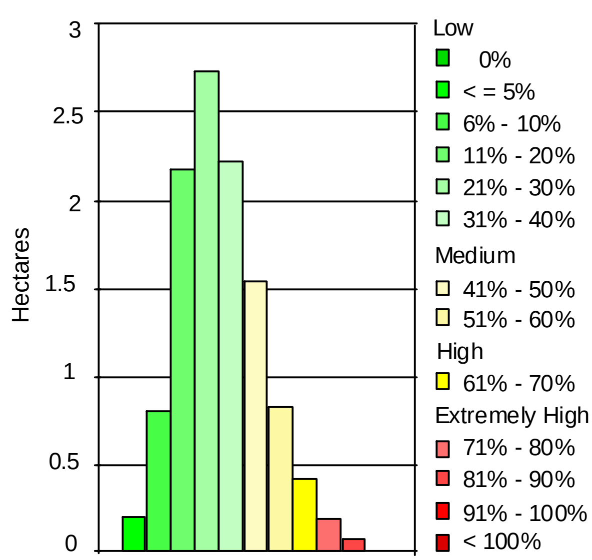


Figure E-12
Slope Stability Risk Classifications

tions of the most northeastern part of this sub-basin. Most of the steepest slopes are found in areas of Tyee silt/sandstone, which means that there is high potential for slope failure in these areas.

Road-Related Erosion

The Echo Creek road and landing survey was conducted between June and July, 2004. All private roads were surveyed where landowner permission was granted. A total of 17.2 miles of roads were surveyed, and there was an average of 3.7 drainage sites per mile. Within the Echo road and landing survey, there were 21 stream crossings, 16 ditch relief culverts, 18 ditch outs, one landslide and seven gullied road surface sites. Table E-5 provides a brief summary of the data collected. See Discussion and Restoration Opportunities for recommended drainage feature upgrades.

Table E-5 Road and Landing Survey Results

Site Type	Sites	Contributing Ditches	Ditch Lengths (ft)
Stream Crossing	21	28	Avg.357 Min.20 Max.1130
Ditch Relief	16	19	Avg.546 Min.60 Max.2130
Ditch Out	18	24	Avg. 344 Min.90 Max.1270
Potential Landslide	1	1	Avg.70 Min.70 Max.70
Gullied Road Surface	7	10	Avg.612 Min.10 Max.1550
Totals	63	82	

Stream Crossing Drainage Evaluation

The 21 stream crossing culverts studied in the road and landing survey were also rated for their ability to properly drain the area upstream during a 50-year peak rain event (see Table E-6, below). Of those 21 stream crossings 11 (52.4%) are at risk of failure or improper drainage or failure because they are undersized.

Table E-6 At-Risk Stream Crossing Evaluation

50-Yr. Rainfall Fill Failure Risk	Fill Volume Size Class									
	Minimal		Small		Medium		Large		Very Large	
	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yrds^3
Low	-	-	2	59	1	96	1	126	-	-
Moderate	-	-	-	-	-	-	-	-	-	-
High	-	-	-	-	-	-	2	542	-	-
Very High	1	2	2	63	2	156	-	-	-	-

Failure Risk, Low = 76% - 100%; Moderate = 51% - 75%; High = 26% - 50%; Very High = 0% - 25%
Fill Volumes, Minimal = $\leq$ 10 yds.^{3}; Small = 10 - 50 yds.^{3}; Medium = 51 - 100 yds.^{3}; Large = 101 - 500 yds.^{3}; and Very Large = > 500 yds.^{3}.

At-risk culverts are ranked in Table E-6 for failure risk based on the percentage of associated drainage area they can properly drain during a 50-year rain event. The number of culverts in each failure risk level (left column) spread across the table depending on the associated fill volume size class. It is important to consider both failure risk and fill volume since it is the fill that becomes the sediment source upon failure of the crossing.

These 11 at-risk culvert sites contain a total of 1044 yards^3 of fill. Of the 11 culverts that were found to be at risk of failure in the Echo sub-basin, five crossings with 221 yards^3 of fill ranked as having very high risk of failure, two crossings with 542 yards^3 of fill ranked as having high risk, and four crossings with 281 yards^3 of fill ranked as having low risk of failure.

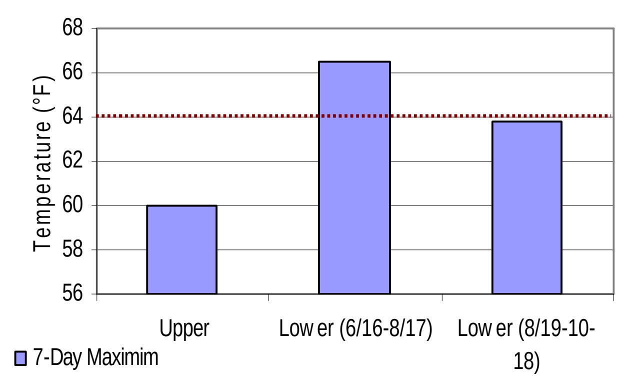
Stream Temperatures

Echo Creek was a new temperature study location in 2004 consisting of two temperature logging sites. One site was in the forested uplands, and the other just upstream of East Bay Drive, slightly east (approximately 300 meters) of where the stream enters the bay. The lower site on Echo was removed and replaced in July due to fear of tampering. The data from both units can be combined and used as one continuous data set but, for accuracy, is kept separate in some graphs.

Table E-7 Temperature Summary and Exceedance of Standards

Site Name	Year	7-Day Average			Days >64°F	Days >70°F	Hours >64°F	Hours >70°F
		Max.	Min.	Daily?? T				
Upper	2004	60.0	57.0	3.0	0	0	0.0	0.0
Lower Combined	2004	66.5	61.3	4.5	33	1	210.5	0.5

Table E-7 shows the 7-day average maximum and minimum temperatures, and the number of days and hours spent exceeding 64 and 70 °F for each temperature logging site on Echo Creek. Exceedance of the 64 °F standard is shown in Figure E-13, below. The data indicate that the lower site on Echo Creek did exceed the 64 °F standard during the first half of the summer. Both lower units combined recorded a total of 33 days exceeding the standard.

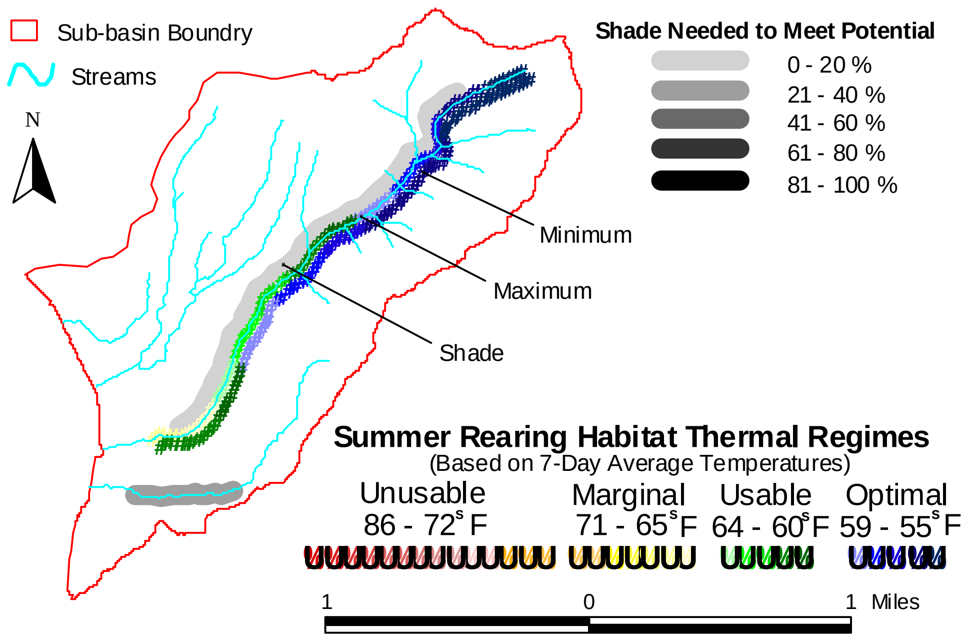


Red dotted line represents 64 °F std, higher temperatures undesirable

Figure E-13 7-Day Moving Averages of Daily Maximum Temperatures

Figure E-14, below, illustrates the temperature trends within the sub-basin using 7-day average maximums, and colors them according to salmonid suitability. The majority of Echo Creek provides optimal or useable temperatures for rearing juvenile salmonids. Temperature increases from 55 °F at the headwaters to 66 °F near the mouth. The average daily high water temperature increased 0.835 °F per 1000 ft. from the upper site to the lower site.

Figure E-14 Temperature Trends and Riparian Shade Condition



Riparian Shade

The difference between current and potential shade is shown in Figure E-14, above, and is expressed as shade needed to meet potential. The darker riparian areas on the map have the least amount of current shade. Current and potential shade values in the Echo sub-basin are 89% and 94% respectively in the upper-most, steep canyon segments. The upper valley has 85% and 96% respectively, and the lower valley segments have 78% and 99% respectively. The Echo sub-basin holds the highest current shade values in the assessment area in all three geographic categories.

Salmonid Distribution

Coho and winter steelhead distribution, according to ODFW, is shown in Figure E-15. Oregon Department of Forestry (ODF) classifies general fish use streams including cutthroat trout (green line is hidden under the steelhead and coho lines). The spawning survey area is enlarged below in Figure E-16.

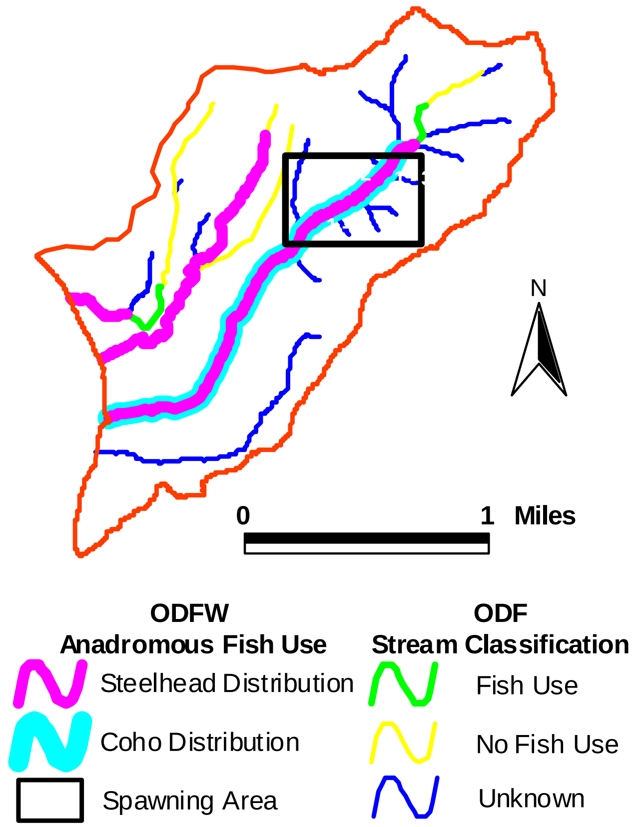


Figure E-15 Salmonid Distribution

Stocking Records

There were no reports of historic stocking in the Echo sub-basin. Communication with local landowners may provide knowledge of historical, smaller, private stocking history.

Spawning Surveys

The Coos Watershed Association conducted its first Echo Creek spawning surveys in the 2003 season. (see Figure E-16). The start of the first segment of the reach begins at a beaver pond that is a wetland marsh. The first segment enters a forest canopy which provides a lot of shade from shrubs, conifers, and firs. There is a large amount of gravel in the first segment, though no fish were seen during the

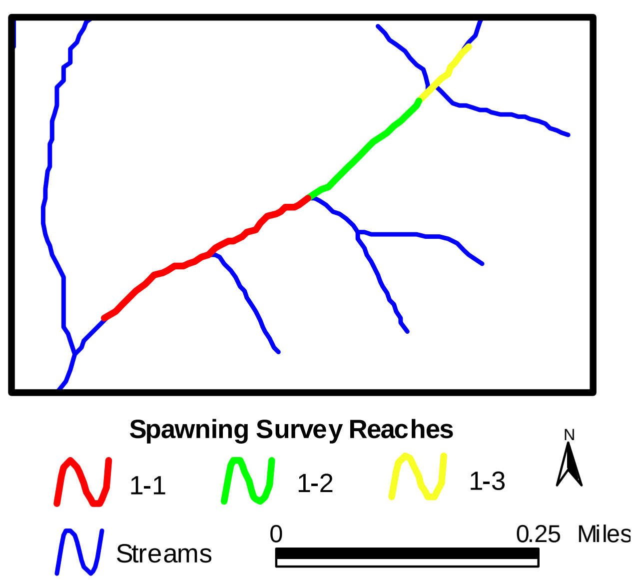
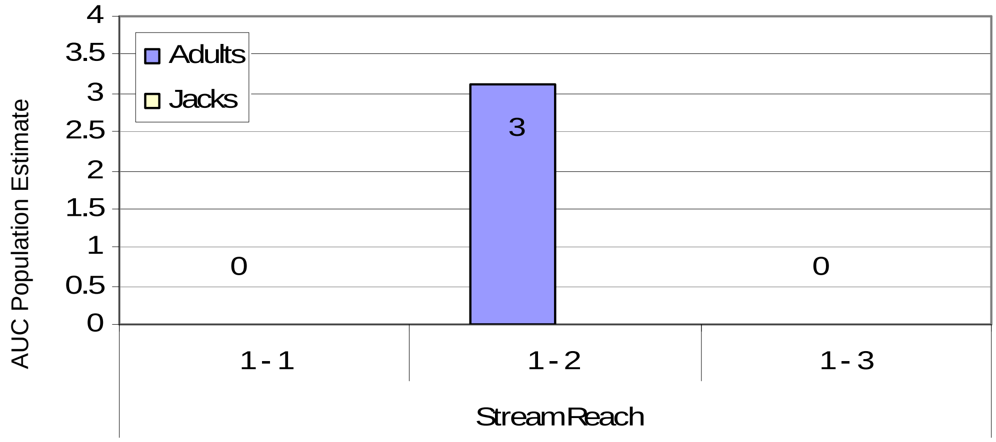


Figure E-16 Spawning Survey

Figure E-17 Spawning Survey AUC Population Estimate, 2003



spawning season. There are several small tributaries that branch from the creek throughout the reach. The dense canopy continues throughout the second and third segments of the reach. The third segment ends at a large pool with a waterfall which is a fish barrier. The upper part of the third segment has much more bedrock and less gravel is visible.

The amount of gravel found in reach 1-3 was significantly lower than in the other two reaches (see Table E-8). No fish were observed in reaches 1-1 or 1-3 (see Figure E-17), however, one redd was observed in segment 1-3. Segment 1-3 showed the highest redds/km, only because one redd was found and it was a short reach (.12 km). Reach 1-2 had 12 adult coho/km with a peak redd/km count of four. There were no other fish observed on the other reaches, and no other species of salmon were observed during the spawning survey season.

Table E-8 Spawning Density

Reach	Total AUC/Km	Gravel (m^2)	Gravel (m^2)/ Female
1 - 1	0	107	0.0
1 - 2	12	107	71.3
1 - 3	0	33	0.0

Echo Creek has many elements of a functioning stream for fish habitat such as adequate gravel, a dense canopy that provides shade, and stream sinuosity. The fact that more fish were not observed in this system may be related to its small size and narrow valley widths. More surveys are needed to truly understand the spawning activity of this system.

Intrinsic Potential for Coho Smolt Production

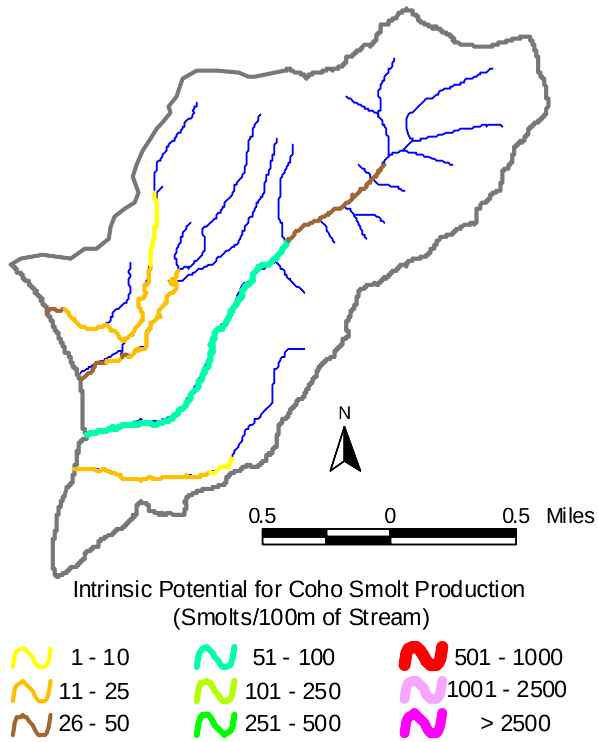


Figure E-18 Intrinsic Potential For Coho Smolt Production

The intrinsic potential for streams in the Lowlands area to produce coho smolts was estimated based on digital elevation models, active channel and valley widths, known natural barriers and coho life histories. The values indicate the number of coho smolts supported by historic, pre-settlement stream conditions. Intrinsic potential for the Echo sub-basin, shown in Figure E-18, indicates that Echo Creek has the highest intrinsic potential in the sub-basin – up to 100 smolts per 100 meters of stream almost the entire length up to the second tributary. to Other streams in the sub-basin indicate intrinsic potentials ranging between 1 and 50 smolts per 100 meters of stream. Intrinsic potentials in the Echo sub-basin are much lower than in other sub-basins, which reach the >2500 range in the main stems. This reflects the coho preference for wider active channel and valley widths than are available in the Echo sub-basin. The thin blue lines, streams, indicate zero intrinsic potential due to gradients above 20% and known natural migration barriers. Understanding intrinsic potential for a particular stream will help to inform restoration efforts and to set realistic coho population goals. Total intrinsic potential for smolt production this sub-basin is 2,191 smolts. Intrinsic potential for adult coho returns under low ocean survival rates (1%) is 22, and under high ocean survival rates (10%) is 219 fish.

While restoring coho smolt populations to these levels is unlikely given current land uses and infrastructure, understanding intrinsic potential for a particular stream will help to inform restoration efforts and to set realistic coho population goals.

Habitat Limiting Factors to Coho

The limiting factors analysis (based on Reeves et al., 1989), shown in Table E-9 below, indicates habitat limiting bottlenecks for coho in both summer and winter rearing habitats based on current conditions. The analysis showed that the system currently has only 66% of the summer habitat needed to support the maximum number of smolts potentially produced from current available spawning gravel. The analysis also shows that while winter and spring habitat was limiting, they are less of a constriction in the life history than summer rearing habitat. Summer temperatures were within acceptable parameters.

Echo Habitat Component	Potential Summer Population	Area/ Survival Factor	Area Needed (M^2)	Current Usable Area (M^2)	Smolt Factor	Smolts Produced
Spawning	22,569	0.006	135	247	95.5	23,589
Spring Rearing	22,569	0.3	6,771	8,962	1.7	15,235
Summer Rearing	22,569	0.6	13,541	8,962	0.9	8,066
Winter Rearing	22,569	0.4	9,028	7,955	1.2	9,546

Table E-9 Limiting Factors to Coho Populations

Resource Issues

Landowner Concerns and Desired Future Conditions

Landowners in the Echo sub-basin expressed their concerns about the area at a Coffee Klatch meeting on April 19, 2005. Of the landowners contacted, eleven percent attended the meeting. As shown in Figure E-19, land management issues were the main concern in this sub-basin. Within this category, the topics of tide gate maintenance, drainage structures and flood control were most common. Culvert and tide gate "blow-outs" were discussed as well as the need for dredging of the lower reaches of streams. Infringement of property rights and the difficult permit process for in-stream work were also listed concerns.

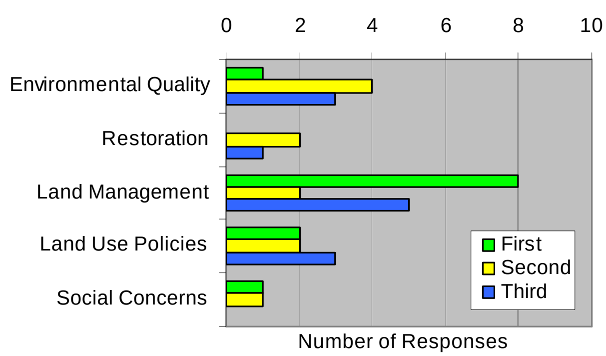


Figure E-19 Landowner Concerns

Landowners also expressed concern about environmental issues including fish and wildlife habitat, and water quality. A wooden dam was mentioned that may be a barrier to fish access. In addition, like other sub-basins, Echo landowners complained of beaver causing damage to dikes, tide gates, and undermining the road. The tide gate functions for tidal exclusion, but the associated culvert is undersized for the drainage and the gate may be an impediment to fish passage.

The residents of the Echo sub-basin have expressed their desires for the future of the area which include restored fish populations, good water quality, and paved roads. There was interest in developing a controlled elk crossing that would reduce erosion to the road and stream bank.

Coos Bay Lowland Assessment and Restoration Plan

Chapter 3:

Restoration Strategy

Coho spawner. Photo CoosWA, 2003.

Chapter 3: Restoration strategy

The goal of this restoration strategy is to capitalize on project opportunities that improve the function of ecological processes while preserving or enhancing economic utility of the land and the overall livability of these sub-basins for the community. The goal of restoration, in this case, is to rehabilitate watershed conditions that allow for habitat connectivity, and sustained anadromous fish populations, as well as other ecological functions such as water quality, and natural sediment transport. Our intention is to combine landowner interests and concerns with a strictly biological ranking to determine which restoration actions have the most synergistic potential.

Potential Restoration Actions

Below are short discussions of various action types considered in this restoration strategy, followed by a description of the scoring and ranking system used to prioritize the actions within regions of each sub-basin. Actions were scored for a series of biological criteria and socio-economic criteria for the region(s) appropriate for that action (see Appendix A – Prioritization Methods and Prioritization Scoring Tables).

Add secondary and off-channel features would involve excavation of pools or ponds adjacent to the stream to create winter rearing habitat for coho salmon. The ponds must be constructed with freshwater flow that will keep the outlet of the pool open and connected to the main stream. The freshwater flow must be from a clean source that does not produce significant amounts of sediment that would cause the pool to fill.

Culvert replacements would involve removing existing culverts and replacing them with culverts or bridges that are able to pass the anticipated 100-year flood event and which are at least as wide as the bank full width of the stream. New culverts would be embedded to create a stream-simulation to ensure full fish passage.

Landslide area protection would involve retaining additional conifers in steep, landslide prone tributary draws.

Levee removal would involve end-hauling or spreading existing levees thinly to allow the stream to flood pasture areas. This project may involve building levees to protect houses or other infrastructure. The project would cause land to flood more often, but may allow land to drain more quickly as flood waters subside. Also, sediment would be deposited on floodplains which would reduce channel sediment deposition and build up potentially productive land, countering the subsidence processes.

Levee setback would involve moving levees away from stream banks to allow for improved stream function including meandering, localized flooding and development of natural streamside vegetation.

Reshape stream channel would involve reconstructing stream channels by creating a natural, meandering channel pattern in places in which channels have been ditched or banks hardened. This would usually only be done in cases in which riparian planting and fencing was going to occur at the same time.

Riparian forestry would involve leaving a wider no-harvest riparian buffer and retaining more conifers in the riparian areas than are required under the Oregon Forest Practices Act.

Riparian planting and fencing would involve excluding livestock from the stream with appropriate fencing designs. Fences would usually be set 15 to 35 feet off the stream and buffers would be planted with a diverse mix of conifers, hardwoods, and shrubs. Planting prescriptions would be designed to meet both landowner and biological objectives.

Roads upgrades typically would involve upgrading or adding additional cross-drain culverts or upgrading stream crossing culverts in order to help prevent ditch water from discharging into streams and help prevent road fills from becoming saturated and failing.

Tide gate relocation would involve removing the tide gate from its existing stream crossing and moving it, usually upstream in order to maximize the tidal exchange. This action would involve construction of levees to protect infrastructure and pasture.

Tide gate removal would involve removing tide gates from stream crossing bridges or culverts to allow tidal water to flow upstream. The project may involve raising levees to protect upstream landowners and replacing the stream crossing structure to increase the flow capacity for tidal fluctuation.

Tide gate replacement would involve replacing the existing, top-hinged gates with improved, fish-friendlier designs including side-hinged gates or gates with a mitigation device that holds the gate open longer. Replacement gates would be expected to maximize the amount of time that the gate remains open, allow fish passage during the entire open time, and allow a saltwater mixing zone upstream of the tide gate.

Wetland restoration would involve restoring hydrological processes to allow an area that was historically inundated at least seasonally by removing tide gates and levees. Supplemental restoration activities may include planting native vegetation, constructing drainage networks or pools, and placing large wood.

Various project types considered in our restoration strategy may raise questions within adjacent communities as to the implications and impacts of these projects. Their function in terms of ecological processes, as well as how the project may affect landowners, is discussed below. At this point, these are conceptual project actions only and only in a few cases have specific projects been proposed.

Tide Gates

Tide gates have a major influence on Lowland streams. The main stem tide gates significantly change the movement of water, sediment, and fish into and out of the stream systems. Smaller tributary tide gates also cause potentially valuable salmon rearing areas to be inaccessible to these fish. While technology in 'fish-friendlier' tide gates is advancing, the ability of newer designs to significantly improve fish passage and to address problems with sediment movement and water temperature have not been proven.

Although relocating or removing of the main tide gate is considered from strictly biological perspective, the CoosWA is not making any assertions about the viability of that project. Such large scale changes would require a significant engineering and design study and does not match well with most landowner concerns. Removal of some of the smaller culvert tide gates, especially in association with culvert improvement, does seem to have the potential to improve conditions. Even with these smaller projects, care would need to be taken in design to protect adjacent landowners.

Wetlands

Land historically drained for agricultural cultivation is often difficult to maintain for its current purpose and many bottom land owners are in constant battle against field drainage issues. In these conditions, wetland plants threaten to reestablish dominance over preferred crops – often rendering pastures marginal or economically unproductive.

CoosWA sees the potential for mutual benefits to landowners and to watershed function with strategic wetland restoration. Many contemporary land managers are finding that taking advantage of natural systems helps increase productivity of their operation. Properly managed, wetlands have the ability to reduce flooding in other areas of the sub-basin by allowing large volumes of water to be stored during peak flow events. Wetlands can also provide natural sediment deposition areas- reducing the need for dredging. Wetlands are prime off-channel and over-wintering fish habitat, which in many sub-basins is the limiting factor to coho populations. Essentially, well-planned wetland restoration could make currently unproductive land ecologically useful while improving conditions on more economically productive areas.

Wetland restoration, although not feasible for the entirety of wetland area shown, would help alleviate some of the top landowner concerns if strategically placed and managed. As discussed in Chapter 1, wetlands function to attenuate flood water, especially when located in the mid reaches of a stream system, thereby reducing flood inundation downstream. Wetlands could potentially be designed specifically for the purpose of storing water during high flow periods while allowing other pasture areas to drain more efficiently. The use of strategic dikes around the wetland could be employed to protect nearby areas from wetland flooding.

Wetlands also function as natural sediment catchments and could function for this purpose in the Lowlands area, which suffers from chronic sediment issues. Dense vegetation can filter sediment from runoff entering the wetland from adjacent land uses. Wetlands can reduce sediment coming downstream by slowing the rate of flow and catching the sediment that falls out of the water column.

Prioritization Process

Restoration prioritization was determined by CoosWA through a process of scoring and ranking of each potential action for two sets of criteria. One set of criteria was used to evaluate actions for biological efficacy towards habitat restoration based on assessment data and limiting factors analysis. Scores for biological criteria are assigned within the context of current watershed conditions and the amount of biological benefit estimated as a result of the potential action. The other set of criteria addressed socio-economic feasibility questions. Appendix A contains detailed information about the methods of prioritization, score definitions and the scoring tables for each sub-basin.

The prioritization scoring process results in two sets of combined weighted scores for each action using higher scores to indicate the likelihood of successful results. The six biological criteria include the actions estimated ability to restore watershed processes, restore connectivity, address (Reeves, 1989) Limiting Factors, longevity of the project type, preservation of a unique habitat type, and the extent that the action type has been proven effective. The socio-economic feasibility criteria, used as a filter to the identified biological priorities, include the action's estimated likelihood of success, educational benefit, ability to address local landowner concerns, measurability of effects, implementation feasibility, fundability, and cost range.

Table 3-1 Priority Levels and Implications

Priority	Implications and CoosWA Approach
(green)	Implementation would be easier and project would have a high biological return. CoosWA would support the project and seek funding.
(yellow)	Implementation would be harder, but project would have a high biological return. CoosWA would seek to build partnerships and educational demonstration opportunities.
(blue)	Implementation would be easier, but project would have a lower biological return. CoosWA may assist with project design, but would not be a lead in funding development.
(red)	These projects either have low scores for biological returns and socio-economic feasibility, or received a zero score in a particular criteria. Implementation is considered unlikely.

Contrasting of the aggregate scores, based on the two sets of criteria for each action, was done using a threshold of two, and particular criteria acting as 'deal killers' if receiving a score of zero. The score threshold system was used to determine levels of priority and inform the nature of CoosWA's involvement with project development. The levels of priority and CoosWA approach are indicated in the sub-basin restoration plan maps using the colors shown in Table 3-1. The levels are shown in Table 3-1 in descending order from green / high priority to red / low priority.

A potential action that scores above a two in both categories (biological and socio-economic) falls into the green priority level. These projects are more likely to be easily implemented and data analysis shows that such projects will have high biological returns. Actions receiving a yellow priority level were scored above a two in the biological category and below a two in the socio-economic category. CoosWA will seek opportunities to build partnerships and provide educational materials to interested landowners to increase project support. Actions within the blue priority level were scored below two for biological returns and above two for socio-economics. In this case CoosWA may assist with project design but would not take a lead role in funding development due to the lower biological benefits. Actions in the red priority level are those that scored low in both categories, or received a zero for particular criteria. Red priority actions are not included on the restoration maps. See Appendix A for prioritization methods and score sheets.

Coos Bay Lowland Assessment and Restoration Plan

Chapter 3:

North Slough Sub-basin

Restoration Opportunities

North Slough historical channel. Photo CoosWA, 2003.

Discussion of Restoration Opportunities

This section discusses the need for restoration in named aquatic habitat survey reaches (see Figure NS-20) within the sub-basin based on analysis of survey data presented in Chapter 2: North Slough Sub-basin Assessment. In conclusion, restoration priorities are presented within each of four larger regions (see Figure NS-22) based on the prioritization scoring system introduced in Chapter 3: Restoration Strategy.

