Okanogan-Wenatchee National Forest: Procedures for Watershed and Aquatic Resource Assessment, Analysis and Proposal Development for Whole Watershed Scale Projects DRAFT

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Introduction

Watershed restoration and forest health have been identified as core management objectives of the United States Department of Agriculture's National Forests and Grasslands (USDA Strategic Plan for FY 2010-2015). To achieve this objective the Forest Service has been directed to identify and restore degraded watersheds by strategically focusing on watershed improvement projects and conservation practices at the landscape and watershed scales (USDA 2011). As part of the identification of degraded watersheds, National Forests throughout the U.S. were mandated to implement the Watershed Condition Framework (WCF) process in 2010. The goal of WCF was to identify current conditions for each 6th hydraulic code sub-watershed and use that assessment to further identify priority sub-watersheds where focused management could restore impaired watershed function.

The term "Restoration" has been defined in a variety of ways, with the major theme of restoration involving the return of a disturbed ecosystem to its condition prior to disturbance.

Restoration as defined by a National Research Council Report (1992) involves "… the return of an ecosystem to a close approximation of its condition prior to disturbance. In restoration, ecological damage to the resource is repaired. Both the structure and the functions of the ecosystem are recreated … The goal is to emulate a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs."

Ecologically based watershed restoration as defined by the EPA (1995) in terms of watershed management is "the restoration of chemical, physical and/or biological components of a degraded system to a pre-disturbance condition". The EPA further states that "restoration is also an important tool for preventing environmental degradation."

The Forest Service defines ***Ecological Restoration*** as "The process of assisting the recovery of resilience and adaptive capacity of ecosystems that have been degraded, damaged or destroyed. Restoration focuses on establishing the composition, structure, pattern, and ecological processes necessary to make terrestrial and aquatic ecosystems sustainable, resilient and healthy under current and future conditions" (FSM 2020.5).

On the Okanogan-Wenatchee National Forest (OWNF), the results of the National Watershed Condition Framework (WCF) assessment show that the majority of sub-watersheds located outside of Wilderness and Inventoried Roadless Areas are currently functioning at risk and need to be restored to be functioning properly. The listing of several fish species under the Endangered Species Act (ESA) further support the need to engage in watershed restoration across the OWNF. For the Okanogan-Wenatchee National Forest, the primary driver impairing contemporary watershed and aquatic ecosystem function identified in the WCF (as well as other large scale regional and forest wide assessments) is the extensive road system. Chronic and road related hydrologic alterations and periodic storm event interactions with the road system only serve to further degrade floodplains, stream channels, water quality and aquatic habitat. Other land management activities can also impair watershed and aquatic function, however most of these management activities are also dependent on roads such as; mining, timber harvest, vegetation management, fire suppression, grazing, recreation, etc.

Over the last 2 decades, Hydrologists and Fisheries Biologists have worked to incorporate needed restorative actions that alleviating target undesired effects from the road system. However, at present, there is no guiding process or procedures that lead to consistent approaches to identify site-specific measurable objectives and design to move watersheds on the Okanogan-Wenatchee NF towards restoration and properly functioning condition. Therefore, a concerted effort is needed to identify and design a process for analyzing watersheds and developing projects that restore the sustainability and resiliency of aquatic ecosystems on the Okanogan-Wenatchee National Forest (OWNF), restore water quality, stream habitat and to recover native fish populations, in particular species listed under the Endangered Species Act (1973).

This document provides information on existing conditions and management direction for the Okanogan-Wenatchee National Forest, a review of scientific literature relevant to watershed response mechanisms and restoration. In addition, a suite of technical procedures that should be used to ultimately determine restoration actions, support project specific watershed and aquatic resource input for required travel analysis, provide the basis for hydrologic effects analysis, and assist in updating essential projects linked in priority Watershed Restoration Action Plans. Restoration actions are those needed to improve watershed condition by targeting impaired watershed processes, water quality, and aquatic habitat function. The following procedures incorporate geomorphic and ecological principles found in existing watershed and aquatic resource restoration planning mechanisms at varying spatial scales. The procedures have been tailored to focus on the degree of impact or impairment roads pose to watershed and aquatic resources and formulating restoration proposals, which cumulatively and/or site-specifically alleviate such impairment.

Strategies for improving vegetative patterns and wildlife habitat across the landscape can be found in the *Okanogan-Wenatchee National Forest Restoration Strategy: adaptive ecosystem management to restore landscape resiliency* (2012). The OWNF Forest Restoration Strategy focuses on the "need to restore the sustainability and resiliency of forested ecosystems on the Okanogan-Wenatchee National Forest (OWNF)" due to (1) increased susceptibility to uncharacteristically large and severe fires; (2) uncharacteristically severe insect outbreaks; and (3) declining habitats for late-successional and old forest associated species. The OWNF Whole Watershed Restoration Procedures serves to revise and replace proposed aquatic restoration concepts and steps found in the Forest Restoration Strategy.

Background

Existing Condition

The Okanogan-Wenatchee National Forest (OWNF) encompasses over four million acres, comprising approximately 9.4 percent of the total land area in Washington State. The Forest stretches north to south, from the Okanogan sub-basin in the north to the Naches sub-basin in the south. The crest of the Cascade Range generally defines the western boundary of the Forest, while the eastern boundary extends from the Okanogan highlands to the breaks of the Columbia River. The Forest landscape and ecological diversity can be attributed to a wide geographic range – from high, glaciated alpine peaks along the crest of the Cascades to dry, shrub-steppe at its eastern edge. Annual precipitation varies widely, from more than 100 inches along the crest of the Cascades to less than ten inches near the Columbia River. There are approximately 11,800 miles of streams and rivers (5,000 miles of perennial streams and 6,800 miles of intermittent streams) on the Forest, of which approximately 1,600 miles are fish-bearing. There are over 1,000 lakes ranging from very large lakes (e.g., Lake Wenatchee and Lake Chelan) to numerous small high mountain lakes. The Forest contains over 750 perennial snowfields and small glaciers, most of which lie within the north half of the Forest. The majority of streams and rivers on the Forest drain into the Columbia River Basin. Major sub-basins include; the Kettle, Sanpoil, Okanogan, Methow, Chelan, Entiat, Wenatchee, Naches, and Upper Yakima.

Streams and rivers that drain from the OWNF are significant contributors to local municipal water consumption, irrigation and hydroelectric power. Approximately 2.15 million acre-feet of water leaves the north half of the Forest each year for an annual value of $1.44 million in hydroelectric power. Approximately 165,000 acre-feet of irrigation water is diverted for irrigation each year. Major reservoirs on the south half of the forest provide irrigation water to the city of Yakima and surrounding communities; Cle Elum, Kachess, Kacheluss, Bumping and Rimrock reservoirs. Reservoir dams were built in the early 1900's (1910-1933) without fish passage structures and currently block access to anadromous fish species and migratory bull trout.

There are 37 native fish species and at least 6 species of introduced or non-native fish that occur on the OWNF (see Appendix C for a list of fish species). Of these, 4 species are listed as federally threatened, endangered, proposed, and/or candidate species under the Endangered Species Act (ESA 1973), 2 species are protected under the Magnuson-Stevens Fishery Conservation Act (MSA), 3 species are listed under the Regional Foresters Sensitive Species List (as updated on December 9, 2011) and 6 species on the Okanogan and 6 on the Wenatchee are designated as Management Indicator Species (MIS).

Approximately 37% of the Forest is in the following congressionally designated wilderness areas which span the crest of the Cascade Range from north to south; Pasayten, Lake Chelan-Sawtooth, Glacier Peak, Henry M. Jackson, Alpine Lakes, Norse Peak, William O. Douglas, and Goat Rocks. Streams, lakes, and aquatic and riparian habitats outside of wilderness areas (63% of the OWNF) have experienced alteration from a variety of past and current management related activities. Beginning in the early 1900's commercial timber harvest, road building, cattle and sheep grazing, stocking of non-native fish species in lakes and streams and other management actions began to impact watersheds and fisheries on a large scale. Commercial timber harvest (predominantly clear-cutting) began in the early 1900's on and off the National Forest System lands, with lowland riparian and adjoining upslope areas harvested first. Streams and rivers were used to move the logs downstream, with splash dams (storing water and logs and releasing the water and logs all at once to move the logs downstream) used as a transportation method into the 1950's. Riparian areas were also cleared and burned to make way for agriculture and development within floodplains. Stream and rivers were channelized and LWD and riparian vegetation were removed as a method of flood control. Historic sheep and cattle grazing began in the late 1800's and was essentially unregulated on NFS lands, until the 1920's when the allotment system was implemented.

Expansion of the road system, beginning in the 1950's and continuing into the 1990's, provided the means to greatly increase timber production both on and off NFS lands. Roads were typically built in valley bottoms within the riparian area, with arterial roads crisscrossing the hill slopes and stream network multiple times. Impacts to watershed, aquatics, fisheries and water quality and quantity from past and on-going management activities include; increased soil erosion and compaction along streams and in the uplands, increased sediment delivery, increased stream temperature, alteration of riparian vegetation, de-stabilization of stream banks, channel widening and loss of undercut banks, LWD and pools and altered flow regimes. At present, the OWNF has approximately 7,700 miles of USFS system roads over approximately 2.5 million acres of active management area allocations and an additional estimated 15-20% comprising user created and unauthorized road network. The ability of any given watershed to recover, improve, and attain a level of resiliency associated with desired function has been affected by these alterations, and is exacerbated by new and ongoing impacts.

Climate Change also has the potential to have profound impacts to fish and aquatic habitat. As summarized by Furniss et al 2013 and Raymond et al 2014, across the Pacific Northwest climate change is expected to result in:

- declines in snowpacks;
- increased streamflow and associated flooding in the winter and early spring;

- decreased streamflow in the late spring, summer and fall;
- increased stress on scarce summer water supplies;
- increased stress on salmon and trout and other cold-water species due to declining summer stream flows and rising stream temperatures.

Streamflow patterns are expected to change in eastern Washington with decreasing snowpacks in mid-elevation and wetter locations. In the eastern Cascades, snowpacks are expected to persist at higher elevations but at diminished levels, which may result in lower summer flows and potentially an increase in stream temperatures that are stressful for native salmonids. Additional changes in streamflow regimes that may be expected include peak flows occurring earlier in the spring, an increase in flood frequency, and reduction in late season low flows.

Climate change will exacerbate impacted stream conditions with warming streams, declining summer flows, and increasing flood risk all expected to negatively affect coldwater fish populations such as salmon, bull trout, redband and westslope cutthroat trout. Bull trout and westslope cutthroat trout are especially vulnerable given that spawning and rearing are constrained by their location in upper watersheds and the species' requirement for cold water temperatures. Climate change could also influence the distribution of non-native fishes, such as eastern brook trout and non-native rainbow trout, as they are typically more tolerant of higher water temperatures. Changing flow regimes, including the timing and magnitude of spring floods, could potentially increase egg mortality due to gravel scour for spring spawning species such as steelhead, redband and westslope cutthroat trout.

Management Direction and Policy

Clean Water Act (1972):

The Clean Water Act of 1972, requires that states restore their polluted waters to be "fishable and swimmable". Section 303(d) of the CWA establishes a process to identify and clean-up polluted waters. In Washington, water quality assessments are compiled every 2 years and water bodies are placed into categories that describe the status of their water quality. The 303 (d) List comprises those waters that are impaired by pollutants and do not meet established Washington State water quality standards. The majority of waters on the forest meet water quality standards developed by the Department of Ecology under the Clean Water Act (CWA). However, the 2008 303(d) list contained 31 stream reaches on the OWNF that did not meet standards for various parameters. Consequently, TMDLs were prepared for the Wenatchee National Forest for temperature, and for the Wenatchee Watershed for pH and dissolved oxygen. Of these streams, pollutants included the following; heavy metals (i.e. copper, lead, mercury and silver), dioxin, dissolved oxygen, PCB, pH and temperature).

Endangered Species Act (1973):

Through federal action and by encouraging the establishment of state programs, the 1973 Endangered Species Act provided for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend. Section 7(a)(2) of the Endangered Species Act (ESA) of 1973 (as amended) requires all federal agencies to review actions authorized, funded or carried out by them to ensure such actions do not jeopardize the continued existence of any listed species. The following species are listed under the ESA:

Endangered:

- **Upper Columbia River Spring Chinook** (*Oncorhynchus tshawytscha*); listed as Endangered on March, 1999; Critical Habitat designated on September 2, 2005 (70 CFR 52630); Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan completed in August, 2007. On March 24, 1999, NMFS listed UCR Spring-run Chinook salmon as an endangered species (64 FR 14308) and their endangered status was reaffirmed on June 28, 2005 (70 FR 37160). This ESU includes all naturally spawned populations of Chinook salmon in all river reaches accessible to Chinook salmon in Columbia River tributaries upstream of Rock Island Dam and downstream of Chief Joseph Dam in Washington (excluding the Okanogan River), as well as six artificial propagation programs: the Twisp River, Chewuch River, Methow Composite, Winthrop National Fish Hatchery, Chiwawa River, and White River Spring-run Chinook hatchery programs. The Interior Columbia Basin Technical Recovery Team (ICBTRT) has identified three populations in one major population group (Eastern Cascades) for this species. A historic population in the Okanogan River has been extirpated (ICBTRT 2005).

Threatened:

- **Upper Columbia River Steelhead** (*Oncorhynchus mykiss*); listed as Endangered on October 17, 1997, reinstated as endangered on June 13, 2007, reclassified as threatened on August, 2009; Critical Habitat designated on September 2, 2005 (70 CFR 52630); Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan completed in August, 2007. This DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border, as well six artificial propagation programs: the Wenatchee River, Wells Hatchery (in the Methow and Okanogan Rivers), Winthrop NFH, Omak Creek, and the Ringold steelhead hatchery programs. The ICBTRT has identified five populations within this DPS: the Wenatchee River, Entiat River, Methow River, Okanogan Basin, and Crab Creek (ICBTRT 2005). The Crab Creek anadromous component is functionally extirpated (ICBTRT 2007).

- **Middle Columbia River Steelhead** (*Oncorhynchus mykiss*); The Middle Columbia River (MCR) steelhead DPS was listed as threatened on March 25, 1999 (64 FR 14517) and their threatened status was reaffirmed on June 28, 2005 (70 FR 37160). Critical Habitat designated on September 2, 2005 (70 CFR 52630); Middle Columbia River Steelhead Recovery Plan completed in November, 2009. This DPS includes all naturally spawned populations of steelhead in streams from above the Wind River, Washington, and the Hood River, Oregon, upstream to, and including, the Yakima River, Washington, excluding steelhead from the Snake River Basin. Seven artificial propagation programs are considered part of the DPS: the Touchet River Endemic, Yakima River Kelt Reconditioning Program (in Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River), Umatilla River, and the Deschutes River steelhead hatchery programs. The ICBTRT (2007) identified 20 populations in four major population groups (Eastern Cascades, John Day River, the Umatilla Rivers/Walla Walla, and the Yakima River).

- **Columbia River Bull Trout** (*Salvelinus confluentus*); listed as Threatened on June 12, 1998, Critical Habitat designated on October 18, 2010 notice (50 CFR Part 17), Bull Trout Recovery Plan completed in April 2002.

Magnuson-Stevens Fishery Conservation and Management Act (as amended in 1996):

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) of 1996 (as amended) requires the identification of Essential Fish Habitats (EFH) for Federally managed fishery species and the implementation of measures to conserve and enhance this habitat as described in Federal Fishery Management Plans (FMP's). Federal agencies are required to review actions authorized, funded or carried out by them to ensure that such actions do not negatively affect any EFH (those waters and substrate necessary to fish for spawning, breeding or growth to maturity). Federal fisheries within the middle and upper Columbia basin which are covered under the MSA (Pacific Coast Salmon FMP) include; chinook and coho (*O. kisutch*).

Region 6 Regional Foresters Sensitive Species

Within the National Forest System, a sensitive species is a plant or animal whose population viability is identified as a concern by a Regional Forester because of a significant current or predicted downward trend in abundance or habitat quality that would reduce its distribution. The primary objective of the Sensitive species program is to ensure that federal actions do not contribute to a loss of viability, or cause a significant trend toward listing under the ESA. The following are Region 6 aquatic sensitive species that are suspected and/or known to occur on the OWNF;

- River Lamprey
- Pygmy Whitefish
- Umatilla Dace

Management Indicator Species (MIS)

36 CFR 219.19 (1982 planning rule) directs forests to establish objectives for maintenance and improvement of habitat for management indicator species (MIS). Management indicator species were designated in the Wenatchee National Forest Plan (1989) and the Okanogan National Forest Plan (1990). Species are selected as MIS because their population changes may indicate the effects of land management activities (36 CFR 219.19 (a) (1)).

Current MIS under Wenatchee Forest Plan:

- Cutthroat trout
- Bull trout
- Steelhead
- Sockeye
- Spring Chinook
- Summer Chinook

Current MIS under Okanogan Forest Plan:

- Cutthroat trout
- Redband/Rainbow trout
- Steelhead
- Spring Chinook
- Brook trout
- Bull trout

Okanogan (1990) and Wenatchee (1989) Forest Plans:

The Okanogan National Forest and the Wenatchee National Forest were administratively combined in 2000. The Okanogan Forest Plan was finalized in 1990 and the Wenatchee Forest Plan was finalized in 1989. Both plans were generally focused on outputs of products, mainly timber harvest. Direction for road management focused primarily on estimating the mileage of new road construction and/or reconstruction that would be needed for timber harvest access based on funding levels associated with the timber sale program of the late 1980s. The plans recognized that timber harvest rates would decline at some future date. However, provisions were not made for the associated decrease in funding that accompanied the decrease in timber production and resulting size of the transportation system that would need to be managed into the future. Forest plans also identified the existing Forest Service road miles that were suitable for public use and transportation. Plans included objectives and/or standards and guidelines to retain the existing road miles available for passenger car travel and those that were suitable only for high clearance vehicles and included stipulations for maintenance appropriate for these types of access.

OWNF Forest Plan Monitoring:

Current information regarding status of aquatic and riparian habitat on the Okanogan-Wenatchee NF comes from Forest Plan Monitoring. Forest plan monitoring consists of; stream and aquatic habitat surveys (1989-1994; 1995-2011), sediment monitoring (1993-present), and stream temperature monitoring (1993-present). Furthermore, data obtained from these monitoring efforts can also be used to inform project level planning and include:

- Aquatic Habitat Inventory: The PNW stream inventory program is an integral part of fish habitat and watershed management programs. Stream surveys are intended to identify existing aquatic and riparian conditions (pools, riffles, waterfalls, chutes, LWD, riparian vegetation, etc.) and identify limiting factors to the productive capabilities of the stream habitat (culverts, bank erosion, unstable banks, etc). Approximately 1000 miles of streams within the Okanogan-Wenatchee National Forest have been surveyed since 1995. Of these streams, approximately 30% of the streams surveyed were not properly functioning for LWD, 50% were not properly functioning for pool frequency, 90% were not properly functioning for deep pool habitat and 50% were not properly functioning for bankfull width to depth ratios. Properly functioning values are derived from definitions in the USFWS and NOAA fisheries matrix of pathways and indicators. Where repeat surveys have occurred, the majority of stream reaches remained at the same functional level or slightly improved.

  As part of the stream survey protocol, channel indicator metrics (bank stability, width to depth ratios and entrenchment ratios) are collected and can be compared to similar stream and valley types (Rosgen 1996) to determine departure from a stable stream channel. In streams that are significantly departed survey data shows undesired levels of channel incision, lateral erosion and aggradation. Reasons for departure vary from stream to stream, but in general, on the Okanogan-Wenatchee degraded stream channels are due mainly to the following past and ongoing land management activities; large wood has been yarded out of the stream channel and timber sales have harvested large trees from the riparian zone; roads have been constructed in the valley bottoms and cross stream channels multiple times leading to acceleration of stream power by artificially increasing drainage networks and confining stream channels; direct impacts to channel form and function from instream mining; and grazing within the riparian area have also impacted stream channels.