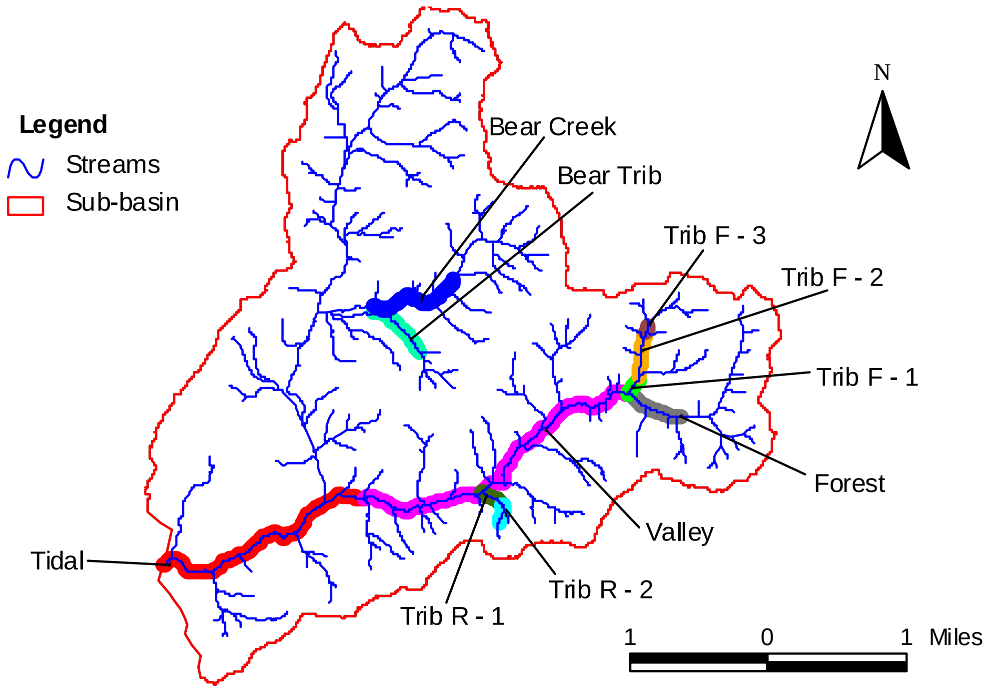


Figure NS-20 Aquatic Habitat Survey Reaches

Assessment data analysis indicated that habitat conditions in the North Slough sub-basin generally decline as streams flow from the upper, narrower valleys toward the lower, larger valleys and then through tide gate. According to the Limiting Factors analysis (Reeves et al., 1989) lack of summer rearing habitat due to high stream temperature is the most limiting to coho populations. Delivery of fine sediment and lack of in-stream complexity also impair stream habitat. Landowner concerns are centered on tide gate and culvert function, road maintenance, and the dredging permit process.

Temperature and Shade

Temperature analysis showed that while the upper main valley and tributary reaches (aquatic habitat survey reaches) have usable to optimal stream temperatures, the North Slough stream system overall did not provide adequate thermal conditions for juvenile salmonids. All sites exceeded the 64°F DEQ state standard with their 7-day maximum averages. The upper valley and tributary sites, although exceeding the 64°F standard at times, had fairly usable habitat for most of the summer. The lower reaches were very warm, with temperatures that could be fatal to juvenile coho. Future surveys should include more temperature data collection from the Bear Creek mainstem to gain insight as to its effects on the temperature of North Slough Creek.

The riparian shade analysis, which generally reflects temperature trends, showed that the Valley and upper tributary reaches were fairly well shaded, but the Tidal reach and segments of Bear Creek had very little shade-producing vegetation. Riparian shade in these lower areas is currently 69% below the potential shade values. Reaches needing riparian planting are Forest, Trib F-3, on Bear Creek between the surveyed reach and the mainstem, an unsurveyed area near the headwaters of the Bear Creek mainstem, a segment of Bear Creek within a mile of its confluence with North Slough Creek, and the entire Tidal reach. The areas needing the most riparian planting are largely in agricultural use, especially along the Tidal reach.

Riparian trees provide a multitude of other functions, many of which are needed in the North Slough sub-basin, including bank stabilization, sediment reduction and large wood recruitment

Sediment

The North Slough sub-basin has high natural sediment production that is accelerated by roads, unstable banks, and other land use practices. Confounding the problems caused by high sediment production is the fact that the tide gate at the lower end of the stream interrupts the natural sediment transport mechanisms and therefore very little sediment leaves the system.

High levels of fine sediment composition are found throughout the sub-basin. Sand-silt dominated channels are expected in the lower reaches where the stream has a very low gradient and low water velocities. However, in North Slough even the upper coho spawning reaches have higher levels of fine sediments in riffles than is desirable for salmon habitat. This is due to the soft sandstone parent material that readily breaks down into fines and the extensive road networks, many of which have excessively long ditches. Road and landing surveys indicate a total of 3,353 yds^3 of fill at culvert sites is in the high to very high risk rating for failure during a fifty year storm event. Most of which is from a single site on North Bay Drive.

More than 10% of the banks are unstable along the North Slough Creek's Main Valley and Forest reaches and on the Bear Creek reaches. Slope stability analysis indicates that 11.1% of the North Slough area is in the medium to very high risk categories for naturally occurring landslides.

Table NS-13 Road and Landing Treatment Recommendations

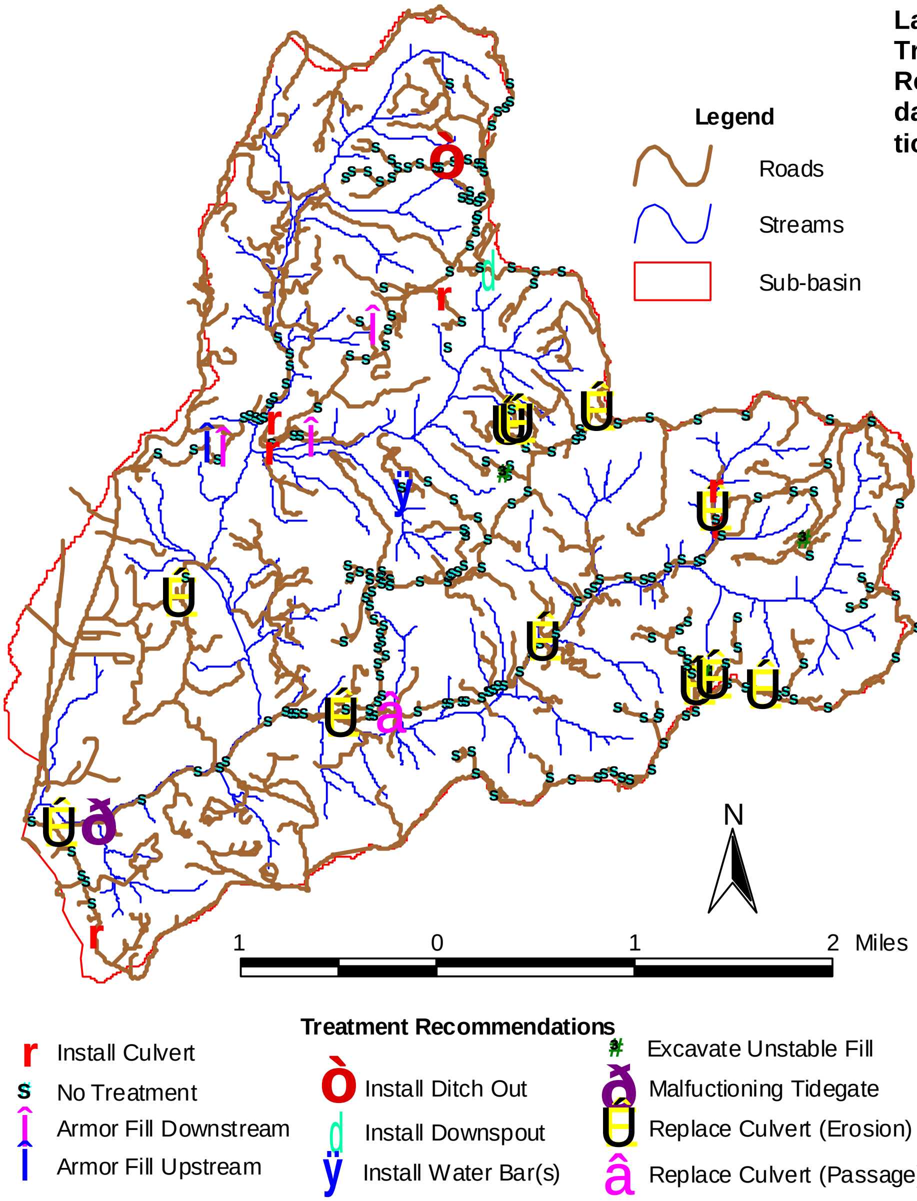
Site Type	New Structures Needed To Meet BMP	Replacement Structures Needed
Stream Crossing	33 Cross Drain Pipes	7 Culverts (6 Erosion) (1 Fish Passage)
Ditch Relief	7 Cross Drain Pipes	5 Cross Drain Pipes
Ditch Out	39 Cross Drain Pipes	-
Potential Landslide	3 Cross Drain Pipes	Excavate Unstable Fill
Ponding/ Gullied Road Surface	2 Cross Drain Pipes 2 Water Bars	1 Breach Berm 1 Install Ditch Out
Totals	86	14

Sediment build-up also contributes to increased temperatures by filling in pool areas that would otherwise be deeper, cooler and provide refuge for juvenile salmon. All pool depths for this sub-basin, except in the Main Valley reach, are below desirable depths, and the Tidal reach even falls below the undesirable depth.

Table NS-13, above, displays treatment recommendations based on the North Slough sub-basin road and landing surveys. "New Structures Needed" are based on Oregon Department of Forestry, 2003, Best Management Practices addressing ditch lengths. "Replacement Structures Needed" are based on field observations by road and landing survey crews following the Pacific Watershed Associates Road and Landing Survey Protocol adapted by the Coos WA.

Based on the Coos WA road and landing surveys, North Slough Creek needs 84 new ditch relief culverts (cross drain pipes) and two water bars to reduce road related sediment. The one site that is listed as a fish passage barrier is an undersized, perched culvert having a one foot drop on the downstream end. Of the 78 existing ditch relief culverts, five are deteriorated and need replacement. Of the three potential land slide sites, all need the unstable fill excavated. Of the four ponding road surface sites, two cross drain culverts and one ditch out should be installed to upgrade, and one gullied road surface site needs two water bars installed, and the other needs the berm breached. Four of the sites on the upper reaches of North Slough Creek have been addressed. One culvert needing replacement and two sites needing culverts installed were not treated due to a road decommission. A fish passage culvert was replaced with an adequate sized pipe. Figure NS-21, below, shows the location of recommended treatments.

Figure NS-21 Road and Landing Treatment Recommendation Locations



Addressing at-risk stream crossings by clearing culverts, upgrading culvert size, or replacing with bridges will alleviate future wash-outs that contribute large amounts of sediment to streams. A particular site needing special consideration is a fill crossing located on North Bay Drive. This site contains 2133 yds3 of fill that are at Very High risk. The drainage area above this site is relatively small yet, because the fill crossing is currently (2005) 99% plugged the site is not draining, and water is ponding behind the culvert.

Large Wood

All reaches in the North Slough sub-basin are severely lacking large wood in terms of wood pieces and key pieces. The Forest reach and Trib F-3 come just under or exceed the benchmark, respectively, for wood volume. Without riparian trees, especially large diameter trees, the lower reaches have very low potential for future large wood recruitment. Also, much of the upper forested land is managed for timber production which, depending on length of harvest cycles and the nature of forest and riparian management, may or may not lead to large wood recruitment.

Large wood and boulder placement projects should be targeted in the upper, forested reaches. These actions would improve spring and summer rearing habitat by creating pools, increasing pool depth by scour action, adding habitat complexity, and enhancing channel sinuosity. Large wood and boulder placement will also improve winter rearing habitat for juveniles by creating secondary or side channel areas, such as alcoves, backwaters, and isolated pools, for fish to find relief from high, fast winter flows. However, large wood placement may not be practical in North Slough at this time due to unstable, un-vegetated banks and lower priority ranking.

Conclusions

The results of the watershed health analysis and the concerns expressed by landowners make it necessary to establish positive working relationships in order to develop and implement successful restoration strategies. Effective habitat restoration efforts in this sub-basin will focus on reducing temperatures and sediment loading, and increasing stream complexity while also addressing concerns of landowners regarding drainage issues. The results from the North Slough sub-basin restoration prioritization process, below, intend to integrate 13 important criteria to provide the most logical and systematic approach to project development.

Prioritization of Potential Actions

Results of the prioritization process for the North Slough sub-basin are mapped below in Figure NS-22. Legend colors indicate how the action scored within its region and implies the general approach that CoosWA would take to the action type. A description of the prioritization process, scoring and action types is provided in Chapter 3 – Restoration Strategy.

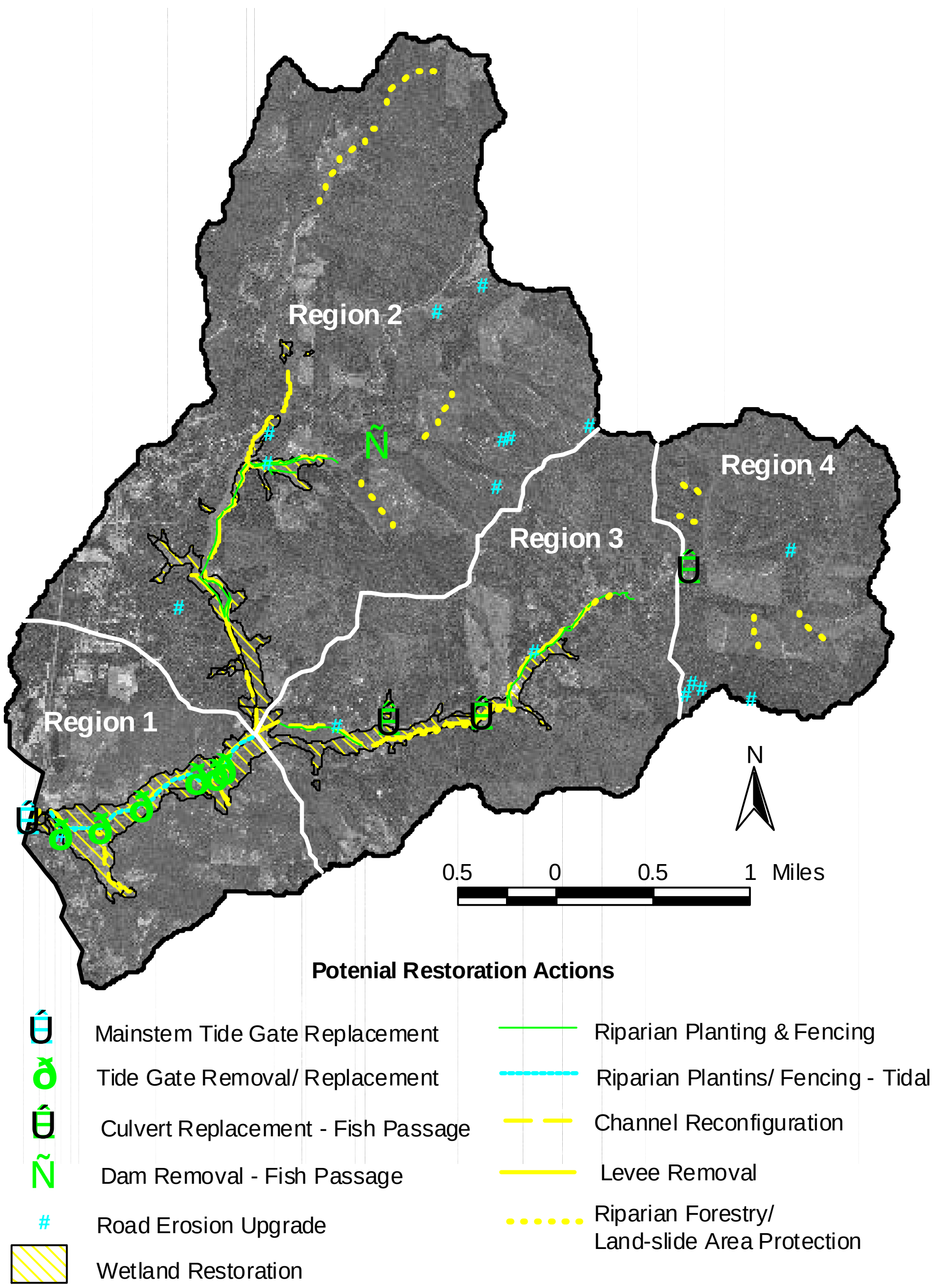


Figure NS-22 Potential Restoration Opportunities

Potential actions within each region are listed in Tables NS-14 and NS-15. The color next to each action corresponds to the colors on the map in Figure NS- 22, and to the prioritization score categories.

Region 1

Potential actions within Regions 1 are listed in Table NS-14. As the score-derived color coding indicates, Region 1 projects addressing fish passage at the tributary tide gates are given priority in this region based on both high biological returns and socio-economic feasibility. Tide gate relocation, levee removal, channel reconfiguration, and wetlands restoration all would have high biological returns but have a lower socio-economic ranking at this time. The CoosWA would seek project partners and encourage better understanding of these types of projects. Tide gate replacements, ditch maintenance, riparian planting and fencing, and implementation of farm plans are potential projects that rate higher socio-economically, yet would not have significant biological results. Therefore the CoosWA would not take a lead role in project development and implementation. Tide gate removal would have very high biological returns for the sub-basin, but received a zero for implementation feasibility. Levee setback, large wood placement and water conservation all scored low in both categories and will not be addressed farther in this restoration strategy.

Table NS-14 North Slough Regions 1 and 2

Region		Potential Actions
1	(light green)	Fish passage (trib tide gates)
	(yellow)	Levee removal
	(yellow)	Wetlands rest.
	(yellow)	Tide gate relocation
	(yellow)	Channel reconfiguration
	(blue)	Ditch maintenance (fish friendlier)
	(blue)	Tide gate replacements
	(blue)	Riparian fencing
	(blue)	Riparian planting
	(blue)	Implement farm plans
	(orange)	Large wood placement
	(orange)	Water conservation
	(orange)	Levee setback
	(orange)	Tide gate removal
2	(light green)	Riparian planting
	(light green)	Fish passage (includes dams etc)
	(yellow)	Channel reconfiguration
	(yellow)	Beaver encouragement
	(yellow)	Wetlands restoration
	(yellow)	Riparian forestry (buffers)
	(blue)	Implement farm plans
	(blue)	Roads (upgrades etc.)
	(blue)	Ditch maintenance
	(blue)	Riparian fencing
	(orange)	Water conservation
	(orange)	Large wood placement
	(orange)	Bank resloping (no plant)
	(orange)	Off-channel creation

Region 2

Potential actions within Region 2 are listed in Table NS-14, and shown in Figure NS-21. In this region, riparian planting and fish passage projects have the highest priority based on high scores for both biological returns and socio-economic feasibility. The next level of potential actions within this region include channel reconfiguration, beaver encouragement, riparian forestry buffers and wetland restoration. These would create significant biological improvements, but are ranked lower socio-economically. CoosWA would seek partnerships and demonstration opportunities where landowners are interested. Actions with lower priority, where CoosWA may assist with projects but not take a lead role include riparian fencing, ditch maintenance, implementation of farm plans, and road upgrades. Large wood placement, bank resloping, creation of off-channel areas, and water conservation projects all had relatively low scores and will not be pursued in this restoration strategy.

Region 3

Priority potential actions in Region 3 with high biological returns and socio-economic feasibility include riparian planting, riparian forestry, culverts for fish passage, channel reconfiguration and wetland restoration. Beaver encouragement rates high for biological improvements but is less feasible socio-economically. Riparian fencing and road upgrades would have less significant biological returns, but are supported more socio-economically. Large wood placement scored low in both categories and will not be pursued as part of this restoration strategy.

Region 4

There are no potential actions within Region 4 that scored high in both categories. Improved riparian forestry practices and landslide area protection would have higher biological returns but are less feasible socio-economically. Inversely, road upgrades, fish passage and large wood placement projects would be more socio-economically feasible, yet would have less significance biologically.

Table NS-15 North Slough Regions 3 and 4 Potential Actions

Region		Potential Actions
3		Riparian planting
		Riparian forestry (buffers)
		Channel reconfiguration
		Wetlands rest.
		Culvert (passage)
		Beaver encouragement
		Riparian fencing
		Roads (upgrades etc.)
		Large wood placement
4		Riparian forestry (buffers)
		Landslide area protection (head wall retention)
		Fish passage
		Large wood placement
		Roads upgrades

Coos Bay Lowland Assessment and Restoration Plan

Chapter 3:
Palouse Sub-basin Restoration Opportunities

Riparian planting on upper Palouse Creek. Photo, CoosWA, 2006.

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Discussion of Restoration Opportunities

This section discusses the need for restoration in named aquatic habitat survey reaches (see Figure P-19) within the sub-basin based on analysis of survey data presented in Chapter 2: Palouse Creek Sub-basin Assessment. In conclusion, restoration priorities are presented within each of four larger regions (see Figure P-21) based on the prioritization scoring system introduced in Chapter 3: Restoration Strategy.

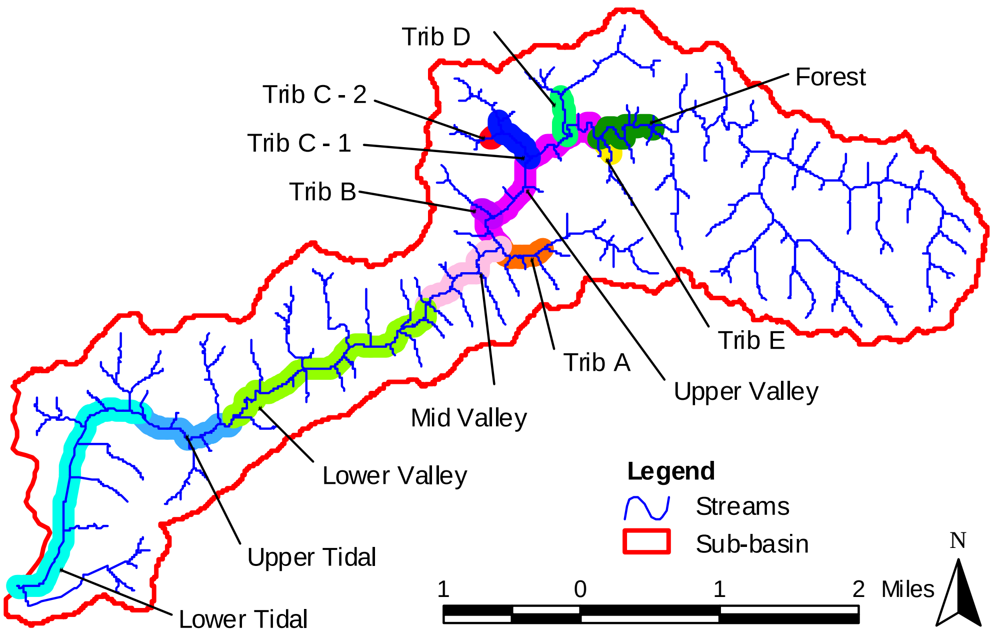


Figure P-19 Aquatic Habitat Survey Reaches

The Palouse sub-basin is affected by many factors influencing its watershed processes including habitat and channel modification in the valley and tidal reaches, and the presence of the Elliot State Forest in the upper forested areas. As mentioned previously, the Palouse sub-basin is one of the largest producers of salmon smolt on the Oregon coast, and it will be important to direct efforts toward protecting and maintaining existing quality habitat as well as restoration of degraded features. Additionally, the CoosWA has already implemented several restoration projects in the sub-basin and is in the process of maintenance and monitoring of those efforts.

Temperature and Shade

As demonstrated by the Limiting Factors analysis (based on Reeves et al., 1989, see Chapter 2: Palouse Creek Sub-basin Assessment), one of the primary habitat bottlenecks in the sub-basin is high summer temperatures. Stream temperatures in the Palouse sub-basin, the highest in the Lowland area, do not provide adequate thermal habitat for juvenile salmonids. Only the upper-most region of the sub-basin (beyond the assessment study area) is within usable and optimal temperature ranges. Stream temperatures become stressful to fish even in the Upper Valley, and become unusable, or lethal, to salmon starting in the Lower Valley reach and extending to the bay.

Data analysis indicates riparian planting projects would improve stream temperatures in three main areas. The upper-most area is in forest land use and includes Trib D, Trib C-1, Trib A, Trib B and the lower half of the Upper Valley reach that the tributaries flow into (see Figure P-18 for reach locations). Stream temperatures in this particular region rise into the 70's °F and then, atypically, cool downstream midway through the Upper Valley reach. This cooling may be due to a high percentage of pools and good pool depths in the Upper Valley reach, combined with shaded areas in the upper half of the reach. Planting and enhancement of riparian forestry practices in these upper sub-basin areas would help decrease temperatures in the Lower Valley reach. Planting Trib A would also help improve its 25% unstable banks.

Riparian planting would help improve conditions in the lower half of the Lower Valley reach. Within this reach temperatures rise to over 86 °F - unusable levels for juvenile coho. Riparian shade drops to 20-40% and stream banks are over 18% unstable.

The entire Upper Tidal and Lower Tidal reaches would also benefit from riparian shade where temperatures increase severely. This entire length of slough and stream has average maximum temperatures unusable to juvenile salmon, making it the most extensive stream habitat limited by high temperatures in the Lowland assessment. This area is within agricultural land use, which routinely dredges the channel. Therefore, riparian restoration should be planned with consideration for low-impact dredge operations. However, these tidal reaches could not be expected to improve without significant efforts to restore other impaired processes and temperature reductions upstream. Lack of shade is most prevalent in the lower areas of the sub-basin where adjacent land use is largely agricultural.

Sediment

The Palouse sub-basin has high natural sediment production that is accelerated by road-related erosion, improperly functioning culverts, unstable banks and other land use practices that are adversely affecting erosion rates and drainage of the area. Confounding the problems caused by high sediment production is the fact that the tide gate at the lower end of the slough interrupts the natural sediment transport mechanisms and therefore, very little sediment is flushed out of the system.

While sand-silt dominated channels are generally expected in lower, low-gradient reaches, the Palouse sub-basin has extremely high levels of fine sediment in both of the Tidal reaches and the Lower Valley reach. Fine sediment drops into desirable levels toward the Upper Valley and Forest reaches, where the highest numbers of spawning coho were counted, and then rises again slightly in the upper tributaries. The most unstable banks are in the Mid and Upper Valley reaches, Trib A, which is the most (25%) unstable, the Forest reach, Trib B and Trib C-1.

The sub-basin has a relatively small amount of fill at risk of failure, however, the larger problem is that 65% percent of the sub-basin's culverts can not drain more than 25% of their flow during a 50-year event. This means that during rain or storms smaller than 50-year events, culverts are becoming at least partially overwhelmed and causing both sediment build-up and erosion to occur around them.

Sediment Control

Table P-11 displays treatment recommendations based on the Palouse sub-basin road and landing survey analysis. "New structures needed" are based on Oregon Department of Forestry, 2003, Best Management Practices addressing ditch lengths. "Replacement structures needed" address all road drainage features, and are based on the Pacific Watershed Associates Road and Landing Survey Protocol adapted by the Coos WA.

Table P-11 Road and Landing Treatment Recommendations

Site Type	New Structures Needed To Meet BMP	Replacement Structures Needed
Stream Crossing	21 Cross Drain Pipes	15 Culverts (8 Erosion) (7 Fish Passage)
Ditch Relief	47 Cross Drain Pipes	14 Cross Drain Pipes
Ditch Out	14 Cross Drain Pipes	
Potential Landslide	1 Cross Drain Pipe 6 Waterbars	Excavate Unstable Fill
Ponding/ Gullied Road Surface	3 Cross Drain Pipes 2 Waterbars	
Totals	94	29

Figure P-20, shows the locations of recommended treatment sites. Based on the Coos WA road and landing surveys, Palouse Creek needs 86 new ditch relief culverts (cross drain pipes) and eight waterbars to reduce road related sediment. Of the existing 61 stream crossing structures, nine culverts need to be replaced, including 8 are rusted out and eroding the road fill around the pipe. The two sites listed as fish passage barriers are undersized and peak flows are crossing over the road. Of the 104 existing ditch relief culverts, 14 are rusted out and need replacing. Of the six potential landslide sites, all need the unstable fill excavated. Of the three ponding road surface sites, three cross drain culverts

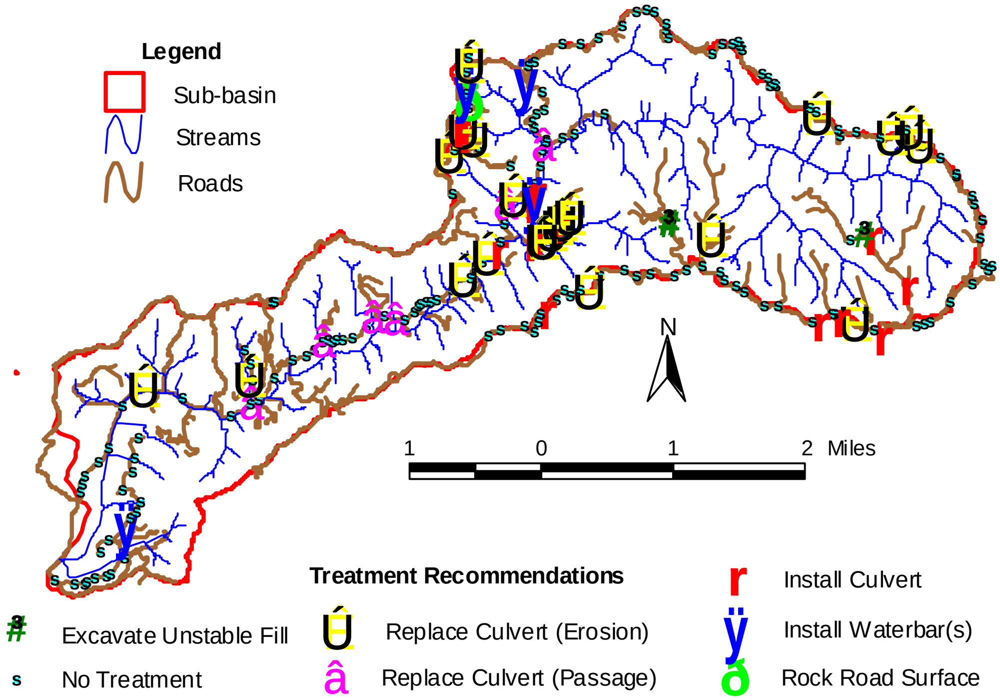


Figure P-20 Road and Landing Treatment Recommendation Locations

should be installed to upgrade and one gullied road surface site needs two waterbars.

Addressing at-risk stream crossings by clearing blocked culverts, upgrading culvert size, or replacing with bridges will alleviate future washouts, and ongoing erosion that contributes large amounts of sediment to streams. The Palouse sub-basin has a relatively small amount of fill at risk of failure. The larger problem is that 22 of the 34 pipes are in the very high risk category. This means that 65% percent of the sub-basin's culverts can not drain more than 25% of their flow during a 50-year rainfall event, and therefore have a much higher risk of fill failure. One of these culverts, for example, is an 18 inch fish passage culvert which is torn and plugged. This culvert doesn't have a lot of fill, but it causes winter flows to wash over the road because it is so restricted. The adult salmon have a hard time reaching spawning beds above the culvert. In the last several years CoosWA spawning surveyors have noticed adult salmon swimming over the road to get above the blocked culvert. For this culvert to function properly during a 50-year rainfall event, it will require a 36 inch diameter culvert.

Unstable stream banks need to be protected from erosion and planted with appropriate riparian species. Planting will also provide shade and other benefits to the stream. Treatment of unstable banks in the Forest reach is currently under way.

Dredging in the lower reaches of Palouse is done routinely to remove sediment build-up. The 2004 dredging operation removed the substrate from the first two reaches on the mainstem and placed the spoils next to the bank. In many areas the spoils were properly leveled and in others they were not. Future dredging should be performed in a way that doesn't disturb riparian shade, compromise bank stability or leave dredge spoils where they can re-enter the channel. Dredge operations that include protection of habitat features may be more likely to be permitted and will help reduce the need for future dredging. Further study of the effects of dredging on stream temperatures is needed.

The Palouse tide gate is not functioning properly and is in need of replacement. It is not passing fine sediment out of the system as fast as it is building up and, therefore encourages the high sediment load that fills in pools, embeds gravel, and helps create the uniform glide found upstream of the tide gate. The tide gate site itself is adding sediment to the system because the fill under North Bay Drive, where it passes over the tide gate, is sloughing into Palouse creek. Further, the county continually patches sections of the road that have caved in over the tide gate. Sediment flushing and road fill stabilization should be considered when maintaining or updating the tide gate.

Spawning

Palouse Creek consistently has one of the highest densities of spawning coho, mile for mile, on the coast of Oregon. This is likely related to the extensive, low-gradient stream and long slough habitats. The spawning usage is primarily supported by the uppermost 4000 meters of mainstem and the four upper valley tributaries.

Spawning density data show the need for future culvert replacement projects on Palouse Creek. These surveys also indicate that more attention should be paid to tributaries due to their potentially high production rates.

In addition to culvert replacements for drainage, there are (culvert) fish passage issues at Tributary B and C – which both have low AUC numbers. The gravel per female is high on these tributaries, which means that other available habitat is not being utilized.

Large Wood

As demonstrated by the Limiting Factors analysis (based on Reeves et al., 1989, see page 19 Chapter 2: Palouse Creek Sub-basin Assessment), the secondary habitat bottlenecks in the sub-basin is lack of winter refugia. Instream structure, meandering channels, off-channel habitat and wetlands naturally provide places for juvenile to seek refuge from high winter flows. Large wood improves instream habitat by creating protected areas for fish to hide, deep pockets of cooler water, and channel complexity that decreases the rate of flow and reduces erosion. Many of these functions have been modified in the Palouse sub-basin. Data analysis indicates large wood debris, naturally recruited from riparian areas, is below desirable levels in the Upper Valley, Forest and Trib E reaches. However, large wood placement may not be practical in the Mid Valley and other reaches where banks are unstable and unvegetated. While directly placing large wood in the channel addresses the symptoms of altered watershed processes, in the long-term instream habitat restoration is best approached through riparian planting, improved riparian forestry practices, and landslide area protection for future wood recruitment to streams.

Stream Flow

The Palouse sub-basin has critically low summer flows, but there appears to be little in the way of designated consumptive uses. The level of use has not changed significantly in the past ten years, but Palouse creek may be very sensitive to large land-use changes such as urbanization. Trib C R1 and R2, surveyed during the summer, are dominated by dry or puddled unit types. Quite often, in these unit types, water is still moving just below the surface in low areas creating residual puddles that will be continually fed by cooler underground water. These puddled units provide refugia for fry during the late summer period. Efforts to control sediment and encourage natural pool formation will help to augment low summer flows.

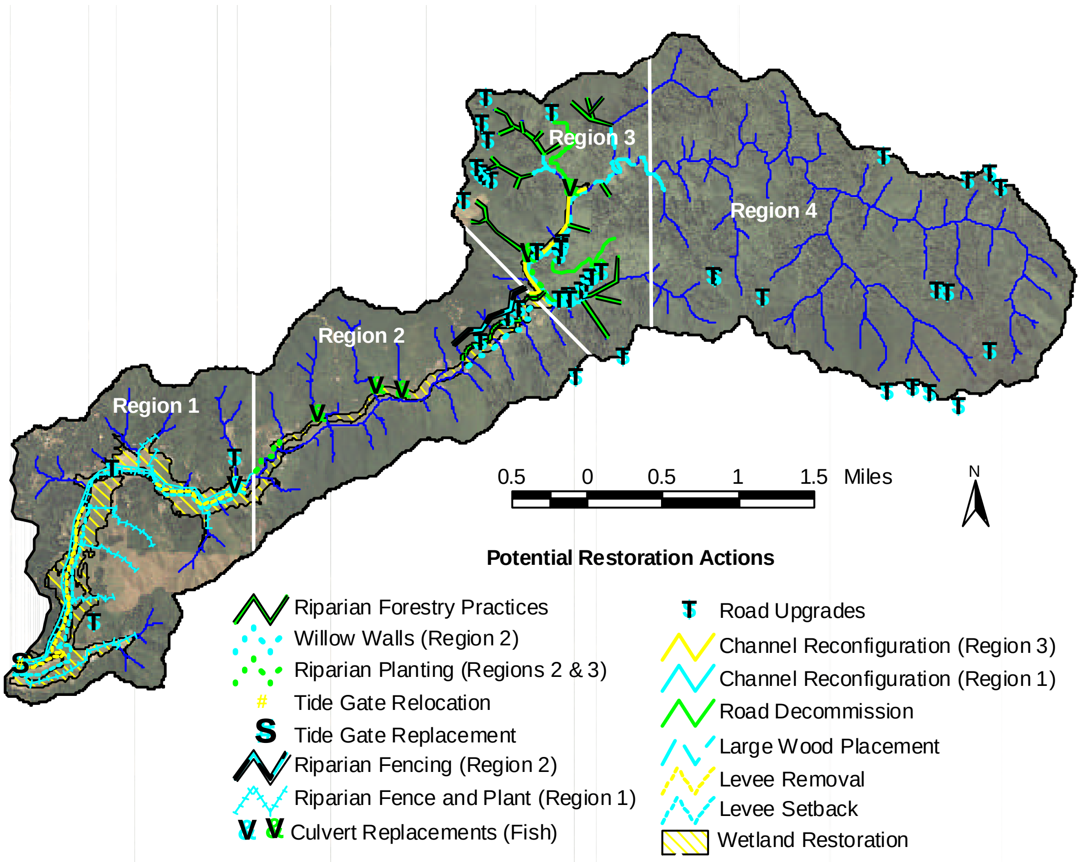
Conclusions

The results of the watershed health analysis and the concerns expressed by landowners make it necessary to establish positive working relationships in order to develop and implement successful restoration strategies. Effective habitat restoration efforts in this sub-basin will focus on reducing temperatures and sediment loading, and increasing stream complexity while also addressing concerns of landowners regarding drainage issues. The results from the Palouse sub-basin restoration prioritization process, below, intend to integrate 13 important criteria to provide the most logical and systematic approach to project development.

Prioritization of Potential Actions

Results of the prioritization process for the Palouse sub-basin are mapped below in Figure P-21. Legend colors indicate how the action scored within its region and implies the general approach that CoosWA would take to the action type. A description of the prioritization process, scoring and action types is provided previously in Chapter 3 – Restoration Strategy.

Figure P-21 Potential Restoration Opportunities



Region 1

As the Table P-12 indicates, there were no green priority level actions within this region. Levee removal, tide gate relocation, and wetlands restoration all scored high for biological returns, and lower for socio-economic favorability. The CoosWA would seek to build partnerships and provide education for such project types in order to increase landowner understanding and acceptance. The blue priority level actions in this region include culvert replacements for fish passage, ditch maintenance, implementation of farm plans, levee setback, channel reconfiguration or reshaping, riparian fencing and planting, and tide gate replacement. These actions received lower scores for biological returns and higher scores for socio-economics. CoosWA would provide recommendations for tide gate replacements but not take a lead on seeking funds. Potential actions in Region 1 receiving the red priority level both scored low in the biological and socio-economic criteria and are not included on the restoration opportunities map. Other potential actions not shown on the map, for logistical reasons, include ditch maintenance and implementation of farm plans.

Table P-12 Palouse Regions 1 and 2 Prioritized Potential Actions

Region		Potential Actions
1		Levee removal
		Tide gate relocation
		Wetlands restoration
		Culvert replacements (passage)
		Ditch maintenance
		Implement farm plans
		Levee setback
		Channel reconfiguration
		Riparian fencing
		Riparian planting
		Tide gate replacement
		Large wood placement
		Tide gate removal
		Water conservation
2		Culvert replacements (passage)
		Riparian planting
		Beaver ponds
		Wetlands restoration
		Ditch maintenance
		Implement farm plans
		Riparian fencing
		Willow walls
		Bank resloping (no plant)
		Channel reconfiguration
		Large wood placement
		Off-channel features
		Water conservation

Region 2

Potential actions within Region 2 are listed in Table P-12. Green priority level actions include culvert replacements for fish passage and riparian planting. These actions are considered easier and biologically rewarding to implement. Yellow priority level actions in Region 2 include beaver ponds and wetlands restoration. These actions scored higher for estimated biological returns, but are known to be less favorable socio-economically. Blue priority level actions include ditch maintenance, implementation of farm plans, riparian fencing and willow wall construction. These actions scored higher for socio-economics than for biological criteria. While willow planting is not always socially accepted, it scored high for likelihood of success (for controlling active bank erosion) and is very inexpensive to install. Neither beaver encouragement nor implementation of farm plans are shown on the map due to the impracticality of display. The red priority level actions all received low scores for both biological and socio-economic criteria and are highly unlikely to be implemented

Region 3

Potential actions within Region 3 are listed in Table P-13. Potential actions receiving the green level ranking in this region include culvert replacements for fish passage, riparian forestry practices, riparian planting, and road decommissioning. These actions scored high for both biological integrity and socio-economic favorability. Yellow level actions include allowing beaver ponds and channel re-configuration or reshaping. While these actions have less socio-economic acceptance, they scored high biologically. Blue priority level actions include large wood placement, riparian fencing, and road upgrades. These actions scored higher in the socio-economic criteria and lower for biological returns. CoosWA would not take a leading role in developing funding for these projects. There were no red priority level actions in this region.

Table P-13 Palouse Regions 3 and 4 Prioritized Potential Actions

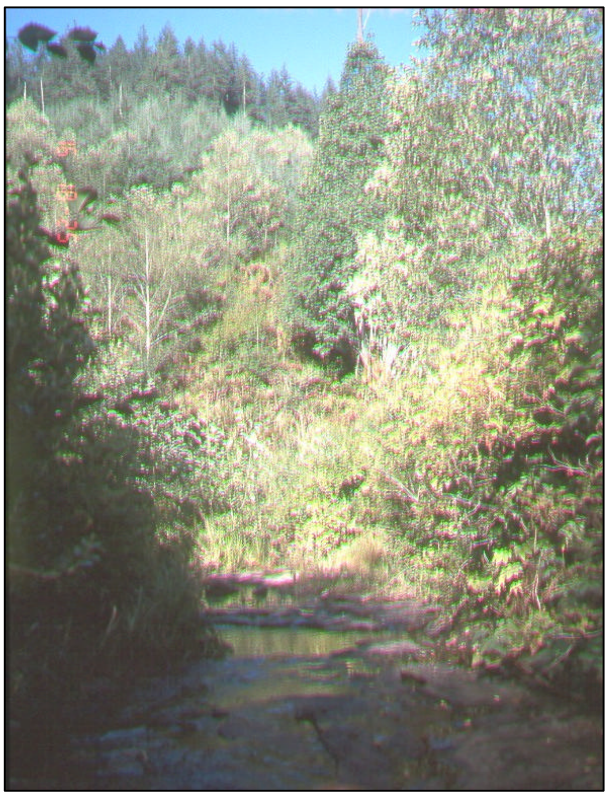
Region		Potential Actions
3	green	Culvert replacements (passage)
	green	Riparian forestry practices
	green	Riparian planting
	green	Road decommission
	yellow	Beaver ponds
	yellow	Channel reconfiguration
	blue	Large wood placement
	blue	Riparian fencing
	blue	Road upgrades
4	green	Riparian forestry practices
	green	Landslide area protection (head wall retention)
	blue	Road upgrades

Region 4

CoosWA ranked the potential actions of enhanced riparian forestry practices, landslide area protection and road upgrades for this region. However, since this region is almost entirely under the management of the Elliot State Forest, only the road upgrade sites were placed on the map. Riparian forestry and landslide area protection, which currently rank high for biological returns, are already included in the Elliot State Forest management plan and CoosWA would not be seeking funds to implement such projects.

Coos Bay Lowland Assessment and Restoration Plan

Chapter 3:
Larson Sub-basin Restoration Opportunities



Sullivan Creek. Photo, ODFW.

Discussion of Restoration Opportunities

This section discusses the need for restoration in named aquatic habitat survey reaches (see Figure L-20) within the sub-basin based on analysis of survey data presented in Chapter 2: Larson Creek Sub-basin Assessment. In conclusion, restoration priorities are presented within each of four larger regions (see Figure L-22) based on the prioritization scoring system introduced in Chapter 3: Restoration Strategy.

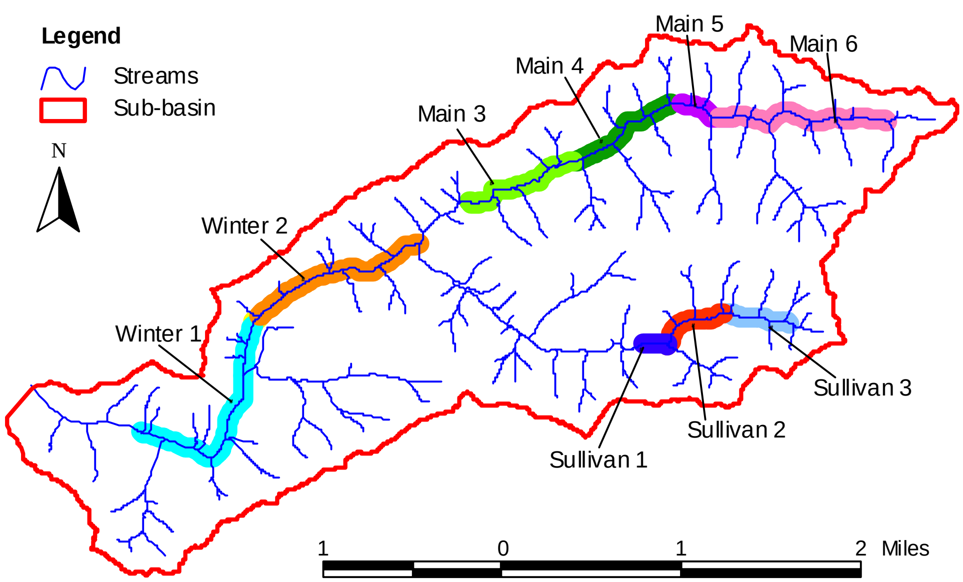


Figure L-20 Aquatic Habitat Survey Reaches

As demonstrated by the limiting factors analysis (based on Reeves et al., 1989, see page 21 Chapter 2: Larson Creek Sub-basin Assessment), the primary habitat bottleneck to coho smolt production is availability of winter rearing habitat. Winter rearing habitat generally consists of secondary or side channel areas where smolts can find relief from the high, fast winter flows. Summer rearing habitat is the secondary habitat bottleneck in this sub-basin. Summer rearing habitat can be improved by restoring deep, complex pools with large wood and boulders, and allowing the stream to return to its natural meandering channel. Since the Larson sub-basin is one of the largest producers, mile for mile, of salmon smolt on the Oregon coast it will be worthwhile to also direct efforts toward protecting and maintaining existing usable habitat as well as restoration of degraded areas in cooperation with landowners.

Large Wood

According to the Larson sub-basin aquatic habitat survey, amounts of large wood are less than desirable in all reaches, with severe deficits in the Winter reaches and Main 3 and 4. Key pieces, are missing entirely from all but reaches Main 5 and 6. Large wood can be strategically placed in the channel as well as naturally recruited from existing riparian trees as they eventually fall into the channel. The upper two reaches on Larson, and the Sullivan Creek reaches, are in the Elliot State Forest and are managed as timberlands with 150 foot buffers on fish-bearing streams (ODF, 2003). While directly placing large wood in the channel addresses the symptoms of altered watershed processes, in the long-term instream habitat restoration is best approached through riparian planting, improved riparian forestry practices, and landslide area protection for future wood recruitment to streams.

Future surveys and restoration planning in the Larson sub-basin should include assessments of the recruitment potential of existing riparian trees, and stream bank conditionl for installing large wood.

Sediment

The Larson sub-basin has high natural sediment production that is accelerated by roads, unstable banks, and other land use practices that are adversely effecting stream health and causing extensive drainage problems for local residents. Confounding the problems caused by high sediment production is the fact that the tide gate at the lower end of the stream interrupts the natural sediment transport mechanisms and therefore, very little sediment is flushed out naturally.

Sand-silt dominated channels are expected in the lower reaches where the stream has low gradients and low water velocities. However, in this sub-basin, even the upper reaches in Sullivan Creek have high, undesirable levels of fine riffle sediment – Sullivan 2 having the most embeddedness of the upper reaches. Extremely high levels (>70%) of riffle sediment are found in the mainstem reach Winter 2 just below the confluence with Sullivan Creek, and just below the unstable banks.

Unstable banks contribute sediment to down-stream reaches, where it eventually builds up behind the tide gate. Main reaches 3 and 4 show high, undesirable portions of unstable and uncovered banks. Both reaches are located in rural residential areas, and failing banks may have the potential to threaten houses and other infrastructure. These were the only two reaches surveyed for bank stability in Larson, and future surveys should include a more thorough survey of bank stability.

Stream crossing drainage evaluations indicate more than 1000 yds^3 of at-risk fill at culvert sites is in the high to very high risk rating for failure, however, this is relatively small compared to other sub-basins in the lowlands assessment area.

Sediment Control

Sediment loading, best treated at its source, can be addressed in many ways. Careful consideration should be taken when planning land use activities that disturb the already erosion-prone soil in the lowlands area. Carefully directing the drainage of run-off through proper culverts, road-side ditches and away from road surfaces will reduce its erosion potential. Table L-13 displays treatment recommendations based on the Larson sub-basin road and landing surveys. "New structures needed" are based on Oregon Department of Forestry, 2003, Best Management Practices addressing ditch lengths. "Replacement structures needed" address all road drainage features, and are based on the Pacific Watershed Associates Road and Landing Survey Protocol adapted by the CoosWA.

Table L-13 Road and Landing Treatment Recommendations

Site Type	New Structures Needed To Meet BMP	Replacement Structures Needed
Stream Crossing	16 Cross Drain Pipes	7 Culverts (5 Erosion) (2 Fish Passage)
Ditch Relief	33 Cross Drain Pipes	3 Cross Drain Pipes
Ditch Out	26 Cross Drain Pipes	
Potential Landslide		Reconstruct Fill
Ponding/ Gullied Road Surface	1 Cross Drain Pipe	
Totals	76	10

Based on the Coos WA road and landing surveys, Larson needs 76 new ditch relief culverts to reduce road related sediment. Of the existing 51 stream crossing structures, seven culverts need to be replaced, five are rusted out and eroding the road fill around the pipe and the two culverts that are listed as fish passage barriers are undersized. Of the 82 existing ditch relief culverts, three are rusted out and need replacing and two downspouts need to be installed to lessen erosion at outlets, one cross drain culvert should be installed to upgrade the one ponding road surface site. Figure L-20 shows the locations of recommended treatment sites.

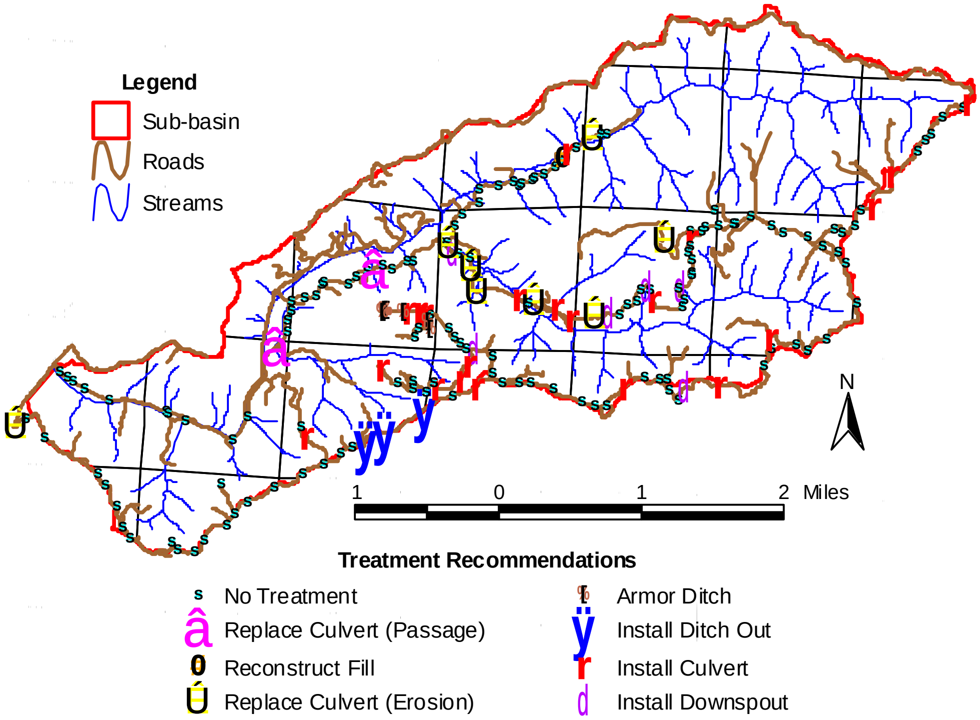


Figure L-20 Road and Landing Recommended Treatment Locations

At-risk stream crossings in the Larson sub-basin need to be fixed, yet it may be more efficient to focus upgrade efforts in other sub-basins prior to addressing Larson stream crossings.

Unstable stream banks need to be protected from erosion and planted with appropriate riparian species. The reaches Main 3 and 4 have undesirable unstable banks. Planting will also provide shade and other benefits to the stream as well as stabilization for installation of needed in-stream large wood. Dense plant roots and stems also help to catch and filter sediment before it enters the stream, however, in some cases, as with Reed Canary grass and other shallow-rooted plants, this may cause the bank to cave in with the weight of the sediment

The Coos WA has performed restoration work on one of the unstable bank sites since the survey was conducted.

Dredging, which is done routinely to remove sediment from the stream channel, is best performed in a way that doesn't disturb riparian shade, compromise bank stability or leave dredge spoils where they can re-enter the channel. Dredge operations that include protection of habitat features may be more likely to be permitted and will help reduce the need for future dredging. Further study of the effects of dredging on stream temperatures is needed.

Tide gates should be maintained, redesigned or removed to allow proper flushing of sediment and upstream and downstream fish passage.

Temperature and Shade

Temperature analysis shows that the Larson sub-basin has only a small area, in the upper-most Larson reach, of optimal thermal conditions for salmonids. Other areas have thermal conditions that cause stress to juvenile fish but are not directly lethal. Lost temperature loggers should be replaced in the middle and lower reaches of the stream to gain a more accurate measure of temperature variations there. Temperature data were not collected from Sullivan Creek and permission from landowners to monitor temperature should continue to be sought in the future.

The reaches needing riparian shade planting are Winter 2, the lower section of Winter 1 to the tide gate, the lower, unsurveyed section of Sullivan Creek and an unsurveyed tributary entering the mainstem at the upper end of Winter 1 reach. Reaches Main 3 and Main 4 also have unacceptable amounts of uncovered (20%) and unstable banks. While shade in this area is provided by the local topography, these reaches should be planted for bank stability. The temperature drop in Main 3, along with topographic shade, is likely due, in part, to the large percentage of deep pools in this reach. Riparian planting on these Main reaches will also provide future recruitment of large wood that is severely lacking from reach Main 4 down to the tide gate.

Spawning

Healthy amounts of gravel are present in all reaches, except the lower two, and should be protected for spawning by reducing riffle sediment. High numbers of coho spawners were surveyed in a small area between the upper Sullivan and lower mainstem aquatic habitat study reaches.

Stream Flow

The Larson and Sullivan Water Availability Basins received the highest level ranking for need to restore in-stream flow for fish use. Both of these streams have very low summer flows and relatively high consumptive uses. OWEB WAM ranks flow restoration opportunity based on consumptive use of >10% (OWEB, 1999). Larson Creek, in this case, is not ranked as having the greatest opportunity for flow restoration due to average consumptive use of 5.5% for the months of July through September. However, Sullivan Creek, for the same time period is ranked as having the greatest opportunity for flow restoration due to average consumptive use (10.7%).

In-stream flow restoration will help to improve temperatures, flush fine sediment, and increase pool depths. Flow can be increased by implementing water conservation measures, increasing soil infiltration rates and vegetative ground cover, and leasing currently un-used water rights to in-stream use. Efforts to control sediment and encourage natural pool formation will help to augment low summer flows.

Conclusion

It is necessary to establish informed, positive working relationships between landowners, their neighbors, and watershed health issues in order to carry out successful restoration strategies. Another key to successful restoration may be educating landowners about watershed functions such as secondary channels, and floodplain connectivity.

Addressing these issues and concerns together at the sub-basin level in a strategic, programmatic approach will aim to produce positive results for both salmon and landowners alike. The results from the Larson sub-basin restoration prioritization process, below, intend to integrate 13 important criteria to provide the most logical and systematic approach to project development.

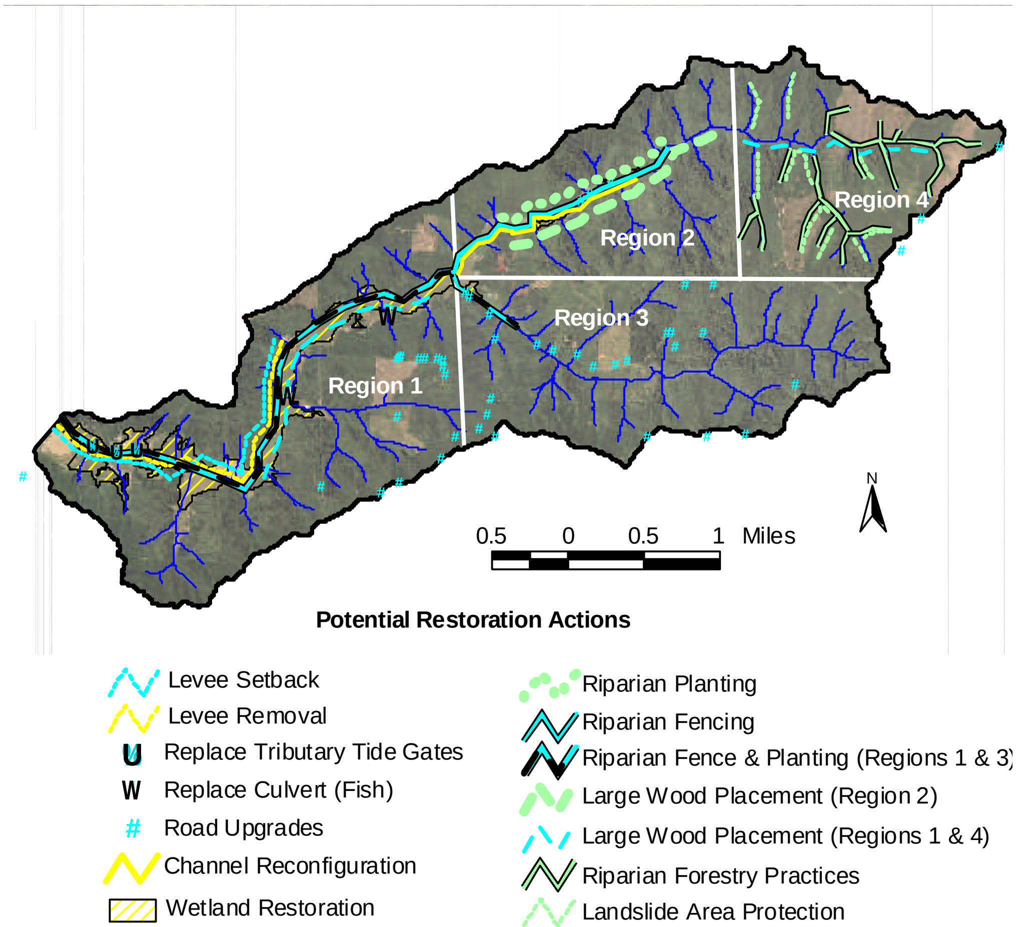
Prioritization of Potential Actions

Results of the prioritization process for the Larson sub-basin are mapped below in Figure L-20. Legend colors indicate how the action scored within its region and implies the general approach that CoosWA would take to the action type. A description of the prioritization process, scoring and action types is provided previously in Chapter 3 – Restoration Strategy. Potential actions within each region are listed in Tables L-14 and L-15 and shown in Figure L-21. Region 1

Region 1

As shown in Table L-14, the only green priority level action in this region is culvert replacement for fish passage. Levee removal and wetlands restoration, yellow priority level actions, scored high for biological returns, and lower for socio-economic favorability. The CoosWA would seek to build partnerships and provide education for yellow level project types in order to increase landowner understanding and acceptance of these project types. Eight potential actions were assigned to the blue priority level in this region. These actions include ditch maintenance, implementation of farm plans (these two actions are not shown on the map), large wood placement, levee setback, riparian fencing and planting, road upgrades, and removal of tributary tide gates. These actions

Figure L-21 Potential Restoration Opportunities



scored higher for socio-economic feasibility and lower for estimated biological returns. Red priority level actions include mainstem tide gate removal and water conservation. These actions are highly unlikely to be implemented and are not shown on the map.

Region 2

Green priority level actions include large wood placement and riparian planting. These actions are considered easier and biologically rewarding to implement. Yellow priority level actions in Region 2 include beaver ponds, channel reconfiguration or reshaping and wetlands restoration. These actions scored higher for estimated biological returns, but are known to be less favorable socio-economically. Blue priority level actions include ditch maintenance, implementation of farm plans and riparian fencing. These actions scored higher for socio-economics than for biological criteria. Neither beaver encouragement ditch maintenance are shown on the map due to the impracticality of display. The red priority level actions, adding off-channel features and water conservation, received low scores for both biological and socio-economic criteria and are highly unlikely to be implemented

Region 3

There are no green priority level actions within Region 3, and the only yellow priority level action is allowing beaver ponds to form. While this 'action' scores low for socio-economic criteria, it is known to be very beneficial for salmon and scores high for biological returns. Blue priority level actions within this region include riparian fencing and planting, and road upgrades. These actions scored higher in the socio-economic criteria and lower for biological returns. CoosWA may not take a leading role in developing funding for these projects. Red priority level actions include channel reconfiguration and large wood placement – these actions are unlikely to be implemented in this region and are not shown on the map.

Table L-14 Larson Regions 1 and 2 Prioritized Potential Actions

Region		Potential Actions
1		Culvert replacements (passage)
		Levee removal
		Wetlands restoration
		Ditch maintenance
		Implement farm plans
		Large wood placement
		Levee setback
		Riparian fencing
		Riparian planting
		Road upgrades
		Tide gate replacement (tribs)
		Tide gate removal
		Water conservation
2		Large wood placement
		Riparian planting
		Beaver ponds
		Channel reconfiguration
		Wetlands restoration
		Ditch maintenance
		Implement farm plans
		Riparian fencing
		Off-channel features
		Water conservation

Region 4

The potential actions of enhanced riparian forestry practices and landslide area protection received the green priority level ranking in this upper forested region. Blue priority level actions in this region include large wood placement and road upgrades.

Table L-15 Larson Regions 3 and 4 Prioritized Potential Actions

Region		Potential Actions
3		Beaver ponds
		Riparian fencing
		Riparian planting
		Road upgrades
		Channel reconfiguration
		Large wood placement
4		Landslide area protection (head wall retention)
		Riparian forestry practices
		Large wood placement
		Road upgrades

Coos Bay Lowland Assessment and Restoration Plan

Chapter 3:

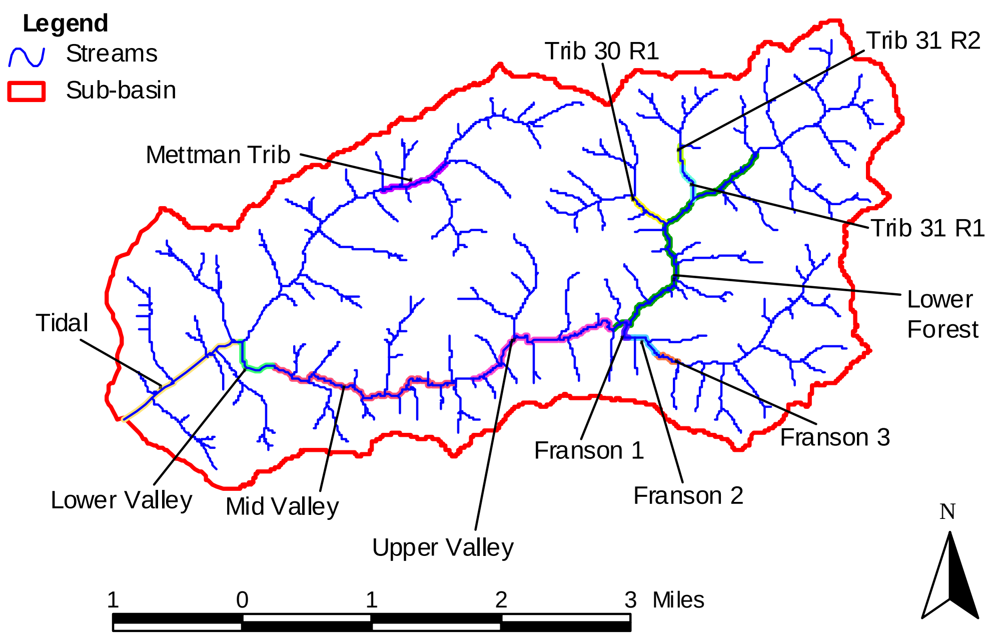
Kentuck Sub-basin Restoration Opportunities

Coho spawning. Photo CoosWA, 2003.