- Sediment Monitoring: Fine sediment is a natural component of streambeds; however, elevated levels of fines resulting from accelerated erosion (e.g., from roads, fires, vegetation removal, mining, grazing, etc.) can adversely affect salmonid and other fish species spawning and rearing success. The deleterious effects of excessive sedimentation on egg-to-fry survival of salmonids are well-documented in the scientific literature and include; suffocation and metabolic-waste-poisoning of eggs; decreased egg survival to emergence; and increased fry mortality due to entrapment and suffocation. Accelerated sedimentation rates can lead to channel widening and down-cutting and loss of important pool habitat. In addition, changes in substrate characteristics also affect the macro-invertebrate community, which is a primary food source for resident and anadromous fishes (Sigler et al. 1984).

  The Wenatchee and Okanogan National Forest Land and Resource Management Plans (WNF LRMP 1990; ONF LRMP 1989) include a standard to *"Maintain <20% fines (≤1.0 mm) as the area weighted average in* *spawning habitat (pool tail-outs and glides)",* as a way to determine when sediment levels are not functioning appropriately. NOAA Fisheries and USFWS also provide indicators for appropriate fine sediment levels within spawning reaches for TES fish species (see Table 2, below).

Table 1. NOAA Fisheries and the U.S. Fish and Wildlife Service Fine Sediment indicators of environmental conditions appropriate for TES species.

Threatened and Endangered Fish Species	Indicator	Functioning Appropriately	Functioning At Risk	Functioning at Unacceptable Risk
Bull Trout (USFWS 1998)	Fine Sediment in Spawning Gravel (<0.85mm)	<12% fine sediment	12-20% fine sediment	>20% fine sediment
Steelhead and Spring Chinook (NMFS 1996)	Sediment (<0.85mm)	<12% fine sediment	12-20% fine sediment	>20% fine sediment

In order to determine the percent of the substrate comprised of fine sediment (< 1.00/<0.85 mm in diameter) within key streams and rivers on the forest, McNeil core sampling was initiated in the early 1990's. Although variability exists in the mean percent fines within reaches, between reaches, and from year to year, and a certain amount of inherent natural variability is expected, management actions can exacerbate natural sediment delivery to streams. Therefore, long-term sediment monitoring sites, have been established in the following key streams and rivers on the Okanogan-Wenatchee National Forest. These streams provide significant spawning and rearing habitat for Upper and Middle Columbia River Evolutionary Significant Unit (ESU) steelhead (threatened); Upper Columbia River ESU spring Chinook salmon (endangered); the Columbia River Distinct Population Segment (DPS) bull trout (threatened); as well as Magnuson-Stevens Fishery Act Essential Fish Habitat (EFH) for summer/fall Chinook salmon, sockeye salmon (*O. nerka*), and coho salmon (*O. kisutch*):

- Chewuch and Twisp Rivers in the Methow Subbasin. Both rivers exceed Forest Plan Standards and are considered functioning at risk for TES fish species based on USFWS/NMFS criteria for sediment.

- Entiat and Mad Rivers in the Entiat Subbasin. The upper reaches of the Entiat River consistently meet the Forest Plan Standard and are functioning appropriately based on USFWS/NMFS criteria and WNF plan standards for TES fish species. The lower reaches of the Entiat River and the Mad River on average exceed the USFWS/NMFS criteria and WNF plan standards and are considered functioning at risk for TES fish species.

- Chiwawa River, Nason Creek, Mission Creek and the upper Wenatchee River in the Wenatchee Subbasin. The Chiwawa River, Nason Creek and the upper Wenatchee River, on average meet the USFWS/NMFS criteria and WNF plan standards and are considered functioning appropriately for TES fish species. Mission Creek exceeds USFWS/NMFS criteria and WNF plan standards and is functioning at unacceptable risk for TES fish species.

- North and West Forks of the Teanaway River and Swauk Creek in the Upper Yakima Subbasin. The North and West Forks of the Teanaway on average exceed USFWS/NMFS criteria and WNF plan standards and are functioning at risk for TES fish species. Swauk Creek consistently exceeds USFWS/NMFS criteria and WNF plan standards for sediment and is considered functioning at unacceptable risk for TES fish species.

- Little Naches River, South and North Forks of the Little Naches River, Bear Creek and Pyramid Creek in the Naches Subbasin, which on average are consistent with the USFWS/NMFS criteria and WNF plan standards and are considered functioning appropriately for TES fish species.

➢ Temperature Monitoring: Water temperature is a key component of fish habitat and aquatic ecology. Cold water fish species such as trout and salmon are particularly sensitive to very high and very low temperatures. Water temperature criteria set by the State (Class AA Streams <60.8ºF, Class A Streams <64.4ºF) and water temperature criteria set by the *Wenatchee and Okanogan Forest Plans* (<61ºF and 7 day average max temperature <58ºF), focus mainly on summer maximum water temperatures. However, several temperature monitoring sites remain in the water year around to determine winter rearing conditions which can be more limiting than summer increases in stream temperatures within some streams. WA state temperature standards for streams and rivers on the Okanogan-Wenatchee are designed to provide appropriate stream temperature for fish species, particularly salmonids. Significant water temperature data have been collected within streams and rivers on the Okanogan-Wenatchee National Forest. The temperature monitoring period typically encompasses expected low flows and the highest water temperatures (June to September). Temperature exceedences typically occur in the lower mainstem rivers during mid- to late summer when low flows, high air temperatures, and high insolation rates coincide. They are usually of short to moderate duration and diurnal in nature. USFS thermograph data indicate that exceedances of the water temperature standard within the majority of lower mainstem rivers most frequently occur from July to September. Factors such as topography, geology, groundwater storage landforms, riparian conditions, and orientation of the drainages with respect to the surrounding landscape are most likely very influential in maintaining water temperatures in streams and rivers. However, management activities that reduce riparian vegetation and stream shade (roads, timber harvest, grazing) can have an effect on stream temperature.

Major Forest Plan Amendments (1994 & 1995):

The Okanogan and Wenatchee Forest plans were amended by additional watershed and aquatics direction by the Northwest Forest Plan (1994), the Interim Strategy for Managing Anadromous Fish producing Watersheds in Eastern Oregon and Washington, Idaho, and portions of California (PACFISH 1994) and the Inland Native Fish Strategy (INFISH 1995). These amendments provided direction that was intended to restore and maintain the ecological health of watersheds and aquatic ecosystems on National Forest lands. These amendments included additional road management guidance specific to watershed and aquatics, riparian areas and key watersheds. These amendments did not set specific numbers for road density components, but rather provided guidance on minimizing effects of roads on the watershed mainly through goals, objectives and standards and guidelines.

Northwest Forest Plan – Aquatic Conservation Strategy (ACS)

Direction within the ACS is based on nine Objectives that are focused on maintaining and restoring natural processes, water quality and healthy fish populations at a regional scale. The nine objectives include maintaining and restoring;

- the distribution, diversity and complexity of watershed features;
- spatial and temporal connectivity between watersheds;
- physical integrity of aquatic systems;

- water quality,
- sediment regimes,
- in-stream flows;
- floodplain inundation and water table elevation;
- species composition and structural diversity of plant communities;
- habitat to support populations of plant, invertebrate and vertebrate species.

PACFISH/INFISH

Direction within PACFISH/INFISH are based on eight Riparian Goals (similar to the nine ACS objectives) that also focus on maintaining and restoring healthy, functioning watersheds, riparian areas and associated fish habitats. PACFISH/INFISH also developed Riparian Management Objectives (RMO), that apply to all streams with anadromous fish (PACFISH) and native fishes (INFISH). RMO's are specific, measurable objectives for in-stream features that must be met or exceeded before habitat conditions are considered "good" for fish. RMO's are the same across the PACFISH/INFISH amendment area (eastern Oregon and Washington, Idaho and portions of California) and therefore may or may not have applicability to site-specific hydrologic and geomorphic conditions on the Okanogan-Wenatchee NF. RMO's include criteria for;

- pool frequency
- water temperature
- large woody debris
- bank stability
- lower bank angle
- width/depth ratio.

Key/Priority Watersheds

In addition to providing general watershed direction, these amendments also developed the concept of Key (NWFP-ACS and PACFISH) and Priority (INFISH) Watersheds. Key watersheds are systems of large refugia comprising watersheds that are crucial to at-risk fish species and stocks and provide high quality water. On the Okanogan-Wenatchee National forest, key/priority watersheds in the PACFISH/INFISH amendment areas were not designated. Key Watersheds were designated under the NWFP using hydrologic 5th code watershed boundaries developed by the USGS in 1994 (see map, below). Of the 4 million acres of lands within the Okanogan-Wenatchee NF, approximately 1,660,000 acres (43%) are designated as Key Watersheds. The following Standard and Guidelines apply to all Key Watersheds:

- Inside Roadless Areas - No new roads will be built in remaining un-roaded portions of inventoried (RARE II) roadless areas.
- Outside Roadless Areas - Reduce existing system and non-system road mileage. If funding is insufficient to implement reductions, there will be no net increase in the amount of roads in Key Watersheds.

Riparian Reserves/Riparian Habitat Conservation Areas (RHCA)

Riparian Reserve (NWFP-ACS) and Riparian Habitat Conservation Areas (PACFISH/INFISH) were designated under the plan amendments. These MA's are portions of watersheds where riparian-dependent resources receive primary emphasis and where special standards and guidelines apply. These MA's include portions of watersheds that are adjacent to streams, rivers, lakes, ponds, wetlands and other areas required for maintaining hydrologic, geomorphic and ecologic processes.   Riparian Reserve and RHCA Management Areas, overlay approximately 520,000 acres (13%) on the Okanogan-Wenatchee NF.

Standards and Guidelines

NWFP- ACS and PACFISH/INFISH included "Standards and Guidelines" for Riparian Reserves and RHCA's and did not differentiate between the two components. NWFP-ACS and PACFISH/INFISH include Standards and Guidelines for Riparian Reserves that constrain management activities in order to achieve the nine ACS Objectives, Riparian Goals and RMO's and ensure protection of physical and biological resources. Standards and Guidelines address the following management activities:

- Timber Management
- Roads Management
- Livestock Grazing Management
- Recreation Management
- Mineral Management
- Fire and Fuels Management
- Lands
- General Riparian Area Management
- Watershed and Habitat Restoration
- Fisheries and Wildlife Restoration

Aquatic and Riparian Effectiveness Monitoring (AREMP) for the NWFP:

Aquatic and Riparian Effectiveness Monitoring Program (AREMP) is used to assess the effectiveness of the NWFP-Aquatic Conservation Strategy (ACS) in maintaining or restoring the structure and function of riparian and aquatic ecosystems and watershed condition. The AREMP randomly selected 250 watersheds across the NWFP area to determine status and trend of in-channel processes as well as watershed function. Of these 250 watersheds, 14 are located within the Okanogan-Wenatchee NF. Based on the 15 year AREMP Summary of Key Findings, the majority of watersheds had a positive change in condition scores across the NWFP amendment area. Status scores for the Okanogan-Wenatchee, however, were low outside of wilderness areas and trend scores on the Okanogan-Wenatchee NF varied from small increases to moderate decreases in watershed condition scores outside of wilderness areas.

PACFISH/INFISH Biological Opinion Monitoring (PIBO):

PACFISH/INFISH Biological Opinion Monitoring (PIBO) is used to assess the effectiveness of the PACFISH/INFISH aquatic strategies in maintaining or restoring the structure and function of riparian and aquatic ecosystems and watershed condition. The PIBO monitoring program randomly selected streams within the PACFISH/INFISH amendment area to determine status and trend of in-channel and riparian processes and the effect that FS management has on those processes. Minimally managed (low road densities, no grazing or timber harvest in the past 30 yrs) stream reaches across the PIBO amendment area were selected as "reference sites" to represent properly functioning condition.   Managed stream reaches are then compared to the reference sites to determine their status. Seven in-channel habitat attributes; residual pool depth, percent pools, D50, fines in pool tails, wood frequency, bank angle and aquatic macroinvertebrate community, are surveyed at each site. These individual attributes are analyzed individually and are also combined into a total index score which is then compared to scores from reference stream reaches to show the status of the stream reach. PIBO also analyzes stream data to determine if habitat trends within streams with repeat surveys, were improving, that is moving in a direction considered to be favorable habitat for salmonids. For the trend analysis the attributes bank stability and percent undercut bank were added. There are 25 “managed” monitoring sites on the Okanogan-Wenatchee NF, 2 of which are surveyed every year and 23 sites that are surveyed on a 5 year rotation. All surveyed streams are located in the eastern portion of the Methow Subbasin and within the Okanogan subbasin. The status of the total index score for sampled streams on the Okanogan-Wenatchee NF were significantly lower than observed in reference streams within the eco-region and within the PIBO monitoring area. The following attributes; bank angle, percent fines in pools, percent pools, residual pool depth and D50 indicators were all significantly lower (poor quality) than observed in reference streams. The macroinvertebrate scores were also significantly lower (poor quality) than reference streams. Trend of in-channel habitat within the sites monitored in the Okanogan-Wenatchee NF show that the macroinvetebrate community, bank stability, percent undercut bank, D50 and residual pool depth were moving in a slightly positive direction, although not statistically significant. Bank angle and percent fines in pools showed a slight negative trend, although not statistically significant. The only attributes with a statistically significant positive increase in trend were LWD and percent pools.

Upper Columbia Spring Chinook and Steelhead Recovery Plan (2007) and Yakima Steelhead Recovery Plan (2009):

The Upper Columbia Spring Chinook and Steelhead Recovery Plan also includes Bull trout, has determined that; the Entiat, Wenatchee and Methow Spring Chinook populations are currently not viable with respect to abundance and productivity and have a greater than 25% chance of extinction in 100 years; the Okanogan Spring Chinook population is extinct; the Entiat, Wenatchee, Methow and Okanogan Steelhead populations are currently not viable with respect to abundance and productivity and have a greater than 25% chance of extinction in 100 years; the USFWS has not developed guidance for estimating risk of extinction for bull trout. The Yakima Steelhead Recovery Plan (YBFWB 2009) has determined that; the Upper Yakima and Naches Steelhead populations are currently not viable with respect to abundance and productivity and have a greater than 25% chance of extinction in 100 years.

Recovery actions identified in the Upper Columbia Recovery Plan of which the US Forest Service would be a key partner include:

- Address passage barriers by removing, replacing or fixing artificial barriers (culverts and diversions)
- Reduce sediment recruitment by improving road maintenance
- Reduce the abundance and distribution of brook trout
- Increase habitat diversity, reconnect floodplain and wetlands, restore riparian habitat, increase LWD Impassable

Recovery actions identified in the Yakima Recovery Plan of which the US Forest Service would be a key partner include:

- Maintain, upgrade, relocate or abandon forest roads
- Replace culverts
- Improve habitat, restore side channels and floodplains, place LWD
- Reduce dispersed recreation impacts
- Restore tributary headwater meadows
- Address forest health issues

Aquatic Ecological Condition Model (2008; 2013)

The Aquatic Ecological Condition model was developed during Forest Plan Revision to evaluate the U.S. Forest Service ability to provide habitat that will maintain viable populations of aquatic focal species on the Okanogan-Wenatchee National Forest. Although the Forest Service primarily manages habitat, pursuant to 36 CFR 219.19 (1982 planning rule), National Forests are required to manage habitat in order "*to maintain viable populations of existing native and desired non-native vertebrate species in the planning area*". A viable population is defined as "*one which has the estimated numbers and distribution of reproductive individuals to insure its continued existence is well distributed in the planning area*". Therefore, the AEC model evaluated focal species population conditions and habitat conditions as an indicator of overall functioning of ecological systems and viability.

The habitat condition component of the HUC 6 AEC model (see figure 1, below) was designed to assess the degree to which Forest Service management activities may have interrupted or altered ecological conditions and aquatic habitat necessary to the viability of aquatic species. Aquatic and riparian resources, water quality and species viability are dependent on the protection of naturally occurring processes. Processes such as, wildfire, flooding, natural flow regimes and retention of riparian vegetation (provides shade, moderates stream temperatures, provides recruitment of downed trees, etc.) are essential to the proper functioning of the stream channel and habitat that provides viability for aquatic species.

For the Okanogan-Wenatchee National Forest, the primary driver impairing watershed and aquatic ecosystem function is the extensive road system. Chronic hydrologic alteration resulting from the road system and periodic storm events that interact with the road network serve to further degrade floodplains, stream channels, water quality and aquatic habitat. Other land management activities can also impair watershed and aquatic function, however most of these management activities are also dependent on roads such as; mining, timber harvest, vegetation management, fire suppression, grazing, recreation, etc. There are approximately 7,700 miles of roads on the Okanogan-Wenatchee National Forest which range from maintenance level 1-5. The 7,700 miles of road both directly and indirectly interact with 11,800 miles of perennial and intermittent streams causing a degree of undesired impacts to streams and aquatic habitat. In addition, the forest does not receive the funding to properly maintain this road system. Therefore, the Habitat Condition attributes of the AEC model focus on the effects of the road network on aquatic habitat and species viability. The habitat condition was evaluated using data on road density, roads located within the riparian area, road interactions within sensitive soil near streams and rivers, and road stream crossings. These habitat attributes serve as indicators for aquatic habitat conditions supporting focal species populations.

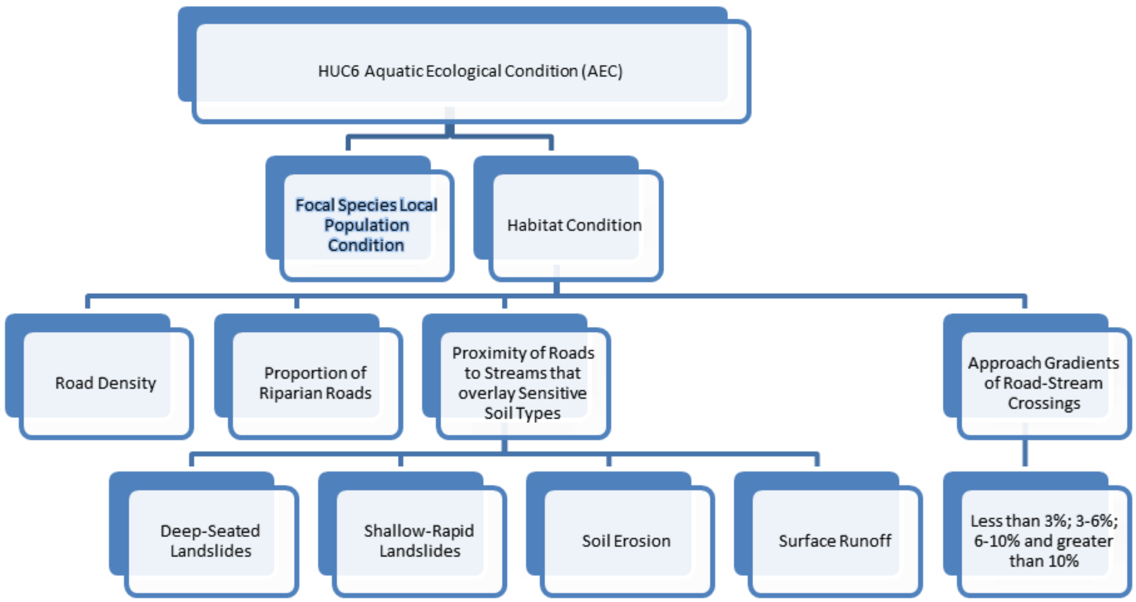


Figure 1. Habitat Condition Component of the Aquatic Ecological Condition Model (2013)

Watershed Analysis (NWFP 1994) and Watershed Condition Framework (2011):

Watershed analysis was a requirement of the NWFP-ACS prior to land management activities and normally performed at the 5th code watershed scale. Watershed Analysis provided insight into the current status of soils, streams, wetlands, riparian ecology and aquatic species. Recommendations were made to improve one or more of these conditions whose desired function had been disrupted by land management actions. The common theme across recommendations was the need to address long standing legacy effects from the extensive road network and connected management activities. For the Okanogan-Wenatchee National Forest, watershed analysis was conducted for the majority of 5th code watersheds in the early to mid-1990's. Watershed Analyses have not been updated since the original documents were completed and most likely will not be updated in the future as funding is no longer available.