Discussion of Restoration Opportunities

This section discusses the need for restoration in named aquatic habitat survey reaches (see Figure K-20) within the sub-basin based on analysis of survey data presented in Chapter 2: Kentuck Creek Sub-basin Assessment. In conclusion, restoration priorities are presented within each of four larger regions (see Figure K-22) based on the prioritization scoring system introduced in Chapter 3: Restoration Strategy.

Figure K-20 Aquatic Habitat Survey Reaches



Our analysis indicated that habitat conditions in the Kentuck sub-basin generally decline as the mainstem flows from the upper reaches to the mouth, where habitat conditions are the worst. The Mettman and Franson tributary reaches, however, are in relatively better condition yet still not meeting many of the ODFW habitat benchmarks. As demonstrated by the limiting factors analysis, the primary habitat bottleneck is availability of summer rearing habitats, which are limited due to high temperatures. Landowner concerns in the Kentuck sub-basin are centered on restoration of fish and wildlife habitat and water quality and quantity, as well as drainage issues.

Temperature and Shade

While the sites upstream from the Tidal reach have temperatures that salmon could potentially survive, high temperatures over 70°F in the Tidal reach make that area unusable to juvenile salmonids. The upstream sites show temperatures over 64°F, however these encompass few enough days that fish can adjust by moving to thermal refugia during those times. Because the 7-day minimums at all sites, except the tide gate, are below 64 °F, the stream overall spent at least part of even the hottest days at levels safe for fish.

The Kentuck headwaters, in and above Trib 31, the Tidal, Mid and Lower Valley reaches, and an unsurveyed tributary entering the main-stem at the top of the Tidal reach are in need of riparian shade planting. All of these reaches, except for the tributary for which there is no aquatic habitat data, also have extremely high levels of unstable banks.

The unsurveyed tributary, mentioned above, should be surveyed for temperature to gain a better understanding of its effect on temperature in the Tidal reach.

Sediment

The Kentuck slope stability analysis shows that 5.6% of the area is in the high to extremely high risk range for naturally occurring landslides. The most unstable slopes are located in the steep areas of the Kentuck headwaters. Soil disturbing activities, such as logging, road building, and excavation should make special precautions against erosion and interrupting proper drainage.

Road and landing treatment recommendations (see Table K-11) are site-specific fixes that bring road drainage problems up to date with current, 2003, Oregon Department of Forestry Best Management Practices (BMP). Based on the road and landing surveys, the Kentuck sub-basin needs 132 new culverts and seven water bars to meet BMP and reduce road related sediment. Of the existing 99 stream crossing structures, 16 culverts need to be replaced, 15 are rusted out and eroding the fill, and the one culvert listed as a fish passage barrier is undersized for fish passage. Of the 140 existing ditch relief culverts, 17 are rusted out and need replacing, and five water bars should be cut to upgrade gullied road surface sites. Locations of treatment sites are shown in Figure K-21.

Table K-11 Road & Landing Treatment Recommendations

Site Type	New Structures Needed To Meet BMP	Replacement Structures Needed
Stream Crossing	57 Cross Drain Pipes	16 Culverts (15 Erosion) (1 Fish Passage)
Ditch Relief	36 Cross Drain Pipes	17 Cross Drain Pipes
Ditch Out	39 Cross Drain Pipes 2 Water Bars	
Potential Landslide		Excavate Unstable Fill
Ponding/ Gullied Road Surface	5 Water Bars	
Totals	139	33

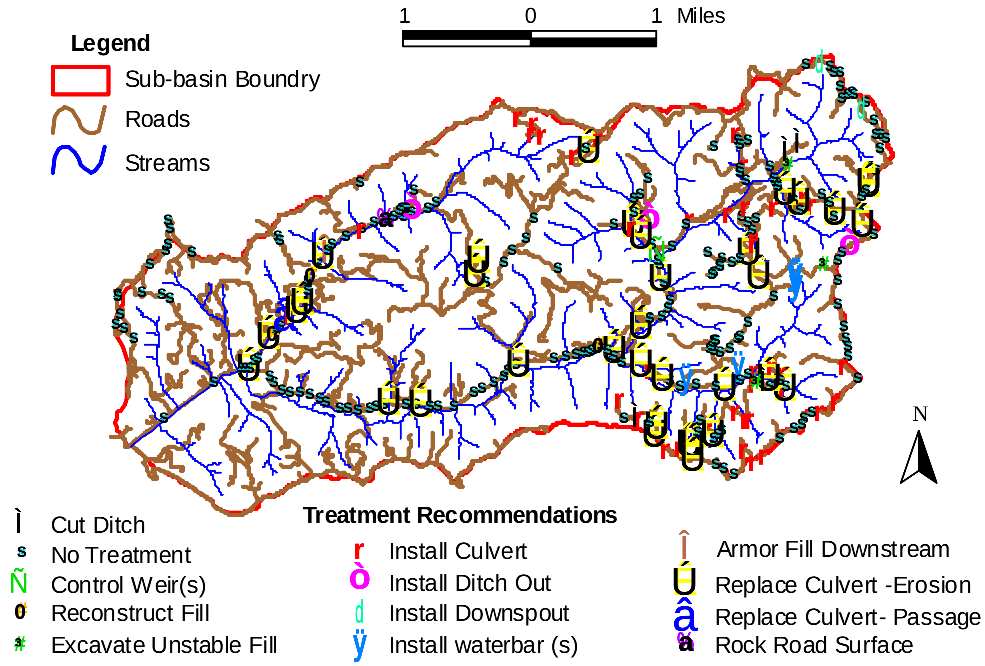


Figure K-21 Road & Landing Treatment Recom-mendation Locations

"New structures needed" are based on Oregon Department of Forestry, 2003, Best Management Practices addressing ditch lengths. "Replacement structures needed" address all road drainage features, and are based on the Pacific Watershed Associates Road and Landing Survey Protocol adapted by the CoosWA.

At-risk stream crossing culvert sites in the Kentuck sub-basin contain 2849 $yards^3$ of fill in the high to very high risk range for failure during a 50-year rain event. This means that these culverts are able to drain less than half of their flow during such an event. Therefore, while habitat in Kentuck is already heavily compromised due to sediment levels, much more sediment is poised to enter the system if these risks are not addressed.

Many of the stream crossing structures surveyed were found to be too small to accommodate the drainage area above them. For example, one site drains an area of 0.5 $mile^2$ through a 30 inch culvert. The undersized culvert backs up 60 cfs of water during a 50-yr peak flow event. This site requires a 60 inch culvert to properly accommodate such an event. Another problem is a subsiding bridge crossing that drains 5.9 $miles^2$ located just below the confluence of Franson and Kentuck Creeks. During a peak event the flow becomes so restricted that 350-400 cfs will either back up or pour over the bridge causing it to settle even more. If the bridge collapses into the stream it may create a fish passage issue for both Kentuck and Franson Creeks. The bridge, which has light use, should be removed or replaced. If the bridge is replaced, the abutments should be raised up to allow for ample stream flow clearance.

The Kentuck sub-basin bank stability survey stands out from other sub-basins due to its very high amount of unstable, or actively eroding, stream banks, the majority of which are covered with Reed canarygrass. Extensive bank stabilization projects are needed on Kentuck creek. Stabilizing banks with native riparian trees, willows and shrubs which will reduce sediment introduction and increase shade to the stream. Riparian planting projects will need to consider ways to control Reed Canary grass until trees are of sufficient height. Exclusion of livestock is important to riparian success and will need to include off-stream watering facilities.

All reaches, except the Tidal reach, have extremely high levels of riffle gravel. However, all of these riffles also contain high amounts of fine sediment at or exceeding the undesirable benchmark. The most embedded reach is the Lower Valley, which has 20% more fine sediment than gravel. This same reach also has the highest percentage (38%) of unstable banks.

The only reaches that have desirable average residual pool depths are the Lower Valley, Mid Valley, Upper Valley, and Lower Forest reaches. The Upper Valley reach, which is more than 70% pools, has outstanding average pool depths. These features are likely influenced by dredging of the channel and should be studied more in the future.

Future dredging should be performed in a way that doesn’t disturb riparian shade, compromise bank stability or leave dredge spoils where they can re-enter the channel. Dredge operations that include protection of habitat features may be more likely to be permitted and will help reduce the need for future dredging.

Large Wood

There is almost no large wood in the mainstem reaches of Kentuck Creek and only Franson Reach 2 approaches the desirable benchmarks. Adding large wood to the system will help create and enhance needed rearing habitat. Before large wood can be placed, however, banks should be stabilized. Riparian plantings will help stabilize banks, and provide shade, as well as produce future large wood for the stream system.

Conclusions

The Mettman tributary reach contains the best habitat of the reaches surveyed in the sub-basin, and has the highest number of spawners.

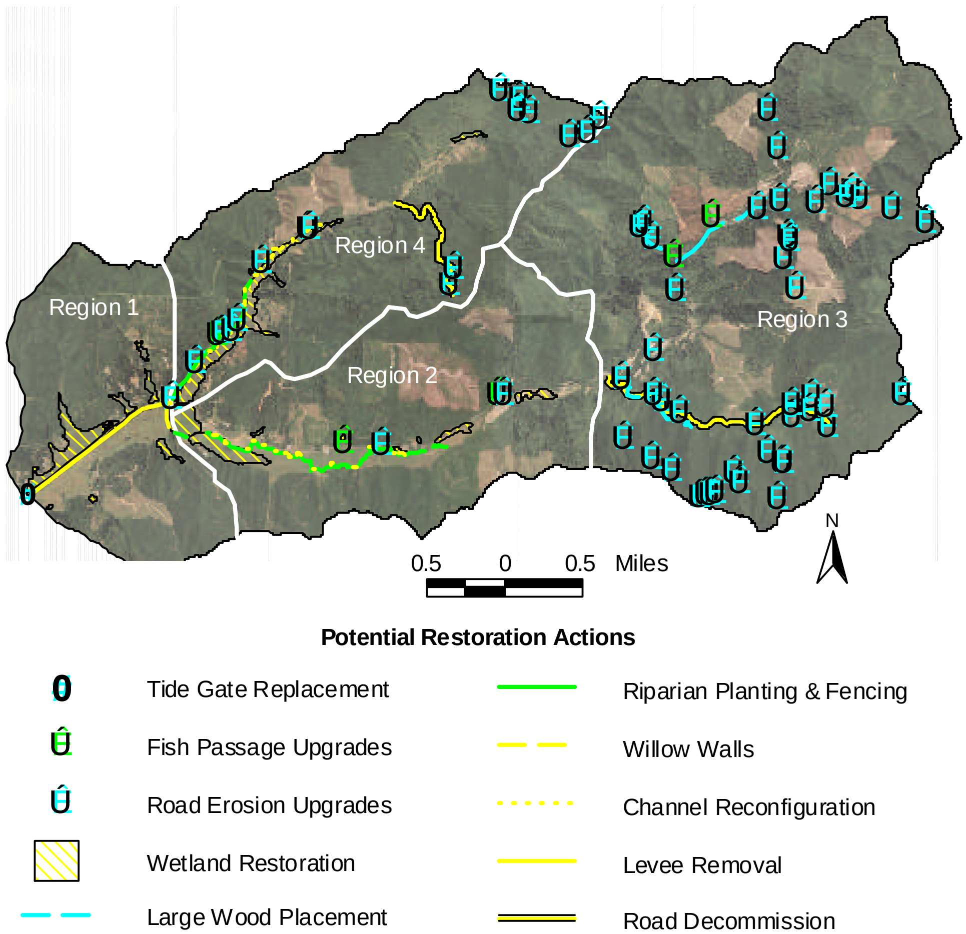
Habitat in this reach should be protected. The Tidal reach has the most undesirable characteristics and should be a priority area for restoration.

The results of the watershed health analysis and the concerns expressed by landowners make it necessary to establish positive working relationships in order to develop and implement successful restoration strategies. In the Kentuck sub-basin, many of the landowner concerns will be addressed simultaneously as habitat is addressed. Effective habitat restoration efforts in this sub-basin will focus on reducing temperatures in the Kentuck headwaters and lower reaches, reducing sediment loading in all reaches using a variety of approaches throughout the sub-basin, and increasing stream complexity that fosters off-channel winter rearing habitat. . The results from the Kentuck sub-basin restoration prioritization process, below, intend to integrate 13 important criteria to provide the most logical and systematic approach to project development.

Prioritization of Potential Actions

Results of the prioritization process for the Palouse sub-basin are mapped below in Figure K-22. Legend colors indicate how the action scored within its region and implies the general approach that CoosWA would take to the action type. A description of the prioritization process, scoring and action types is provided previously in Chapter 3 – Restoration Strategy.

Figure K-22 Potential Restoration Opportunities



Potential actions within each region are listed in Tables K-13 and K-14. The color next to each action corresponds to the colors on the map in Figure K-22, and to the prioritization score categories.

Region 1

As the score-derived color coding indicates, Region 1 potential actions with highest priority include levee removal, reshaping the channel to its natural form and wetland restoration. The yellow priority level of these actions indicates high estimated biological returns, yet lower socio-economic favorability. The potential actions of tide gate replacements, ditch maintenance, culvert replacements for fish passage, and implementing farm plans received lower scores for biological returns and higher scores for socio-economics. CoosWA would provide recommendations for these project types but not take a lead on funding development. Potential actions in Region 1 receiving the red priority level all scored low in both the biological and socio-economic criteria and are not included on the restoration potentials map.

Table K-13 Kentuck Regions 1 and 2 Potential Actions

Region		Potential Actions
1		Levee removal
		Reshape channel
		Wetlands restoration
		Tide gate replacements
		Ditch maintenance
		Culvert replacements (passage)
		Implement farm plans
		Riparian planting
		Large wood placement
		Tide gate removal
		Tide gate relocation
		Levee setback
		Water Conservation
2		Culvert replacements (passage)
		Riparian planting
		Wetlands restoration
		Willow wall
		Beaver encouragement
		Riparian fencing
		Ditch maintenance
		Culvert replacements (erosion)
		Implement farm plans
		Large wood placement
		Reshape channel
		Bank resloping (no plant)
		Off-channel features
		Water Conservation

Region 2

Top priority actions include culvert replacement for fish passage and riparian planting. These actions are considered easier to implement and should significantly benefit the watershed. Yellow priority level potential actions include wetlands restoration, willow wall construction, and beaver encouragement. The CoosWA would seek to develop partnerships and education or demonstration opportunities for these potential actions. Potential actions where the CoosWA may provide design assistance but not take a lead in funding development include riparian fencing, ditch maintenance, culvert replacements for erosion control, and implementation of farm plans. The red priority level actions all received low scores for both biological and socio-economic criteria and are highly unlikely to be implemented.

Region 3

Road decommissioning and culvert replacement for fish passage received the highest priority level in this region. These actions are assumed to have both high biological returns and socio-economic favorability and would be generally easier to implement in this region. The yellow priority level actions, beaver encouragement and landslide area protection, are cases in which the CoosWA may seek partnerships and funding development if interest from landowners is shown. Blue priority level actions include large wood placement and road upgrades. These actions scored higher in the socio-economic criteria and lower for biological returns. CoosWA would not take a leading role in developing funding for these projects. The red priority level action in this case scored just below two in both categories.

Region 4

The highest level priority action in this region is riparian planting. Potential actions in which the CoosWA would seek funding and opportunities to build partnerships include road decommissioning, willow wall creation, reshaping of the channel, riparian forestry practices, wetland restoration, beaver encouragement and landslide area protection. These actions scored higher biologically and lower for socio-economics. Actions in which the CoosWA would not take a lead role, those that scored lower biologically and higher for socio-economics, include road upgrades, riparian fencing and or planting, ditch maintenance, culvert replacements for erosion control, and implementation of farm plans. The red priority level actions scored low in both categories and are highly unlikely to be implemented.

Table K-14 Kentuck Regions 3 and 4 Potential Actions

Region		Potential Action
3		Road decommission
		Culvert replacement (passage)
		Beaver encouragement
		Landslide area protection
		Large wood placement
		Road upgrades
		Riparian forestry practices
4		Riparian planting
		Road decommission
		Willow wall
		Reshape channel
		Riparian forestry practices
		Wetland restoration
		Beaver encouragement
		Landslide area protection
		Road upgrades
		Riparian fencing
		Ditch maintenance
		Culvert replacements (erosion)
		Implement farm plans
		Large wood placement
		Bank resloping (no plant)
		Off-channel creation
		Water conservation

Coos Bay Lowland Assessment and Restoration Plan

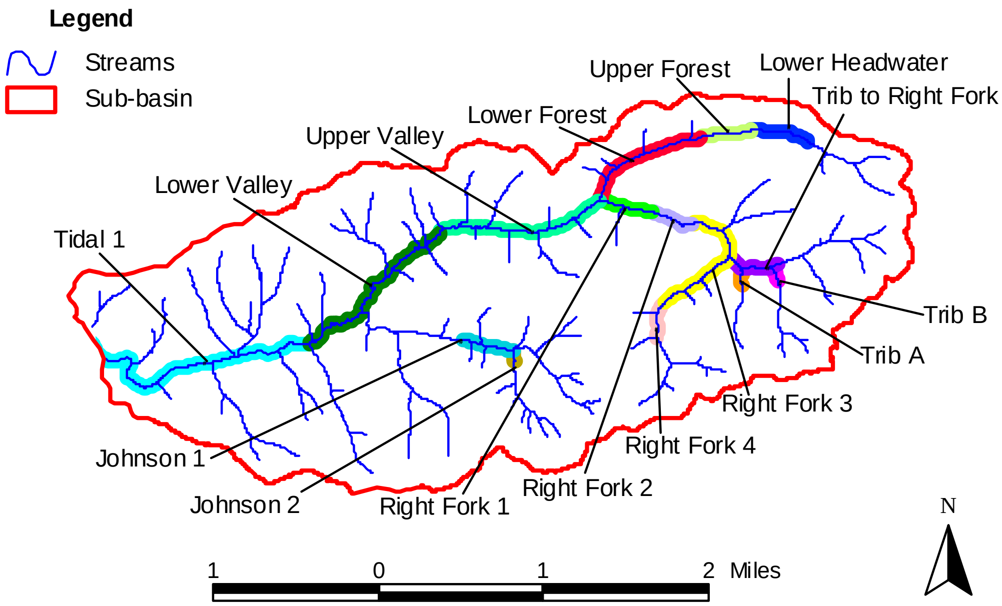
Chapter 3:
Willanch Sub-basin Restoration Opportunities

Willanch Creek riparian restoration. Photo CoosWA, 2004.

Restoration Opportunities

This section discusses the need for restoration in named aquatic habitat survey reaches (see Figure W-21) within the sub-basin based on analysis of survey data presented in Chapter 2: Willanch Creek Sub-basin Assessment. In conclusion, restoration priorities are presented within each of four larger regions (see Figure W-22) based on the prioritization scoring system introduced in Chapter 3: Restoration Strategy.

Figure P-21 Aquatic Habitat Survey Reaches



Our analysis indicates that the quality of salmon habitat meets some benchmarks but fails others. There is not a definite, predictable pattern across the sub-basin. As demonstrated by the Limiting Factors analysis in Chapter 2, the primary habitat issue in this sub-basin is quality of winter and summer rearing habitats. Key features of winter rearing habitat are off-channel areas where juvenile coho can find refuge from high winter flows. Key features of summer rearing habitat, where temperature is not a priority issue, as in Willanch, are deep residual pools, and channel sinuosity. It will be important to consider how landowners are affected by these habitat issues, and to find ways in which they can each benefit or improve.

Temperature and Shade

Stream temperatures in Willanch creek, although above current standards in the lower reaches, are still within marginal to optimal habitat ranges for salmonids. However, as the quality of other habitat features declines, high temperatures become more stressful to fish.

Long-term data suggest that using planting projects to restore streamside vegetation in the mid and upper sections of a stream is effective in lowering overall stream temperatures. Taking yearly temperature fluctuations into account, the stream temperatures in Willanch creek have steadily cooled since the planting project in the lower valley reach in 1997.

Riparian shade is lacking on the upper half of the Upper Valley reach, on the lower segments and a couple tributaries to Johnson Creek, the entire Tidal reach as well as a tributary entering the mainstem at the top of the Tidal reach, and the lower section of the Lower Valley reach to the confluence with Johnson Creek. These areas should be planted, especially on the southern banks, to avoid excess solar heating. The areas needing the most riparian planting are largely in agricultural use, especially along the Tidal reach. Therefore, riparian restoration planning will need to consider ways in which agricultural land managers can best integrate riparian management into their operations. Examples of such management practices to consider include the use of appropriate fencing, off-stream livestock watering, noxious weed control, and planning for the nearby use of heavy farm equipment. Existing should also be protected and managed to continue providing shade in the future.

Riparian planting projects will not only contribute to keeping water cool, but also stabilize banks, catch and filter sediment in run-off, and increase future large wood recruitment.

Sediment

The Willanch sub-basin has high natural sediment production that is accelerated by road-related erosion, improperly functioning culverts, and other land use practices that are adversely affecting drainage of the area. Slope stability is relatively good, with only 13.38% of the sub-basin in the medium to extremely high risk range for naturally occurring landslides. The most unstable banks, 20% unstable, are in the Tidal and Lower Valley reaches and on the Right Fork. Unstable banks contribute sediment to the stream system and may undermine riparian plantings. Bank stability surveys were not done on three tributary reaches and should be sought in the future.

The Willanch sub-basin has a relatively moderate amount of fill at high to very high risk of failure - 1536 yds^3 during a 50-year event. However, the larger problem may be that 18% of the sub-basin's culverts cannot drain more than 25% of their flow during a 50-year event. This means that during rain or storms smaller than 50-year events, culverts are becoming at least partially overwhelmed and causing both sediment build-up and erosion to occur around them.

Confounding the problems caused by high sediment production is the fact that the tide gate at the lower end of the slough interrupts the natural sediment transport mechanisms and therefore, very little sediment is flushed out of the system.

Table W-11 Road & Landing Treatment Recommendations

Site Type	New Structures Needed To Meet BMP	Replacement Structures Needed
Stream Crossing	46 Cross Drain Pipes	24 Culverts (16 Erosion) (8 Fish Passage)
Ditch Relief	6 Cross Drain Pipes	6 Cross Drain Pipes
Abandoned Road	12 Water Bars	
Totals	64	30

While sand-silt dominated channels are generally expected in lower, low-gradient reaches, the Willanch sub-basin has undesirable high levels of fine sediment in almost all of the reaches. Most of the mainstem reaches, including the headwaters, have more fine sediment in the riffles than gravel. Sediment loading may also be contributing to low residual pool depths.

All reaches meet or exceed benchmark levels of riffle gravel however, the gravel is highly embedded with fine sediment. Four of the reaches, including areas in the upper sub-basin, have more fine sediment in the riffles than gravel. The mainstem reaches with the most riffle sediment also have the lowest pool depths.

Road and landing treatment recommendations (see Table W-11) are site-specific fixes that bring road drainage problems up to date with current, 2003 Oregon Department of Forestry Best Management Practices (BMP). “New structures needed” are based on Oregon Department of Forestry, 2003, Best Management Practices addressing ditch lengths. “Replacement structures needed” address all road drainage features, and are based on the Pacific Watershed Associates Road and Landing Survey Protocol adapted by the Coos WA. Based on the road and landing surveys, Willanch sub-basin needs 52 ditch relief culverts (cross drain pipes) to reduce road related sediment and 24 existing stream crossing culverts need to be replaced. Locations of treatment sites are shown Figure W-22, below.

Of the culverts that need replacing, 16 are rusted out and eroding the road fill under the pipe. The 8 culverts that are listed as fish passage barriers, are either badly undersized or have perched outlets. Five of the fish passage culverts are high priority based upon the potential amount of habitat above the site.

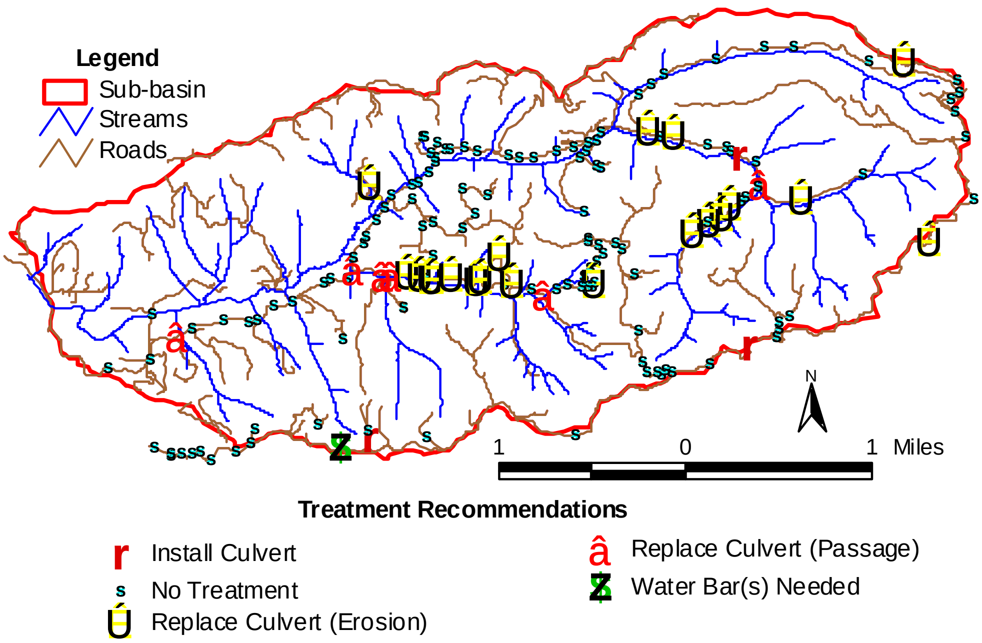


Figure W-22 Road & Landing Treatment Recommendation Locations

The Willanch sub-basin is one of the sub-basins where surveyed stream crossing upgrades have already begun. Over the last few instream working seasons several undersized culverts have been replaced with bridges. There have been four bridges replaced on Willanch Creek, three of which were replaced in the summer of 2004 and one several years prior. These bridges helped to allow year-round access to spawning and rearing areas for both juvenile and adult salmon. Another of the at-risk stream crossing culverts is a 72 inch culvert up stream from the main forks on Willanch Creek. This culvert drains only 80% of the area above it, and has 650 yds^3 of associated fill. Replacement of the culvert with a bridge would be most beneficial to the stream system however, steep hill slopes at the site necessitate a particularly long-spanning bridge.

Large Wood

Large wood is missing completely in some lower areas of Willanch, gains some in the mid sections of the sub-basin, although still far below benchmark levels, and in some of the smaller, upper tributary reaches there is ample large wood yet almost no key pieces. Large wood and boulders should be placed in the Tidal, Lower Valley, and Right Fork 4 reaches where there is no current large wood.

Placement of large wood and boulders will improve summer rearing habitat by creating pools, increasing pool depth by scour action, adding habitat complexity, and enhancing channel sinuosity. Residual pool depths are also below desirable levels in all reaches, and would be benefited by large wood placement. Large wood and boulder placement will improve winter rearing habitat for juveniles by creating secondary or side channel areas, such as alcoves, backwaters, and isolated pools, for fish to find relief from high, fast winter flows. However, large wood placement may not be practical in the Tidal and Lower Valley reaches until banks are stabilized there. Other reaches needing large wood should also be surveyed and treated for bank stability before large wood can be installed.

Conclusions

The results of the watershed health analysis and the concerns expressed by landowners make it necessary to establish positive working relationships in order to develop and implement successful restoration strategies. Effective habitat restoration efforts in this sub-basin will focus on improving summer and winter rearing habitat while addressing sediment loading, stream complexity and concerns of landowners regarding drainage issues. The results from the Willanch sub-basin restoration prioritization process, below, intend to integrate 13 important criteria to provide the most logical and systematic approach to project development.

Prioritization of Potential Actions

Results of the prioritization process for the Willanch sub-basin are mapped below in Figure W-23. Legend colors indicate how the action scored within its region and implies the general approach that CoosWA would take to the action type. A description of the prioritization process, scoring and action types is provided previously in Chapter 3 – Restoration Strategy.

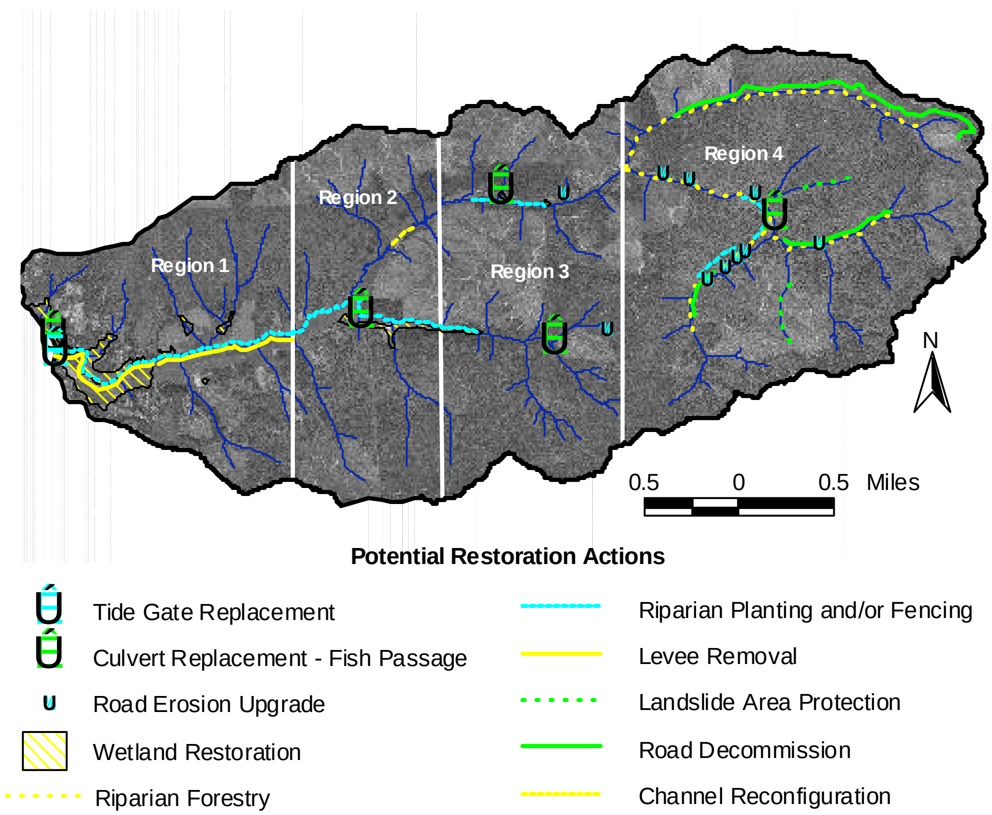


Figure W-23 Potential Restoration Opportunities

Potential actions within each region are listed in Tables W-12 and W-13. The color next to each action corresponds to the colors on the map in Figure W-23, and to the prioritization score categories.

Region 1

As the score-derived color coding indicates, replacement of culverts for fish passage is the highest priority potential action in Region 1. Yellow priority level potential actions include levee removal and wetlands restoration. The potential actions of riparian planting and fencing, tide gate replacements, and implementation of farm plans received lower scores for biological returns and higher scores for socio-economics. Implementation of farm plans generally applies to agricultural land, and is not displayed on the map in Figure W-23. Red priority level potential actions in Region 1 scored low in both the biological and socio-economic criteria and are not included on the restoration potentials map.

Table W-12 Willanch Regions 1 and 2 Potential Actions

Region		Potential Actions
1		Culvert replacements (passage)
		Levee removal
		Wetlands restoration
		Riparian planting
		Riparian fencing
		Tide gate replacements
		Implement farm plans
		Ditch maintenance
		Large wood placement
		Tide gate removal
		Levee setback
		Water Conservation
2		Culvert replacements (passage)
		Wetlands restoration
		Reshape channel
		Beaver encouragement
		Riparian fencing
		Riparian planting
		Willow wall
		Implement farm plans
		Large wood placement
		Ditch maintenance
		Bank resloping (no plant)
		Off-channel features
		Water Conservation

Region 2

The top priority action in this region is culvert replacement for fish passage. Yellow priority level potential actions include wetlands restoration, reshaping the channel, and beaver encouragement. The CoosWA would seek to develop partnerships and education or demonstration opportunities for these potential actions. Blue priority level potential actions, in which the CoosWA may provide design assistance but not take a lead in funding development, include riparian fencing and planting, willow wall construction, and implementation of farm plans. Implementation of farm plans generally applies to agricultural land, and is not displayed on the map in Figure W-20. The red priority level actions all received low scores for both biological and socio-economic criteria and are highly unlikely to be implemented.

Region 3

Road decommissioning and road upgrades received the highest priority level in this region. These actions are assumed to have both high biological returns and socio-economic favorability and would be generally easier to implement in this region. The yellow priority level actions, beaver encouragement, riparian forestry practices and channel reshaping, are cases in which the CoosWA may seek partnerships and funding development if interest from landowners is shown. Blue priority level actions include culvert replacements for fish passage, large wood placement, riparian fencing and riparian planting. These actions scored higher in the socio-economic criteria and lower for biological returns.

CoosWA would not take a leading role in developing funding for these projects.

Region 4

The highest level priority actions in this region are culvert replacement for fish passage, landslide area protection, and road decommissioning. The yellow level potential action is riparian forestry practices. Actions in which the CoosWA would not take a lead role, those that scored lower biologically and higher for socio-economics, include riparian planting and culvert replacements for erosion control.

Table W-13 Willanch Regions 3 and 4 Potential Actions

Region		Potential Action
3	(green)	Road decommission
	(green)	Road upgrades
	(yellow)	Beaver encouragement
	(yellow)	Riparian forestry practices
	(yellow)	Reshape channel
	(blue)	Culvert replacement (passage)
	(blue)	Large wood placement
	(blue)	Riparian fencing
	(blue)	Riparian planting
4	(green)	Culvert replacement (passage)
	(green)	Landslide area protection
	(green)	Road decommission
	(yellow)	Riparian forestry practices
	(blue)	Riparian planting
	(blue)	Culvert replacements (erosion)

Coos Bay Lowland Assessment and Restoration Plan

Chapter 3:
Echo Sub-basin Restoration Opportunities

Echo valley. Photo CoosWA, 2004.

Discussion of Restoration Opportunities

This section discusses the need for restoration in particular reaches (aquatic habitat survey reaches) within the sub-basin based on survey data analysis, and then introduces restoration priorities within each of four larger regions based on the prioritization scoring system.

This sub-basin is unique in that it encompasses several small streams with direct drainage to the bay, yet only Echo Creek was surveyed for this assessment. Our analysis indicates that the quality of salmon habitat in the Echo Creek varies between the five study reaches. The Beaver Pond reach and the Tidal reach are the outliers - both consisting of almost all pool units. Given the nature of the small drainage size of streams in this sub-basin and the low intrinsic potential for smolt production, restoration in the Echo sub-basin is generally a lower priority than in the other Lowland sub-basins.

Large Wood

Surveys indicate a severe lack of large wood in all reaches on Echo Creek with three out of five reaches registering zero to very negligible amounts. Large wood should be placed in the Valley, Forest, and Beaver Pond reaches and recruitment of large wood should be managed for in the Upper Forest reach. CoosWA surveyor's notes state, however, that the estimates for large wood in the Beaver Pond were possibly very low because of visibility problems and that approximately one third of the pond's surface is covered with live trees growing in the pond. As these trees die they should be kept in the pond for habitat enhancement.

Large wood can foster many of the characteristics of summer rearing habitat such as development of gravel beds, creating and increasing pool depth, and generally adding habitat complexity that serves as refugia from predators. Winter rearing characteristics can be restored by placement of large wood and boulders in the stream channel, enhancing the stream's ability to access its floodplain during high flows, and allowing channel sinuosity to form over time.

Sediment

The Echo sub-basin has high natural sediment production that is accelerated by roads, unstable banks, and other land use practices that are adversely effecting stream health and causing extensive drainage problems for local residents. Confounding the problems caused by high sediment production is the fact that the tide gates, at the lower end of three streams in the sub-basin, interrupt the natural sediment transport mechanisms and therefore, very little sediment is flushed out naturally.

Sand-silt dominated channels are expected in the lower reaches where the stream has low gradients and low water velocities. However, in this sub-basin, even the upper reaches have high amounts of silt, and all riffle sediment is far above even the undesirable amounts. The Beaver Pond reach contains 60% silt/organics.

Echo Creek has problems with bank stability and is in need of bank restoration and protection in the Valley, Forest, and Upper Forest reaches. The Valley reach also contains approximately 15% uncovered stable banks, adjacent to a county road, which should be managed to maintain its stability.

Landuse practices that disturb the erosion-prone silt/sandstone soil should be planned in a way that minimizes their impact, especially in the upper areas of the sub-basin. The slope stability analysis indicates that 27.4% of the Echo sub-basin is in the medium to extremely high risk range for naturally occurring landslides. At-risk fill at culvert sites is relatively small compared to other sub-basins.

Table E-10 Road & Landing Treatment Recommendations

Site Type	New Structures Needed To Meet BMP	Replacement Structures Needed
Stream Crossing	18 Cross Drain Pipes	4 Culverts (3 Erosion) (1 Fish Passage)
Ditch Relief	14 Cross Drain Pipes	3 Cross Drain Pipes
Ditch Out	7 Cross Drain Pipes	4 Water Bars
Potential Landslide		
Ponding/ Gullied Road Surface	3 Cross Drain Pipes	1 Water Bars
Totals	42	12

Road and landing treatment recommendations (see Table E-10) are site-specific fixes that bring road drainage problems up to date with current, 2003, Oregon Department of Forestry Best Management Practices (BMP). Based on the Coos WA road and landing surveys, the Echo sub-basin needs 42 new ditch relief culverts to reduce road related sediment. Of the existing structures, 4 stream crossing culverts need to be replaced, 3 are rusted out and eroding the road fill under the pipe and the 1 culvert that is listed as fish passage barrier is undersized and 20% restricted due to the crushed outlet. Three ditch relief pipes are rusted out and need replacing and 13 water bars should be cut to upgrade ditch out and gullied road surface sites. Treatment site locations are shown in Figure E-20, below.

“New structures needed” are based on Oregon Department of Forestry, 2003, Best Management Practices addressing ditch lengths. “Replacement structures needed” address all road drainage features, and are based on the Pacific Watershed Associates Road and Landing Survey Protocol adapted by the CoosWA.

There were two stream crossing culverts that are especially undersized; they are both 48 inch culverts that drain over 1.1 square miles each. At least 100 cfs of water is backed up behind these culverts during high flow events, and each require at least 72 inch culverts to pass a 50-year event. Most of the fill at risk in this sub-basin is in the very high and high categories.

Tide gates should be maintained, redesigned or removed to allow proper flushing of sediment and upstream and downstream fish passage.

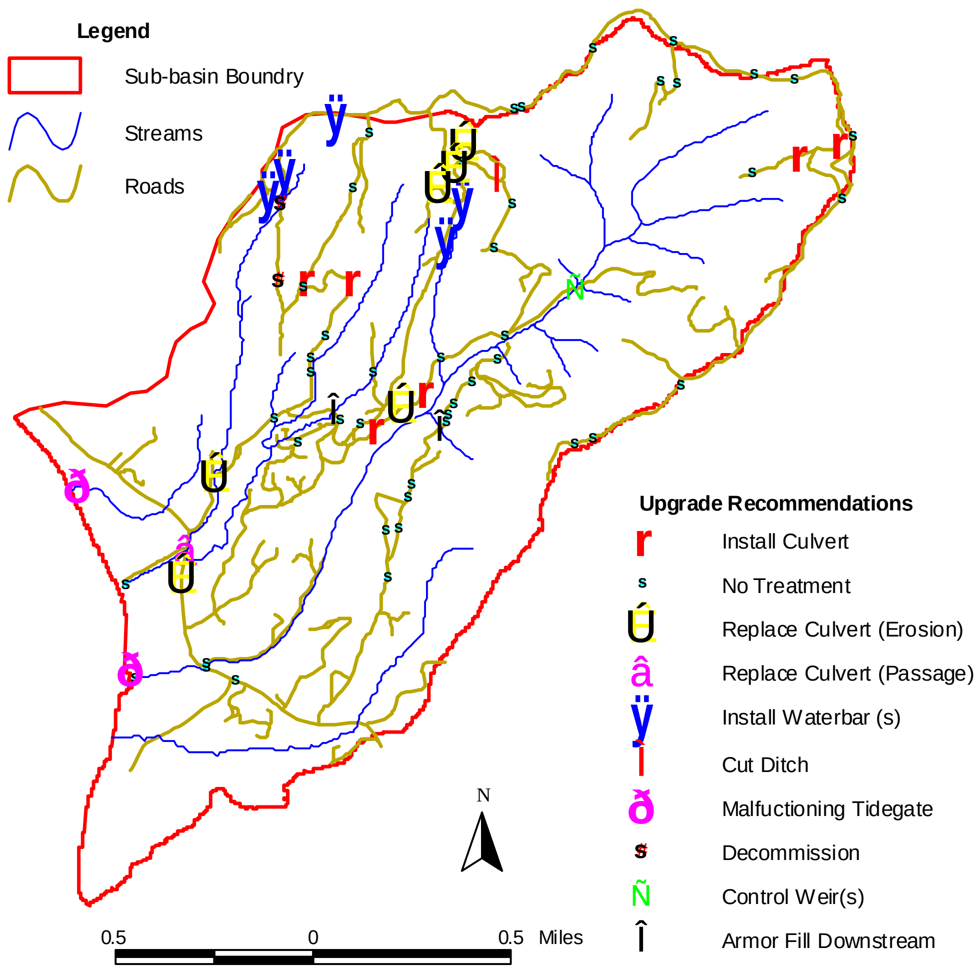


Figure E-20 Road & Landing Treatment Recommendation Locations

Temperature and Shade

Based on temperature data, Echo Creek appears to provide suitable summer habitat for salmonids, with only the lowest half-mile of stream showing marginal temperatures. Conservation measures should be taken to ensure continued cool temperatures.

Echo Creek has the highest current shade values compared to other sub-basins in the assessment area. Riparian shade analysis shows that there is only moderate, up to approximately 20%, lack of shade. Riparian planting, though not a priority in this sub-basin, should be considered along the Forest reach, which shows the largest need for shade and more than 10% unstable banks. Just downstream of this reach, temperatures rise into marginal levels and the steam enters the rural residential area. Care should be taken to preserve the shade that currently exists.

There are only two temperature gauging sites on Echo Creek, and assessment of the sub-basin would benefit by expanding the number and location of study sites to other streams in the sub-basin area.

Stream Flow

The Echo Creek Water Availability Basin received a low level ranking for need to restore in-stream flow for fish use. The opportunity for flow restoration received a poor ranking. Echo sub-basin was not assigned as a priority. OWEB WAM, however, ranks flow restoration opportunity based on consumptive use of >10% (OWEB, 1999). Echo Creek, in this case, is not ranked as having the greatest opportunity for flow restoration due to no change in consumptive use from 1993.

Conclusion

As demonstrated by the Limiting Factors analysis in Chapter 2, the primary habitat bottleneck in the Echo sub-basin is summer rearing habitat while landowners' primary concerns include maintenance of tide gates, drainage structures and flood control. While many of the features discussed above can be altered to augment or enhance habitat, long-term success will depend on addressing watershed processes that naturally create and sustain quality habitat. It will also be necessary to establish informed, positive working relationships between landowners order to carry out successful restoration strategies. The results from the Echo sub-basin restoration prioritization process, below, intend to integrate 13 important criteria to provide the most logical and systematic approach to project development.

Prioritization of Potential Actions

Results of the prioritization process for the Echo sub-basin are mapped below in Figure E-21. Legend colors indicate how the action scored within its region and implies the general approach that CoosWA would take to the action type. A description of the prioritization process, scoring and action types is provided in Chapter 3 – Restoration Strategy.

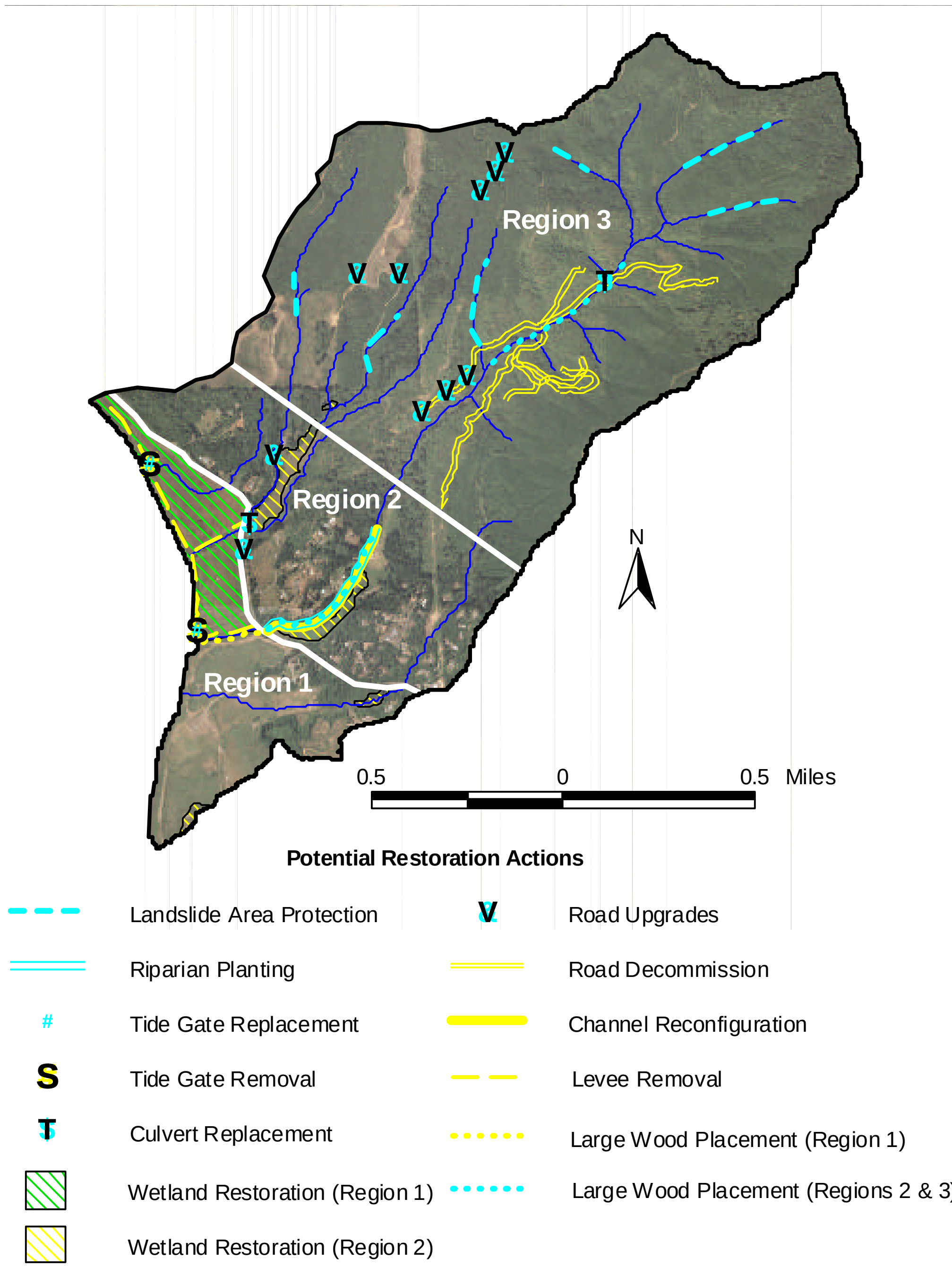


Figure E-21 Potential Restoration Opportunities

Region 1

Potential actions within Region 1 are listed in Table E-11 and shown in Figure E-21. As the table indicates, the only green priority level action in the Echo sub-basin is wetland restoration in Region 1. This action scored higher in this region than in Region 2 since projects affecting East Bay Drive (the need to move fill and close the road while working) and pose a significant increase in cost and implementation feasibility. Estuarine wetland restoration in Region 1 scored high for both biological returns and socio-economics. Potential actions receiving a yellow priority ranking in Region 1 include tide gate removal, tide gate relocation, levee removal and large wood placement. The yellow priority level of these actions indicates high estimated biological returns, yet lower socio-economic favorability. The blue priority level potential action of tide gate replacements received lower scores for biological returns and higher scores for socio-economics. CoosWA would provide recommendations for tide gate replacements but not take a lead on seeking funds. Potential actions in Region 1 receiving the red priority level both scored low in the biological and socio-economic criteria and are not included on the restoration opportunities map.

Region 2

Potential actions within Region 2 are listed in Table E-11 and shown in Figure E-21. Yellow priority level actions in Region 2 include reshaping the stream channel (channel reconfiguration), beaver encouragement and wetlands restoration. Blue priority level actions include large wood placement, willow wall construction, and implementation of farm plans. Neither beaver encouragement nor implementation of farm plans are shown on the map due to the impracticality of display. The red priority level actions all received low scores for both biological and socio-economic criteria and are highly unlikely to be implemented

Table E-11 Echo Regions 1, 2 and 3 Potential Actions

Region		Potential Actions
1	(green)	Wetlands restoration
	(yellow)	Tide gate removal
	(yellow)	Tide gate relocation
	(yellow)	Levee removal (includes tide gate removal)
	(yellow)	Large wood placement
	(blue)	Tide gate replacements
	(red)	Riparian planting
	(red)	Riparian fencing
2	(yellow)	Reshape channel
	(yellow)	Beaver encouragement
	(yellow)	Wetlands restoration
	(blue)	Large wood placement
	(blue)	Willow wall
	(blue)	Implement farm plans
	(blue)	Culvert replacements (passage)
	(blue)	Riparian planting
	(red)	Riparian fencing
	(red)	Off-channel features
	(red)	Ditch maintenance
3	(yellow)	Road decommission
	(blue)	Riparian forestry practices
	(blue)	Large wood placement
	(blue)	Culvert replacement (passage)
	(blue)	Road upgrades
	(blue)	Landslide area protection (head wall retention)

Region 3

Potential actions within Region 3 are listed in Table E-11 and shown in Figure E-21. Road decommissioning received the highest level ranking in this region, although it scored below a two for socio-economics it scored higher for biological returns. Blue priority level actions include riparian forestry practices, large wood placement, culvert replacements for fish passage, road upgrades, and landslide area protection. These actions scored higher in the socio-economic criteria and lower for biological returns. CoosWA would not take a leading role in developing funding for these projects. There were no red priority level actions in this region.

Appendix A - Survey Methods and Supplemental Data

Hydrology

The Oregon Watershed Assessment Manual (OWEB, 1999) was used as a guideline for rating potential risks of stream flow enhancement. This procedure was followed step by step to assess the Hydrologic processes present in the lowlands. ArcView 3.2a was used for the GIS analysis.

Numerous sources were needed for the hydrologic and water use condition characterization analysis. Stream flow data was collected from the US Geological Society (USGS), and Oregon Water Resources Department (OWRD), as well the Coos Watershed Association. Peakflow data was acquired from OWRD using their interactive mapping system. Precipitation data was collected from the Oregon Climate service (OCS), and National Oceanic and Atmospheric Administration (NOAA). A GIS Prisms shapefile of the mean annual precipitation map was from OCS, and a NOAA Atlas 2 map was used for a 2-year, 24-hour precipitation component. Soil maps were acquired from the National Resource Conservation Service to determine Hydrologic Soil Groups (HSG) for analysis of the infiltration rate of agriculture lands.

Forestry, agriculture/rangeland, forest and rural roads, and urban and rural residential areas were evaluated for possible impacts on hydrology. Included within the rural road area, there are a small amount of urban roads.

GIS was used to calculate the area of road surfaces in each land use type, and total linear road lengths. Then, the linear lengths of roads were multiplied by default road widths set by OWEB (25 feet for forestry roads and 35 feet for rural residential) (OWEB, 1999). Once the road areas were calculated they were divided by the total area within that land use, and a percentage of total area of roads helped determine the potential risk for peak-flow enhancement.

In the water use section, water rights were compiled using the Water Rights Reporting System (OWRD, 2005) for water use analysis. Each individual permit or certificate was reviewed to determine type and amount of water use. Water availability reports for 50% exceedance levels were obtained for the Water Availability Reporting System (OWRD, 2005). The flow restoration assessments were obtained from

ODFW and OWRD to determine need, opportunity, and priority of flow restoration in the lowlands area.

Aquatic Habitat Surveys

Aquatic habitat surveys were conducted from 2000 to 2004 using the ODFW protocol *Aquatic Inventories Project: Methods for Stream Habitat Surveys* (Moore, et al., 2004). Surveys generally started at the mouth of the stream system and progressed upstream. Individual landowners are contacted each year for permission to allow Coos WA field staff access to conduct specific surveys. Reach beginnings and endings were determined by a number of factors including changes in habitat type, land use changes, and access to private property.

Habitat Benchmarks

Aquatic habitat survey data, with the exception of bank stability, is compared to established ODFW Aquatic Inventory Project benchmark habitat values for West-side forested basins. These benchmarks are the most appropriate tool currently available for analyzing such data. (The Coos WA, however, anticipates future development of analysis tools for more accurately defining habitat benchmarks for tidally-influenced stream systems such as those in the assessment area.)

Habitat benchmarks are provided for pool depth, riffle gravel/ sediment, large wood, and bank stability. These benchmarks are presented on graphs in this assessment using dotted lines to represent desirable (good) levels, and solid lines to represent undesirable (poor) levels. See the table below for benchmark details.

ODFW developed benchmark standards for large wood by analyzing stream reaches whose habitat characteristics provided high productive capacity for salmonid species. These reference values were then compared to the frequency distributions of habitat characteristics within a basin or region. Analyzing the frequency distributions, ODFW generally accepted that values from the 66th percentile or higher represented desirable habitat conditions, and values from the 33rd or lower percentile represented undesirable conditions. The benchmarks developed from the distributions were then tailored to stream gradient as well as regional and geologic setting. Benchmarks for other characteristics (pool frequency and depth, and silt-sand-organics) were developed by comparing distributions and generally accepted or published values (Moore, 1997). The benchmark for riffle gravel was developed through correlation analysis between winter gravel estimates (habitat and spawning surveys) and summer gravel estimates (habitat surveys). If a reach has at least the threshold value for riffle gravel (35%) during summer habitat surveys, then sufficient gravel was generally available for spawning in pool tailouts and other common spawning habitat for coho (Kim Jones (ODFW), personal communication November 2001).

The bank stability benchmark is considered an anticipated average minimum performance level possible under various geomorphic conditions which will provide favorable biological conditions over time (McCullough, 1999). This benchmark, ≥90% stable, is the standard suggested by the US Environmental Protection Agency, Region 10 (Bauer, Ralph, 1999).

Habitat benchmark details

Benchmark parameters and desirable / undesirable standards developed by ODFW (Table modified from Moore, 1997).

Table M-1 Benchmark Details

Parameters (ODFW Benchmarks)	Undesirable	Desirable
POOLS		
Pool Area (% Total Stream Area)	<10	>35
Residual Pool Depth		
Small Streams (<7m)	<0.2	>0.5
Medium Streams (>= 7m and < 15m)		
Low Gradient (Slope <3%)	<0.3	>0.6
High Gradient (Slope >3%)	<0.5	>1.0
Large Streams (>= 15m width)	<0.8	>1.5
RIFFLE SEDIMENT		
Gravel (% Riffle Area)	<15	>=35
Silt-Sand-Organics (% Riffle Area)		
Sedimentary Parent Material	>20	<10
Volcanic Parent Material	>15	<8
Channel Gradient < 1.5%	>25	<12
LARGE WOODY DEBRIS		
Pieces /100m Stream Length	<10	>20
Volume/ 100m Stream Length	<20	>30
Key Pieces (>60cm diameter & >= 10m long/ 100m)	<1	>3
Parameter (EPA Benchmark)		
BANK STABILITY		
Stable Banks (% not actively eroding)	**<90**	**>90**

Wetlands Inventory

Wetland conditions were evaluated in three ways: (1) we looked at the historical extent on wetlands; (2) we surveyed the current extent of wetlands in the six study sub-basins; and (3) we identified potential wetland restoration opportunities using the National Wetland Inventory maps. This wetland evaluation does not include site-specific ranking or prioritization of potential restoration sites, but is a broad scale look at a critically important habitat type in the Coos Bay Lowlands.

The historical extent of wetlands in the assessment area was determined from three sources of data. First, soils provide the most reliable indication of wetlands because they tend to not change over time. Specific types (series) can be further used to identify areas where the soils developed under tidal inundation (Brophy, 2005). In the Lowlands Assessment area, these soil series include Brallier, Chetco, Coquille, Fluvaquents-Histosols Complex, and Langlois. Soil types indicative of freshwater inundation are based on *Hydric Soils of Oregon* (NRCS, 1995), which, along with National Wetland Inventory data, is used to create the historical wetland maps (USFWS, 1997). The *Soil Survey of Coos County* (USDA-SCS, 1989) and its electronic data layer is used to identify soil series formed under tidal influence (Brophy, 2005).

Specific soil series in this class are overall in the assessment area based on estuarine soil types, vegetation mapping listed in the OWEB Watershed Assessment Manual chapter on estuarine assessment (Brophy, 2005).

Table M-2 National Wetland Inventory Wetland Types

	Acres within Sub-basin					
Wetland Type	**North Slough**	**Palouse**	**Larson**	**Kentuck** (USFWS, 1979)	**Willanch**	**Echo**
Aquatic Bed - Permanently Flooded	12			1		
Emergent - Temporarily Flooded	72	74	18	129	112	26
Emergent - Seasonally Flooded	318	371	285	174	85	80
Emergent - Seasonal (Tidal)		19	83			
Emergent – Semi-permanently Flooded			15			
Forested - Temporarily Flooded	1	2				
Forested - Seasonally Flooded	19			1		
Scrub Shrub - Temporarily Flooded	1					
Scrub Shrub - Seasonally Flooded	19			1		
Scrub Shrub - Seasonal (Tidal)		9	2			
Scrub Shrub – Semi-permanently Flooded						1
Unconsolidated Bed - Permanently Flooded	1		3			1
Unconsolidated Shore - Temporarily Flooded						2
Riverine Unconsolidated Bed (Tidal)	2	21	8	7	1	
Total NWI Wetland Area	444	496	414	314	198	110

Sediment Sources

Slope Stability

A 10-meter Demographic Elevation Model (DEM) was used for the GIS analysis of the slopes of this sub-basin. An ODF classification of potential risks of slopes was used to group the slopes in to larger categories for analysis. They are as follows:

Low Risk: Less than 40% slope, essentially no risk of a rapidly moving debris flow. Gentle to moderate slope steepness precludes shallow landslides, but area may be subject to deep-seated, slower moving slides.

Moderate Risk: 40-60% slope, debris flows (moves down-slope as a semi-fluid, watery mass scouring soils from the slope in its path) may occur.

High Risk: 60-70% slope, debris flows fairly common after major storms, and sometimes after moderate storms, steep to very steep slopes with steep stream channels.

Extreme Risk: More than 70% slope, multiple rapidly moving debris flows during major storms and moderate intensity storms. Very steep slopes with confined stream channels.

A geology layer was obtained from the State Service Center of GIS, and used to determine the types of underlying parent material present in the lowlands.

Road and Landing Survey

Coos Watershed Association completed road and landing surveys on the lowland tributaries from January 2001 to March 2005 using Pacific Watershed Associates methodology as adapted by the Coos WA. Coos WA surveyors were trained by Dan K. Hagans of Pacific Watershed Associates.

Each drainage feature location was mapped and a data form filled out. Up to 63 fields are collected per site, and a stream profile and cross section is taken to calculate the volume of sediment at risk at each stream crossing.

The length and the slope of each ditch contributing flows to the site was measured and compared to the 2003 Oregon Forest Practices Act Best Management Practices for ditch-length recommendations (see below). Each of the culverts was evaluated for size and condition, and upgrade and maintenance recommendations were made where needed.

Recommended Ditch Lengths
Cross-drainage structures

Science and Monitoring
Soil properties and road grade have a major influence on ditch erosion and potential for gullies to develop (Arnold, 1957). ODF monitoring found that culverts comprise about 35 percent of the cross drainage structures used on forest roads in western Oregon. Waterbars and ditch-outs each make up about 15 percent of the cross drainage structures used in western Oregon. Many roads also had non-engineered drainage features (water flowing across the road without any structure). ODF monitoring also found that roads with steeper grades (over 9 percent) often had fewer cross drains than less steep roads, with spacing exceeding that recommended to reduce ditch erosion.

Implementation
The location and installation of cross-drainage structures is the final element of drainage, and recognizes there are many ways to drain a road. Local experience is important here. First, look for opportunities that do not require the use of structures across the road. Use of ditch-outs as roads cross ridges is very effective, as are grade reversals. Cross drains must be placed more frequently as road grades get steeper and in more erodible materials, like decomposed granite. The culvert spacing guidelines in Table 2 are based on Arnold (1957) but have been simplified to consider only two soil types, normal and erodible. Most soils are considered normal. Erodible soils include decomposed granitics in southwest Oregon, volcanic ash in eastern Oregon, and any soils with natural gullies or a history of surface erosion problems at that location.

Table 2. Typical minimum culvert spacing for erosion control

	Culverts draining to forest floor	
Road Grade	**Normal Soils**	**Erodible Soils**
0 to 1 % dry season	1500 feet	1000 feet
*0 to 1 % wet season**	*300 feet*	*300 feet*
2 to 5 %	1000 feet	700 feet
6 to 12 %	700 feet	400 feet
13 to 19 %	400 feet	250 feet
over 20 %	250 feet	150 feet

** water ponds on flat grades so extra drainage is needed for roads used during wet periods*

Table 2 is applicable for effective, well-maintained structures only. If waterbars are used, they should be installed at closer spacing, since waterbars can be easily damaged if filled with sediment by traffic (authorized or unauthorized). Note that the lengths in Table 2 are typical, and should always be adjusted to make sense for local conditions. If another local criteria effectively works to keep sediment out of streams, it should be used instead of the criteria in Table 2.

(Excerpt from Installation and Maintenance of Cross Drainage Forest Practices Technical Note Number 8,*Version 1.0,* June 20, 2003, Oregon Department of Forestry)

Data collected at fish bearing stream crossings was used to determine if the crossing created a fish passage barrier.

The effectiveness of road drainage features was evaluated using a slightly modified Pacific Watershed Associates protocol. The data collected has been entered into a Road and Landing Access Database, Excel Spreadsheets and exported into ArcView. This is used to track the status of road systems and for more comprehensive basin-wide sediment budget modeling. Key fields that describe sediment hazard included road gradient and side slopes, ditch length, proximity to stream channels, and potential delivery volumes. Ditch length is only one of three factors, the other two being gradient and soil type (permeability), that determine erosion potential and sediment transport from ditches. This survey and analysis work has enabled Coos WA to make informed recommendations for road drainage projects that will reduce chronic sediment delivery as well as prevent catastrophic road fill failures.

Stream Crossing Drainage Evaluation

Using ArcView 3.2a, Coos WA was able to calculate the area of land above each stream crossing that drains into that site. We used the ArcView extension Spatial Utilities to collect these calculations. Using the Oregon Road/Stream Crossing Restoration Guide, 1999, we were able to get the current cfs (cubic feet per second) capacity of each culvert using the existing culvert diameters from recent Coos WA road and landing surveys. The fifty and one hundred-year peak flow events were calculated using the drainage area for each stream crossing multiplied by the common peak flow values found in the Oregon Road/Stream Crossing Restoration Guide. We then subtracted the current cfs capacity of the culvert from the cfs that a fifty and one hundred- year event will produce to determine if the current culvert will pass both of these events.