In 2010, National Forests throughout the U.S. were mandated to implement the new Watershed Condition Framework (WCF) process, which is a rapid evaluation process that is similar in intent to that of Watershed Analysis. WCF uses an interdisciplinary approach to characterize the health and condition of sub-watersheds (HUC6) on NFS lands. Watershed condition is determined based on the health of hydrologic and soil function in the watershed indicated by physical (water quality, soil productivity, erosion, etc.) and biological characteristics (populations and conditions of desired fisheries and/or invasive species). The goal of WCF is to identify current conditions for each 6th hydraulic code sub-watershed and use that broad scale assessment to further identify priority watersheds where focused management over a 5-10 year period could change constituent elements that impair watershed function and improve watershed condition. The result of the watershed assessment portion of WCF demonstrated that distribution of the current extensive road network across the OWNF is the primary driver impairing watershed and aquatic ecosystem function and desired conditions.

The Need for a Whole Watershed Restoration Approach

The objective for watershed protection and management of Forest Service system lands (FSM 2520.2) is "to protect National Forest System watersheds by implementing practices designed to maintain or improve watershed condition, which is the foundation for sustaining ecosystems and the production of renewable natural resources, values and benefits".

In order to assess the current watershed condition on NFS lands, National Forests throughout the U.S. were mandated to implement the Watershed Condition Framework (WCF 2010). The Watershed Condition Framework (USFS 2011) defines watershed condition as "the state of the physical and biological characteristics and processes within a watershed that affect the soil and hydrologic functions supporting aquatic ecosystems". Watersheds that are functioning properly are resilient and recover rapidly from disturbances, have a high degree of connectivity along the stream, across the floodplain and valley bottom and between surface and subsurface flows, provide high quality and quantity of water, provide intact riparian communities, maintain long-term soil productivity and provide habitat that supports native animal and plant species.

Step A of the WCF used the following 12 National Watershed Condition Indicators (and constituent attributes) to identify and classify the current conditions for each 6th hydraulic unit code (HUC) sub-watersheds (see Figure 2, below):

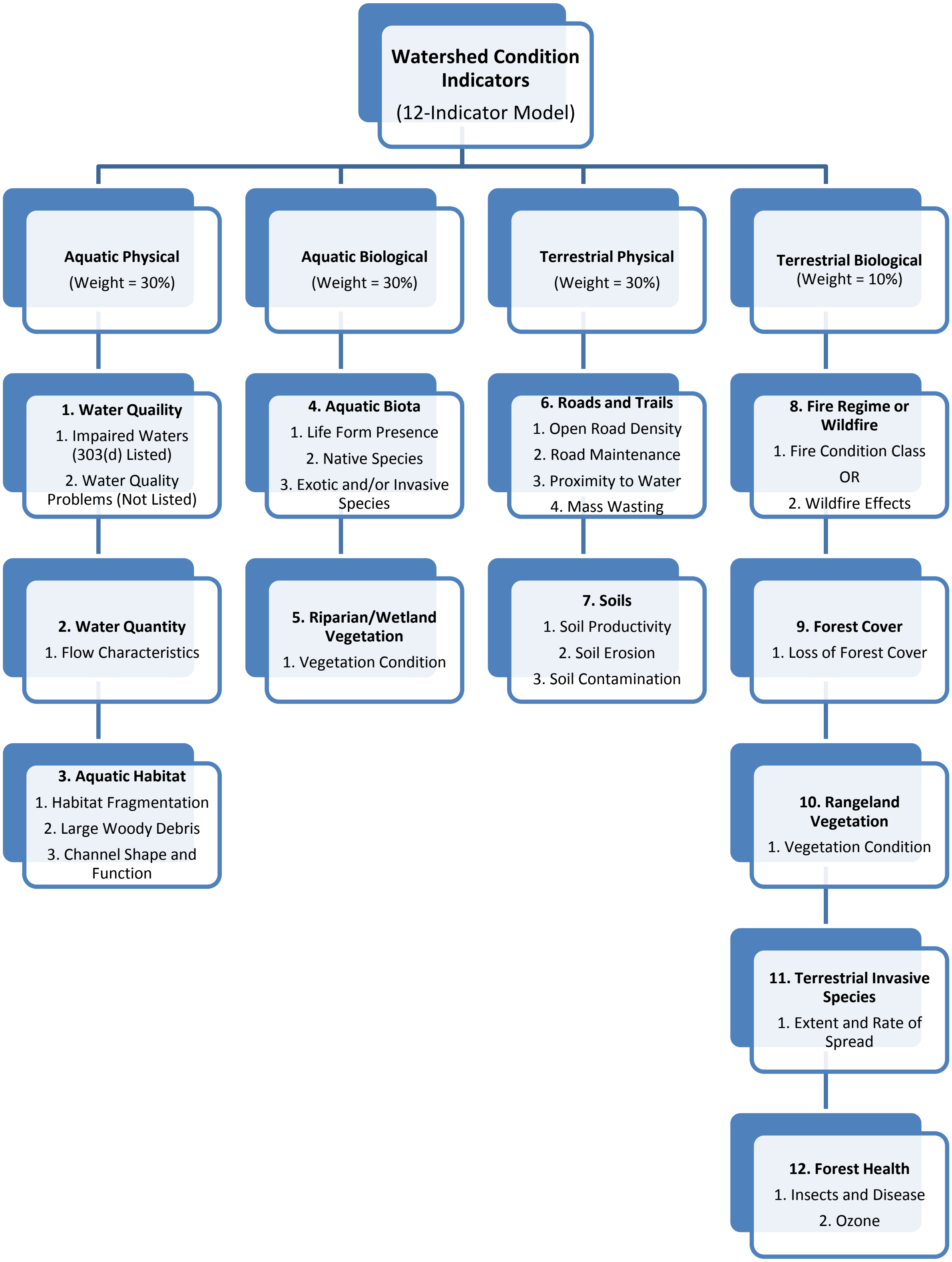


Figure 2. Core national watershed condition indicators and attributes (WCF 2011)

On the Okanogan-Wenatchee National Forest, 250 sub-watersheds were analyzed during the assessment phase of the Watershed Condition Framework, with 113 sub-watersheds (45%) ranked as “functioning properly”; 124 sub-watersheds (50%) ranked as “functioning at risk” and 13 sub-watersheds (5%) ranked as having “impaired function”.

The majority of the sub-watersheds (66%) that were determined to be “functioning properly” were partially or entirely located within designated Wilderness and/or Inventoried Roadless Areas, whereas only 20% of the sub-watersheds that were “functioning at risk” and 8% of the “impaired functioning” sub-watersheds were located within Wilderness and/or Inventoried Roadless Areas.

The result of Step A of WCF demonstrated that the distribution of the current extensive road network across the OWNF is the primary driver impairing watershed and aquatic ecosystem function and desired conditions. Road location and density within valley bottoms, floodplains, where they have become part of active channels and they’re occurrence on active or dormant landslides are generally the common denominators influencing factors of watershed condition. There are over 7,700 miles of Forest Service System Roads, Maintenance Level’s 1-5 (the level of service provided by, and maintenance required for, a specific road [FSH 7709.59, sec. 62.3]) on the OWNF in addition to many more miles of authorized and un-authorized private roads that cross NFS lands.

Broad scale cursory metrics indicating undesired road-stream interactions can include road length to stream length, number of stream crossings per mile, percentage of roads intersecting sensitive Land Type Associations, etc. For instance, the ratio of road length (approximately 7,700 miles of Forest System Road and an estimated 1,500 miles of unauthorized roads) to stream length (approximately 11,800 miles of intermittent and perennial streams in non-Wilderness and Roadless Areas) within active management areas across the forest is 0.8 indicating potentially high degrees of undesired road-stream intersection and drainage network interaction. In other words, there are 0.8 miles of road for every 1 mile of stream. In addition, the percentage of roads intersecting sensitive Land Type Association units (high degree for erosion and hillslope failure) is 60%.

Step B and C of the WCF requires National Forests to use the condition assessment (step A) to identify priority sub-watersheds for restoration and to develop Watershed Restoration Action Plans (WRAP) that would identify essential restoration projects that would be implemented over a 5-10 year period. Essential restoration projects are intended to improve watershed condition class (moving impaired and functioning at risk sub-watersheds towards properly functioning) and to move the landscape to a condition that will become more resilient to changing climates and disturbances and restores ecological processes, patterns, and functions. Therefore, on the Okanogan-Wenatchee NF, essential restoration projects developed in WRAP’s for priority sub-watersheds, focus on the road network and the impacts to watershed and aquatic conditions.

In addition, over the last 5-7 years a suite of OWNF National Environmental Policy Act (NEPA) and ESA Section 7 project specific analyses have demonstrated undesired cumulative effects from the road network on watershed and aquatic resources. This is especially the case where such analyses display high levels of degraded and impaired resources in existing or baseline conditions. Project planning that does not proactively address such conditions in NEPA purpose and need statements and project design poses additional risk to watershed and aquatic resource function and ultimately may further expose water quality and fisheries populations to undesired effects.

Over the last 5 decades scientists have moved to address critical questions regarding road and road related land management actions (logging practices, trails, etc.) effects on hill slope processes, streams, wetlands and interrelated changes to aquatic ecosystem function. With declining road maintenance funding, the risk of chronic road failures and elevated sediment delivery is increasing, particularly in the event of large storms. Periodic high intensity storm and associated flood events common to east-Cascade Range hydrology has resulted in a number of large-scale road-stream interactions resulting in continual and chronic degradation of floodplains, stream channels, water quality, and aquatic habitat. Other drivers impairing watershed and aquatic ecosystem function include the reduced distribution of native and TES fish species (due to reduction in population size, decreased genetic connectivity, increased distribution of non-native species and man-made habitat barriers) and legacy stream channel impacts.

Watershed Key Concepts and Definitions

Watershed Health

Watershed health or integrity can be viewed as a relative measure of the deviation from some "natural" or un-disturbed condition (EPA 2011). The Forest Service Manual defines watershed condition and healthy (Class 1) watersheds as those that exhibit high geomorphic, hydrologic and biotic integrity relative to their natural potential condition (FSM 2521.1). The Watershed Condition Framework (USFS 2011) defines watershed condition as "the state of the physical and biological characteristics and processes within a watershed that affect the soil and hydrologic functions supporting aquatic ecosystems".

The *Land-type Associations of North Central Washington* survey (Davis et al. 2004) used soils, geology, vegetation, and landform mapping to delineate land-types within the Okanogan-Wenatchee National Forest. Each land-type was assigned interpretive ratings for various attributes, such as erosion hazard. In 1997, the Okanogan-Wenatchee and Colville National Forests collectively began a Landscape-level, Land-type Association (LTA) survey to facilitate the needs of Forest Plan revision. To meet these needs, a detailed landscape survey over a tri-forest area (Okanogan, Wenatchee and Colville) was conducted (Davis, et. al 2004), which followed guidance provided by the National Hierarchical Framework of Ecological Units (USDA Forest Service 1993) for ecological surveys. This direction established a consistent approach to ecosystem mapping and evaluation by providing a mapping and classification system that stratified the forest into "progressively smaller areas of increasingly uniform ecological potential" (USDA Forest Service 1993). Land-type Associations are defined by: general topography, geomorphic process, surficial geology, soil, potential natural vegetation, and local climate. Collectively, these features are factors that control or strongly influence biotic distribution, hydrologic function, and ecological functions including natural disturbance regimes and further influenced by the presence of roads (Swanson et al 1988).

Undeveloped, undisturbed watersheds with limited land management most closely fit the definition of a Class 1 healthy watershed as they are the least deviated from their natural condition. Disruption of larger watershed processes directly and indirectly affects the stability of streams and rivers, which ultimately affects the viability of fish species (OWNF Viability Analysis 2013). Natural stream channel stability is the ability of a stream or river to maintain its dimension, pattern and profile over time and neither aggrade (excessive sediment deposition) or degrade (scouring) despite being an active channel (Rosgen 1996).

Effectively managing for healthy watersheds also involves the ability to predict watershed response mechanisms to imposed change. This can be accomplished by using a set of predictor variables to evaluate a degree of change or indicators of watershed adjustment. These indicators or measures can further inform practitioners spatially of where such change has led to varying degrees of natural process impairment and potentially localized degradation.

Ecologically Based Watershed Restoration

In restoration, ecological damage to the resource is repaired and natural processes are allowed to occur. Both the structure and the function of the ecosystem are recreated (EPA 1995, EPA 2011, USFS 2012). The goal of restoration is to emulate a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs.

Restoration is an integral part of broad, watershed-based approach for achieving water resource goals. Specifically, watershed restoration is the re-establishment of chemical, physical, and biological components of an aquatic ecosystem that have been compromised by stressors such as point or nonpoint sources of pollution, habitat degradation, hydro-modification, and others (EPA 1995). Activities range from preservation and protection (e.g., the designation and protection of biologically diverse areas as Outstanding National Resource Waters under 40 CFR 131.12[a][3]) to intense repair/recovery efforts (e.g., highly disturbed areas such as Superfund sites and waters or sediments contaminated with PCBs).

Watershed restoration approaches need to consider all sources of stress on watersheds, aquatic and riparian systems and therefore should not be restricted to in-stream mitigation of impacts. The health and protection of a stream or river cannot be separated from the larger interconnected watershed ecosystem, and restoration must address all watershed processes that degrade an ecological system, e.g., sediment loading from road cuts or development or increased polluted runoff from impervious areas (EPA 1995). A narrow "in-channel" view of a river or stream does not capture the actual complexity and diversity of aquatic ecosystems. Many scientific studies and reports have documented that aquatic systems are closely coupled with and created by the characteristics of the watersheds including; processes that connect the longitudinal (upstream-downstream), lateral (riparian, floodplains, upland), and vertical (hyporheic or groundwater zone-stream channel) dimensions of the aquatic system (EPA 1995; National Research Council 1992; Doppelt et al. 1993; Caldwell 1991; Cairns 1991).

Conceptually, the median point between degradation or impairment and restoration is improvement. Watershed-wide or site specific social and political constraints can highly influence or control the amount of ecosystem benefit, which active management may yield. Therefore, situations can exist where achieving pre-disturbance conditions is either not acceptable and/or not possible.

Impairment

Impairment of watershed function is caused by disturbances that lead to physical (e.g., increase in water energy release component into a stream causing geometric channel adjustment), chemical (e.g., introduction of sediments or pollutants at concentrations harmful to organisms), and/or biological (e.g., introduction of non-native aquatic vertebrate, invertebrate or pathogenic species) functional alterations of "natural" conditions (EPA 2002).

Watershed, aquatic and riparian resources, water quality and native fish species are dependent on the protection of naturally occurring processes. Water and sediment is naturally delivered to stream channels via a complex system of overland flow, groundwater and varying degrees of recharge zones in the form of springs, seeps and other wetland types. The amount and timing of water delivery to stream channels varies by seasonal precipitation phases interacting with local geology and soils. To some degree the presence of vegetative ecological communities is an expression of soil type, elevation and surface and ground water regimes, which can be further influenced by various stochastic events such as wildfire, floods or large-scale hill slope failure (Swanson 1979; Swanson et al 1998; Davis et al. 2004; Chase et al 2012). Vegetation influences stream flow by intercepting precipitation and transpiring water (Bosch and Hewlett 1982). The natural state of sediment availability and quantity in streams is a by-product of the energy associated with flow interacting with hill slope, overland surface and channel erosion processes. Processes such as, floods, wildfire, natural sediment delivery to streams, natural flow regimes and retention of riparian vegetation (provides shade, moderates stream temperatures, provides recruitment of downed trees, etc.) are essential to the proper functioning conditions of watersheds, stream channel and aquatic habitat. Forest Service management activities that interrupt, alter or exacerbate these processes can lead to impaired ecological conditions.

An indicator of large-scale impairment can be found in the results of the 2013 Draft Viability Model. For instance, the model displayed results for roads within 300 feet of the stream network that intersected Land-type Associations with a high surface runoff potential and intersection with streams with occupied TES fish species. High surface runoff is defined as site features with: steep slope gradients (45%+); less than 30 percent vegetation cover; shallow regolith; exposed bedrock exceeds 25 percent of the area; high drainage density of confined or entrenched first order streams; area is exposed to frequent rain on snow events or high intensity summer storms. This degree of overlap causes concerns in multiple ways, however two examples include: 1) a decadal scale of exposure to cumulative effects all or in-part exacerbated from the road network directly on focal fish species (i.e. ESA federally listed species) and 2) chronic impacts on aquatic habitat function indirectly leading to disruption of aquatic biological life history mechanisms.

Road density is also often used as a broad scale indicator of the intensity of a suite of anthropogenic disturbances in a sub-watershed (logging, grazing, mining, etc.), not just those due directly to effects of the roads themselves (Haskins and Mayhood 1997, Hitt and Frissell 2000, Baxter et al. 1999). Multiple scientific studies have used road densities and road-stream crossings as a proxy for land use intensity and watershed condition (Haskins and Mayhood 1997, Baxter et al. 1999, Roth et al. 1996), and have shown that high road density indicates high probability for aquatic habitat to exhibit degraded conditions. In contrast, Hitt and Frissel (2000) analyzed aquatic bio-integrity in sub-watersheds located in Wilderness and Roadless Areas compared to sub-watersheds with active land management use (timber harvest, roads, grazing, etc) and showed that bio-integrity was disproportionately higher in Wilderness and roadless areas.

As stated previously in this document, the results of multiple watershed assessments indicate that the extensive road network across the OWNF is the primary driver impairing watershed and aquatic ecosystem function and is the primary habitat impairment to aquatic species viability (WCF, AEC Viability, ARMP, PIBO). In the 2009 and 2011 floods on the OWNF, multiple negative stream-road interaction sites were observed, which included the following impact types:

- Channel evulsion into roads that directly dissect active floodplains.
- Flow, sediment and debris over-topping undersized road crossings with associated road prism failure.
- Large-scale hill slope failure intercepting down valley road prisms.
- Drainage ditch failure with accelerated surface road erosion.

Recovery actions identified in the Upper Columbia River and Yakima River Recovery Plans for listed spring chinook, steelhead and bull trout of which the US Forest Service would be a key partner include, addressing passage barriers by removing, replacing or fixing artificial barriers (culverts and diversions), reducing sediment recruitment by improving road maintenance and maintaining, upgrading, relocating or obliterating forest roads. The consequence of not addressing such road related factors include loss of functional aquatic habitat (i.e. spawning and rearing habitat) and a decrease of inter-tributary production (i.e. migration corridors and inter-connectivity between populations).

The Whole Watershed approach to aquatic restoration, focuses mostly on impairment caused by the road network as it relates to watershed and aquatic resources across physical, chemical and biological components as described below:

Physical: Watershed Processes

Road density is used as a "coarse filter" indicator of road effects on hydrologic pathways, which can result in high connectivity between the roads and the channel network (Wemple 1994, Luce and Wemple 2001, Wemple and Jones

2003). Concerns for high road densities within a given watershed include: the potential for interception of subsurface flow where roads cross shallow soils, shallow water tables, and seasonally wet areas, decrease soil infiltration capabilities, increasing localized runoff due to efficient flow pathways and compacted surfaces, and changes to stream channel geomorphology (incision and/or aggradation) due to increased energy yields in flow, increased sediment delivery, and amount of associated debris. The magnitude of the road-hydrology interaction within a watershed also depends on many factors such as; location, design and maintenance of the road, watershed characteristics, adjacent soil and stream conditions and storm characteristics.

Forest roads can affect the timing and magnitude of runoff by increasing the extent and efficiency of the drainage network and redistributing the water through the road network. Potential effects can range from localized sites (plugged culverts, localized landslides, etc.) to broad watershed scale effects, such as drainage density increases and gullying. Roads influence hydrologic and geomorphic processes of a forested ecosystem through a variety of ways (Pechenick et al .2014; Dymond 2010; Luce and Wemple 2001; Lane 1955), including:

1) *Interception of Subsurface Flow*: Where shallow water tables are cut by a road prism, subsurface flow can be captured by the road network and efficiently channeled to the larger watershed drainage network. Roads have the potential to increase peak flow by collecting overland flow within ditches along cutbanks or sometimes within the road prism itself, then carrying the water directly to streams, to road crossings or concentrate water flow downhill which carves gullies into the hillslope (Jones et al. 2000).

2) *Decreased Infiltration and Excess Runoff*: Compacted road surfaces decrease the infiltration capacity of the soil and the excess water becomes runoff. Roads represent relatively impervious surfaces that generate overland flow and efficiently route it to stream and rivers (Pechenick et al. 2014).

3) *Overland Flow*: Road and drainage systems intercept overland flow and re-routes it from the hillslope through the road network. The more drainage density is increased the more efficient watersheds will drain themselves. Dymond (2010) found potential alterations to average streamflow discharge (i.e. increases in local stream flows) and water yield regimes in a forested watershed were correlated to high road densities ($\geq$ 4.3 km/km²/> 2.7 mi/mi²). Segments of the road network can act as extensions of the native stream system, thus increasing the drainage density of watersheds, which may alter peak flow events (Wemple et al 1996; Jones and Grant 1996).

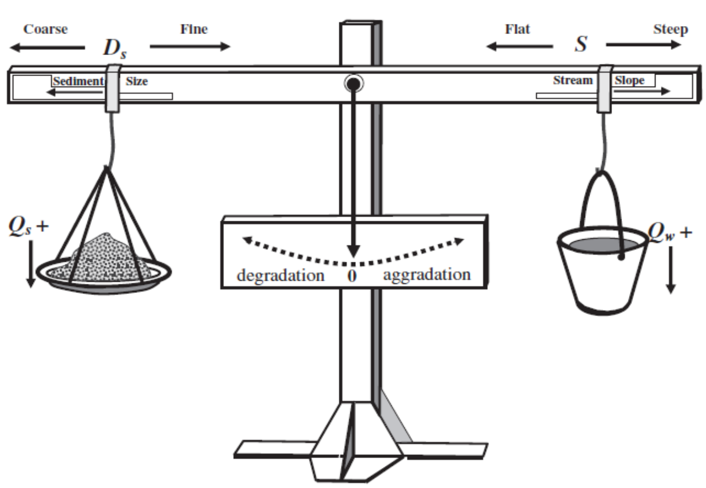


Fig. 1. Depiction of the original Lane's relation as a balance (after Prof. Whitney Borland, Colorado State University, unpublished).

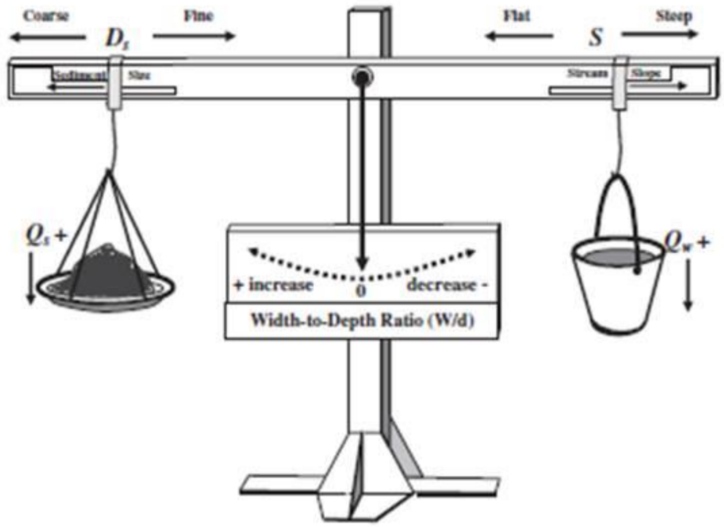


Fig. 9. Graphical depiction of the expanded Lane's relation, where potential adjustment to the width-to-depth ratio is reflected by the pointer and scale in the center of the balance.

Figure 3. Lane's flow and sediment balance and influences on stream condition (Lane 1955)

In addition to affecting the routing of water, roads can affect the routing of sediment to streams resulting in localized accelerated erosion of stream channels, aggradation of channels, and sediment delivery from road prisms (Wemple et al. 2012). Figure 3 demonstrates Lane's (1995) early view of this concept, which conceptualizes the effects to stream channels when water and sediment are either kept in balance with the natural system, unnaturally increased or decreased (all or in combination to one another). Such affects can lead to undesired vertical and lateral adjustment resulting in floodplain disconnection or accelerated lateral migration of the channel due to increases in sediment supply and stream energies. Altered flow paths lead to diversion or extension of channels onto un-channeled portions of the landscape and result in further efficient drainage of watersheds. Large scale impacts from high road densities on watersheds includes, increased flows after rain events and decreased base flows during natural low-flow conditions. Increasing flow concentrations from roads may lead to undesired responses in hydrologic and geomorphic regimes. Trails, particularly OHV trails, share many road attributes, such as decreased vegetative cover, increased compaction, increased runoff, and are a source of accelerated erosion. Vegetation management impacts are transient (re-vegetation), however ML 1-5 roads are permanent on the landscape. Foltz et al. (2009) studied the impacts of re-opening roads that have been brushed in and no longer have traffic on them (i.e. decommissioned and ML 1 roads) on infiltration and erosion. The study showed significantly higher sediment concentrations from the reopened road than from the roads that remained brushed in. The level of traffic also played a role in increased erosion. The study indicated that many decades of non-use are required for a road to approach the erosion rates of an undisturbed forest and that even after 30 years of non-use "brushed in/closed roads" were still closer to the erosion rates associated with a skid trail than with a pristine hill side.

The location of forest roads, especially hillslope position, can alter stream channel morphology, intercept groundwater and re-route sub-surface water into streams which can result in channel enlargement, down-cutting and stream bank erosion (Cook and Dresser 2007, Jones et.al. 2004). Roads adjacent to streams (within the riparian area) can constrain lateral mobility of the channel, disconnect rivers from their floodplain, reduce large wood recruitment into the stream channel and under some conditions can function as sediment traps. Roads within the riparian area are more likely to directly transport water and sediment to stream channels. Roads on or near ridges have limited interaction with streams, except where they cross small, headwater streams. Roads on steep upper and mid slopes, often cross streams perpendicular to the channel and therefore, road-stream crossings can have a larger impact in these areas. Valley bottom roads are typically in close proximity and parallel to the stream network and can act as corridors for flow on the road or along road cuts and ditches, which can pose a risk of shallow landslide initiation as well as extend the channel network through new channelized flow paths (Pechenick 2014, Jones et al. 2004).

Road- stream crossings (culverts, fords, bridges, etc.), provide a direct connection between road and stream networks. Stream crossings can intercept and alter geomorphic processes related to flood events, such as debris flows (Wemple et al. 2001). The majority of sediment is delivered to streams at road crossings (Shaw and Thompson 1986, Case et al. 1994, Clarke and Scruton 1997), which make crossings a potentially useful and easily-measured predictor of sediment delivery to watercourses (Haskins and Mayhood 1997, Case et al. 1994 and Eaglin and Hubert 1993).

Chemical: Water Quality

Roads can alter natural hydrologic and geomorphic regimes in any given watershed and can have significant impact on water quality and aquatic ecosystems. The dominant chemical effect of road networks on watershed, stream and riparian systems involve alteration of routing of water and runoff characteristics of watersheds, water-born chemicals, acceleration of erosion and sediment loading, and mass land movement to and through native stream networks (Cook and Dresser 2007; Swanson et al 2000; Wemple et al. 2001).

Sediment

Sediment is one of the most common causes of water quality impairment for streams and rivers in the U.S. (http://oaspub.epa.gov/waters/national_rept.control#TOP_ IMP). The majority of Forest Service roads are unpaved, natural surfaced roads which have been shown to be a dominant source of surface erosion and sediment delivery in many forested landscapes (Coe 2006). One study conducted in the Sierra Nevada in California show that sediment production rates from forest roads were twice as high as those of other land uses such as; timber harvest, off-road vehicle use, prescribed fire and wildfire (Coe 2006). Coe (2006) found that sediment production rates from native surfaced roads were 12-25 times greater than rocked roads and sediment production from recently graded native surface roads were two times greater than ungraded native surface roads. The amount of sediment production from forest roads was predicted using the road area multiplied by the slope of the road segment, the erosivity of the road surface, the amount of grading and road maintenance (outsloping vs. insloping, relief culverts, drain dips, etc), the amount of use and annual amount and type of precipitation (Coe 2006).

Road- stream crossings (culverts, fords, bridges, etc.), provide a direct connection between road and stream networks. Roads are by far the greatest source of sediment to streams in developed forest watersheds (Haskins and Mayhood 1997). This sediment is delivered to streams mainly at stream crossings (Shaw and Thompson 1986, Case et al. 1994, Clarke and Scruton 1997), making stream crossings a potentially useful and easily-measured predictor of sediment delivery to watercourses (Haskins and Mayhood 1997).

Temperature

Water temperature is a key component of fish habitat and aquatic ecology. Cold water fish species such as trout and salmon are particularly sensitive to very high and very low temperatures. Water temperature criteria set by the State

(Class AA Streams <60.8ºF, Class A Streams <64.4ºF) and water temperature criteria set by the *Wenatchee and Okanogan Forest Plans* (<61ºF and 7 day average max temperature <58ºF), focus mainly on summer maximum water temperatures and are designed to provide appropriate stream temperature for fish species, particularly salmonids. Stream temperatures can increase when riparian vegetation is removed, effectively reducing shade cover, causing channel widening, and ultimately exposing the stream channel to direct insolation (Torgersen et al. 1999). Studies have demonstrated that land management activities such as; timber harvest, roads, grazing, recreation, mining, etc., which remove riparian vegetation along tributaries or increase channel width to depth ratios can lead to increased water temperatures (Torgersen et al. 1999, Hewlett and Fortson 1982, Barton et al. 1985, Beschta and Taylor 1988, Holtby 1988).

Pollutants

Maintenance and use of roads and runoff from roads potentially contribute several classes of chemicals to the environment including; heavy metals, salt, increased water and sediment and hydrocarbons from vehicle exhaust (Trombulak and Frissell 1999). Heavy metals and salts can be derived from gasoline, engine oil, de-icing salts, any chemical dust abatement practices that are utilized, etc. Contamination from heavy metals and salts decreases the greater the distance from the road, however studies indicate that the range can begin at 20 meters (60 ft.) and extend to over 200 meters (660 ft.). Therefore, roads within the riparian area, close to stream channels have a greater potential to transport chemical contaminants to streams and rivers (Trombulak and Frissell 1999).

Biological: Aquatic and Riparian Species

There are 37 native fish species located throughout streams and rivers on the OWNF, along with 6 introduced or non-native fish species (see Appendix C for a list of species). Of the 37 native fish species that occur on the OWNF, 4 species are listed as federally threatened, endangered, proposed, and/or candidate species under the Endangered Species Act (ESA 1973), 2 additional species are protected under the Magnuson-Stevens Fishery Conservation Act (MSA), 3 species are listed under the Regional Foresters Sensitive Species List (as updated on December 9, 2011) and 6 species on the Okanogan and 6 on the Wenatchee are designated as Management Indicator Species (MIS). Aquatic habitats on the OWNF provide spawning, rearing, refugia and migration for most of these species. However, high road densities in addition to other land management practices have altered the function of aquatic habitat and limited where aquatic species reside and effectively fulfill their life histories.

The distribution and behavior of fish species is influenced by the quality and quantity of available habitat for expression of key life history traits, such as migration corridors and spawning and rearing habitat. Fisheries studies and recovery plans tend to focus on spawning and rearing habitats which allows the identification of potential limiting factors for species survival. Though rearing areas and migratory corridors are important, without access to suitable spawning and rearing habitat, the species will not survive. Studies of quality, connectivity and distribution of habitat patches for aquatic species often use spawning and rearing as the defining characteristic for use (Rieman and McIntyre 1995, Burnett et al. 2007, Peterson et al. 2013). Quality spawning and rearing habitat is a potential limiting factor that affects fish populations in any specific area (Baxter et al. 1999). Stream habitats that are selected for spawning are often influenced by stream gradient, substrate composition, stream temperature, in-stream flow, channel stability (width to depth ratio), pool density and cover (Baxter et al. 1999, Torgersen et al. 1999).

Water temperature is a key component of fish habitat and aquatic ecology. Factors such as topography, geology, groundwater storage landforms, riparian conditions, and orientation of the drainages with respect to the surrounding landscape are influential in maintaining water temperatures in streams and rivers. However, management activities that reduce riparian vegetation and stream shade (roads, timber harvest, grazing, mining, etc) can have direct and indirect effects on stream temperature. Salmonids are particularly influenced by increased stream temperature and have been shown to move to cooler areas, such as seeps, confluences with colder streams, groundwater recharge zones, etc. when stream temperatures exceed their upper tolerances. Bull trout are especially highly influenced by areas of high ground water – surface water exchange which provide upwelling of cold water. Studies have shown that redd densities increase in these areas of ground water upwelling (Baxter et al. 1999). High stream temperatures increase the energy that salmonids expend to migrate and hold in streams prior to and during spawning. This can directly affect their reproductive success as well as increase susceptibility to infection and disease (Torgersen et al 1999).

Studies have also shown that bull trout redd densities are negatively correlated with road density and number of road-stream crossings (Baxter et al. 1999), i.e. the number of redds decrease as the road density and/or number of road-stream crossings of a sub-watershed increases and vice versa.

Responses of salmonid populations to changes in their freshwater environment brought about by land-management activities are similar in many respects. Increases in fine sediment, nutrient loading, removal of riparian vegetation all potentially have the same biological effect in streams whether they results from mining, streambank erosion in grazed pasture lands, or road construction and clear-cut logging (Lloyd et al. 1987). The severity of the effect differs depending on the source and concentration.

Elevated fine sediment delivery to streams can detrimentally alter aquatic stream habitat (e.g., from roads, clear cuts, grazing, fire) and can adversely affect salmonid spawning and rearing success. Negative effects of excessive sedimentation on egg-to-fry survival of salmonids are well-documented in the scientific literature and include; suffocation and metabolic-waste-poisoning of eggs; decreased egg survival to emergence; and increased fry mortality due to entrapment and suffocation. Accelerated sedimentation rates can lead to channel widening and loss of important pool habitat. Elevated fine sediment can also reduce microorganism primary production, aquatic insect diversity and productivity, and overall biomass and organic content in streams. Water temperature influences timing of migration and spawning, egg maturation, growth, incubation success, intra- and inter-specific competitive ability, and a resistance to parasites, diseases, and pollutants. Increased stream temperatures relate to reductions in salmonid abundance and changes in their spatial distribution. Removal of vegetation that shades streams and wetlands contributes to increased stream temperatures and impair fish habitat and viability. Habitat barriers caused by undersized or perched culverts, dams, irrigation diversions, etc. that restrict threatened, endangered and sensitive fish species from accessing potential spawning and rearing habitat.

Identification and Prioritization of Sub-watersheds

Step A of WCF resulted in assigning Upper and Lower Little Naches River, Upper Peshastin Creek, Tillicum Creek, and Eight Mile Creek as priority watersheds. And for every fish, watershed and legacy road and trail dollar allocated the expectation is that the OWNF focus its management on completing essential projects identified in Priority Watershed Restoration Action Plans. However, the need to also conduct landscape scale vegetation management and a Forest desire to make watershed and aquatic restoration more proactive as a part of such management increases the need for an integrated approach to identifying where the greatest needs for restoration are. Therefore, a procedure was developed to answer the question, what are the highest needs for watershed and aquatic restoration on the OWNF?

The following evaluation factors were used to rank and sort priority groupings across all 6-code watersheds on the OWNF (see Appendix B for excel spreadsheet with Watershed Ranking Scores and map below).

- **Watershed Condition Framework** - Final Scores from the 2011 WCF assessment procedure (WCATT). Preference is given to sub-watersheds that are functioning at risk or have impaired function.
- **% USFS Ownership** - preference is given to sub-watersheds with larger contiguous land area within NFS ownership
- **% Wilderness and Inventoried Roadless Areas** – The majority of HUC6's with large sections of Wilderness and/or IRA were found to be properly functioning in WCF and would not require active restoration, but rather continued protection. Preference was given to HUC6 outside of Wilderness and IRA.
- **Road Density** – Preference was given to HUC6 with high (>2.4 mi/sq mi) and moderate (1-2.4 mi/sq mi) road density.
- **Road Density within 300 ft. of Streams** – Preference is given to HUC6 with high and moderate Riparian Road Densities
- **Key Watershed** – Preference was given to HUC6 that were identified during Forest Plan Revision as being Key Watersheds (*a network of watersheds selected to serve as strongholds for important aquatic resources or having the potential to do so. They are areas crucial to threatened or endangered fish and aquatic species of concern and/or interest, and/or areas that provide high quality water important for maintenance of downstream populations*)
- **TES Fish Species Occupancy** – Preference was given to HUC6 that support multiple T&E Fish species
- **AEC Viability Model Habitat Condition Scores** – Preference was given to HUC6 that had "function at risk" and "not properly functioning" scores in the Habitat Condition componenet of the AEC Viability Model.
- **Recovery Plan Focus** - Upper Columbia River Biological Strategy and Mid-Columbia Steelhead Recovery Plan. Preference given to HUC6 where recovery planning places emphasis on alleviating infrastructure caused threats to species.
- Input from District Fisheries Biologists, Hydrologists and Soils personnel was also included when during construction of this prioritization scheme.

Table 2. Evaluation criteria and data source.