The Coos WA road and landing surveys determined that several of the stream crossing culverts were currently plugged or crushed and, therefore, restrict flow. Using of the Oregon Road/Stream Crossing Restoration Guide, we were able to calculate the percent of cross-sectional area loss to account for the percent of flow restriction. By doing this, Coos WA was able to recalculate the cfs capacity of all restricted stream crossing sites and compare these values with cfs requirements for fifty and one hundred-year peak flow events.

Stream Temperature

Continuous stream temperature data was collected using HOBO Water Temp Pro loggers (Part #H20-001) made by Onset Computer Corporation. The sampling interval was set at 30 minutes and each unit was deployed at the same sites throughout the study to minimize equipment bias. Pre and post-deployment accuracy checks and field audits were done with a National Institute of Standards and Technology (NIST) calibrated digital thermometer. Onset BoxCar Pro version 4.3 software was used to launch and download the loggers, plot graphs and export data to Excel. The *Temperature* 1.1 macro developed by the Oregon Department of Environmental Quality was used to process the data files to provide metrics used to assess the temperature standards. Methods described in the Stream Temperature Protocol chapter of the *Water Quality Monitoring Technical Guide Book* (Oregon Plan for Salmon and Watersheds, 1999) were used to standardize logger accuracy checks, site selection, and field audits. Post-season ice-bath audits showed the HOBO units to be functioning correctly, all rated Grade A. Field audits were taken three times during the summer for most units. Ratings for the field audits ranged from Grade A to Failing. The results in these audits were likely due to errors in the field, with the thermometer not being close enough to the HOBO unit. This is likely in the audits of the tide gate units on Palouse and Larson -- where two out of three field audits failed -- because the units were so difficult to precisely locate. One site on Echo failed once and Larson had two additional sites with one failed audit each. If pre- and post-deployment audits rate the temperature sensor as Grade A, then there is strong evidence that the units were operating correctly throughout the period deployed, irregardless of the field audit results.

Most of the sites consisted of one temperature logger below the water surface attached to a rebar spike driven into the stream bed. At sites in deep stream channels, the temperature logger was affixed to a heavy cement block resting on the stream bottom. Logger sites were chosen to give a representative idea of the water temperatures throughout the streams.

Table M-3, below, shows the change in average daily temperature between sites.

Table M-3 Difference In Average Daily Temperature (^{O}f) Per 1000 Feet Between Sites

2003				2004			
Creek	**Site-Site**	**Distance (ft)**	**^{o}F/ 1000 ft**	**Creek**	**Site-Site**	**Distance (ft)**	**^{o}F/ 1000 ft**
N Slough	1-2	3084	0.593	**N Slough**	4-6	7138	0.990
	2-3	7136	0.432				
	3-4	72	-13.350				
	4-5	3183	0.721				
	5-6	3955	0.717				
Palouse	1-2	10344	0.375	**Palouse**	2-2.5	4622	-0.274
	3-4	10842	0.049		2.5-3	5129	0.249
	4-5	3267	2.403		3-4	3267	3.921
					4-5	5338	-0.165
Kentuck	1-2	6074	-0.785				
	2-3	6874	0.262				
	3-4	11693	0.039				
Larson	3-2	13197	-0.562	**Larson**	3-2	3073	-0.241
	2-1	3067	0.609		2-TG upper	26914	0.324
					TG upper - TG lower	30	6.453
Willanch	8-7	837	2.016	**Willanch**	8-R. Fk Trib	242	3.708
	7-6	2028	0.053		8-7	837	0.999
	6-5	1788	-0.286		7-5	2865	0.165
	5-4	2362	0.991		5-3	4432	0.479
	4-3	2070	1.140		3-1	4248	-0.058
	3-2	942	-0.726		1-0	3642	0.236
				Echo	Upper-Lower	6826	0.944

Riparian Shade

The value of the shade analysis is in its use for strategic planning for lowering elevated stream temperatures. The results and all associated data for the shade analysis have been attached to a GIS map. A similar set of data and GIS maps are made from the results of stream temperature surveys. The two maps (temperature and shade) will be overlaid to analyze where insufficient shading of the streams is correlated with elevated stream temperatures. Those reaches where the stream heating is occurring can then be prioritized and targeted for riparian restoration. The highest priority areas for restoration are where there is a clear connection between lack of stream shading and heating of the water column.

The full results of the shade analysis for all stream reaches are presented below in Table M-4.

The six assessment streams and their fish-bearing tributaries were divided into reaches based on aspect, flow and land use. If the two sides of the stream differed significantly they were split and subsequently analyzed separately.

The stream reaches were examined on topographic maps and the aspect determined for each reach. The streams were each divided into three sets of reaches corresponding to: forested narrow canyons with steeper gradient, broader valleys with a defined floodplain and moderate gradient, and broad valleys with extensive floodplains and low gradient.

The stream reaches were analyzed on aerial photos for canopy overhang (estimated at 10% classes), canopy density (estimated at 10% classes), buffer width (measured in 20' increments), existing vegetation composition (recorded as conifer, mixed, mixed hardwood, alder, willow, grass), presence of a road within 100' (Y or N), and land use (recorded as forestry, agriculture, or rural residential)

Coos County supplied a stereoscope, work station and a copy of the BLM 2002 aerial photo set. The reaches were made into a GIS shape file for use in later analyses. The reach lengths (in feet) were measured using the GIS shape file.

Landowners along the streams were contacted for permission to enter their property for the purpose of taking field plots. These field plots have two purposes. The first is to gather additional data on the reaches to better estimate parameters that could not be directly measured in the field for all reaches such as tree-channel distance and tree heights. The second was the direct measurement of shade for validation of the SHADOW model results. The plot measurements included: tree-channel slope (in 10% classes), tree-channel distance (in feet), tree heights (in feet), active channel width (in feet), canopy overhang (estimated in 10% classes) and canopy density (estimated in 10% classes). The shade on the active channel was measured using a Solar Pathfinder instrument. A transect of the channel was established and for each 10' of active channel width a shade reading was taken. These readings were averaged for the shade over the length of the transect.

All data was entered in an Excel spreadsheet. Separate worksheets were constructed for use in running the SHADOW model for current vegetation, potential vegetation and validation plots. The current vegetation run took all measured and estimated data that described current conditions and used the SHADOW Model to calculate the current shading of the streams. The potential vegetation run used estimated values for the potential climax vegetation community (tree height, tree-channel distance, canopy overhang, canopy density) along with current measures such as tree-channel slope to calculate the potential stream shading under vegetative climax conditions.

Table M-4 Riparian Shade Values

		Steep Canyon	Upper Valley	Lower Valley
All Streams	Current	81	62	22
	Potential	95	95	84
North Slough	Current	88	54	9
	Potential	98	99	82
Palouse Creek	Current	73	65	23
	Potential	93	94	92
Larson Creek	Current	75	52	19
	Potential	96	92	78
Kentuck Creek	Current	86	76	38
	Potential	97	95	85
Willanch Creek	Current	69	34	25
	Potential	97	92	89
Echo Valley	Current	83	5	77
	Potential	90	96	99

The potential vegetation for each of these stream types was determined in consultation with Coos WA staff. Current and potential shade values for all streams in the assessment area are shown in Table M-4. The potential vegetation is the community that would develop if the area was left alone for hundreds of years. The narrow, steep valleys are expected to develop dense conifer stands with a mature height of 200' (see Table M-5, below). The small, upper, moderate-gradient valleys are expected to develop dense mixed hardwood stands with a mature height of 120'. The lower, broad, low-gradient valleys are expected to develop spruce stands with a mature height of 140'.

Table M-5 Characteristics of Potential Vegetation

	Canopy Overhang	Canopy Density	Tree-Channel Distance	Tree Height
Conifer Forest Narrow Canyon	50%	80%	15'	200'
Mixed Hardwood Small Valley	90%	80%	5'	120'
Spruce Forest Broad Valley	70%	70%	10'	140'

SHADOW Validation Protocol

A series of 19 field plots was used for validation of the SHADOW model results. Plot parameters are measured in the field and fed into the SHADOW model to produce current shade values for those points. A Solar Pathfinder instrument is also used to take a direct reading of the shade on the channel at those points. The current shade as determined from these tow methods are compared to analyze whether the results of the SHADOW model are close to what is actually measured in the field. The SHADOW model has limitations such as not taking into account topographic shading (i.e., that which is caused by a steep ridge next to the stream) and only taking one tree height for a calculation when there may be two tree canopy heights at a point. The Solar Pathfinder has limitations in that it is time consuming to take multiple plots that produce an average value for a point.

Table M-6 presents the results of the validation work completed for this study.

Table M-6 SHADOW Model Validation Plots

Map ID #	SHADOW Shade %	Validation Shade %	Difference %
NS24	0.94	0.81	0.13
NS26	0.99	0.83	0.17
NS33	0.16	0.27	-0.11
PC21	0.91	0.69	0.22
PC22	0.84	0.95	-0.11
PC28B	0.92	0.95	-0.03
PC37	0.78	0.87	-0.09
PC46	0.04	0.16	-0.12
LC5	0.77	0.89	-0.11
LC6	0.81	0.85	-0.03
KC20	0.93	0.81	0.12
KC27	0.86	0.72	0.14
KC36	0.68	0.81	-0.13
KC47	1.00	0.85	0.16
WC4	0.97	0.85	0.12
WC23	0.93	0.85	0.08
WC25	0.18	0.65	-0.47
EV4	0.90	0.89	0.01
EV5	0.85	0.95	-0.10
		Mean	**-0.01**
			0.16

Given the limitations of both the SHADOW model and the number of Solar Pathfinder readings taken, all of these values are within an acceptable range except for Palouse Creek reach 21 (PC21) and Willanch Creek reach 25 (WC25). After consideration of the specific sites and resulting data it is probable that additional Solar Pathfinder readings would yield an average value that would reduce the difference between the two sets of readings to an acceptable level. This would result in a small increase in the mean difference between SHADOW and Solar Pathfinder values, but would substantially reduce the standard deviation of the values about the mean.

Salmonid Distribution

Fish presence data is based on the classification of streams according to Oregon Department of Forestry (ODF) Forest Practice Rules. General 'fish use' classification is assumed in basins draining more than 60 acres and where the gradient is less that 20%. The fish presence (map) was extended for streams where Coos WA surveys confirmed fish presence.

Data for anadromous fish species extents are gathered from GIS layers available through ODFW. Historical salmonid stocking records, for releases directly into assessment streams, were also obtained from ODFW.

Spawning Surveys

Coos WA coho spawning surveys were conducted according to the ODFW Costal Salmon Spawning Survey Procedures Manual (ODFW, 2004). Coos WA surveyors were trained with ODFW surveyors to ensure data compatibility with ODFW's spawning survey data. The Larson Creek Standard Survey reach was conducted according to this protocol, including the collection of DNA and scale samples. Fish counts, gravel estimates, carcass species, length, and sex data were all collected as described in the procedures manual. For supplemental surveys, DNA and scale samples were not collected.

Coos WA spawning surveys were conducted in conjunction with the ODFW Coastal Salmonid Inventory Project (CSIP). The CSIP coho inventory estimates coastal coho escapement by surveying a combination of standard reaches, surveyed annually, and random reaches, selected with stratified random sampling (SRS) criteria including predicted spawner density and geographic location (Jacobs and Nickelson, 1998). The SRS method improves population estimates by reducing bias in reach selection. However, for restoration efforts within a particular basin, selecting reaches associated with projects or within priority regions was required. On streams that had CSIP random reaches, the CWA surveys were conducted according to the descriptions of those surveys. The surveys increased the sampling frequency of these reaches that are usually only surveyed once every five years.

The length of survey reaches range from .31 km to 1.57 km and average .96 km of stream length. All reaches were sub-divided into segments which averaged .26 km in stream length to increase the resolution of fish counts, redd counts, and gravel estimates. Generally, segments breaks were located at permanent landmarks such as bridges or tributaries for easy relocation. Survey lengths were measured with a hip chain.

Full-season standard and supplemental reaches were surveyed every seven to ten days (except when high turbidity prevented fish counts) so that the data could be used to calculate Area-Under-the-Curve (AUC) coho population estimates. The AUC calculation estimated the abundance of adult and jack coho in a given stream reach.

The Area-Under-the-Curve population estimates are calculated as:

$O_i=[?^{a}_{h=1}(C_{hi}T_{hi})]/D$

where

a = number of periods

C_{hi} = mean count in period h for stream segment i,

T_{hi} = number of days in period h for stream segment i, and

D = average spawning life of coho salmon in survey segments (11.3 days) (Jacobs and Nickelson, 1998).

The AUC was calculated for each stream and for each segment. In order to compare fish density between segments of different lengths, AUC/km was derived by dividing the AUC by the segment length. Similarly, redd counts were divided by the segment length for redd density.

Because of the dynamic nature of streams during high winter flows, the area of available coho spawning gravel was estimated approximately once a month. These estimates were used as a measure of available spawning habitat. Using the estimates, gravel area per spawning female was calculated. Because of the low carcass recovery on most streams, a female per area of spawning gravel was calculated based upon an assumed equal female to male ratio. In order for gravel to be included in the coho spawning gravel estimate, it had to meet the following requirements: diameter of 2-15 cm, less than 50% fines or larger rock, minimum of 20 cm depth of gravel deposit and a minimum of $2m^2$ surface area.

Intrinsic Potential for Coho Smolt Production

Intrinsic Potential is the capability of a stream reach to support specific fish species. In our case, we are interested in the potential of a stream to support coho salmon. The application of the intrinsic potential concept to Oregon coastal streams is the result of work by Kelly Burnett and colleagues at the

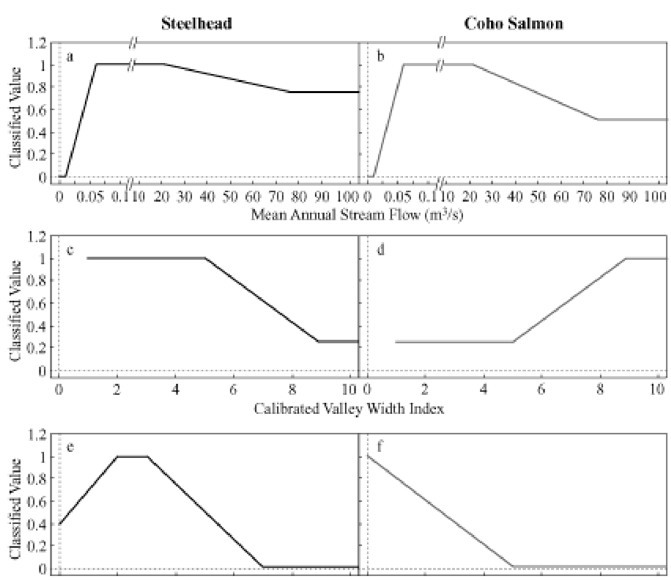


Figure M-1 Habitat Suitability Indices (HIS) For Steelhead and Coho Salmon Juveniles (Burnett et al., 2007)

U.S. Forest Service's Pacific Northwest Research Station for the Coastal Landscape Analysis and Modeling Study (CLAMS). The method is generically a "habitat suitability index," and in this case is based on three geomorphic characteristics of the stream reach: channel gradient, valley-width index, and mean annual stream flow, as shown in Figure M-1 above (Burnett et al., 2007).

The three separate indices are used to determine the intrinsic potential of a stream reach for coho salmon (or steelhead) through the following formula:

$$IP = \sqrt[3]{F_I * VW_I * G_I}$$

Where:

- IP = Intrinsic Potential (Scale: 0 – 1),
- F_I = Flow Index (Scale: 0 – 1),
- VW_I = Valley Width Index (Scale: 0 – 1), and
- G_I = Channel Gradient Index (Scale: 0 – 1)

The above equation represents the geometric mean of the index scores shown in Figure _-1 for the mean annual stream flows, valley-width index, and channel gradient. Note that in geometric means if any one of these indices is zero then the resulting intrinsic potential index will also be zero. Reaches with an index of 0.75 or greater are rated as "high" for their potential to produce coho salmon smolts.

The intrinsic potential of a given stream reach can be used to infer its ability to sustain coho smolts (its original use), as well as to estimate historic coho spawning populations (Lawson et al., 2004). Using the Lawson et al. procedures, a given stream reach is first classified by whether its stream gradient is greater than 0.5% (less than 0.5% gradient is considered wetlands). For reaches less than 0.5% gradient, the following formula was used to estimate the number of coho smolts that could be supported:

$$S = 0.0741L(V - W)P$$

Where:

- S = Potential number of smolts produced in the reach,
- L = Reach length, in meters,
- V = Valley width, in meters
- W = Active channel width, in meters
- P = Intrinsic potential of the reach (unitless), and
- 0.0741 = Number of smolts per square meter of poten tial habitat.

The formula for stream reaches with channel gradients greater than 0.5% is:

$$S = (0.3405)(0.5)LWP$$

Where:

S =	Potential number of smolts produced in the reach,
0.3505 =	Number of smolts in main channel pools,
0.5 =	Proportion of area in pools based on assumed 50%:50% pool:riffle ratio
L =	Reach length, in meters,
W =	Active channel width, in meters, and
P =	Intrinsic potential of the reach (unitless).

Individual stream reaches were aggregated to provide an estimate of the number of coho smolts that could be produced for each sub-basin. Estimates of the intrinsic potential of a sub-basin to produce coho adults use a range of 1% (poor) and 10% (good) ocean survival of smolts to adults (Lawson et al., 2004). These two numbers provide the low and high estimates of adult spawners in each sub-basin.

Limiting Factors to Coho Production

In order to populate the Limiting Factors Analysis Method, the Coos WA collected summer Aquatic Habitat Inventory (AHI) data from 2002 to 2004. Resulting AHI data was analyzed according to the Methods for Stream Habitat Surveys protocol (Moore et al. 2002, 2003, 2004). AHI data was collected from the tide gates to the end of anadromous fish usage, except where landowners denied access.

Spawning surveys provided estimates of spawning gravel areas for the Limiting Factors model. Gravel counts were conducted multiple times each season and, in most cases for multiple seasons, on spawning survey reaches in each of the basins. The model's Current Usable Area for spawning habitat was derived from the average of these gravel counts.

Three criteria were used to determine current usable fish habitat based on stream temperature. The first is the seven-day moving average of the daily maximum temperatures. This is the method used by ODEQ and OWEB to determine sufficient stream temperature conditions. It is calculated by taking the seven consecutive days with the hottest temperatures and averaging the daily maximums for these seven days. Seven-day moving average maximum temperatures of 64 °F (17.8 °C) or below are considered acceptable. Anything with higher temperatures is undesirable and will provide poor habitat. All six streams studied in the assessment exhibit seven-day moving average maximums exceeding the

ODEQ 64°F standard for summer juvenile salmonid rearing at some location along their length, typically in the lower reaches.

The second criterion for determining adequate thermal habitat for salmonids is the USDA Forest Service assessment of limiting physical factors for coho (Reeves, et al, 1989; Reeves, 2005). The summer daily minimum temperatures are the focus: any stream reaches with temperatures that never drop below 22 °C (71.6 °F) would have cumulative toxic effects on fish physiological functions. Likewise, a consecutive stretch of 14 days or more with temperature minimums at or above 22 °C would be unsuitable habitat, causing fatalities. Areas with less than 14 consecutive days with daytime minimums exceeding 22 °C may not be lethal, but can still have harmful effects on salmonid physiology.

> Note: The only sites that fail this criterion are the lowest segments of Palouse before the tide gate (sites 4 and 5) during 2004. From station 4 downstream is unsuitable habitat. The furthest downstream site on Palouse in 2003 (site 5), as well as the tide gate sites on Larson and Palouse in 2004, had days with minimums over 22°C, but less than two weeks consecutively, and can be considered marginal habitat.

The third temperature criterion is determining which stream reaches had days where temperatures reached levels directly lethal to fish. Studies have shown that 25 °C (77 °F) water will kill salmonids. If part of a stream hits or exceeds this temperature for any part of a day, it could be unusable summer habitat.

> Note: In 2003, the furthest downstream sites on Kentuck, North Slough, and Palouse all exceeded 25 °C on numerous occasions. In 2004, the furthest downstream sites on Kentuck and North Slough, and the three lowest sites on Palouse all exceeded 25 °C on multiple dates.

If a stream segment exceeds any one of these criteria, it provides less favorable habitat for salmonids and may be considered unusable for summer rearing. Stream reaches exceeding two or more criteria are highly likely to be completely uninhabitable for juvenile salmonids during the summer, and will have negative impacts on coho and chinook populations.

Potential coho summer populations were estimated using both stream habitat surveys and expected fish carrying capacity for those habitats according to the Limiting Factors Analysis Method of Reeves et al. (1989). Area of spawning and various seasonal habitats needed to support the estimated potential summer population was calculated based on area/survival factors derived by Reeves et al. (1989) from the coho salmon literature. Usable areas were derived from spawning gravel surveys. Numbers of smolts were estimated by multiplying the usable areas by the smolt factors. The smolt factor is the potential number of smolts that could be produced from a given life history stage if no limiting factors occurred at a life history stage further along in the life cycle. This factor is the mean density of fish expected at a given life history stage multiplied by the density-independent mortality rate of the succeeding life history stages. The smolt factor aids in determining which habitat represents the most important bottleneck. This can also be corroborated by comparing the "usable area" with the "area needed"; if the former is smaller than the latter then the amount of habitat available for that life history stage is in short supply.

The limiting factors analysis is a useful tool for examining the AHI data at the sub-basin level. However, the analysis was run with summer AHI data only. Although some estimates could be made of the winter habitat with expected increased flow for example, however, this method likely does not accurately portray winter habitat availability. The current model likely understates winter off-channel habitats and overestimates winter beaver dam backwater pools. Because of the high potential utility of the limiting factors analysis in prioritizing restoration work, it is recommended that winter habitat data be collected on at least a sample of the lowlands streams in order to improve the analysis.

Landowner Concerns / Coffee Klatches

Landowner feedback was collected in each of the sub-basins by means of neighborhood meetings, or Coffee Klatches, held in April and May of 2005, and February and March of 2006. The purpose of the first round of meetings was to present preliminary lowland assessment data summaries, inquire about local landowners' top land management concerns and values, and to then incorporate that input into the restoration prioritization process. The later round of meetings served to provide landowners with the assessment documents, inform them of restoration opportunities and to collect survey data from them regarding their acceptability of potential restoration actions.

To make the meetings less formal, or more conducive to positive, neighborly interaction, they were each held in someone's home within the sub-basin. Mailing lists were compiled from digital tax lot ownership layers using ArcView GIS 3.2. Addresses were collected for landowners of more than approximately five acres. Invitation letters were mailed with a stamped return postcard included, on which landowners could register to attend, request assessment data by mail, or express disinterest.

During the meetings, input from landowners was collected in the following different forms. First, meeting attendees were asked as a group to vocally list land management activities or issues they are most concerned about. Landowners were also asked to list their desired future conditions and what they value most about the geographic area in which they live, or manage land. Responses to these questions were called out by attendees and Coos WA staff recorded them on a large, visible flip chart.

The second form of collecting input was done in a more anonymous way. Landowners were asked to write their top three concerns on colored index cards with the colors representing their first, second and third priority concerns. All responses from the cards were collected and issue categories were formed directly from these responses. Each response was assigned to one of the categories in Table M-7, below, and

Table M-7 Landowner Concerns Categories

Environmental Quality	Restoration	Land Management	Land Use Policies	Social Concerns
Fish populations and fish habitat	Riparian restoration	Tide gate maintenance	Preserve agriculture and local business	Neighbor problems and disputes
Wildlife and ecosystem preservation	County road maintenance	Drainage / culvert maintenance / flood control / wet pastures	Government regulation and property rights	Need for education
Water quality and quantity	Noxious weed control	Mosquito control	Urban development infringement	Dumping of garbage
Non-watershed causes of fish decline such as ocean conditions and predation	Restoration project maintenance	Logging impacts	Ecological reserves restricting land uses	Trespass
		Beaver control	Difficulties with permit processes	Watershed tours and monitoring infringe upon privacy
		Fire threat	Proposed fill and sludge disposal	Access to forest roads
		Drainage District – new / reorganized		Community clean-up
		Desire riparian clearing		

graphs of responses by category are shown in the Assessment sections. ‘Concerns’ data were later referenced during the Coos WA process of prioritizing potential actions (see Prioritization Methods, below).

During the last round of Coffee Klatches, held in February and March of 2006, Coos WA ground-checked their portrayal of landowner concerns using another, more structured survey. The survey asked specific questions and requested specific answers (multiple choice format) regarding concerns associated with the list of potential restoration actions (see Table M-9 in Prioritization Methods, below). The survey was handed out to Coffee Klatch attendees and a Coos WA presenter ‘walked’ through the questionnaire showing sample photos of action types and providing descriptions of what each action may entail. Landowners answered, in multiple choice format, the same three questions for each restoration action. A sample section of the survey is provided below in Table M-8.

Table M-8 Potential Action Feasibility Survey (sample)

Key 0: absolutely not, 1: potentially but unlikely, 2: likely at least in part, 3: generally true, 4: absolutely, NA: not applicable		
Potential Action	**Question**	**Rating (circle one)**
1. Add secondary & off-channel features	Would this project address your needs or concerns?	NA 0 1 2 3 4
	Do you think this type of project would be accepted by your neighbors?	NA 0 1 2 3 4
	Do you think this type of project would be accepted by the community?	NA 0 1 2 3 4

Prioritization Methods

The process used for prioritizing potential restoration actions was developed by the Coos Bay Lowland Assessment Advisory Committee during a workshop held in November, 2005. The Advisory Committee consists of 16 professional experts in watershed and salmon fishery management from the Coos Bay area and the Pacific Northwest. Elements of the process developed during the workshop were then refined by Coos WA staff and reviewed by the Advisory Committee. Results of the process include a ranking of restoration opportunities at the sub-basin region level, and general descriptions of the CoosWA approach to those actions, (i.e. assistance with design, funding and outreach) based on the ranking, or priority, levels. The steps and elements of the process are provided below, and the overall restoration strategy and Coos WA approach is described in Chapter 3 of this document.

A selection of potential habitat restoration, or rehabilitation, actions was prioritized for each of three to four geographical regions within each sub-basin. The suite of potential actions is provided below in Table

M-9, and described in Chapter 3. Each column, in Table M-9, roughly represents a region and lists the associated potential actions. Due to variations in land conditions, these associations are not strictly held and actions may be evaluated for a region in one sub-basin and not evaluated for the same region number in another sub-basin. Regions were labeled with numbers that generally correspond to the following geography; (1) tidally influenced area, (2) lower valley, (3) upper valley, or major tributary, and (4) forested headwaters of the mainstem stream.

Table M-9 Potential Actions Within Sub-Basin Regions

Tidal (1)	Lower Valley (2)	Upper Valley (3)	Forest (4)
Tide Gate Removal	Riparian Planting	Riparian Planting	Roads Upgrades
Tide Gate Replacements	Riparian Fencing	Riparian Forestry Practices	Riparian Forestry Practices
Tide Gate Relocation	Riparian Willow Walls	Riparian Fencing	Fish Passage
Ditch Maintenance	Large Wood Placement	Riparian Willow Walls	Landslide Area Protection
Riparian Planting	Bank Resloping (no planting)	Large Wood Placement	Road Decommission
Riparian Fencing	Reshape Channel	Culvert Replacement	
Levee Removal	Add Secondary and Off-Channel Features	Roads Upgrades	
Levee Setback	Ditch Maintenance	Reshape Channel	
Culvert Replacements	Culvert Replacements	Beaver Encouragement	
Reshape Channel	Implement Farm Plans		
Large Wood Placement	Water Conservation		
Implement Farm Plans	Beaver Encouragement		
Water Conservation	Wetlands Restoration		
Wetlands Restoration			

Next, the degree of alteration from natural conditions was assessed for a series of watershed processes within each region. Degree of alteration was indicated as either H, M or L (High, Moderate or Low), and was assigned based on assessment data and CoosWA staff knowledge. Table M-10 below shows the different watershed processes and characteristics evaluated in this step of the prioritization process.

The most significant step in the prioritization process was assigning scores to each potential action for two categories of criteria – biological and socio-economic. Definitions of the 13 criteria and their scores, zero to four, are shown in Table M-11 and Table M-12, below. CoosWA staff evaluated each potential action case-by-case, assigning a series of scores based on survey data, field knowledge, and experience with landowners, grantors and project types. Individual scores for each action were then multiplied by the relative weights of the corresponding criterion, and totaled for the two main categories. Using a threshold of two, the aggregate scores for socio-economic and biological criteria were used to determine the level of priority for each action. The level of priority, shown using colors, directs the nature of CoosWA involvement in restoration actions and projects, and is described in Chapter 3 – Prioritization Process. Resulting scores of the prioritization process for the six Lowland sub-basins are provided in the following section titled Prioritization Scoring Tables.

Table M-10 Watershed processes

Process	Sub-Process	Indicators of Process	Land Management that Alters Process
Hydrologic Processes	Water quantity	Peak flows	Roads, culverts, ditches, loss of wetlands, land use, tide gates
		Base flows, stream temperature	Water withdrawals
	Tidal exchange	Changes in water elevations, temperature, salinity	Tide gates, levees, channel simplification
	Hyporheic flow (subsurface water)	Infiltration, run-off, temperature	Ground water withdraws, vegetation clearing, compaction
Sediment Movement Processes	Sediment delivery	Landslide frequency & magnitude	Roads, forest practices
		Eroding streambanks	Altered riparian vegetation, upland hydrology, channel
		Surface erosion	Grazing, roads, removal of vegetation
		Floodplain deposition (tidal and flood	Tide gates, levees, channel simplification, ditching
Riparian Processes	Large wood Delivery	Large wood quantity & size	Removal of upland & riparian vegetation, road & stream crossings
	Stream shading	Temperature	Removal of riparian vegetation, water withdrawals
	Nutrient production/ storage	Invertebrate production, dissolved oxygen, aquatic vegetation	Nutrient loading, removal of riparian vegetation
	Bank stabilization	Bank shape, channel bed load	Removal/ planting of riparian vegetation
Channel Processes	Large wood Transport	Large wood quantity & size	Stream/ road crossings, dikes
	Sediment transport	Channel incision / aggradation	Tide gates, culverts, channel modification
	Sediment size sorting	Substrate composition	Channel simplification, increase fine sediment inputs
	Channel migration	Incision, sinuosity	Channel armoring or straightening
	Hydraulics	Current velocity, channel cross section & gradient	Channel simplification (straightening, removing large wood)
Biological Processes	Nutrient cycling (food web; carcasses; microorganisms, nutrient uptake)	Dissolved oxygen, aquatic vegetation, water-borne pathogens	Unfiltered nutrient run-off (livestock, septic)
	Beavers	Beaver dams	Beaver removal, riparian vegetation removal
	Evapotranspiration	Water table level, local weather (RH)	Vegetation clearing
	Fish migration / connectivity	Fish presence	Road/stream crossings, tide gates, channel constrictions
Floodplain Processes	Sediment deposition	Buildup of islands and wetlands; subsidence and accretion	Levees, tide gates, roads
	Channel migration	Meandering, oxbows, alcoves; off-channel areas	Channel armoring, riparian roads
	Nutrient exchange	Macroinvertebrate production	diking, riparian vegetation removal
	Channel / floodplain interaction	Current velocity; hydrograph, wetlands,	Diking, tide gates, roads

Table M-11 Prioritization Score Definitions, Biological Criteria

Biological Criteria			Scores				
Weight	Criterion	Statement	0	1	2	3	4
25%	Processes [1]	This action re-establishes natural watershed processes and maintains functional processes.	Does Not Address Any Impaired Processes	Partially Improves At Least One Impaired Processes	Significantly Improves At Least 1 Moderately-Impaired Process	Significantly Restores At Least 1 Highly-Impaired Process	Significantly Restores 3 Or More Highly-Impaired Processes
25%	Connectivity [2]	This action improves or re-establishes habitat connectivity.	Does Not Restore Any Connectivity	Partially Restores Connectivity For Some Life Stages/Species To At Least Some Moderate Quality Habitat	Significantly Restores Connectivity For Some Life Stages/Species To Some High Quality *Or* Lots Of Moderate Quality Habitat	Significantly Restores Connectivity Of Most Stages/Species To A Moderate Amount Of High Quality Habitat	Restores Full Connectivity For All Life Stages For All Species To A Large Amount Of High Quality Habitat
20%	Limiting Factors [3]	This action will promote healthy coho populations by removing one or more limiting factor(s).	Does Not Address Any Coho Life-History Bottlenecks	Addresses One Coho Life-History Bottleneck, But Not The Primary One	Addresses The Primary Coho Life-History Bottleneck, But Low to Moderate Effect on The Bottleneck	Has A High Likelihood Of Significantly Relieving The Primary Life-History Bottleneck	Has A High Likelihood Of Significantly Relieving The Primary And Secondary Life-History Bottlenecks
15%	Longevity	The effects of this action will persist into the future.	Expected Life Span ≤10 Years	Expected Life Span 11-25 Years	Expected Life Span 26-50 Years	Expected Life Span 51-100 Years	Project Expected To Be Self Maintaining In Perpetuity
5%	Unique Habitat Type [4]	This action will benefit or provide specifically needed or unique habitat types.	Does Not Address Any Needed Or Unique Habitat Types	Partially Addresses One Needed Or Unique Habitat Type	Partially Addresses More Than One Needed Or Unique Habitat Type	Completely Addresses One Needed Or Unique Habitat Type	Completely Addresses More Than One Needed Or Unique Habitat Type
10%	Proven Technique	This action will use a technique proven to be successful or test the effectiveness of a new restoration technique.	Technique Known Not To Be Effective	Technique Unproven, But Not Experimental Or Innovative	Technique Experimental And/Or Innovative, But Efficacy Unknown	Technique Proven To Be Effective	Technique Proven To Be Effective And Innovative

1. See watershed processes table - High/Medium/Low degrees of process impairment.
2. Life stages accessible, quality of habitat assessed, extent of habitat assessed.
3. See Reeves et.al. limiting factors analysis.
4. I.e. spruce bogs, braided channels, anastomosed channels, high salt marshes, off-channel habitats, estuarine habitat.