METRIC	SCORING CRITERIA	DATA SOURCE
WCF Rating	green = -1 yellow = 1 red = 2	Final watershed condition scores from 2011 WCF assessment procedure (WCATT).
% Forest Ownership	<25% = -2 26-50% = -1 50-75% = 0 >75% = 1	Oka-Wen NF ownership GIS data set
Road Density	<1 mi/mi sq = -1 1-2 mi/mi sq = 1 >2-3 mi/mi sq = 2 >3mi/mi sq = 3	Oka-Wen NF GIS data set (system road network and current USGS HUC layer)
Road Density within 300 ft of Streams	<1 mi/sq mi = 0 1-2 mi/sq mi = 1 >2 mi/sq mi = 3	Oka-Wen NF GIS data set (system road network and LLID stream layer)
Key Watershed	yes = 1 no = 0	Oka-Wen NF GIS data set (proposed network used in Forest Plan Revision)

T&E Fish Species Occupancy	Yes (3 UCR Spp) = 3 Yes (2 MCR Spp) = 3 Yes (2 UCR Spp) = 2 Yes (1 MCR Spp) = 2 Yes (1 UCR Spp) = 1 No = 0	Oka-Wen NF GIS data set (fish distribution database)
Habitat AEC Score	green = -1 yellow = 1 red = 2	Oka-Wen NF GIS data set (species viability model)
Recovery Plan Focus	yes = 1 no = 0	Upper Columbia River Biological Strategy and Mid-Columbia Steelhead Recovery Plan.
Wilderness Land Allocation	< 50% Wilderness = 0 > 50% Wilderness = -1	Oka-Wen NF ownership GIS data set

Table 3. Priority Sub-watershed Grouping based on ranking criteria

Priority Grouping	Scoring Range	Number of Sub-Watersheds
Group 1: These watersheds have the highest degree of watershed impairment from the road network, which threaten T&E species in the greatest ways (habitat and life history). Highest priority for focused restoration.	10 to 15	46
Group 2: These watersheds have a high to moderate degree of watershed impairment from the road network, which threaten T&E species (habitat and life history). High priority for focused restoration.	7 to 9	42
Group 3: These watersheds have a low to moderated degree of watershed impairment from the road network. Watersheds have a low – moderate degree of importance for T&E fishes. Low - Moderate priority for focused restoration.	4 to 6	50
Group 4: These watersheds have a very low to low degree of watershed impairment from the road network. Watersheds have a very low – low degree of importance for T&E fishes. Low to no priority for focused restoration.	-5 to 3	112
Okanogan-Wenatchee SubWatersheds	**TOTAL**	**250**

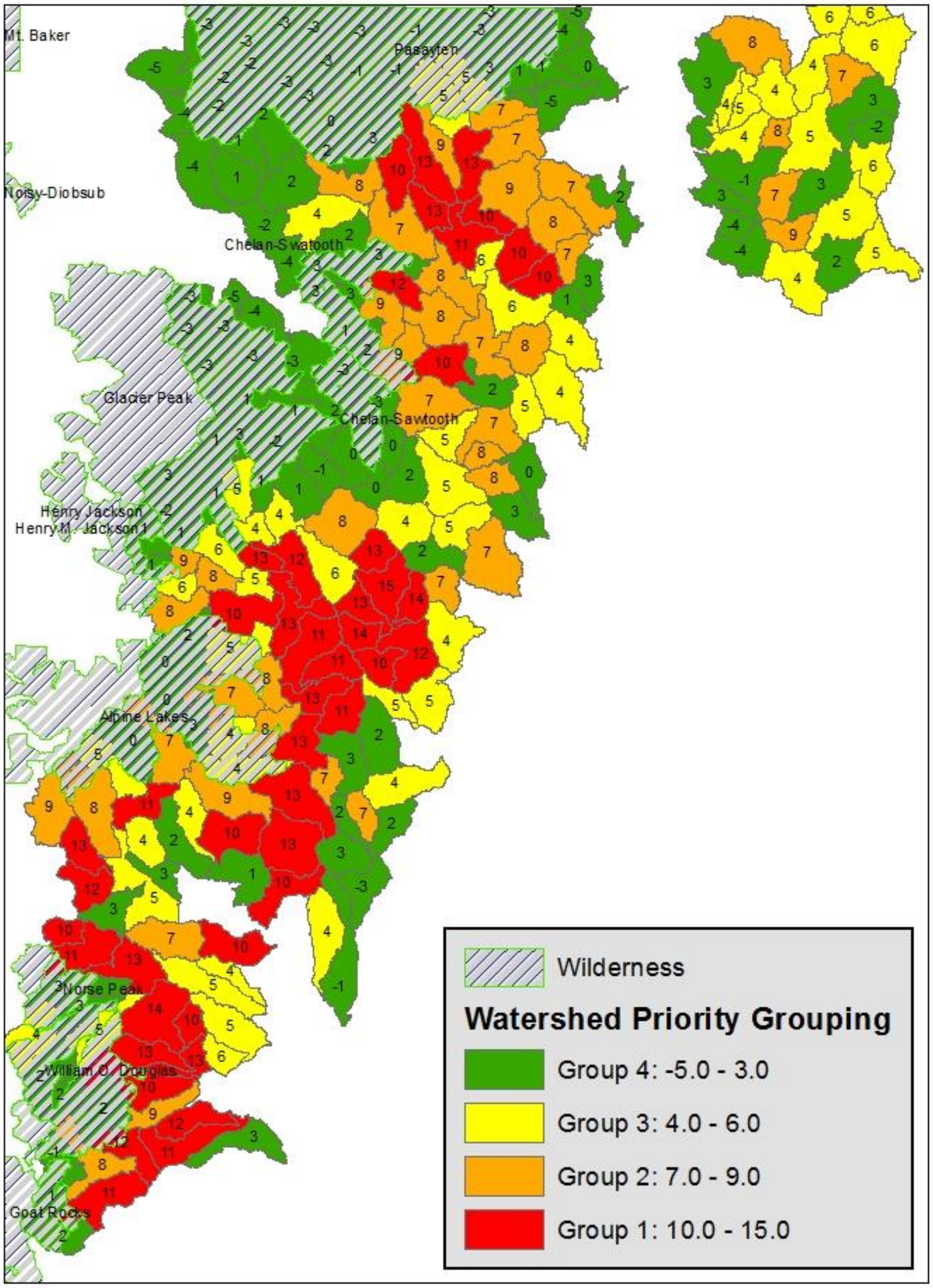


Figure 4. Distribution of watershed and aquatic restoration prioritization scores

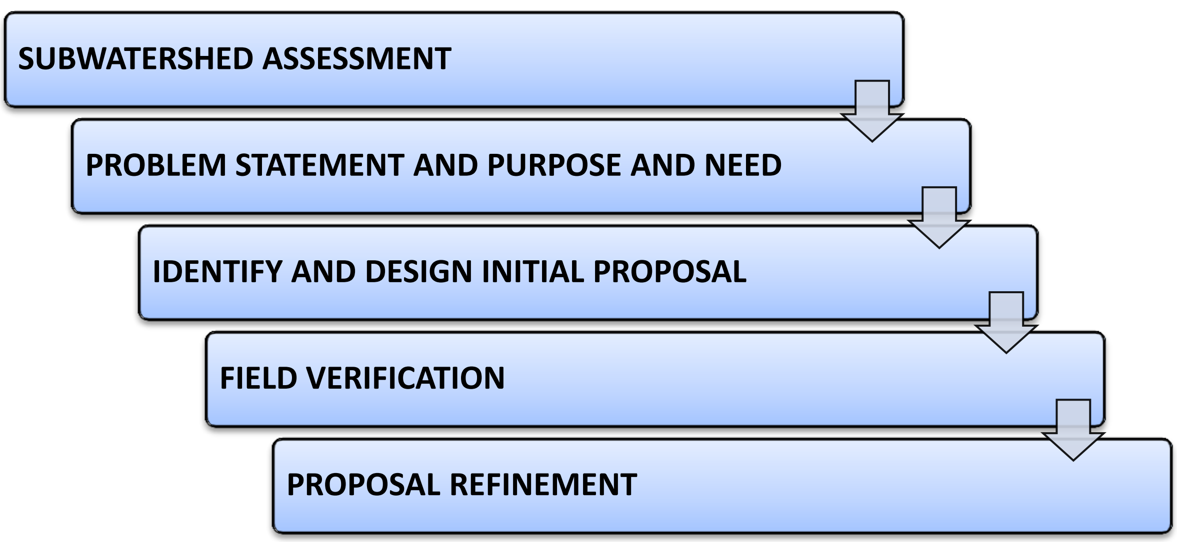
Input from Ranger District fisheries and hydrology staff was conducted in order to help validate the results of watershed restoration groupings and to validate the appropriateness of its management applications. The results of the watershed and aquatic prioritization scheme can then be integrated into a larger Forest decision support analysis that incorporates other terrestrial ecological components as well other social and political issues.

Procedures for Whole Watershed Restoration Planning and Project Design

The following procedures incorporates geomorphic and ecological principles found in existing watershed and aquatic resource restoration planning mechanisms and principles designed to be applied at varying spatial scales (i.e. Robinson et al. 2010, Beechie et al. 2008 , Rosgen 2006, Luce et al. 2001 and Ecosystem Analysis at the Watershed Scale: Federal Guide for Watershed Analysis 1996). The procedures have been tailored to focus on the degree of impact or impairment roads pose to watershed and aquatic resources and formulating restoration proposals, which should be designed to completely or substantially alleviate such impairment.

It's critical that Hydrologists and Fisheries Biologists (also termed Watershed Practitioners) work together when implementing these restoration planning and project design procedures as they are broken into 3 functional impairment assessment categories: hydro-geomorphic, water quality and biological condition. When brought together the results of functional assessments provide the basis for a) demonstrating the degree of restoration need, b) guide where in a watershed restoration is needed and for what reasons, c) give indication as to what restoration methods should be considered and d) provide a "look back" as to how effectively a proposal truly addresses critical elements in the projects purpose and need. Functional assessments, identifying elements of purpose and need and designing a restoration proposal are comprised of a set of procedures, which are conceptually displayed in Figure 4.

Figure 5. Conceptual Framework for Whole Watershed Restoration Project Planning and Design



A sequential list of all technical procedures from the sub-watershed assessment to proposal refinement can be found in Appendix F.

1. Sub-Watershed (HUC6) Assessment: Identify Degree of Road Related Impairment

The sub-watershed assessment is a process performed at the sub-watershed scale (HUC 6) and incorporates an analysis of metrics tied to assess disruption of physical watershed functional processes and subsequent impacts on water quality, aquatic habitat and fish populations.

Sub-watersheds or 6th field hydrologic unit codes (HUC6) are relatively large areas of land ranging from 10,000 to 40,000 acres. This assessment is conducted at the sub-watershed and catchment scales to more effectively account for the varying levels of cumulative effects that roads can create on watershed function and aquatic ecosystems.

Watershed Practitioners compare a suite of causal mechanism metrics (the intensity and position of the existing road network) to indicators of biological and water quality conditions. Both sets of metrics are designed to initially predict where indicator variables throughout a sub-watershed express a negative relationship to causal mechanisms. The results of this analysis are intended to display the degree of need for restoration specifically targeting the road system, as well as steer the eye of the Watershed Practitioner to sectors of the sub-watershed where treatment potentially needs to occur. Table 4 displays the causal mechanism and indicator analysis metrics.

Table 4. Causal Mechanisms, Indicator Metrics and Technical Rational

Metric and Catchment Ranking Criteria	Causal Mechanism	Indicator	Rational	Data/GIS Tool Source
Percent increase in drainage area from roads Low = <10% Med = 10-30% High = >30%	X		Displays the predicted degree of road caused artificial increase in drainage networks leading to an undesired increase in efficiency of watershed drainage patterns.	HUC 6 layer Catchment layer Road Layer NHD Stream Layer Road-Drain Model DEM Layer
Percent of roads within riparian areas Low = <10% Med = 10-30% High = > 30%	X		Displays the number of roads within 300 feet of the mapped stream network predicting undesired degrees of surface flow interruption and efficiency of water flow energy delivery to stream networks.	HUC 6 Layer Catchment Layer Road Layer NHD Stream Layer
Percent of roads within mapped floodplains Low = <10% Med = 10-20% High = >20%	X		Displays the ratio of road length to stream length in mapped floodplains.	HUC 6 Layer Catchment Layer Road Layer Floodplain Layer
No. of road crossings per stream mile Low = 0-1 Med = 1-3 High = >3	X		Displays the ratio of road length to stream length in mapped floodplains.	HUC 6 Layer Catchment Layer Road Layer NHD Stream Layer Road-Stream Crossing Layer
Miles of current focal fish species known distribution		X	Displays the location of fish distribution and its physical relationship to road related impacts that effect aquatic habitat (i.e. receiving effects produced from upper watershed sectors).	HUC 6 Layer LLID Stream Layer Oka-Wen Fish Distribution Layer
Location of designated critical habitat		X	Overlays designated critical habitat and compares undesired proximity and magnitude of the causal mechanism outputs to it (i.e. receiving effects from upper	HUC 6 Layer LLID Stream Layer Critical Habitat Layers for; Bull trout, Upper and Middle Columbia

			watershed sectors).	Steelhead and Upper Columbia Spring Chinook
Miles of potential focal fish species habitat		X	Predicts potential habitat (stream gradients less than or equal to 10% for Bull Trout and Steelhead and 4% for Spring Chinook) and compares undesired proximity and magnitude of the causal mechanism outputs to it.	HUC 6 Layer NHD Stream Layer Oka-Wen Fish Distribution Layer Oka-Wen Habitat Barrier Layer Oka-Wen Stream Gradient Layer
Miles of unstable stream banks		X	Displays field derived measurement and locations of unstable stream banks and compares undesired proximity and magnitude of the causal mechanism outputs to them.	HUC 6 Layer NHD Stream Layer NRIS AqS Unstable Stream Bank
Field measured width/depth ratio to predicted (from Rosgen 1996)		X	Displays field derived measurement of width/depth ratio and compares undesired proximity and magnitude of the causal mechanism outputs to them.	HUC 6 Layer NHD Stream Layer NRIS AqS Width to Depth Ratio Layer
Field measured entrenchment ratio to predicted (from Rosgen 1996)		X	Displays field derived measurement of entrenchment ratio and compares undesired proximity and magnitude of the causal mechanism outputs to them.	HUC 6 Layer NHD Stream Layer NRIS AqS Entrenchment Ratio Layer

Delineating the Sub-watershed into Catchments

Land management activities which have caused impairment are not always distributed evenly across a given HUC6. Therefore, it's necessary to divide a HUC6 into smaller catchments in order to focus the analysis on areas within the HUC6 that have the highest degree of impairment. The following provides Watershed Practitioners procedures for delineating catchments:

ArcHydro is an ArcMap product that can be downloaded and run on Arcmap 10.0 or newer. Run ArcHydro Tools on the subwatershed(s) that need to be broken into smaller catchments. The desired size range of catchments is 300-1500 acres. Size is dependent on the value selected in the "Enter stream threshold to initiate a stream" box in the stream definition tool. For instance, for a 15,000 acre subwatershed a value of approximately 0.8 m^2 (2 km^2) can be used to generate 13 catchments. Using this example the Watershed Practitioner may further need to lump small catchments (< 300 acres) in order to better consolidate the analysis. Make sure that the input layers have a projected coordinate system instead of a geographic coordinate system. In Archydro Tools perform the following steps:

a. From the Terrain Preprocessing, DEM Manipulation menus, choose DEM Reconditioning.

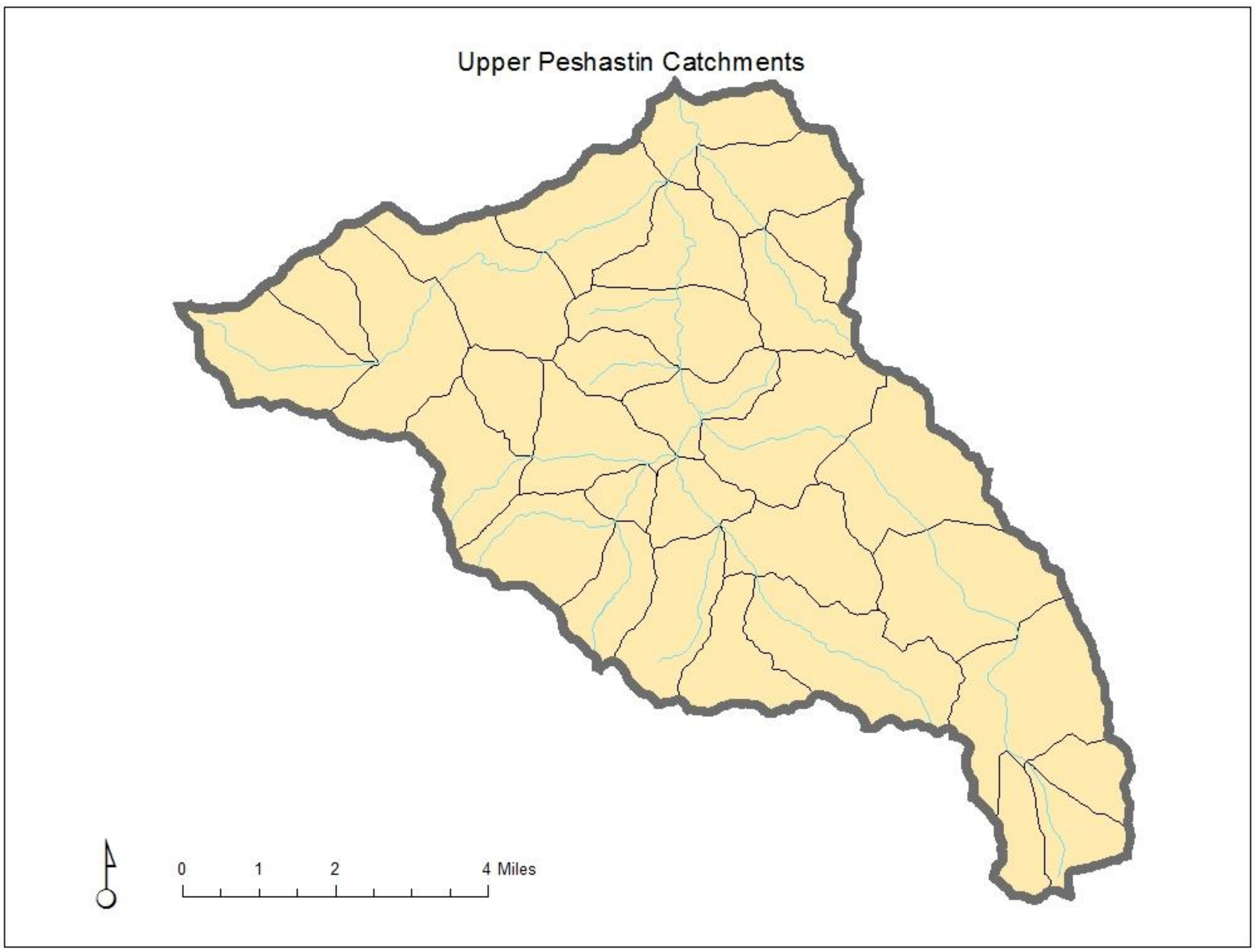
b. Next run Flow Direction (Terrain Preprocessing). If the flow direction values extend beyond "132" then you have sinks in your DEM and you will need to go back to the DEM Manipulation menu and run Fill Sinks. Then run Flow Direction again.

c. Run Flow Accumulation and then Stream Definition. The value you enter in the "Enter stream threshold to initiate a stream" will affect how many catchments are delineated. A smaller value in general will produce more catchments. However if there are long stream sections with only 1st order tributaries then these areas may not be subdivided into smaller catchments despite choosing a small stream threshold value and you may need to subdivide these by hand.

d. Run Stream Segmentation and Catchment Grid Delineation and finally Catchment Polygon Processing. The process may produce many 1 pixel catchments (100 m^2 area if you are using a 10 m dem). You can eliminate them by selecting them and choosing Eliminate (Data Management, Generalization) in ArcToolbox.

e. Large catchments may need to be subdivided by hand using the Cut Polygons Tool in the Editor toolbar. Having a contour layer turned on will help generate topographically appropriate catchments.

Figure 6. Example of completed catchment delineation for the Upper Peshastin Restoration Project



Hydro-geomorphic Functional Impairment Assessment

Once catchments have been delineated, the Watershed Practitioners will then perform an initial GIS-based analysis that separately scores each catchment. It's important to note the procedural descriptions below will be incorporated into an all-encompassing model that will have capability of running all metric outputs simultaneously.

The following provides Watershed Practitioners procedures for conducting the GIS level hydro-geomorphic functional assessment:

Percent Potential Increase in Drainage Area from Roads:

Assumptions:

- During runoff generating precipitation and melt off events, water that drains off of a road that is within 300 ft. of the stream network, has a high potential of creating artificial channels and other conduits that provide efficient flow and sediment delivery to streams.

- The more that drainage networks increase as a result of roads, the more efficient a watershed will drain itself.

- Flow accumulation values determined using GIS analysis, represent a "potential" drainage amount. Storm proofing and drainage features, which are typically installed during road construction (such as cross-drains, waterbars, or drivable dips), can't be spatially represented using GIS analysis tools. In reality these drainage features do exist to some degree, and are intended to move surface water away from road prisms. Therefore, the flow accumulation values represent a "potential" drainage amount, however the existence of drainage features and the degree to which they effective will need to be field verified.

Steps:

1. Create a road elevation raster

    a. Use the "interpolate shape" tool (in Arc Tool Box select: "3d analyst", then "functional surface") to estimate the elevation of each 3.3 feet (1 m) segment along the road. Elevation values to .003 feet (.001 m) are then generated.
    b. Use the "feature vertices to point" tool (Data management, features) to take elevation values every 3.3 feet (1 m), which will converts the output to points spaced at 3.3 feet (1 m) intervals.
    c. Use the "point to raster" tool (in Arc Tool Box select: "Conversion", then "to raster") to create an actual road elevation raster. In the value field drop box select "shape.z", which contain the elevation values.

2. Drop elevation of road crossing 33 feet (10 m) so that road drainage is forced into stream at crossing. This isn't required, but it prevents the situation where very large flow accumulation numbers can build up due to a road dropping smoothly in elevation thru a stream crossing. None of the flow is shown as draining into the crossing.
    a. Take the stream crossing points and create a 3.3 feet (1 m) buffer, and then clip the road elevation raster by this buffer (in Arc Tool Box select: "Data Management", "raster", then "raster processing").

b. Use the "Raster Calculator" to subtract a value of 10 from road crossing grid value. (in Arc Tool Box select: "Clipped raster – 10").
c. Put the dropped elevation road crossing cells back in the road elevation raster. Navigate to the "Cell statistics" tool (in Arc Tool Box select: "Spatial Analyst", "Local"), then in the "Overlay statistic" box choose the "MIN" option. This combines the 2 rasters using the minimum value where raster cells overlap. In order to allow alignment of the output cells, under "Cell statistics" select "Environments", "processing extent". In the "Snap Raster" drop down menu select the road elevation raster that you created in Step 2 above.

3. Apply Flow Direction and Flow Accumulation tools to the road elevation raster (in Arc Toolbox select: "Spatial Analyst", "hydrology")

4. Identify/extract the drainage points from the Flow Accumulation raster.

    a. Use the "Focal Flow" tool (in Arc Toolbox select: "Spatial Analyst", "Neighborhood") apply the Flow accumulation raster. This identifies accumulated drainage points, which are recognized by grid code values equaling 0 (the remaining cells have values > 0).
    b. Use the "Set Null" tool (in Arc Toolbox select: "Spatial Analyst", "Conditional") to set all values. However, zero values will be unchanged and are the only outputs that represent drainage points (values = 0).
    c. Use the "Raster calculator" tool (in Arc Toolbox select: "Spatial analyst", "map algebra") to add the flow accumulation and drainage point rasters together. The result will be one raster with drainage points and their road drainage length values. This raster should be titled "Flowacc maxval".
    d. Use the "Raster to point" (in Arc Toolbox select: "Conversion", "From raster") to convert the raster to a point coverage layer, which should then be titled "Flowacc maxvalPts".

5. Now use usual and customary geo-processing tools to buffer your stream layer by 300 feet (91 m), intersect your facmaxvalPts by the 300 feet (91 m) stream buffer and the catchment polygons and then export the attribute table in Xtools to excel. Run a pivot table to summarize road accumulation values that are within 300 feet (91 m) of the stream network by catchments. Similarly you want to intersect the stream and road layers by the catchment polygons and export the attribute table to excel to generate a pivot table of stream and road lengths within each catchment.

6. Use the "Multipart to singlepart" tool (in Arc Toolbox select: "Data Management", "features") to intersect the road and stream layers to get road crossings, which then become single part features (otherwise the road crossing count has potential to be inaccurate).

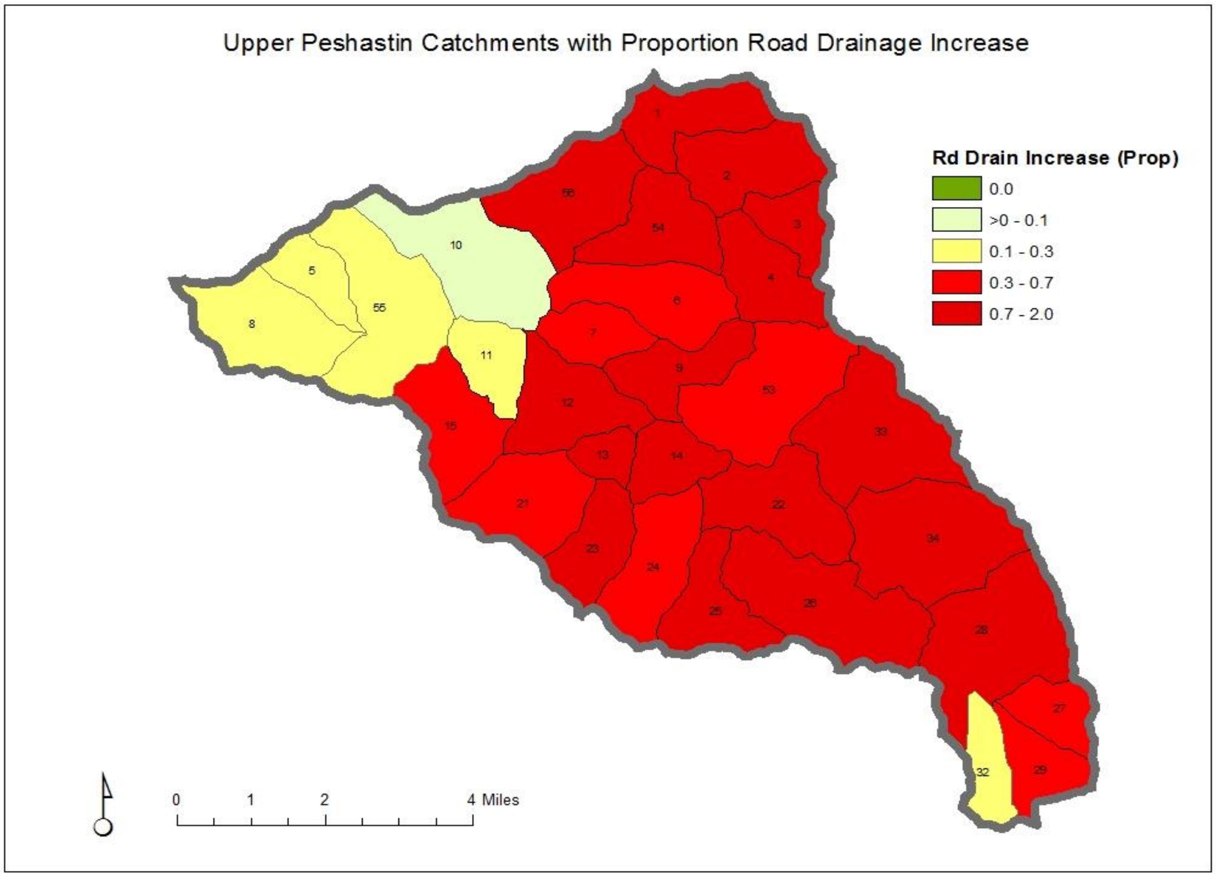


Figure 7. Example catchment ranking for the Upper Peshastin Restoration Project

Percent of Roads within Riparian Areas:

Assumptions and Rationale:

- Roads within 300 feet of the stream network have a high potential to alter natural riparian processes.

Steps:

Take the 300 ft stream buffer from step 5 above in the road drainage section and intersect it with your roads layer (and catchment layer). Export the resulting attribute table to excel using Xtools Pro and summarize with a pivot table. The parameter is expressed as the ratio of the length of roads within the 300 ft stream buffer to the length of streams within the catchment.

Percent of Roads Within Mapped Floodplains:

Assumptions and Rationale:

- Roads have a high potential to disconnect streams from floodplains and further disrupt channel migration and aquatic habitat functional processes

Steps:

Take the floodplain layer and intersect it with the stream and roads layer. This parameter is calculated as the ratio of total road length with floodplains within a catchment to the total stream length within those same floodplains within the catchment.

Number of Road Crossings per Stream Mile:

Assumptions and Rationale:

- Crossings have a high potential to disrupt stream flow and natural sediment transport processes.
- Crossings have the potential to impede aquatic organism passage.

Steps:

1. Intersect the road and stream layers to get a road crossing layer.
2. Use the "Multipart to singlepart" tool (in Arc Toolbox select: "Data Management", "features") on the road crossings, which then become single part features (otherwise the road crossing count has potential to be inaccurate). (In one sub-watershed the road crossing count changed from 106 to 140 after this step.)

Biological Condition Functional Impairment Assessment

The following provides Watershed Practitioners procedures for conducting the biological condition functional assessment:

1. Set up a data file: in your workspace folder for the project, for example: (T:\FS\NFS\OkanoganWenatchee\Project\WNR\PeshastinRestoration2011\GIS\Workspace\craekes), and create a file geodatabase to save work products to.
2. Set up project: Bring in HUC6 data layer, select HUC6 that is to be analyzed and save as layer file in your file geodatabase. All other data layers will be "clipped" to this layer (and saved in the geodatabase). The following are the layers that will be needed.

   They can be found in the following location;
   T:\FS\NFS\OkanoganWenatchee\Program\Fisheries\GIS\WholeWatershedRestorationSupport

   a. Stream LLID (NOTE: once the fish distribution and critical habitat layers are tied to the NHD layer, the NHD layer will be used for this analysis)
   b. OWNF Fish Distribution Line and Point layers
   c. Culvert Survey 2000
   d. Critical Habitat data layers (for all species that are present; Bull trout, Upper Columbia Spring Chinook, Upper Columbia and Middle Columbia Steelhead)
   e. Riparian Reserve/RHCA layer
   f. Habitat Barriers
   g. OWNF Stream gradient layers used for predicting Potential Habitat

3. Calculate the miles of Occupied Habitat within the HUC6
4. Calculate the miles of Critical Habitat within the HUC6
5. Calculate the miles of Potential Habitat within the HUC6

a. **Display the Stream Gradient Data**:

- For steelhead and bull trout - use 7% as the maximum gradient for estimating potential habitat. To display this in your project symbolize the table attribute MEAN_GRAD as a quantity and graduated colors, classify one category, with a range from 0.0001-0.07.00 and label it </= 7% gradient.
- Channel gradient may need to be adjusted and include stream gradients greater than 7% if local knowledge and/or fish distribution data indicates confirmed observations of fish use in those habitats.
- For spring Chinook - use 4% maximum gradient for estimating potential habitat.

b. **Identifying Blocked Potential Habitat using Potential Values**

- Intersect the Stream Gradient layer with the sub-watershed in question. Apply a Definition Query to the resulting layer to limit the analysis to records which meet the average gradient requirement for potential habitat:
  "MEAN_GRAD" </= 7% - Steelhead and Bull Trout.
  "MEAN_GRAD"</= 4% - Chinook.
- Plot the Culvert and Natural Barrier data layer for the sub-watershed.
- Add a "BarrierID" field to the analysis layer. This will be populated to track potential habitat segments upstream from a barrier.
- Split potential habitat segments where required at barriers.
- Select segments upstream from barriers and populate the "BarrierID" field with route number of the road or with the type of natural barrier.
- Add a "GIS_Miles" field and use the "Calculate Geometry" tool to populate the field with segment measures.
- This layer can now be added to a map document and symbolized off of the "BarrierID" field to show segments of Blocked Potential Habitat
- Additionally the "Summarize" tool can be run on the "BarrierID" field with the selection of "Sum" under "GIS_Miles" to tabulate the number of miles blocked by barrier.

c. **Identifying Unblocked Potential Habitat**

- Overlay the existing fish distribution layer for the species in question and symbolize so it is easily visible
- Add a field to the analysis layer called "UnblockedPH"
- By hand Select Stream Gradient layer Potential Habitat which is below barriers and unoccupied according to the species distribution layer
- Attribute the "UnblockedPH" field for the selected records with the name of the stream the segments are a part of or flow into. For Example, unnamed tributaries that flow into Scotty Creek are attributed as Scotty Creek etc.
- Hand select potential habitat segments which are upstream from natural barriers and attribute those records in the "UnblockedPH" field with the main stream name and a comment about its location. For example, Scotty Creek, above a natural barrier.
- This layer can now be added to a map document and symbolized with the "UnblockedPH" field to display unblocked Potential Habitat, including that which is above natural barriers.
- Here again the "Summarize" tool can be run on the "UnblockedPH" field to tabulate the mileage of unblocked Potential Habitat by Stream.

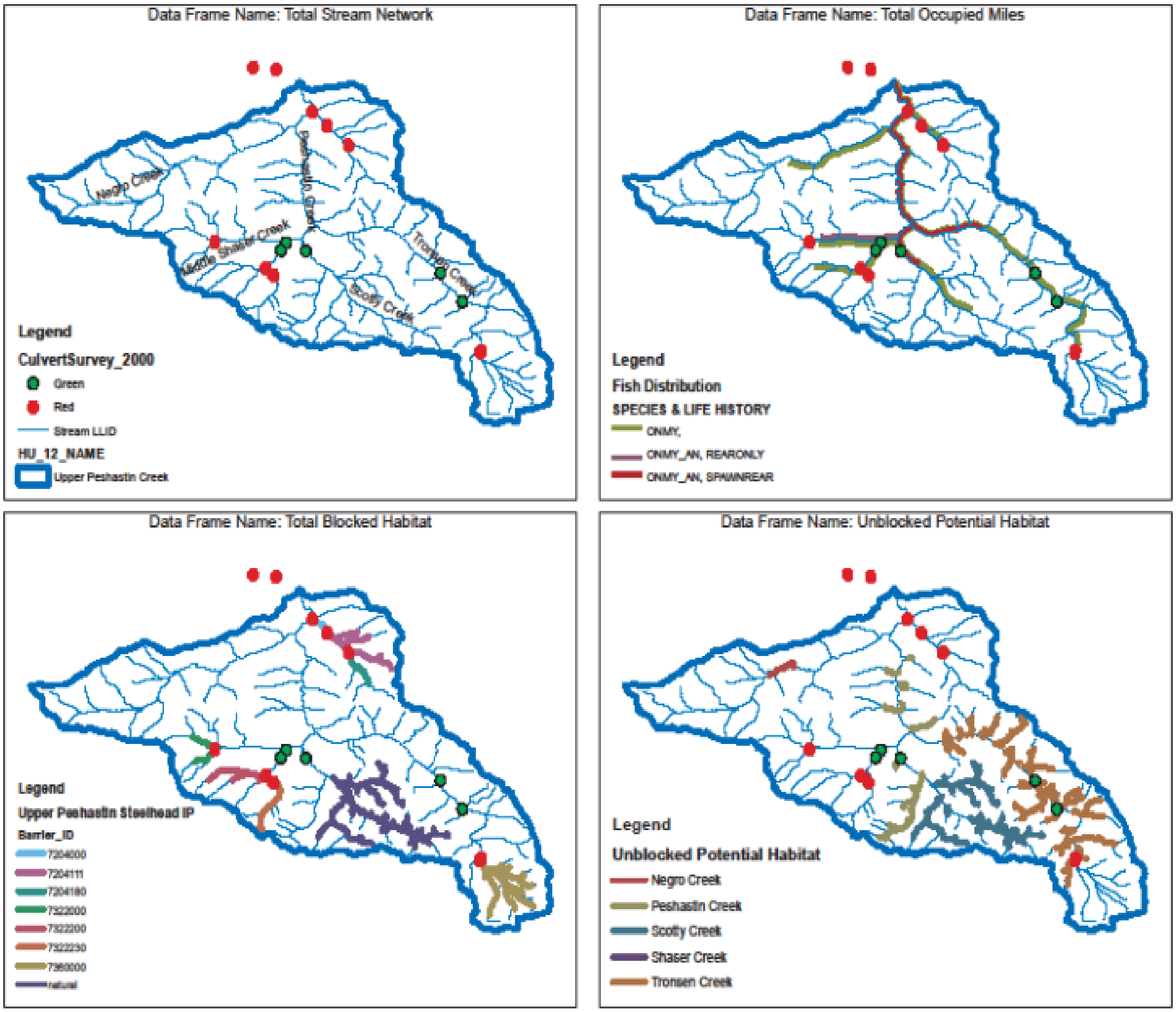


Figure 8. Example of a biological condition assessment for the Upper Peshastin Restoration Project

6. Habitat data from NRIS AqS. Run the HydroSumPart1RSW and HydroSumPart2RSW in your AqS Outputs Map (refer to http://fsweb.nris.fs.fed.us/products/AqS/ for instructions on how to query data). Data layer file should include; entrenchment ratio, Rosgen stream reach classification, average bankfull width to depth ratio (BFWD), substrate composition, bank instability, LWD, and habitat types. Save these layer files in your geodatabase and import into this analysis.
    - In ArcMap, categorize BFWD, Entrenchment ratio and bank instability based on Rosgen definitions and symbolize accordingly.
    - Analyze data for indications of channel adjustment (i.e. channel incision or aggradation). For instance, the Watershed Practitioner finds a correlation between high frequency of bank

instability and width to depth ratio of a highly entrenched channel, which is not what would be expected.

- Based on valley type and stream type (Rosgen 1996), predict the historical stream types (see Figure 9).
- Correlate these channel adjustment metrics/indicators to the catchment rankings.

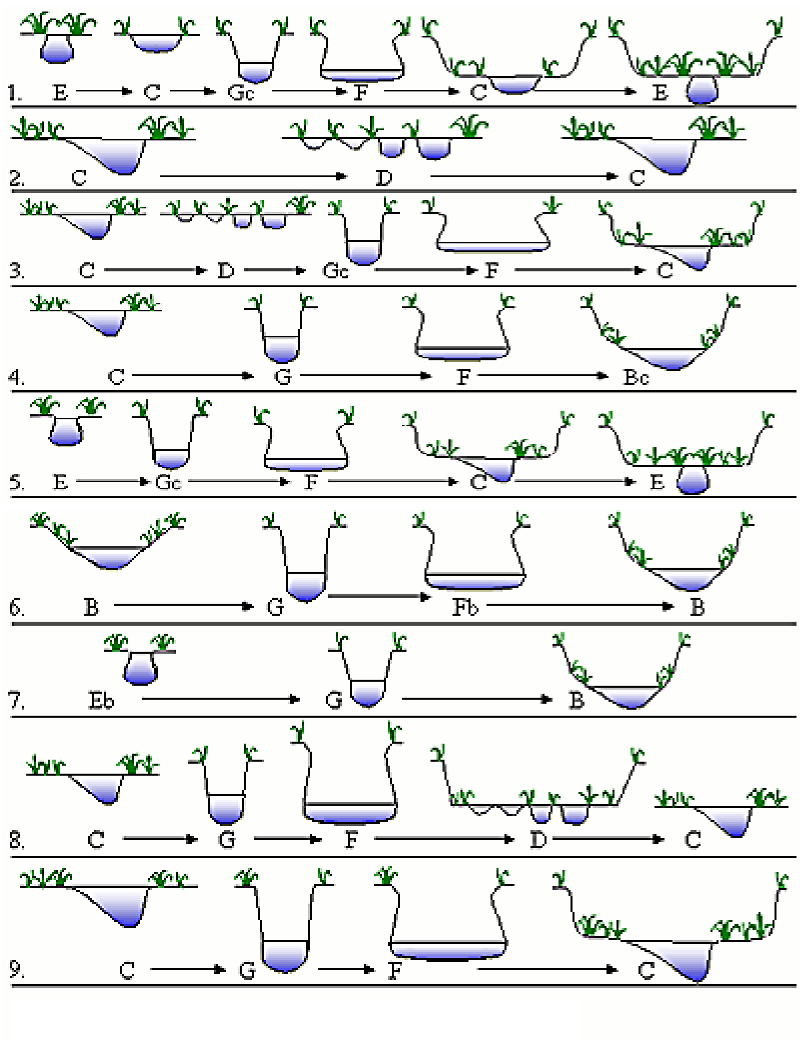


Figure 9. Common channel evolutionary scenarios

2. Problem Statement and Purpose and Need

During the NEPA planning process development of a problem statement is crucial to demonstrating specific elements in the watershed that are need of active restoration and may include the following ecological relationships:

- miles of occupied habitat verses the miles of potential habitat,
- miles or percent of stream channels entrenched or are in non-functioning conditions,
- relationship of road crossing to measured width/depth ratio and entrenchment ratio, and
- other key ecological relationships demonstrated by the sub-watershed assessment.

The problem statement also provides indication to the degree of cumulative effects and provides the foundation for identification of desired conditions for a given sub-watershed. The results of the sub-watershed assessment and problem statement are integrated into the interdisciplinary team (IDT) NEPA planning process. An example of a problem statement includes:

> *The existing conditions of the aquatic ecosystem in Upper Peshastin sub-watershed demonstrate a high degree of physical and biological functional impairment. The sub-watershed assessment demonstrates high road-related values for increase in drainage area, roads in floodplains and road crossings per mile within 17 of 26 catchments. Historically this area supported spawning populations of steelhead and bull trout and provided other salmonid species, such as spring Chinook salmon, rearing and foraging habitats. Large-scale land disturbances, especially the building of roads and associated timber harvest, have led to undesired impacts on aquatic habitat and severely diminished fish distribution and abundance, which some species are now listed under the Endangered Species Act (ESA). Of the 98 miles of estimated potentially occupied steelhead trout habitat in Upper Peshastin, only 36 miles remain currently occupied. Of the 90 miles of estimated potentially occupied bull trout habitat, only 4.7 miles remain currently occupied.*

The purpose and need statements build on the problem statement and forms the basis for designing and implementing various site-specific restoration actions. The purpose and need feeds directly into the NEPA process and becomes integrated with the IDT. For instance, in the assessment phase of planning it's discovered that the current road network has played a critical role in disconnecting steelhead trout migration by 40% from predicted historic/potential levels. Watershed Practitioners also demonstrate that through management actions, which include road decommissioning, closure and/or crossing upgrades it's possible to reclaim access to 100% of those historic/potential habitats. In addition, Watershed Practitioners may be able to hypothesize about a range of benefits to steelhead trout life history processes and needs. For example, based on local survey data the number of redds per mile in the same or similar habitat type currently ranges from 10-20 annually. It's predicted that by allowing for adult steelhead passage we can increase the number of redds per mile by 8-15 annually. An example of purpose and need statements include:

A purpose of the project is to change the current state of watershed and aquatic ecosystem function by targeting impaired hydrologic and geomorphic processes and conditions throughout the Upper Peshastin sub-watershed.