Table M-12 Prioritization Score Definitions, Socio-Economic Criteria

Socio-Economic Criteria			Scores				
Weight	**Criterion**	**Statement**	**0**	**1**	**2**	**3**	**4**
10%	Likelihood of success	This action is highly likely to fulfill its goals.	Not Likely To Be Successful	Small Likelihood Of Success	Project Likely To Meet Some Goals	Project Likely To Meet Most Goals	Project Likely To Meet All Goals
5%	Educational benefit	This action will provide educational or outreach benefits.	No Educational Or Outreach Benefits	Few Educational Or Outreach Benefits	Local Outreach And Educational Benefits	Regionally-Prominent Outreach And Educational Benefits	Nationally-Prominent Outreach And Educational Benefits
35%	Landowner concerns	This action addresses a stated landowner concern.	Meets No Landowner Objectives In The Sub-Basin	Meets At Least One Landowner's Objective, But May Conflict With Objectives of Other Landowners	Meets At Least One Landowner's Objectives, But May Conflict With Other Objectives of that Landowner	Meets More Than One Landowners' Objectives And Does Not Conflict With Any Other Landower(s) Objectives	Meets All Landowners' Objectives And Will Result In A Synergistic Effect For Other Projects
5%	Measurability	The effects of this action will be measurable through monitoring.	Benefits Of The Project Cannot Be Measured	Monitoring Is Possible, But Beyond The Capacity Of The Organization To Conduct	Monitoring Will Be Expensive And Require Long-Term Study	Monitoring Is Feasible With Known Protocols	Monitoring Has A High Likelihood Of Leading To Publishable Results
30%	Implementation Feasibility	This action is highly likely to be feasible, and political or social resistance to this action is unlikely.	Unlikely To Be Implementable Because Of Political And Social Constraints	Has Potential To Be Politically Or Socially Divisive	Some People In The Sub-Basin Will Like The Project And Others Will Be Neutral Or Oppose It	Most People In The Sub-Basin Will Be Supportive Of The Project	People In The Sub-Basin And Local And Political Leaders Will Be Supportive Of The Project.
10%	Funding	This action is highly likely to be funded. There are no significant social, political, or other constraints to funding this action.	This Project Is Unfundable	This Project Is Unlikely To Be Funded By Known Source	This Project Can Probably Be Funded From Known Sources, But It Might Be Difficult	This Project Will Likely Be Funded From Known Sources	This Project Is Highly Likely To Be Funded From A Source We Would Like To Develop
5%	Cost	This action provides an acceptable cost/benefit ratio and is within the abilities of the funding and implementing groups.	> $1,000k	$250k-1,000k	$100k - $250k	$50-$100k	< $50k

Prioritization Scoring Tables

Table M-13 Prioritization Score Results North Slough Sub-basin

Rating of Actions - North Slough (0-4 scoring system)

		Biological Criteria							Socio-Economic Feasibility								Scores		
	Criterion weight	25%	25%	20%	15%	5%	10%		10%	5%	35%	5%	30%	10%	5%				
Region	Potential Action	Restores Processes*	Restores Connectivity	Limiting Factor(s) addressed	Longevity	Unique habitat	Proven technique	Raw Score	Likelihood of success*	Educational benefit	Landowner concerns*	Measurability	Implementation feasibility*	Fundability*	Cost	Raw Score	Weighted Socio-economic	Weighted Biological	Approach to Action
1	Channel reconfiguration	3	2	2	4	2	2	15	2	3	1	2	1	3	2	14	1.5	2.55	Channel reconfiguration
1	Ditch maintenance	1	1	1	0	1	2	6	2	2	3	2	2	1	4	16	2.35	0.95	Ditch maintenance
1	Fish passage (trib tide gates)	3	1	2	2	1	3	12	2	2	3	2	3	2	3	17	2.7	2.05	Fish passage (trib tide gates)
1	Implement farm plans	1	0	0	1	0	1	3	2	2	3	3	3	3	3	19	2.85	0.5	Implement farm plans
1	Large wood placement	1	0	1	2	1	2	7	1	1	1	1	1	1	3	9	1.1	1	Large wood placement
1	Levee removal	4	2	1	4	3	2	16	3	2	1	2	1	3	3	15	1.6	2.65	Levee removal
1	Levee setback	1	1	1	2	1	2	8	2	2	2	1	2	2	2	13	1.95	1.25	Levee setback
1	Riparian fencing	3	0	1	1	0	3	8	3	2	3	2	3	3	4	20	2.95	1.4	Riparian fencing
1	Riparian planting	2	0	2	3	1	3	11	3	2	2	2	2	3	3	17	2.25	1.7	Riparian planting
1	Tide gate relocation	3	2	2	2	2	2	13	2	3	1	2	1	3	1	13	1.45	2.25	Tide gate relocation
1	Tide gate removal	4	4	3	4	3	2	20	3	4	1	2	0	4	1	15	1.4	3.55	Tide gate removal
1	Tide gate replacements	1	1	2	2	0	2	8	2	3	4	2	4	2	2	19	3.35	1.4	Tide gate replacements
1	Water conservation	0	0	0	1	0	3	4	1	2	0	1	2	1	4	11	1.15	0.45	Water conservation
1	Wetlands restoration	4	4	3	4	3	3	21	3	2	1	2	1	4	2	15	1.65	3.65	Wetlands restoration
2	Bank resloping (no plant)	0	0	0	0	0	1	1	1	2	1	0	2	1	4	11	1.45	0.1	Bank resloping (no plant)
2	Beaver encouragement	4	2	3	4	4	3	20	3	3	1	3	1	3	4	18	1.75	3.2	Beaver encouragement
2	Channel reconfiguration	4	3	3	4	3	2	19	3	3	1	3	1	4	1	16	1.7	3.3	Channel reconfiguration
2	Ditch maintenance	1	1	1	0	1	2	6	2	2	3	2	2	1	4	16	2.35	0.95	Ditch maintenance
2	Fish passage (dams)	3	2	2	2	1	3	13	3	2	3	2	3	3	2	18	2.85	2.3	Fish passage (dams)
2	Implement farm plans	1	0	0	1	0	1	3	2	2	3	3	3	3	3	19	2.85	0.5	Implement farm plans
2	Large wood placement	1	0	2	2	1	3	9	3	2	1	2	2	3	3	16	1.9	1.3	Large wood placement
2	Off-channel features	1	2	1	1	3	1	9	2	1	2	2	2	1	4	14	1.95	1.35	Off-channel features
2	Riparian fencing	1	0	2	1	0	3	7	3	2	3	2	3	3	2	18	2.85	1.1	Riparian fencing
2	Riparian forestry practices	4	0	3	4	0	3	14	3	2	2	2	2	1	1	13	1.95	2.5	Riparian forestry (buffers)
2	Riparian planting	3	0	3	3	1	3	13	3	2	2	3	2	3	2	17	2.25	2.15	Riparian planting
2	Road upgrades	1	0	2	2	0	3	8	3	2	3	2	3	3	4	20	2.95	1.25	Road upgrades
2	Water conservation	0	0	0	1	0	3	4	1	2	0	1	2	1	4	11	1.15	0.45	Water conservation
2	Wetlands restoration	4	4	4	4	3	3	22	3	3	1	3	1	3	2	16	1.65	3.85	Wetlands restoration
3	Beaver encouragement	4	2	3	4	4	3	20	3	3	1	3	1	3	4	18	1.75	3.2	Beaver encouragement
3	Channel reconfiguration	4	4	4	4	3	2	21	3	3	2	3	1	3	2	17	2	3.75	Channel reconfiguration
3	Culvert (passage)	3	2	2	2	1	3	13	3	2	3	3	3	3	3	20	2.95	2.3	Culvert (passage)
3	Large wood placement	1	0	2	2	1	3	9	3	2	1	2	2	3	2	15	1.85	1.3	Large wood placement
3	Riparian fencing	1	0	2	1	0	3	7	3	2	3	2	3	3	3	19	2.9	1.1	Riparian fencing
3	Riparian forestry	4	0	3	4	0	3	14	3	3	2	2	2	1	1	14	2	2.5	Riparian forestry (buffers)
3	Riparian planting	3	0	3	3	1	3	13	3	2	2	3	3	3	2	18	2.55	2.15	Riparian planting
3	Road upgrades	1	0	2	2	0	3	8	3	2	3	2	3	3	4	20	2.95	1.25	Road upgrades
3	Wetlands restoration	4	4	4	4	3	3	22	3	3	1	3	1	3	2	16	1.65	3.85	Wetlands restoration
4	Fish passage	2	1	1	2	0	3	9	3	2	3	3	3	3	4	21	3	1.55	Fish passage
4	Landslide area protection (head wal	4	0	3	4	0	2	13	3	3	1	2	2	3	1	15	1.85	2.4	Landslide area protection (head wall rete
4	Large wood placement	2	1	2	2	1	3	11	3	2	3	3	3	3	2	19	2.9	1.8	Large wood placement
4	Riparian forestry practices	4	0	3	4	0	3	14	3	2	2	2	2	1	1	13	1.95	2.5	Riparian forestry practices
4	Road upgrades	3	0	2	2	0	3	10	3	2	3	3	3	3	3	20	2.95	1.75	Road upgrades

Table M-14 Prioritization Score Results Palouse Sub-basin

Rating of Actions - Palouse (0-4 scoring system)

		Biological Criteria							Socio-Economic Criteria								Scores		
	Criterion weight	25%	25%	20%	15%	5%	10%		10%	5%	35%	5%	30%	10%	5%				
Region	Potential Action	Restores Processes*	Restores Connectivity	Limiting Factor(s) addresse	Longevity	Unique habitat	Proven technique	Raw Score	Likelihood of success*	Educational benefit	Landowner concerns*	Measurability	Implementation feasibility*	Fundability*	Cost	Raw Score	Weighted Socio-economic	Weighted Biological	Approach to Actions
1	Culvert replacements (passage)	1	1	2	2	1	3	10	3	1	3	2	3	3	3	18	2.85	1.55	Culvert replacements (passage)
1	Ditch maintenance	1	1	1	0	1	2	6	2	2	3	2	2	1	4	16	2.35	0.95	Ditch maintenance
1	Implement farm plans	1	0	0	1	0	1	3	2	2	3	3	3	3	3	19	2.85	0.5	Implement farm plans
1	Large wood placement	1	0	2	2	1	2	8	2	2	1	2	2	3	3	15	1.8	1.2	Large wood placement
1	Levee removal	4	3	1	4	3	4	19	2	3	1	3	2	3	3	17	1.9	3.1	Levee removal
1	Levee setback	1	1	1	2	1	2	8	2	2	2	2	2	2	3	15	2.05	1.25	Levee setback
1	Channel Reconfiguration	1	1	2	4	1	2	11	2	2	2	2	2	3	3	16	2.15	1.75	Channel Reconfiguration
1	Riparian fencing	1	0	2	1	0	3	7	3	2	3	2	3	3	3	19	2.9	1.1	Riparian fencing
1	Riparian planting	1	0	2	4	2	2	11	2	2	2	3	3	3	3	18	2.5	1.55	Riparian planting
1	Tide gate relocation	3	2	2	2	2	2	13	2	4	2	2	1	2	1	14	1.75	2.25	Tide gate relocation
1	Tide gate removal	4	4	3	4	2	2	19	2	4	1	4	0	4	1	16	1.4	3.5	Tide gate removal
1	Tide gate replacements	1	2	2	2	1	2	10	2	3	4	2	4	2	2	19	3.35	1.7	Tide gate replacements
1	Water Conservation	0	0	0	1	0	3	4	1	2	0	1	2	1	4	11	1.15	0.45	Water Conservation
1	Wetlands restoration	3	3	4	2	3	2	17	2	3	2	3	1	3	2	16	1.9	2.95	Wetlands restoration
2	Bank resloping (no plant)	0	0	0	0	0	1	1	1	2	1	0	2	1	4	11	1.45	0.1	Bank resloping (no plant)
2	Beaver encouragement	4	2	3	4	4	3	20	3	3	1	3	1	3	4	18	1.75	3.2	Beaver encouragement
2	Channel reconfiguration	4	3	4	4	3	3	21	4	3	1	3	0	4	1	16	1.5	3.6	Channel reconfiguration
2	Culvert replacements (passage)	2	2	2	2	2	3	13	3	1	4	3	4	3	4	22	3.6	2.1	Culvert replacements (passage)
2	Ditch maintenance	1	1	1	0	1	2	6	2	2	3	2	2	1	4	16	2.35	0.95	Ditch maintenance
2	Implement farm plans	1	0	0	1	0	1	3	2	2	3	3	3	3	3	19	2.85	0.5	Implement farm plans
2	Large wood placement	1	0	2	2	1	3	9	3	2	1	2	2	3	3	16	1.9	1.3	Large wood placement
2	Off-channel features	1	1	1	1	3	1	8	2	2	1	2	2	2	4	15	1.75	1.1	Off-channel features
2	Riparian fencing	1	0	2	1	0	3	7	3	2	3	2	3	3	3	19	2.9	1.1	Riparian fencing
2	Riparian planting	4	0	3	2	0	3	12	3	3	3	4	3	3	2	21	3	2.2	Riparian planting
2	Water conservation	0	0	0	1	0	3	4	1	2	0	1	2	1	4	11	1.15	0.45	Water conservation
2	Wetlands restoration	3	3	4	2	3	2	17	2	3	2	3	1	3	2	16	1.9	2.95	Wetlands restoration
2	Willow wall	3	0	2	2	0	4	11	4	3	2	3	2	3	4	21	2.5	1.85	Willow wall
3	Beaver encouragement	4	2	3	4	4	3	20	3	3	1	3	1	3	4	18	1.75	3.2	Beaver encouragement
3	Channel reconfiguration	4	3	3	4	2	2	18	3	3	1	3	1	3	2	16	1.65	3.25	Channel reconfiguration
3	Culvert replacement (passage)	3	3	2	2	1	3	14	4	1	4	3	3	3	4	22	3.4	2.55	Culvert replacement (passage)
3	Large wood placement	1	0	2	2	2	3	10	3	2	2	2	3	3	3	18	2.55	1.35	Large wood placement
3	Riparian fencing	1	0	2	1	0	3	7	3	2	3	2	3	3	3	19	2.9	1.1	Riparian fencing
3	Riparian forestry practices	2	0	3	4	0	4	13	4	3	2	3	2	1	2	17	2.2	2.1	Riparian forestry practices
3	Riparian planting	4	0	3	3	0	3	13	3	3	3	4	3	3	3	22	3.05	2.35	Riparian planting
3	Road decommission	3	1	2	4	0	3	13	3	2	2	3	2	3	4	19	2.35	2.3	Road decommission
3	Road upgrades	1	0	1	2	1	3	8	3	2	3	2	3	3	4	20	2.95	1.1	Road upgrades
4	Riparian forestry practices	2	0	3	4	0	3	12	4	3	4	4	3	3	1	22	3.4	2	Riparian forestry practices
4	Road upgrades	3	0	2	2	0	3	10	3	2	3	2	3	3	3	19	2.9	1.75	Road upgrades
4	Landslide area protection (head wa	4	0	3	4	0	2	13	3	3	4	2	2	3	1	18	2.9	2.4	Landslide area protection

Table M-15 Prioritization Score Results Larson Sub-basin

Rating of Actions - Larson (0-4 scoring system)

		Biological Criteria							Socio-Economic Criteria								Scores		
	Criterion weight	25%	25%	20%	15%	5%	10%		10%	5%	35%	5%	30%	10%	5%				
Region	Potential Action	Restores Processes*	Restores Connectivity	Limiting Factor(s) addressed	Longevity	Unique habitat	Proven technique	Raw Score	Likelihood of success*	Educational benefit	Landowner concerns*	Measurability	Implementation feasibility*	Fundability*	Cost	Raw Score	Weighted Socio-economic	Weighted Biological	Approach to Action
1	Culvert replacements (passage	3	3	2	2	2	3	15	3	2	3	2	3	3	3	19	2.9	2.6	Culvert replacements (passage)
1	Ditch maintenance	1	1	1	0	1	2	6	2	2	3	2	2	1	4	16	2.35	0.95	Ditch maintenance
1	Implement farm plans	1	0	0	1	0	1	3	2	2	3	3	3	3	3	19	2.85	0.5	Implement farm plans
1	Large wood placement	1	0	3	2	1	2	9	3	2	2	2	2	3	3	17	2.25	1.4	Large wood placement
1	Levee removal	4	3	3	4	3	2	19	3	2	1	2	1	3	3	15	1.6	3.3	Levee removal
1	Levee setback	1	1	2	2	1	2	9	2	2	2	2	2	2	2	14	2	1.45	Levee setback
1	Riparian fencing	2	0	3	1	0	3	9	3	2	2	3	3	3	2	18	2.55	1.55	Riparian fencing
1	Riparian planting	1	0	2	3	1	3	10	2	2	2	2	2	3	3	16	2.15	1.45	Riparian planting
1	Road upgrades	1	0	1	2	0	3	7	3	2	3	2	3	3	4	20	2.95	1.05	Road upgrades
1	Tide gate removal	4	4	2	4	3	2	19	4	4	0	2	0	1	2	13	0.9	3.35	Tide gate removal
1	Tide gate replacements (tribs)	1	2	3	2	1	2	11	2	2	3	2	3	2	3	17	2.7	1.9	Tide gate replacements (tribs)
1	Water conservation	3	1	1	2	0	3	10	3	3	1	2	1	4	4	18	1.8	1.8	Water conservation
1	Wetlands restoration	4	4	4	4	4	3	23	3	3	1	3	1	3	2	16	1.65	3.9	Wetlands restoration
2	Beaver encouragement	4	3	4	4	3	4	22	4	3	1	3	1	3	4	19	1.85	3.7	Beaver encouragement
2	Channel reconfiguration	3	2	3	4	3	2	17	3	3	1	3	1	3	2	16	1.65	2.8	Channel reconfiguration
2	Ditch maintenance	1	1	1	0	1	2	6	2	2	3	2	2	1	4	16	2.35	0.95	Ditch maintenance
2	Implement farm plans	1	0	0	1	0	1	3	2	2	3	3	3	3	3	19	2.85	0.5	Implement farm plans
2	Large wood placement	3	1	3	2	1	3	13	3	2	2	3	2	3	3	18	2.3	2.25	Large wood placement
2	Off-channel features	1	2	3	1	2	1	10	1	1	2	2	2	2	4	14	1.95	1.7	Off-channel features
2	Riparian fencing	2	0	1	1	0	3	7	3	2	2	2	2	3	3	17	2.25	1.15	Riparian fencing
2	Riparian planting	4	0	2	3	0	3	12	3	2	2	3	2	3	3	18	2.3	2.15	Riparian planting
2	Water conservation	0	0	0	1	0	3	4	1	2	0	1	2	1	4	11	1.15	0.45	Water conservation
2	Wetlands restoration	4	3	4	4	3	3	21	3	2	1	3	1	4	2	16	1.7	3.6	Wetlands restoration
3	Beaver encouragement	4	3	4	4	3	4	22	4	3	1	3	1	3	4	19	1.85	3.7	Beaver encouragement
3	Channel reconfiguration	3	1	3	4	3	2	16	1	3	0	3	0	1	0	8	0.5	2.55	Channel reconfiguration
3	Large wood placement	1	0	2	2	1	2	8	3	2	1	3	1	3	3	16	1.65	1.2	Large wood placement
3	Riparian fencing	1	0	2	1	0	3	7	3	2	3	2	3	3	3	19	2.9	1.1	Riparian fencing
3	Riparian planting	4	0	1	3	0	3	11	3	2	3	3	3	3	3	20	2.95	1.95	Riparian planting
3	Road upgrades	1	0	1	2	0	3	7	3	2	3	2	3	3	4	20	2.95	1.05	Road upgrades
4	Landslide area protection (head	4	0	3	4	0	2	13	3	3	2	2	2	3	1	16	2.2	2.4	Landslide area protection
4	Large wood placement	1	1	2	2	1	3	10	3	2	2	3	2	3	3	18	2.3	1.55	Large wood placement
4	Riparian forestry practices	4	0	3	4	0	3	14	4	3	4	4	3	3	1	22	3.4	2.5	Riparian forestry practices
4	Road upgrades	1	0	1	2	0	3	7	3	2	3	2	3	3	4	20	2.95	1.05	Road upgrades

Table M-16 Prioritization Score Results Kentuck Sub-basin

Rating of Actions - Kentuck (0-4 scoring system)

		Biological Criteria							Socio-Economic Criteria								Scores		
	Criterion Weight	25%	25%	20%	15%	5%	10%		10%	5%	35%	5%	30%	10%	5%				
Region		Restores Processes*	Restores Connectivity	Limiting Factor(s) addressed	Longevity	Unique habitat	Proven technique	Raw Score	Likelihood of success*	Educational benefit	Landowner concerns*	Measurability	Implementation feasibility*	Fundability*	Cost	Raw Score	Weighted Socio-Economic	Weighted Biological	Approach to Action
1	Culvert replacements (passage)	1	1	1	2	1	3	9	3	2	3	2	3	3	3	19	2.9	1.35	Culvert replacements (passage)
1	Ditch maintenance	1	1	1	0	1	2	6	2	2	3	2	2	1	4	16	2.35	0.95	Ditch maintenance
1	Implement farm plans	1	0	0	1	0	1	3	2	2	3	3	3	3	3	19	2.85	0.5	Implement farm plans
1	Large wood placement	1	0	1	2	1	2	7	1	2	1	2	1	1	4	12	1.25	1	Large wood placement
1	Levee removal	4	3	1	4	4	2	18	3	3	1	2	1	3	2	15	1.6	2.95	Levee removal
1	Levee setback	1	1	1	2	0	2	7	2	2	1	1	2	2	2	12	1.6	1.2	Levee setback
1	Reshape stream channel	3	2	1	4	1	1	12	2	2	1	1	2	2	3	13	1.65	2.2	Reshape stream channel
1	Riparian planting	1	0	1	3	0	2	7	2	2	2	2	1	3	4	16	1.9	1.1	Riparian planting
1	Tide gate relocation	1	2	1	2	2	2	10	2	3	1	2	1	2	1	12	1.35	1.55	Tide gate relocation
1	Tide gate removal	4	4	1	4	3	2	18	3	3	0	3	0	4	1	14	1.05	3.15	Tide gate removal
1	Tide gate replacements	1	2	1	2	0	2	8	2	2	4	3	2	4	1	18	2.9	1.45	Tide gate replacements
1	Water conservation	0	0	0	1	0	3	4	1	2	0	1	2	1	4	11	1.15	0.45	Water conservation
1	Wetland restoration	4	4	1	4	4	2	19	2	2	1	2	1	3	1	12	1.4	3.2	Wetland restoration
2	Bank resloping (no plant)	0	0	0	0	0	1	1	1	2	1	0	2	1	4	11	1.45	0.1	Bank resloping (no plant)
2	Beaver encouragement	3	1	1	4	3	3	15	4	2	1	2	1	3	4	17	1.75	2.25	Beaver encouragement
2	Reshape stream channel	1	1	1	4	3	2	12	3	3	1	3	1	3	2	16	1.65	1.65	Reshape stream channel
2	Culvert replacements (fish pass)	3	3	2	2	1	3	14	3	2	3	2	3	3	3	19	2.9	2.55	Culvert replacements (fish pass)
2	Culvert replacements (erosion)	1	0	2	2	0	3	8	3	2	3	2	3	3	3	19	2.9	1.25	Culvert replacements (erosion)
2	Ditch maintenance	1	1	1	0	1	2	6	2	2	3	2	2	1	4	16	2.35	0.95	Ditch maintenance
2	Implement farm plans	1	0	0	1	0	1	3	2	2	3	3	3	3	3	19	2.85	0.5	Implement farm plans
2	Large wood placement	1	0	2	2	1	3	9	3	2	1	3	2	3	3	17	1.95	1.3	Large wood placement
2	Off-channel features	1	2	1	1	1	1	7	1	1	2	2	2	2	4	14	1.95	1.25	Off-channel features
2	Riparian fencing	1	0	1	1	0	3	6	3	2	2	2	3	3	3	18	2.55	0.9	Riparian fencing
2	Riparian planting	3	0	2	3	2	3	13	3	2	2	3	3	3	2	18	2.55	2	Riparian planting
2	Water conservation	0	0	0	1	0	3	4	1	2	0	1	2	1	4	11	1.15	0.45	Water conservation
2	Wetland restoration	4	3	3	2	1	2	15	3	3	1	2	1	3	2	15	1.6	2.9	Wetland restoration
2	Willow wall	3	0	2	3	1	4	13	3	2	1	3	2	3	3	17	1.95	2.05	Willow wall
3	Beaver encouragement	3	1	1	4	3	3	15	4	2	1	2	1	3	4	17	1.75	2.25	Beaver encouragement
3	Culvert replacement (passage)	3	3	2	2	0	3	13	3	1	3	2	3	2	3	17	2.75	2.5	Culvert replacement (passage)
3	Landslide area protection	4	0	2	4	0	2	12	3	2	2	2	2	1	1	13	1.95	2.2	Landslide area protection
3	Large wood placement	2	1	2	2	1	3	11	3	2	3	3	3	3	3	20	2.95	1.8	Large wood placement
3	Riparian forestry practices	2	0	2	4	0	3	11	3	2	2	3	1	3	1	15	1.9	1.8	Riparian forestry practices
3	Road decommission	3	0	2	4	0	3	12	3	3	2	3	2	3	2	18	2.3	2.05	Road decommission
3	Road upgrades	2	0	2	2	0	3	9	3	2	3	2	3	3	2	18	2.85	1.5	Road upgrades
4	Bank resloping (no plant)	0	0	0	0	0	1	1	1	2	1	0	2	1	4	11	1.45	0.1	Bank resloping (no plant)
4	Beaver encouragement	3	1	1	4	3	3	15	4	2	1	2	1	3	4	17	1.75	2.25	Beaver encouragement
4	Culvert replacements (erosion)	1	0	2	2	0	3	8	3	2	3	2	3	3	3	19	2.9	1.25	Culvert replacements (erosion)
4	Ditch maintenance	1	1	1	0	1	2	6	2	2	3	2	2	1	4	16	2.35	0.95	Ditch maintenance
4	Implement farm plans	1	0	0	1	0	1	3	2	2	3	3	3	3	3	19	2.85	0.5	Implement farm plans
4	Landslide area protection	4	0	2	4	0	2	12	3	2	2	2	2	1	1	13	1.95	2.2	Landslide area protection
4	Large wood placement	1	0	2	2	1	3	9	3	2	1	3	2	3	3	17	1.95	1.3	Large wood placement
4	Off-channel creation	1	2	1	1	1	1	7	1	1	2	2	2	2	4	14	1.95	1.25	Off-channel creation
4	Reshape stream channel	4	3	2	4	3	2	18	3	3	1	3	1	3	2	16	1.65	3.1	Reshape stream channel
4	Riparian fencing	1	0	1	1	0	3	6	3	2	2	2	3	3	3	18	2.55	0.9	Riparian fencing
4	Riparian forestry practices	2	0	3	4	0	3	12	3	2	2	3	1	3	1	15	1.9	2	Riparian forestry practices
4	Riparian planting	3	3	2	2	1	3	14	3	2	2	3	3	3	2	18	2.55	2.15	Riparian planting
4	Road decommission	3	0	2	4	0	3	12	3	2	1	2	2	3	3	16	1.9	2.05	Road decommission
4	Road upgrades	2	0	2	2	0	3	9	3	2	3	3	3	3	2	19	2.9	1.5	Road upgrades
4	Water conservation	0	0	0	1	0	3	4	1	2	0	1	2	1	4	11	1.15	0.45	Water conservation
4	Wetland restoration	4	3	3	2	1	2	15	2	3	2	2	1	4	2	16	1.95	2.9	Wetland restoration
4	Willow wall	3	0	2	3	1	4	13	3	2	1	3	2	3	3	17	1.95	2.05	Willow wall

Table M-17 Prioritization Score Results Willanch Sub-basin

Rating of Actions - Willanch (0-4 scoring system)

		Biological Criteria							Socio-Economic Criteria								Scores		
	Criterion weight	25%	25%	20%	15%	5%	10%		10%	5%	35%	5%	30%	10%	5%				
Region	Potential Action	Restores Processes*	Restores Connectivity	Limiting Factor(s) addressed	Longevity	Unique habitat	Proven technique	Raw Score	Likelihood of success*	Educational benefit	Landowner concerns*	Measurability	Implementation feasibility*	Fundability*	Cost	Raw Score	Weighted Socio-economic	Weighted Biological	Approach to Action
1	Culvert replacements (passage)	2	3	3	2	2	3	15	4	2	4	3	4	3	3	23	3.7	2.55	Culvert replacements (passage)
1	Ditch maintenance	0	1	2	0	1	1	5	2	2	3	2	2	1	4	16	2.35	0.8	Ditch maintenance
1	Implement farm plans	1	0	0	1	0	1	3	2	2	3	3	3	3	3	19	2.85	0.5	Implement farm plans
1	Large wood placement	1	0	2	2	1	2	8	2	3	1	2	2	3	4	17	1.9	1.2	Large wood placement
1	Levee removal	4	3	3	4	2	2	18	3	3	1	2	1	4	3	17	1.75	3.25	Levee removal
1	Levee setback	1	1	2	2	1	2	9	2	3	2	1	1	2	2	13	1.7	1.45	Levee setback
1	Riparian fencing	1	0	1	1	0	3	6	3	2	3	1	3	3	4	19	2.9	0.9	Riparian fencing
1	Riparian planting	3	0	1	3	1	3	11	3	2	2	3	2	3	3	18	2.3	1.75	Riparian planting
1	Tide gate removal	4	4	4	4	4	2	22	3	4	0	4	0	4	1	16	1.15	3.8	Tide gate removal
1	Tide gate replacements	3	1	2	2	0	2	10	2	3	3	2	3	2	3	18	2.75	1.9	Tide gate replacements
1	Water conservation	0	0	0	1	0	3	4	1	2	0	1	2	1	4	11	1.15	0.45	Water conservation
1	Wetlands restoration	4	4	4	4	4	3	23	3	3	1	3	1	3	2	16	1.65	3.9	Wetlands restoration
2	Bank resloping (no plant)	1	0	0	1	0	1	3	0	1	1	1	2	1	4	10	1.35	0.5	Bank resloping (no plant)
2	Beaver encouragement	4	2	3	4	4	3	20	3	3	1	3	1	3	4	18	1.75	3.2	Beaver encouragement
2	Reshape channel	4	3	3	4	3	2	19	3	3	1	3	1	3	2	16	1.65	3.3	Reshape channel
2	Culvert replacements (passage)	3	2	2	2	1	3	13	3	2	3	3	3	3	3	20	2.95	2.3	Culvert replacements (passage)
2	Ditch maintenance (fish-friendlier)	0	1	2	0	1	1	5	2	2	3	2	2	1	4	16	2.35	0.8	Ditch maintenance (fish-friendlier)
2	Implement farm plans	1	0	0	1	0	1	3	2	2	3	3	3	3	3	19	2.85	0.5	Implement farm plans
2	Large wood placement	1	0	2	2	1	2	8	3	2	1	2	2	3	4	17	1.95	1.2	Large wood placement
2	Off-channel features	1	2	2	1	2	2	10	2	2	1	2	2	2	4	15	1.75	1.6	Off-channel features
2	Riparian fencing	1	0	1	1	0	3	6	3	2	3	2	3	3	4	20	2.95	0.9	Riparian fencing
2	Riparian planting	3	0	2	3	1	3	12	3	2	2	3	2	3	3	18	2.3	1.95	Riparian planting
2	Water conservation	0	0	0	1	0	3	4	1	2	0	1	2	1	4	11	1.15	0.45	Water conservation
2	Wetlands restoration	4	3	3	4	3	3	20	3	2	1	3	1	3	2	15	1.6	3.4	Wetlands restoration
2	Willow wall	3	0	2	3	1	3	12	3	2	2	2	2	3	4	18	2.3	1.95	Willow wall
3	Beaver encouragement	4	2	3	4	4	3	20	3	3	1	3	1	3	4	18	1.75	3.2	Beaver encouragement
3	Reshape channel	4	3	4	4	3	2	20	3	3	1	3	1	3	2	16	1.65	3.5	Reshape channel
3	Culvert replacement (passage)	1	1	1	2	0	3	8	3	1	3	2	3	2	4	18	2.8	1.3	Culvert replacement (passage)
3	Large wood placement	1	0	3	2	2	3	11	3	2	2	3	2	3	3	18	2.3	1.55	Large wood placement
3	Riparian fencing	2	0	2	1	0	3	8	3	2	3	1	3	3	4	19	2.9	1.35	Riparian fencing
3	Riparian forestry practices	4	0	2	4	1	3	14	3	3	2	1	2	1	1	13	1.95	2.35	Riparian forestry practices
3	Riparian planting	1	0	2	3	1	3	10	3	2	3	3	3	3	4	21	3	1.45	Riparian planting
3	Road decommission	4	1	2	4	0	3	14	4	2	2	3	2	3	3	19	2.4	2.55	Road decommission
3	Road upgrades	3	1	2	2	0	3	11	3	2	3	2	3	3	3	19	2.9	2	Road upgrades
4	Culvert replacement (erosion)	1	0	2	2	0	3	8	3	2	3	2	3	3	3	19	2.9	1.25	Culvert replacement (erosion)
4	Culvert replacement (passage)	3	3	2	2	1	3	14	2	2	3	2	3	3	2	17	2.75	2.55	Culvert replacement (passage)
4	Landslide area protection	4	0	2	4	0	2	12	3	3	2	2	2	1	1	14	2	2.2	Landslide area protection
4	Riparian forestry practices	4	0	2	4	1	3	14	3	3	2	1	2	1	1	13	1.95	2.35	Riparian forestry practices
4	Riparian planting	2	0	2	3	0	2	9	2	1	3	2	2	1	4	15	2.3	1.55	Riparian planting
4	Road decommission	4	2	2	4	2	3	17	3	3	2	2	3	3	4	20	2.65	2.9	Road decommission

Table M-18 Prioritization Score Results Echo Sub-basin

Rating of Actions - Echo (0-4 scoring system)

		Biological Criteria							Socio-Economic Criteria								Scores		
	Criterion weight	25%	25%	20%	15%	5%	10%		10%	5%	35%	5%	30%	10%	5%				
Region	Potential Action	Restores Processes*	Restores Connectivity	Limiting Factor(s) addressed	Longevity	Unique habitat	Proven technique	Raw Score	Likelihood of success*	Educational benefit	Landowner concerns*	Measurability	Implementation feasibility*	Fundability*	Cost	Raw Score	Weighted Socio-economic	Weighted Biological	Potential Action
1	Large wood placement	1	0	0	2	1	2	6	2	2	2	1	2	3	4	16	2.15	0.8	Large wood placement
1	Levee removal (includes tg remova	4	4	3	4	4	3	22	3	3	1	3	1	4	2	17	1.75	3.7	Levee removal (includes tg removal)
1	Riparian fencing	0	0	0	1	0	3	4	3	1	3	1	3	3	4	18	2.85	0.45	Riparian fencing
1	Riparian planting	0	0	0	3	3	2	8	3	3	3	3	2	3	4	21	2.75	0.8	Riparian planting
1	Tide gate relocation	2	2	2	2	4	2	14	3	3	1	2	1	3	2	15	1.6	2.1	Tide gate relocation
1	Tide gate removal	4	4	3	4	4	2	21	3	3	1	3	1	4	2	17	1.75	3.6	Tide gate removal
1	Tide gate replacements	2	2	2	2	0	2	10	2	2	3	2	3	2	3	17	2.7	1.9	Tide gate replacements
1	Wetlands restoration	3	2	2	3	3	3	16	3	2	2	2	2	3	2	16	2.2	2.55	Wetlands restoration
2	Beaver encouragement	4	2	1	4	3	3	17	3	2	1	3	1	3	4	17	1.7	2.75	Beaver encouragement
2	Culvert replacements (passage)	1	1	2	2	0	3	9	3	2	4	2	3	3	2	19	3.2	1.5	Culvert replacements (passage)
2	Ditch maintenance	0	0	0	1	0	2	3	2	2	2	2	2	2	4	16	2.1	0.35	Ditch maintenance
2	Implement farm plans	1	0	0	1	0	1	3	2	2	3	3	3	3	3	19	2.85	0.5	Implement farm plans
2	Large wood placement	1	0	1	2	1	3	8	2	2	2	2	2	3	4	17	2.2	1.1	Large wood placement
2	Off-channel features	1	1	1	1	1	1	6	1	1	2	2	2	2	4	14	1.95	1	Off-channel features
2	Reshape channel	4	3	1	4	3	2	17	3	3	1	3	1	3	2	16	1.65	2.9	Reshape channel
2	Riparian fencing	0	0	0	1	0	3	4	3	1	3	1	3	3	4	18	2.85	0.45	Riparian fencing
2	Riparian planting	2	0	2	3	0	3	10	3	2	3	3	3	3	4	21	3	1.65	Riparian planting
2	Wetlands restoration	4	1	1	3	2	3	14	3	2	2	2	1	3	3	16	1.95	2.3	Wetlands restoration
2	Willow wall	1	0	1	3	0	3	8	3	2	2	2	2	3	4	18	2.3	1.2	Willow wall
3	Culvert replacement (passage)	1	2	2	2	0	3	10	3	2	3	2	3	3	4	20	2.95	1.75	Culvert replacement (passage)
3	Landslide area protection (head wa	2	0	2	4	0	2	10	3	2	2	2	2	2	2	15	2.1	1.7	Landslide area protection
3	Large wood placement	2	0	2	2	2	3	11	3	2	3	2	3	3	3	19	2.9	1.6	Large wood placement
3	Riparian forestry practices	2	0	1	4	0	2	9	2	2	3	1	3	4	3	18	2.85	1.5	Riparian forestry practices
3	Road decommission	4	0	2	4	0	3	13	3	2	1	2	2	3	3	16	1.9	2.3	Road decommission
3	Road upgrades	2	0	2	2	0	3	9	3	2	3	2	3	3	3	19	2.9	1.5	Road upgrades

Appendix B – Channel Morphology

Table M-19 North Slough Sub-Basin Channel Morphology

	Aquatic Habitat Study Reach									
	Main Tidal	Main Valley	Main Forest	Bear Crk	Bear Crk Trib	Trib R Reach 1	Trib R Reach 2	Trib F Reach 1	Trib F Reach 2	Trib F Reach 3
W:D Ratio	13.5	8	6.3	9	3.3	4.8	4.9	6	4.5	6
Valley Width Index	12.9	12.2	4.6	6.3	20	12.7	1.5	16	6.5	3
Active Channel Width (M)	18.4	7.4	4.2	3.7	2	2.8	2.5	3	2.8	2.7
Active Channel Height (M)	1.4	1	0.7	0.4	0.6	0.6	0.5	0.5	0.5	0.5
Floodprone Width (M)	45.3	28.1	13.4	6.2	60	6.2	4.6	4.5	10.8	7.7
Floodprone Height (M)	2.8	1.9	1.4	0.9	1.2	1.2	1	1	1	0.9
Valley and Channel Morphology	FP1 US	FP2 CT	FP3 CA	LC MV	FP3 US	FP3 US	MV CH	FP3 US	FP3 US	MV CH
Stream Length (M) (secondary & primary)	2146	4518	515	1292	386	289	247	324	586	80
Stream Gradient Average %	0	0.3	0.8	1	0.5	2.1	6.7	1.3	1.3	1.2
Secondary Channel % Area (M^2)	14.7	8.3	1.7	1.2	0.3	0	12.1	1.5	4.4	12.5

Table M-20 Palouse Sub-Basin Channel Morphology

	Aquatic Habitat Study Reach											
	Lower Tidal	Upper Tidal	Lower Valley	Mid Valley	Upper Valley	Forest Reach	Trib A	Trib B	Trib C R1	Trib C R2	Trib D	Lower Tidal
W:D Ratio	22	5.2	4.4	6.1	8.9	15.4	9.8	7	7.5	25.6	4.6	22
Valley Width Index	10	25.8	42.5	17.1	9	1.7	6.1	3	6.8	1.8	4.6	10
Active Channel Width (M)	20.5	4.2	3.3	6.9	8.4	10.3	4.2	3.5	4.5	12.8	2.6	20.5
Active Channel Height (M)	1.1	0.8	0.8	1.1	1	0.7	0.5	0.5	0.6	0.5	0.5	1.1
Floodprone Width (M)	68.7	41.4	30.7	14.7	38.7	17	5.9	5.6	14.7	17.9	11	68.7
Floodprone Height (M)	2.2	1.6	1.5	2.3	2.1	1.4	1	1	1.2	1	1.2	2.2
Valley and Channel Morphology	FP1 US	FP3 US	FP3 US	FP3 US	FP2 US	MV CH	MV CA	MV CA	FP3 US	MV CH	FP3 US	FP1 US
Stream Length (M) (secondary & primary)	3274	1375	2790	1182	2838	1161	687	147	529	255	323	3274
Stream Gradient Average %	0	0.3	0.5	0.7	0.7	1.8	2.8	2.4	1.8	0.8	1.8	0
Secondary Channel % Area (M^2)	11.7	1.1	0.6	0.6	6.5	0.6	2.8	1.8	0	0.9	0.9	11.7

Table M-21 Larson Sub-Basin Channel Morphology

	Aquatic Habitat Study Reach								
	00 Winter Reach 1	00 Winter Reach 2	Main Reach 3	Main Reach 4	01 Main Reach 5	01 Main Reach 6	Sullivan Reach 1	Sullivan Reach 2	Sullivan Reach 3
W:D Ratio	7.4	5.4	11.4	10.2	43	34.4	14.5	9.4	11.4
Valley Width Index	4	4	11.7	8.3	3.2	1.3	2.5	1.6	3.5
Active Channel Width (M)	14.8	4.3	8	7.1	5.6	3.9	2.9	3.6	2
Active Channel Height (M)	2	0.8	0.7	0.7	1.2	0.1	0.2	0.4	0.2
Floodprone Width (M)	31.5	7.2	14.4	9.5	7.7	4.7	4.5	4.4	2.8
Floodprone Height (M)	4	1.6	1.4	1.5	0.4	0.3	0.5	0.9	0.5
Valley and Channel Morphology	FP1 CT	FP3 CT	FP2 CT	FP2 US	MM AT	MV CH	MV CH	MV CH	MM AT
Stream Length (M) (secondary & primary)	2657	2120	1251	1044	1272	2479	225	730	1041
Stream Gradient Average %	0.50	0.70	0.40	0.90	4	6.70	5.70	3.10	3.20
Secondary Channel % Area (M^2)	0.2	0.4	2.0	8.9	2.7	5.6	1.8	3.0	10.7

Note: In the Larson sub-basin, some of the Channel Habitat Type data, used in Valley and Channel Morphology codes, erroneously reports the channel is constrained by terraces, where it is actually constrained by landuse (dikes).

Table M-22 Kentuck Sub-Basin Channel Morphology

	Aquatic Habitat Study Reach											
	Mettman Trib	Main Tidal	Main Lower	Main Mid Valley	Main Upper Valley	Main Lower Forest	Trib 31 Reach 1	Trib 31 Reach 2	Trib 30 Reach 1	Franson 1	Franson 2	Franson 3
W:D Ratio	12.7	64.2	7.5	4.3	10.8	15.7	13.6	11.2	16.3	9.3	15.1	20.3
Valley Width Index	2	19.4	20	12.5	6.9	1.8	5	2	1.5	1.8	3.8	2.2
Active Channel Width (M)	3.5	22.6	4.5	5.8	8.8	5.9	3.1	2.8	3.3	3.5	4.5	4.9
Active Channel Height (M)	0.3	0.3	0.6	0.8	0.9	0.4	0.2	0.3	0.2	0.4	0.3	0.3
Floodprone Width (M)	4.9	24.5	8.3	28.1	28.2	7.5	3.8	4.3	4.3	5.6	5.9	5.9
Floodprone Height (M)	0.6	0.7	1.2	1.5	1.7	0.8	0.5	0.5	0.4	0.8	0.6	0.5
Valley and Channel Morphology	MV CH	FP1 CL	FP3 CL	FP3 CL	FP3 CT	MV CH	MM AT	MM CH	MM CH	MV CH	LM AT	MC CH
Stream Length (M) (secondary & primary)	706	1875	689	2770	2450	3461	505	203	583	198	624	380
Stream Gradient Average %	3.3	0.0	0.0	0.0	0.5	1.8	2.5	2.0	2.0	4.2	0.7	3.0
Secondary Channel % Area (M^2)	1.2	0.1	0.9	8.0	1.3	1.0	0.0	0.0	0.4	0.0	11.8	0.8

Table M-23 Willanch Sub-Basin Channel Morphology

	Aquatic Habitat Study Reach																		
	Tidal R1 03	01 Main Willanch 1	01 Main Willanch 2	01 Main Willanch 3	01 Main Willanch 4	01 Main Willanch 5	01 Main Willanch 6	01 Main Willanch 7	01 Main Willanch 8	01 Main Willanch 9	Right Frk R10	Right Frk R11	R1 Right Frk 04	R2 Right Frk 04	Right Frk 13	R1 Trib to Left Frk	R2 Trib to Left Frk	Trib A	Trib B
W:D Ratio	5.3	9.2	8.3	10.5	17.7	14.5	8.5	9.1	9	9.2	8.4	11.9	16.9	15.4	19.2	18.4	11.1	9.9	3.4
Valley Width Index	10	8.6	9.2	7	4.7	3.8	4.3	3	8	4.2	4.1	1.8	2	2.5	2.2	1.8	2	2.3	1.5
Active Channel Width (M)	6.8	3.6	4.3	5	6.8	6	3.7	2.9	2.2	2.3	5.8	9.4	5.3	3.2	10.6	4.1	5.2	4.4	2.4
Active Channel Height (M)	5.6	0.4	0.5	0.5	0.4	0.4	0.5	0.3	0.3	0.3	0.7	2.1	0.3	0.2	0.7	0.2	0.5	0.4	0.7
Floodprone Width (M)	24.7	5.7	8.3	10.6	12.1	7.3	7.1	4.4	3.4	4	16.1	15.2	6.9	4	18.4	5.5	8.1	5.3	3.6
Floodprone Height (M)	2.5	0.8	1.1	1	0.9	0.9	0.9	1.4	0.5	0.6	1.4	1.2	0.6	0.5	1.3	0.5	1	0.9	1.7
Valley and Channel Morphology	FP3 US	LM CT	LM CT	LM AT	LM AT	LM AT	MM AT	MM AT	MM AT	MC AT	MM AT	MV CH	MV CH	MV CH	MV CH	MV CH	MV CH	MV CH	SV CH
Stream Length (M) (secondary & primary)	2496	719	646	288	686	860	893	727	214	1116	633	1069	732	843	477	175	479	160	128
Stream Gradient Average %	0.20	0.30	0.50	0.50	1.10	1.80	3.50	4.50	4.70	6.40	2.30	2.40	2.30	1.60	3.10	1.70	4.60	6.40	11.90
Secondary Channel % Area (M^2)	2.5	0.1	0.0	0.7	4.3	3.2	3.5	1.2	1.9	2.7	3.2	1.3	2.7	1.4	2.3	0.0	3.1	3.3	5.8

**Table M-24
Echo
Sub-Basin
Channel
Morphology**

	Aquatic Habitat Study Reach				
	Lower	Valley	Forest	Beaver Pond	Upper Forest
W:D Ratio	6.7	5	6.7		13.1
Valley Width Index	99	22.7	7.6	1.2	2.3
Active Channel Width (M)	8	2.3	4.5	46.7	5.8
Active Channel Height (M)	1.2	0.5	1.7	2.2	0.4
Floodprone Width (M)	12.6	4.3	7	52.7	9.7
Floodprone Height (M)	2.4	0.9	1.5	4.4	0.8 M
Valley and Channel Morphology	FP3 CT	FP3 CT	FP3 CT	AF CH	MC CH
Stream Length (M) (secondary & primary)	319	475	469	317	905
Stream Gradient Average %	0.20	0.10	0.70	0	1.50
Secondary Channel % Area (M^2)	2.1	0	0.4	NA	2.6

Channel Morphology Definitions

The W:D Ratio is the width to depth ratio average of the reach represented.

Valley Width Index is estimated by dividing the average Active Channel Width into the average Valley Floor Width.

Two valley and channel morphology codes are given for each reach. These codes are Channel Habitat Types (CHTs), as described by the Oregon Watershed Assessment Manual (OWEB, 1999), as well as Channel Morphology as described by the ODFW aquatic habitat survey protocol (Moore, et al., 2004).

The Active Channel Width is described as the distance across channel at "bank full" flow. The Active Channel Width is used to determine the size of the stream. This data is used to find the ODFW benchmark depth levels for pools.

Bankfull Flow is the level that the stream flow attains every 1.5 years on average.

The Active Channel Height is the vertical distance from the streambed to the top of the active channel. This measurement is taken in fast water units or at pool tail crests.

The Floodprone Width is the distance across the stream channel and /or unconstraining terraces at Floodprone Height, which is determined by doubling the active channel height.

The main stream channel is defined as the primary channel, and all other off-channel units, such as alcoves, isolated pools, tributary units and backwaters are defined as secondary and tertiary channels.

Appendix C – Fish Life History

Table M-25 Generalized Life History Patterns Of Anadromous Salmon, Steelhead, And Trout In The Pacific Northwest.

Species	Adult Return	Spawning Location	Eggs in Gravel[2]	Young in Stream	Freshwater Habitat	Young Migrate Downstream	Time in Estuary	Time in Ocean	Adult Wt. (avg.)
Coho *Oncorhynchus kisutch*	Oct - Jan	Coastal streams, shallow tributaries	Oct - May	1+ yrs	Tributaries, main-stem, slack water	Mar – Jul (2nd yr)	Few days	2 yrs	5-20 lb (8)
Chinook (spring) *Oncorhynchus tshawytscha*	Jan - July	Main-stem large and small rivers	July - Jan	1+ yrs	Main-stem large and small rivers	Mar – Jul (2nd yr)	Days - months	2-5 yrs	10-20 lb (15)
Chum *Oncorhynchus keta*	Sept - Jan	Coastal rivers and streams lower reaches	Sept - Mar	Days-weeks	Little time in fresh water	Shortly after leaving gravel	4-14 days	2.5-3 yrs	
Steelhead (winter) *Oncorhynchus mykiss*	Nov - Jun	Tributaries, streams, and rivers	Feb - Jul	1-3 yrs	Tributaries	Mar – Jul (2nd yr)	Less than a month	1-4 yrs	5-28 lb (8)
Coastal Cutthroat Trout *Oncorhynchus clarki*	Jul - Dec	Tiny tributaries of coastal streams	Dec - Jul	1-3 yrs (2 avg.)	Tributaries	Mar – Jun (2nd -4th yr)	Less than a month	0.5-1 yr	0.5-4 lb (1)

1 Life history patterns vary – fish in each watershed may have unique timing and patterns of spawning, growth, and migration.
2 The eggs of most salmonids take 3-5 months to hatch at the preferred water temperature of 50-55^{O} C; steelhead eggs can hatch in 2 months.

(Table adapted from the Oregon Watershed Enhancement Board Watershed Assessment Manual)

Appendix D - Solar Load Reduction

Potential Reduction

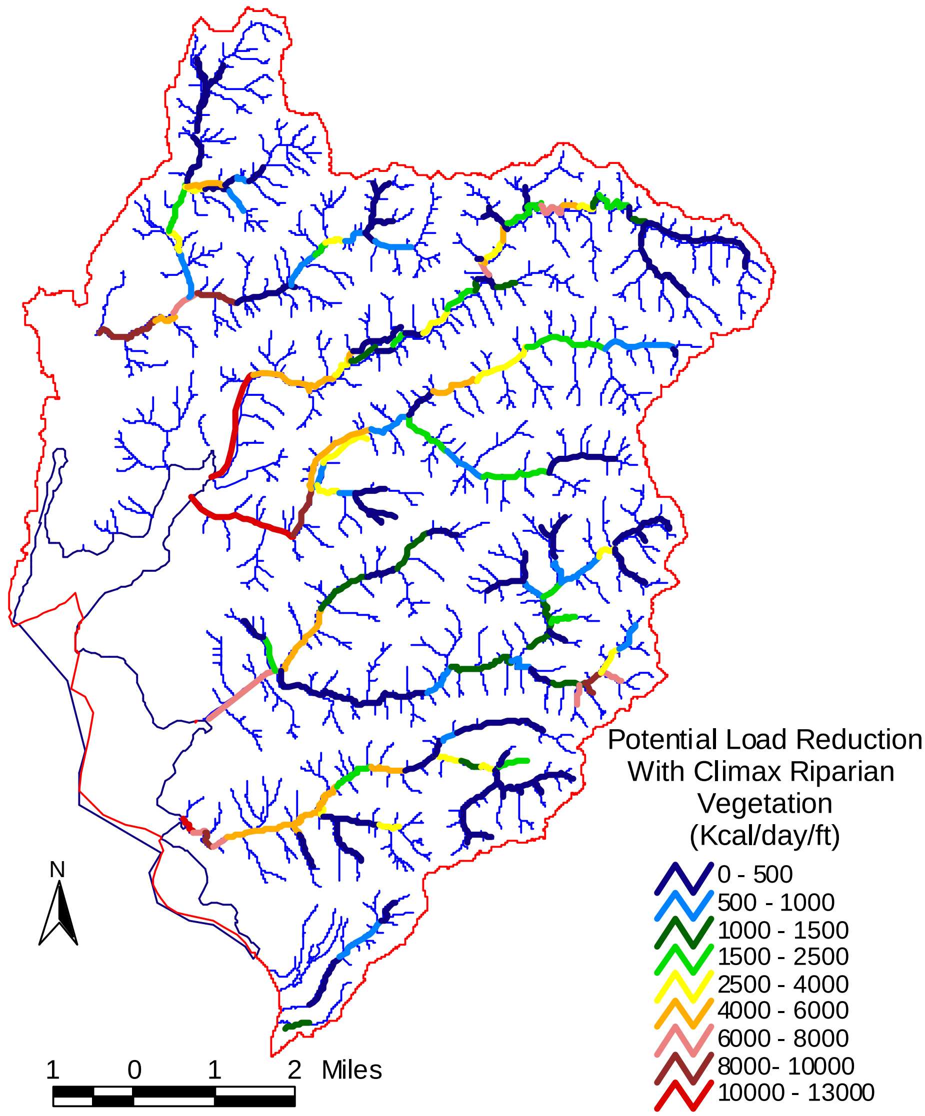
Current and potential shade values for each stream (weighted average of reaches) were calculated using the SHADOW model. Inputs to the model include data describing the existing conditions (tree height, tree-channel distance, canopy overhang, canopy density, valley morphology, and aspect) to calculate current shade. The model calculated potential shade using estimates for climax vegetation characteristics along with known features (aspect and valley morphology). Appendix A - Riparian Shade, provides more details on using the SHADOW model.

Table M-26 Lowland Streams Potential Solar Load Reduction

	Solar Load (gigacalorie per day)					kcal/day/ft
Stream	**Unshaded**	**Current Shade**	**Restored Full Potential Shade**	**Potential Reduction**	**Potential Reduction %**	**Potential Load Reduction/ft**
Bear Creek	98.0	39.5	2.5	37.1	94%	1191.8
North Slough	478.7	387.8	76.6	311.4	80%	7395.7
Palouse Creek	525.4	243.7	34.2	209.9	86%	2928.4
Larson Creek	481.6	315.5	82.3	233.3	74%	3978.4
Sullivan Creek	48.6	14.9	0.7	14.3	96%	1148.5
Kentuck Creek	530.3	220.9	55.6	165.7	75%	2613.3
Mettman Creek	95.5	41.3	4.7	36.5	88%	1624.8
Franson Creek	66.0	10.0	1.9	8.2	82%	550.1
Willanch Creek	269.6	141.6	20.7	121.6	86%	2237.7
Johnson Creek	45.3	7.0	0.4	6.7	95%	720.0
Echo Creek	56.5	9.5	4.3	5.3	56%	488.2

Table M-26, above, displays various shade values and the potential solar load reduction for each assessment stream. The 'unshaded' values are gigacalories/day of solar energy load that would warm the stream if no shade were present. In this case, North Slough, Palouse, Kentuck and Larson Creeks would receive the most solar load. The 'current shade' values are gigacalories/day that are currently loading the stream under existing shade conditions. Currently, North Slough and Larson Creeks are receiving the most solar load, with very little shade cover. The 'restored full potential shade' values represent the solar loading under potential shade conditions. Potential shade is the shade that would be created if native trees were allowed to populate the riparian area unhindered by human impacts. These values show that even with full potential shade there is some amount of solar loading due to stream width, orientation, and potential shade densities.

Figure M-2 Potential Load Reduction



The 'potential reduction' values represent the change in solar load between current shade conditions and potential shade conditions. These values are also displayed spatially in Figure M-2, above.

On a typical stream, the majority of heat gains come from air temperature and insolation, both of which are directly affected by solar load amounts. Therefore, restoring the riparian canopy in the upper stream reaches with high reduction potential should reduce stream temperatures. Potential reduction in percentages and per linear stream foot should be considered when making riparian management decisions. These values indicate those streams that are most vulnerable to solar loading and where riparian planting will be the most effective per foot for reducing stream temperatures. As indicated in Table M-22 above, Sullivan, Bear and Johnson Creeks (all major tributaries) have the highest potential for solar load reduction as a percent change. North Slough and Palouse Creeks also have high potential for solar load reduction per stream foot.

Riparian Planting

Coos WA calculated future shade resulting from a variety of hypothetical planting techniques shown in Table M-28. The estimated input values used in calculating the resulting shade, using the SHADOW model, are shown in Table M-27.

Table M-27, shows the percent of shade on stream channels produced from planting techniques that differ in their tree species, buffer width, stream orientation, active channel width, and growth stage. (Column headings are defined below, see indent.) Comparison of these scenarios leads to can help riparian managers plan the most effective actions for temperature reduction. Managers should note that potential shade val-

Table M-27 Estimated Input Values of Planting Techniques

ACW	Measurement	Species type and buffer width			
		Willow 15'	Hardwoods Willow 15'	Hardwoods 15'	Willow/ Hardwoods/ Conifers 35'
10 ft	Overhang, % of ACW	50	50	0	50
	Tree Height (ft)	15	25	25	25
	Bank Slope ^{o}	45	45	45	45
	Tree-Channel Distance (ft)	1	1	5	1
	Shade Density %	80	65	40	70
20 ft	Overhang, % of ACW	50	50	50	50
	Tree Height (ft)	15	50	50	50
	Bank Slope ^{o}	45	45	45	45
	Tree-Channel Distance (ft)	1	1	5	1
	Shade Density %	90	65	50	70
30 ft	Overhang, % of ACW	50	75	75	75
	Tree Height (ft)	15	70	70	70
	Bank Slope ^{o}	45	45	45	45
	Tree-Channel Distance (ft)	1	1	5	1
	Shade Density %	95	70	60	80

ues can often be attained in a shorter time period by planting native species other than the historical climax vegetation – i.e., use of willow cuttings can reduce the time needed to produce potential shade.

Table M-28 demonstrates that, for all stream channel widths, hardwoods/willow and willow/hardwood/conifer plantings provide a high percentage of shade the quickest and that increases through the years. On a 10 foot channel width, these two types provide almost complete shade in thirty years. Willows would provide shade the fastest, being nearly fully grown by ten years, but with a lower shade percentage and little increase with age. Hardwoods provide the lowest amount of early shade, but by twenty years have exceeded the shade provided by willows, and are close to the willow/hardwood/conifer percentages after thirty years.

Table M-28 Percent Shade Produced From Planting Techniques

ACW	Planting Technique	10 year growth			20 year growth			30 year growth		
		Diag.	N S	E W	Diag.	N S	E W	Diag.	N S	E W
10ft	Willow 15'	77	63	79	78	64	79	79	65	80
	Hardwoods/ willow 15'	89	83	90	92	93	92	97	100	95
	Hardwoods 15'	69	52	73	85	82	86	94	96	95
	Willow/ Hardwoods/ Conifers 35’	83	73	83	92	92	91	97	100	95
20ft	Willow 15'	48	35	57	50	36	59	52	37	61
	Hardwoods/ willow 15'	67	51	71	80	69	80	90	91	89
	Hardwoods 15'	40	28	48	69	48	71	84	79	83
	Willow/ Hardwoods/ Conifers 35’	60	42	65	78	66	79	89	88	87
30ft	Willow 15'	33	24	39	35	24	41	36	25	43
	Hardwoods/ willow 15'	48	36	56	69	48	70	83	77	82
	Hardwoods 15'	2	19	33	54	33	60	74	57	75
	Willow/ Hardwoods/ Conifers 35’	42	29	49	67	46	69	80	70	80

ACW: Active Channel Width - distance across channel at “bank full” flow.
Diag.: Diagonal orientation of the stream in relation to the sun’s path from east to west. Same results for 45^{o} northeast or 135 ^{o} northwest.
NS: North-south orientation of the stream.
EW: East-west orientation of the stream.

Appendix E – Lowland Streams Intrinsic Potentials

Table M-29 Coho Smolt Production Total Intrinsic Potential for the Lowlands Sub-basins

Intrinsic Potential	Echo	Kentuck/ Mettman	Larson	North Slough	Palouse	Willanch	Total
Smolt Production	2,191	135,417	125,867	140,438	141,765	61,622	**607,300**
Adults (1% - Low Ocean Survival)	22	1,354	1,259	1,404	1,418	616	**6,073**
Adults (10% - High Ocean Survival)	219	13,542	12,587	14,044	14,177	6,162	**60,730**

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