To meet the purpose in the Upper Peshastin sub-watershed, there is a need to:

- *Decrease the impacts of road crossing streams in headwater tributaries,*
- *Reduce barriers to steelhead, bull trout and juvenile chinook salmon migration caused by roads crossing streams,*
- *Reduce water flow alterations caused by roads that primarily existing within 300 feet of streams,*
- *Alleviate other altered flow regimes caused by roads which have impacted stream channel stability, especially where connected to altered aquatic biological processes such as spawning,*
- *Reduce stream channel confinement caused by roads in floodplains,*
- *Reduce surface road and dispersed campsite generated sediment as well as floodplain and stream channel impingement.*

The problem statement and purpose and need combined with the results of the sub-watershed assessment are integrated into the IDT process and matched with the terrestrial analysis (Forest Restoration Strategy EMDS Landscape Evaluation Results) during delineation of one or more project areas. The goal is to overlay the final catchment ranking scores with the vegetation landscape evaluation results to identify the critical sectors of the sub-watershed where restoration actions are most needed and where the IDT and Line Officer gain agreement on project area boundaries.

3. Identify and Design Initial Proposal

A project area(s) within a sub-watershed should follow hydrologic unit boundaries, preferably the HUC 6. This rational follows common logic that hydro-geomorphic processes are based in physics with the stream and road networks constituting linear features. Therefore, both natural processes and anthropogenically caused impacts will accumulate along and at predicted points (valley bottoms, stream channels, tributary confluences, etc.) within a defined hydrologic unit. Thus, Watershed Practitioners can more effectively target restoration actions in scope and scale at HUC 6 levels.

Developing a List of Roads:

A list of roads which are linked to the high, medium-high and medium catchment ranking outcomes is developed by using the Road Binning Matrix (Figure 10). At this point the Watershed Practitioner will need to acquire any relevant Forest Service road network information from the Roads Planning Specialist (i.e. private easements, use agreements, right of ways, and other existing encumbrances) and integrate this information into the road binning format/spreadsheet (Appendix E).

Figure 10. Road Binning Matrix

		CAUSAL MECHANISMS					
		L	***LM***	***M***	***MH***	***H***	
	L	L	LM	M	MH	M	
	LM	L	LM	M	MH	M	Highest Need for Restoration Priority 3 and 4
INDICATORS	***M***	M	M	MH	MH	H	
	MH	MH	MH	MH	MH	H	Highest Need for Restoration Priority 1, 2 or 3
	H	M	M	H	H	H	

Google Earth Fly-over and Road Binning:

Google Earth is a virtual globe, map and geographic information program and allows users to view landscapes both perpendicularly down and at various oblique angles. Google Earth is also a tool that when coupled with the sub-watershed assessment GIS coverages provide the Watershed Practitioner ability to dynamically and artistically develop an initial proposal. Google Earth will therefore allow Watershed Practitioners to view needed landscape features (i.e. riparian areas, ridges, roads, etc.) to a) validate road presence and locations and b) begin to identify the appropriate restoration treatments specifically tied to the purpose and need. GIS coverages for catchment rankings (all metric evaluations), roads data layers (including system, non-system, unauthorized and various encumbrances), HUC6 boundary, and stream data layers are loaded into Google Earth as Keyhole Markup Zipped (kmz) files.

As the Watershed Practitioner scrolls across the landscape (at appropriate elevations and view angles), the GIS coverages are turned on and off as needed to provide insight to bin roads into pertinent restoration treatment options (Appendix E). The Watershed Practitioner will then include comments (into the road binning spreadsheet) that provide various observations specifically related to restoration treatment options. Such observations (comments) may confirm road existence, position in relation to various larger geomorphic features (hillslope failure scarfs, floodplains, stream channels, etc.), note special attributes that should be verified in the field and identification of un-mapped roads or other related features (i.e. dispersed camp-sites in close proximity to perennial streams).

Each road will then be binned into restoration treatment options, which for each method may be used exclusively or in combination across one or more roads. For instance, it may be determined that decommissioning part of Forest Road 780 while upgrading in-place remaining sections (i.e. installing a new culvert to attain aquatic organism passage) will achieve 100% of the purpose and need. In another example, the Watershed Practitioner observes that Forest Road 230 has a repeated history of interacting with a 4th order tributary supporting three Federally listed fish species during high flow events, and determines that it be decommissioned and relocated . The goal is to demonstrate how each individual prescription measurably moves the larger watershed to restored conditions.

Figure 11. Example of a road binning spreadsheet from the Upper Peshastin Restoration Project.

RTE_No	Road Length (mi)	Steelhead Barrier	Chinook Barrier	Bull Trout Barrier	Stream Xings per Catchment	Road Miles within 300 ft	Road Miles within the Floodplain	**Road Encumb**	**Decom System**	**Decom NonSystem**	**Relocate**	**Hydro Close**	**Upgrade**	Comments	Aquatic Proposed Treatment	IDT Comments	Treatment A	Treatment B
7201410	4.33					0.29						Hydro Close	upgrade crossings	Decom 7201411. Check and upgrade 7201410 crossings.	Upgrade	outside plta	Upgrade	
7204000	10.13	Y		Y		1.03	0.05					Hydro Close	Remove Barriers		Upgrade	outside plta	Remove Barriers, Outside PLTA	Upgrade
7204111	3.38	Y	Y	Y		0.23						Hydro Close	Remove Barriers	Check drainage Crossings, upgrade barriers.	Upgrade	outside plta	Remove Barriers, Outside PLTA	Upgrade
7204160	1.99					0.21		Y				Hydro Close	Remove Barriers	upgrade crossings, outslope etc. Potential to gain ridge from 7201410 road and follow ridge out, decom lower half, work with pvt.		outside plta	Remove Barriers, Outside PLTA	Upgrade
7204180	1.36	Y		Y		0.25	0.23		Decom		relocate	Hydro Close	Remove Barriers	Upgrade barries. Decom or hydro close FS past jct with 7204181.	Decom Upgrade	outside plta	Remove Barriers, Outside PLTA	Decom
7204181	2.81					0.00	0.17					Hydro Close	Upgrade	Check Crossings at draws. Investigate closing other duplicate roads.	Upgrade	outside plta	Upgrade	

Development of an Initial Proposal:

The linkage between the project purpose and need and prescribed restoration treatments are made by linking elements of the Google Earth fly-over and road binning exercise with the Priority Restoration Scale Model (Figure ??):

Priority Restoration Scale Model

Restoration Method	Estimated Percent of Impairment Reduced
Priority 1: DECOMMISSION (could be any ML) that have long-standing impairment on watershed/aquatic resources.	90-95 %
Priority 2: RELOCATE ML 2-5 roads where access to a site or area is deemed necessary AND DECOMMISSION the abandoned road segment.	80-90 %
Priority 3: HYDROLOGICALLY CLOSE system roads (i.e. ML-2 to ML-1; ML-3 to ML-1, etc.) as a part of a sustainable future road network need AND where that need isn't immediate and streams and associated water quality/biological components can be resilient to effects of road re-opening.	60-80 %
Priority 4: UPGRADE roads determined to stay on the system.	50-70 %

Figure 12. The Priority Restoration Scale Model

The Priority Restoration Scale Model functions as the Watershed Practitioners "tool box" when considering the spectrum of watershed and aquatic resource impairments in a sub-watershed. The "priority" and its number relates to a predicted amount of and effectiveness in removing a given impairment. There may be multiple priority restoration scenarios that lead to achievement of a common set of objectives for any given set of circumstances.

Table 5. Restoration Methods and Treatment Types

DECOMMISSION	RELOCATE	HYDROLOGICALLY CLOSE	UPGRADE
Removal of culverts and the associated fill in stream crossings; Re-contouring the stream crossing to as close to the original channel morphology as possible. Obliterate and completely re-contour the road bed. Ripping (sub-soiling) to reduce soil compaction, and seeding	Where possible, utilize existing road network routes that are in high capability sectors of a sub-watershed (ridges, stable soil and land association geomorphic types, etc.).	Hydrologically disconnect the road: • remove culverts • provide channel bed-level grade control • shape road prism to a stable condition and site conditions that promote vegetation recruitment	Rock native surface roads. Improve and maintain road drainage. Avoid road construction where soil characteristics increase road surface and ditch runoff. Provide for stream simulation and aquatic organism passage. Rock stream crossings and

with native plants to improve natural re-vegetation, reduce surface erosion and improve soil structure.		• replace culvert cross drains with rolling dips • physically close road entrance to prevent vehicle access • provide ground cover to minimize surface erosion.	approaches. Decrease the length and slope of roads draining to stream crossings (i.e. water bars, rolling dips, cross drainage, etc.). Minimize gully formation below drainage outlets.

The Watershed Practitioner will only identify the appropriate restoration treatment methods, which meet the purpose and need for each road in the binning spreadsheet (Appendix E), which will then be integrated into the IDT process for further consideration. Larger IDT agreement is normally needed regarding Priority 1, 2 and 3 methods as these treatments potentially will affect a broader level of administrative and public access.

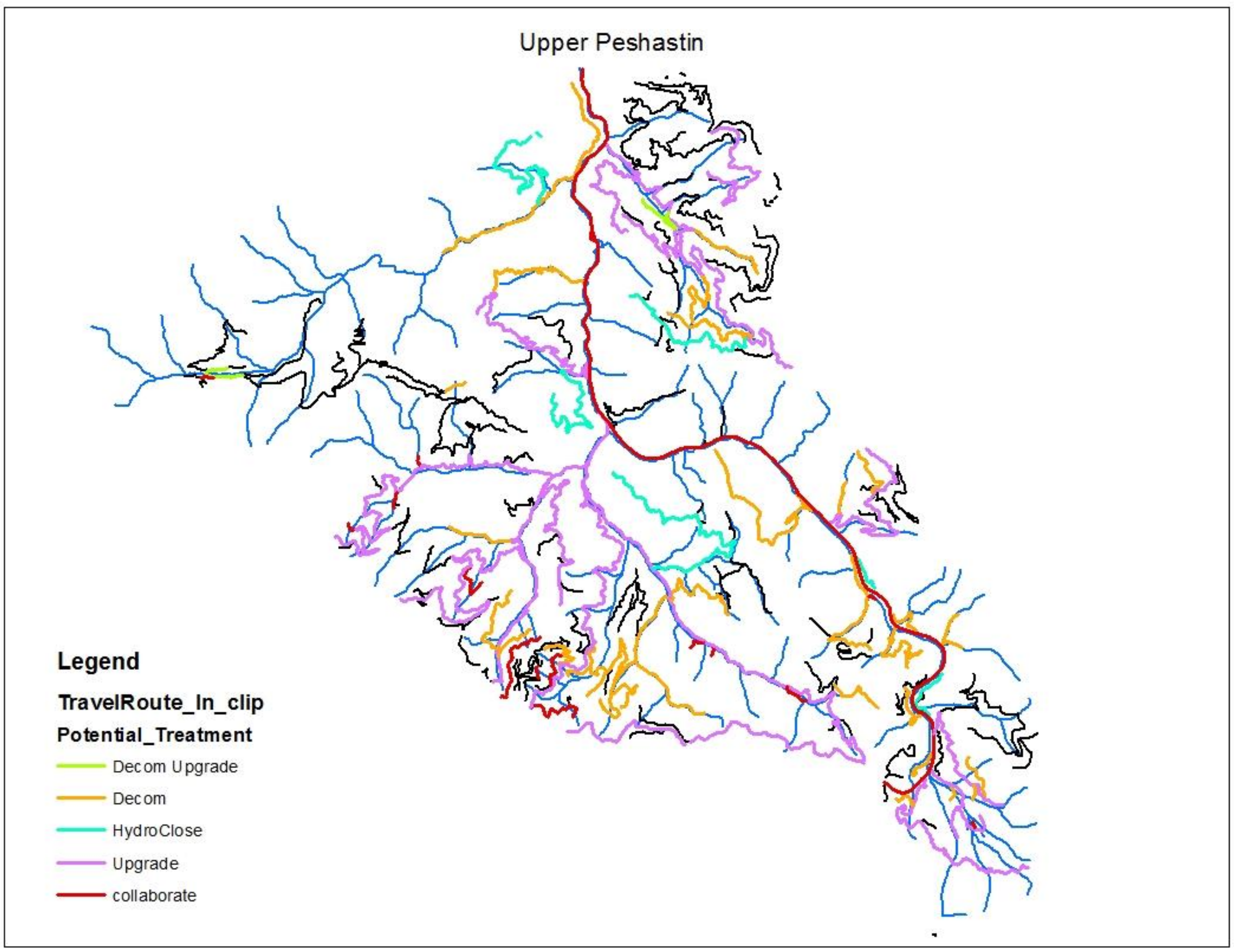


Figure 12. Example initial proposal for the Upper Peshastin Restoration Project

4. Field Verification

Field verification is needed to ensure that observations in the office portion of the restoration analysis are consistent with resource conditions on-the-ground. In addition, it's important to validate various components of the initial proposal with a Roads Planning Engineer and ensure they can be reasonably implemented. Watershed Practitioners perform this process by following elements found in the field verification form. It's also understood that other IDT specialists will be conducting field reconnaissance, which could influence how additional adjustments may need to occur in the initial proposal.

5. Proposal Refinement and Integrating Other Needed Watershed and Aquatic Restoration Actions

Consistent with the purpose and need, other facets of Forest Plan direction and in response to pertinent phases of public comment, the IDT will refine appropriate elements of the watershed and aquatic and terrestrial restoration proposals. During various stages of refinement Watershed Practitioners should continue to update the road binning spreadsheet as appropriate. In addition, the Google Earth fly-over and Restoration Priority Scale Model procedures should be used to ensure consistency of a potentially refined proposal's effectiveness to improving the catchment criteria scores. In other words, a refined proposal results in changing needed red catchments to yellow or green, yellow catchments to green, and so on. Watershed Practitioners always have the option of simulating a completed proposal or alternative by adjusting pertinent GIS layers (i.e. removing roads off the system) tied to the catchment scoring criteria and re-running the procedures to demonstrate anticipated watershed-scale and biological level benefits.

By implementing the Whole Watershed Restoration Procedures and working with various external collaborative processes, Watershed Practitioners may discover a need to incorporate other actions into a restoration proposal. However, such actions should be directly linked to the results of the sub-watershed assessment and target restoration of the following criteria:

- restoring floodplain, stream channel and wetland condition and function;
- increasing soil stability and productivity;
- improving water quality conditions in 303d listed waterbodies; and
- increasing localized distribution and population resiliency of focal fish species.

Incorporating non-road targeted restoration actions (Table 6) should also be supported by and directly linked to a project's problem statement and purpose and need as well as be reasonably implementable in a proper management sequence. Furthermore, Watershed Practitioners should also be able to link non-road targeted actions to other pertinent Federal and State plans (i.e. ESA recovery plans, water quality restoration plans, etc.).

Table 6. Example of non-road targeted restoration actions.

Watershed and Aquatic Restoration Action Criteria:			
Floodplain, Stream Channel and Wetland	**Soil Stability and Productivity**	**303d Listed Streams**	**Fish Distribution and Population Resiliency**
Channel relocation Channel aggradation Headcut and/or stream bank stabilization Levee removal In-stream structures Riparian planting and protection Prescribed fire	Soil de-compaction Placement of organic ground cover Seeding Floodplain, stream channel and wetland actions	Floodplain, stream channel and wetland actions Water diversion upgrades Eliminating point source contaminants	Floodplain, stream channel and wetland actions 303d listed stream actions Management of non-native fisheries Protection of native resident and anadromous fishes

References

Barton, D. R., W. D. Taylor, and R. M. Biette. 1985. Dimensions of riparian buffer strips required to maintain trout habitat in southern Ontario streams. North American Journal of Fisheries Management 5: 364–378.

Baxter, C.V., C.A. Frissell and F.R. Hauer. 1999. Geomorphology, Logging Roads and the Distribution of Bull Trout Spawning in a Forested River Basin: Implications for Management and Conservation. Transactions of the American Fisheries Society. 128:854-867

BC Forest Service. 1995a. Coastal watershed assessment procedure guidebook (CWAP). BC Environment, Government of British Columbia, Victoria, BC. vi + 66 p.

BC Forest Service. 1995b. Interior watershed assessment procedure guidebook (IWAP) Level 1 analysis. BC Environment, Government of British Columbia, Victoria, BC. vi + 82 p.

Beechie, T., G. Pess, P. Roni, and G. Giannico. 2008. Setting river restoration priorities: a review of approaches and a general protocol for identifying and prioritizing actions. North American Journal of Fisheries Management 28:891-905.

Beschta, R.L. and R.L. Taylor. 1988. Stream temperature increase and land use in a forested Oregon watershed. Water Resources Bulletin 24 (1): 19-25.

Bosch, J.M. and Hewlett, J.D. 1982. A review of catchment experiments to determine the effects of vegetation changes on water yield and evapotranspiration. Journal of Hydrology, 55: 3-23.

Burnett, K.M., G.H. Reeves, D.J. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. Distribution of salmon-habitat potential relative to landscape characteristics and implications for conservation. Ecological Applications 17 (1): 66-80.

Cairns, J. 1991. The status of the theoretical and applied science of restoration ecology. The Environmental Professional, Volume 13, pp. 186-194.

Caldwell, L. K. 1991. Restoration ecology as public policy. The Environmental Professional, Volume 13, pp. 275-284.

Davis, C., M. Karrer, B. Kovolchik, T. Lillybridge, and C. Narsisco. Landtype Associations of North Central Washington (Wenatchee, Okanogan, and Colville National Forests). USDA Forest Service, Wenatchee, WA.

Case, P., T. Clark, J. Maxwell and T. Sale. 1994. Spatial analysis of the cumulative effect of land management activities on stream water quality within forested watersheds. Proceedings of the Fourteenth Annual Esri User Conference 14:383-399.

Chase, M.N, E. A. Johnson, and Y. E. Martin. 2012. The influence of geomorphic processes on plant distribution and abundance as reflected in plant tolerance curves. Ecological Monographs 82:429–447.

Clarke, K. D., and D. A. Scruton. 1997. Use of the Wesche method to evaluate fine-sediment dynamics in small boreal forest headwater streams. North American Journal of Fisheries Management 17:188-193.

Cook, C. and A. Dresser. 2007. Erosion and channel adjustments following forest road decommissioning, Six Rivers National Forest. Advancing the Fundamental Sciences: Proceedings of the Forest Service National Earth Sciences Conference, San Diego, CA, 18-22 October 2004, PNWGTR-689, Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Coe, D. 2006. Sediment production and delivery from forest roads in the Sierra Nevada, California. MSc thesis, Colorado State University, Fort Collins, CO. 110 p.

Eaglin, G. S. and W. A. Hubert. 1993. Effects of logging and roads on substrate and trout in streams of the Medicine Bow National Forest, Wyoming. North American Journal of Fisheries Management 13:844-846.

Doppelt, B., M. Scurlock, C. Frissell, and J. Karr. 1993. Entering the watershed: a new approach to save America's river ecosystems. Island Press, Covelo, California.

Dymond, S.F. 2010. Modeling the effects of forest road density on streamflow in the blue ridge mountains. Master thesis: Virginia Polytechnic Institute and State University, Blacksburg, VA.

Environmental Protection Agency. 1995. Ecological restoration: a tool to manage stream quality. Office of Water Report: EPA 841-F-95-007. Washington D.C.

Environmental Protection Agency. 2002. A framework for assessing and reporting on ecological condition. SAB Report Number: EPA-SAB-EPEC-02-009.

Environmental Protection Agency. 2011. Healthy watersheds initiative: national framework and action plan. Publication Number: EPA-841-R-11-005.

Foltz, R.B., N. Copeland, and W.J. Elliot. 2009. Reopening abandoned forest roads In Northern Idaho, USA: Quantification of runoff, sediment concentration, infiltration, and interrill erosion parameters. Journal of Environmental Management 90:2542–2550.

Furniss, M.J., K.B. Roby, D. Cenderelli, J. Chatel, C.F. Clifton, A. Clingenpeel, P.E. Hays, D. Higgins, K. Hodges, C. Howe, L. Jungst, J. Louie, C. Mai, R. Martinez, K. Overton, B.P. Staab, R. Steinke, and M.

Weinhold. 2013. Assessing the Vulnerability of Watershed to Climate Change: Results of National Forest Watershed Vulnerability Pilot Assessments. Gen. Tech. Rep. PNW-GTR-884. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Haskins, W. and D. Mayhood. 1997. Stream Crossing Density as a Predictor of Watershed Impacts. 17th Annual ESRI User Conference. Page 457.

Hicks, B.J., J.D. Hall, P.A. Bisson and J.R. Sedell. 1991. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. Chapter 14; Responses of Salmonids to Habitat Changes. American Fisheries Society Special Publication 19:483-518.

Hitt, N. P., and C. A. Frissell. 2000. An evaluation of Wilderness and aquatic biointegrity in western Montana. Pages 138-142 in McCool, S.F., D.N. Cole, W. Borrie, and J. OLoughlin (compilers). Wilderness science in a time of change conference--Volume 2: Wilderness within the context of larger ecosystems, May 23-27, 1999, Missoula, Montana. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-15-2, Ogden, Utah.

Holtby, L. B. 1988. Effects of logging on stream temperature in Carnation Creek, British Columbia, and associated impacts on the coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 45: 502–515.

Intergovernmental Advisory Committee (IAC). 1995. Ecosystem analysis at the watershed scale: the revised Federal guide for watershed analysis. Version 2, Portland, OR.

Jones, J.A. and G.E. Grant. 1996. Peak flow responses to clear-cutting and roads in small and large basins, Western Cascades, Oregon. Water Resources Research 32 (4): 959-974.

Jones, J.A., J. Fredrick, J. Swanson, B.C. Wemple, and K.U. Snyder. 2002. Effects of roads on hydrology, geomorphology, and distribution patches in stream networks. Conservation Biology 14: 76-85.

Jones, J.A., F.J. Swanson, B.C. Wemple and K.U. Snyder. 2004. Effects of roads on hydrology, geomorphology and disturbance patches in stream networks. Conservation Biology, Vol. 14, No. 1, pgs 76-85.

Lane, S. 1995. The dynamics of dynamic river channels. Geography 80:147–162.

Lloyd, D. S., J. P. Koenings, and J. D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management 7:18-33.

Luce, C.H. and B.C. Wemple 2001. Introduction to special issue on hydrologic and geomorphic effects of forest roads. Earth Surface Process and Landforms 26: 111-113.

Luce, C.H., B.E. Rieman, J.B. Dunham, J.L. Clayton, J.G. King, and T.A. Black. Incorporating aquatic ecology into decisions on prioritization of road decommissioning. Water Resources Impact 3 (3): 9-15.

National Research Council et al. 1992. Restoration of aquatic ecosystems. National Academy Press. Washington D.C.

Raymond, C.L., D.L. Peterson and R.M. Rochefort. 2014. Climate change vulnerability and adaptation in the north cascades region, Washington. Gen. Tech. Rep. PNW-GTR-892. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Rieman, B.E. and J.D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124: 285-296.

Robinson, C., P.N. Duinker, and K.F. Beazley. 2010. A conceptual framework for understanding, assessing, and mitigating ecological effects of forest roads. Environmental Rev 18:61-86.

Rosgen, D.L. 1996. Applied river morphology. Wildland Hydrology. Pagosa Springs, CO.

Rosgen, D.L. 2006. The natural channel design method for river restoration. ASCE Environmental & Water Resources Institute, Omaha, Nebraska, available at http://pubs.usgs.gov/misc_reports/FISC_1947-2006/.

Pechenick, A.M., D.M. Rizzo, L.A. Morrissey, K.M. Garvey, K.L. Underwood and B.C. Wemple. 2014. A multi-scale statistical approach to assess the effects of connectivity of road and stream networks on geomorphic channel condition. Earth Surface Process and Landforms 39: 1538-1549.

Peterson, D.P., B.E. Rieman, D.L. Horan, and M.K. Young. 2013. Patch size but not short-term isolation influences occurrence of westslope cutthroat trout above human-made barriers. Ecology of Freshwater Fish. DOI: 10.1111/eff.12108.

Shaw, G. L. and D. Thompson. 1986. Water quality management and timber operations in southwest Alberta. Report prepared for the Alberta Environmental Research Trust Fund, Grant #T0953, by the Faculty of Environmental Design, University of Calgary, Calgary, AB. 75 p.

Swanson, F.J. 1979. Geomorphology and ecosystems. In: Forests: Fresh perspectives from ecosystem analysis. Proceedings of the 40th Annual Biology Colloquium.

Swanson, F.J., T.K. Kratz, N. Caine, and R.G. Woodmansee. 1988. Landform effects on ecosystem patterns and processes. BioScience 38, 92–98.

Swanson, F.J., N. Caine and R.G. Woodmansee. 1998. Landform effects on ecosystem patterns and processes: geomorphic features of the earth's surface regulate the distribution of organisms and processes. BioScience Vol. 38 No. 2.

Swanson, F.J., J. Jones, B. Wemple, and K. Snyder. 2000. Roads in forest watersheds – assessing effects from a landscape perspective. Published in Proceedings of the Seventh Biennial Watershed Management Conference. Water Resources Center Report No. 98, University of California, Davis.

Torgersen, C.E., D.M. Price, H.W. Li and B.A. McIntosh. 1999. Multiscale thermal refugia and stream habitat associations of chinook salmon in Northeastern Oregon. Ecological Applications. 9(1). Pages 301-319.

Trombulak S.C. and C.A. Frissell. 1999. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology, Vol. 14, No. 1, pgs 18-30.

US Department of Agriculture. 2010. Strategic plan for FY 2010-2015.

USDA Forest Service. 1989. Land and resource management plan. Wenatchee, WA: Wenatchee National Forest.

USDA Forest Service. 1990. Land and resource management plan. Okanogan, WA: Okanogan National Forest.

USDA, Forest Service. 1993. National hierarchical framework of ecological units. Washington, DC.

USDA Forest Service. 2011. Watershed condition framework: a framework for assessing and tracking changes to watershed condition.

USDA Forest Service. 2013. Okanogan-Wenatchee National Forest aquatic species viability evaluation.

Wemple, B.C. 1994. Hydrologic integration of forest roads within stream networks in two basins, Western Cascades, OR. Masters thesis. Oregon State University, Corvallis, OR.

Wemple D.C., J.A. Jones and G.R. Grant. 1996. Channel network extension by logging in two basins, Western Cascades, Oregon. Water Resources Bulletin 32: 1195-1207.

Wemple D.C., J.S. Frederick and J.A. Jones. 2001. Forest roads and geomorphic process interactions, cascade range, OR. Earth Surface and Landforms. 26: 191-204.

Wemple, D.C., K. Garvey, L.A. Morrissey, A. Pechenick, D.M. Rizzo and D. Ross. Hydrological connectivity of road and stream networks and implications for material transfer and channel morphology. EGU General Assembly Conference, Vienna, Austria.

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Special thanks goes out to every OWNF District Hydrologist, Fisheries Biologist, Technician and Soils Scientist who are committed to designing, implementing and contributing to the best watershed and aquatic habitat restoration projects possible. Although this document was developed as an approach to restore watershed and fisheries resources, it’s dedicated to you.

Appendix A – Road Definitions

Watershed Condition Framework Road Definition For the purposes of WCF assessment; "*the term "road" is broadly defined to include roads and all lineal features on the landscape that typically influence watershed processes and conditions in a manner similar to roads.* **Watershed Condition Framework Road Definition** For the purposes of WCF assessment; "*the term "road" is broadly defined to include roads and all lineal features on the landscape that typically influence watershed processes and conditions in a manner similar to roads. Roads, therefore, include* <u>*Forest Service system roads (paved or non-paved)*</u> *and any* <u>*temporary roads (skid trails, legacy roads) not closed or decommissioned*</u>*, including private roads in these categories. Other linear features that might be included based on their prevalence or impact in a local area are motorized (off-road vehicle, all-terrain vehicle) and non-motorized (recreational) trails and linear features, such as railroads. Properly closed roads should be hydrologically disconnected from the stream network. If roads have a closure order but are still contributing to hydrological damage they should be considered open for the purposes of road density calculations*" (WCC Technical Guide 2011).

Table A1. Road and trail condition indicators from the Watershed Condition Classification Guide.

Attributes	**Good (1) Functioning Properly** The density and distribution of roads and linear features within the watershed indicate that the hydrologic regime is substantially intact and unaltered.	**Fair (2) Functioning at Risk** The density and distribution of roads and linear features within the watershed indicates that there is a moderate probability that the hydrologic regime is substantially altered.	**Poor (3) Impaired Function** The density and distribution of roads and linear features within the watershed indicates that there is a higher probability that the hydrologic regime (timing, magnitude, duration, and spatial distribution of runoff flows) is substantially altered.
Open road density	Default road/trail density: less than 1 mi/mi², or a locally determined threshold for good conditions supported by forest plans or analysis and data.	Default road/trail density: From 1 to 2.4 mi/mi², or a locally determined threshold for fair conditions supported by forest plans or analysis and data.	Default road/trail density: more than 2.4 mi/mi², or a locally determined threshold for poor conditions supported by forest plans or analysis and data.
Road and trail maintenance	Best Management Practices (BMPs) for the maintenance of designed drainage features are applied to more than 75 percent of the roads, trails, and water crossings in the watershed.	BMPs for the maintenance of designed drainage features are applied to 50 to 75 percent of the roads, trails, and water crossings in the watershed.	BMPs for the maintenance of designed drainage features are applied to less than 50 percent of the roads, trails, and water crossings in the watershed.
Proximity to water	No more than 10 percent of road/trail length is located within 300 feet of streams and water bodies or hydrologically connected to them.	Between 10 and 25 percent of road/trail length is located within 300 feet of streams and water bodies or hydrologically connected to them.	More than 25 percent of road/trail length is located within 300 feet of streams and water bodies or hydrologically connected to them.
Mass wasting	Very few roads are on unstable landforms or rock types subject to mass wasting with little evidence of active movement or evidence of road damage. There is no danger of large quantities of debris being delivered to the stream channel because of mass	A few roads are on unstable landforms or rock types subject to mass wasting with moderate evidence of active movement or road damage. There is some danger of large quantities of debris being delivered to the stream channel,	Most roads are on unstable landforms or rock types subject to mass wasting with extensive evidence of active movement or road damage. Mass wasting that could deliver large quantities of debris to the stream channel is a

	wasting.	although this is not a primary concern in this watershed.	primary concern in this watershed.

Forest Service Road System Definition

Maintenance levels define the level of service provided by, and maintenance required for, a specific road (FSH 7709.59, sec. 62.3). The Forest Service classifies maintenance of National Forest System roads by five levels: 1, 2, 3, 4, and 5. Maintenance level 1 roads are closed to motor vehicle use. Maintenance level 2 roads are maintained for high-clearance vehicles. Maintenance level 3, 4, and 5 roads are maintained for passage by standard passenger cars during the normal season of use (USFS 2012).

- **Road maintenance level 5** is defined in the FSH 7709.59, sec. 62.32 as: "Assigned to roads that provide a high degree of user comfort and convenience. These roads are normally double lane, paved facilities. Some may be aggregate surfaced and dust abated. "Manual on Uniform Traffic Control Devices" is applicable. The appropriate traffic management strategy is "encourage." "

- **Road maintenance level 4** is defined in the FSH 7709.59, sec. 62.32 as: "Assigned to roads that provide a moderate degree of user comfort and convenience at moderate travel speeds. Most roads are double lane and aggregate surfaced. However, some roads may be single lane. Some roads may be paved and/or dust abated. "Manual on Uniform Traffic Control Devices" is applicable. The most appropriate traffic management strategy is 'encourage'. However, the 'prohibit' strategy may apply to specific classes of vehicles or users at certain times."

- **Road maintenance level 3** is defined in the FSH 7709.59, sec. 62.32 as: "Assigned to roads open and maintained for travel by a prudent driver in a standard passenger car. User comfort and convenience are not considered priorities. The "Manual on Uniform Traffic Control Devices" (MUTCD) is applicable. Warning signs and traffic control devices are provided to alert motorists of situations that may violate expectations. Roads in this maintenance level are typically low speed with single lanes and turnouts. Appropriate traffic management strategies are either 'encourage' or 'accept.' Discourage or prohibit strategies may be employed for certain classes of vehicles or users".

- **Road maintenance level 2** is defined in the FSH 7709.59, sec. 62.32 as: "Assigned to roads open for use by high-clearance vehicles. Passenger car traffic, user comfort, and user convenience are not considerations. Warning signs and traffic control devices are not provided with the exception that some signing, such as W-18-1 "No Traffic Signs" may be posted at intersections. Motorists should have no expectations of being alerted to potential hazards while driving these roads. Traffic normally is minor, usually consisting of one or a combination of administrative, permitted, dispersed recreation, or other specialized uses. Log haul may occur at this level."

- **Road management level 1** is defined in the FSH 7709.59, sec. 62.32 as: "These are roads that have been placed in storage between intermittent uses. The period of storage must exceed 1 year. Basic custodial maintenance is performed to prevent damage to adjacent resources and to perpetuate the road for future resource management needs. Emphasis is normally given to maintaining drainage facilities and runoff patterns. Planned road deterioration may occur at this level." "Roads receiving level 1 maintenance may be of any type, class, or construction standard, and may be managed at any other maintenance level during the time they are open for traffic." The only traffic management strategy that is appropriate for maintenance level 1 roads is "prohibit".

Table A2. Analysis Parameters for Determining Effects to TES fish species

Threatened and Endangered Fish Species	Indicator	Functioning Appropriately	Functioning At Risk	Functioning at Unacceptable Risk
Bull Trout**	Road Density*	<1mi/mi ^{2}	1-2.4 mi/mi ^{2}	>2.4 mi/mi ^{2}
	Location of Roads	No Valley Bottom Roads	Some Valley Bottom Roads	Many Valley Bottom Roads
Steelhead and Spring Chinook***	Road Density*	<2mi/mi ^{2}	<2-3mi/mi ^{2}	>3mi/mi ^{2}
	Location of Roads	No Valley Bottom Roads	Some Valley Bottom Roads	Many Valley Bottom Roads

*Road density for aquatic analysis takes into account Maintenance Levels 1-5

** A Framework to Assist in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Bull Trout Subpopulation Watershed Scale (USFWS 1998)

***Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale (NMFS 1996)

Appendix B - Road Management Activities – Forest Restoration Projects

Prepared by Michael Carroll, Scott Lynn and Miki Fujikawa

I. Definitions

For the purposes of this discussion and Forest Restoration Project planning we need to be concerned with five types of roads.

1) Forest System Road (FSR): Also more formally known as a 'National Forest System Road'. A forest road other than a road which has been authorized by a legally documented right-of-way held by a state, county, or local public road authority (36 CFR 212.1). Note that a Forest Road is a road wholly or partly within or adjacent to and serving the National Forest System Lands (NFSL) that the United States Forest Service (USFS) determines is necessary for the protection, administration, and utilization of the NFSL and the use and development of its resources (36 CFR 212.1).

   NOTE: Only Forest System Roads have USFS maintenance levels. The other roads (non-system, unauthorized, public and temporary) are not maintained by the USFS and thus do not have USFS maintenance levels assigned. Expected maintenance conditions should be identified in the road authorization, operating plan, or maintenance agreement associated with non-system, public or temporary roads.

2) Non-System Road: These are roads on the forest that are authorized by a legally documented right-of-way and are not needed by the USFS to manage the forest. These roads stay on the landscape for indefinite periods of time and thus do not meet the definition of a temporary road. Examples include; utility access roads, and private drive-ways, etc. The authorized entity is responsible for all construction, operation, and decommissioning costs of these roads. The USFS cannot expend system road maintenance funds on non-system roads.

3) Unauthorized Road: A road that is not a FSR, Public Road, Non-System Road or Temporary Road.

4) Temporary Road: A road necessary for emergency operations or authorized by contract, permit, lease, or other written authorization that is not a forest road and that is not included in a forest transportation atlas. (36 CFR 212.1) Note that these roads are on the landscape for a relatively short and defined period of time and are associated with a specific project or mining plan of operations. Examples include: Timber sale roads, mining access roads, abandoned mine reclamation access roads, etc. Temporary roads are typically not open to the public.

5) Public Road: A road that is not a FSR but instead is a road that is under the jurisdiction of the State, County or other public entity. This road may cross NFSL but is not the Forest Service's responsibility to maintain. It has some historic right-of-way or other authorization and is generally open to the public. The USFS may be able to use system road maintenance funds on these County roads if there is an active cooperative agreement with the associated County.

6) Real Property: Any interest in land, land and anything permanently affixed to the land.

II. Maintenance levels and restoration of FSRs encumbered by an easement, special use permit, etc.

Existing agreements and authorizations must be evaluated in the NEPA planning process,. Maintenance or Restoration actions taken on a road encumbered by an easement must follow the terms agreed to within the authorizing document(s). The USFS's ability to change maintenance levels and conduct restoration activities may be limited by those prior existing authorizations and agreements. The USFS may need to focus its planning efforts on those actions that it can reasonably take given prior agreements and authorizations, even in cases where we would ideally be making more significant changes.

NOTE: Cost-share roads carry specific requirements. Changes to road maintenance levels must be agreed upon by both cost-share partners. If the maintenance level is changed, a supplement to the cost-share agreement, in addition to potential easement actions, must be completed and signed by both parties prior to implementation of the new maintenance level.

1) Decommissioning roads:

If proposed maintenance actions on an FSR vary from agreed upon maintenance levels (i.e. closing or decommissioning), legal amendments to or vacating of the legal documents must be affected prior to the maintenance action taking place. If there is any potential need for future access to an area accessed by a road, it is better to store the road in ML-1 closed condition rather than decommission it.

Restoration teams should complete a thorough travel analysis when deciding to decommission roads. Regional engineering direction is that by decommission roads we are stating that we will never need that access again. It is not appropriate to reconstruct a road that was decommissioned based on a previous decision. To spend money to destroy real property only to spend more money to replace the same infrastructure a few years later is not good stewardship of resources.

Do not plan to decommission an FSR with an easement over non-federal lands unless one of the following rare exceptions apply:

a) Alternate access is established
b) The road no longer serves NFSL.
c) The authorized officer determines there are no future access needs to the area.

For those exceptions, decommissioning of an FSR on private lands requires review of the vesting easement to determine what obligations/limitations the USFS may have with the landowner/grantor.

2) Storing roads in ML-1 Closed status

Storing a road in ML-1 closed status is done to reduce environmental impacts of the road. This is accomplished by excluding all over-the-ground motorized vehicular use and improving hydrologic conditions disrupted by construction of the road prism. It is not intended to discourage people from using the road on foot, nor is it intended to make the road completely disappear. If there is a need to discourage human use of an area then placing an area closure might be appropriate.

The techniques used to attain the objective of placing a road in ML-1 will be tailored to fit the site conditions on each particular segment of road. This can range from the low end of scarifying the road surface a few inches deep to encourage grass growth and installing water bars, to the high end of de-compacting the road bed, scattering large-woody-debris, removing culverts, and partial fill pull back. Engineering will work with Hydrology and Soils to determine the appropriate techniques to be used on each road segment.

The process of converting a road from an ML-2 thru 5 status to storing it in ML-1 condition consists of the following steps:

1) Determining that the road is not needed in the near term for access but may be needed in the more distant future for access.
2) Determine if the road is encumbered by any easements, special use permits, or other authorizations.
3) Engineering and district specialists develop a closure plan that addresses relevant environmental, recreation, and transportation needs on the road.
4) If the road has any encumbrances in item #2 ensure any potential impacts are addressed in the closure plan developed in #3 and communicated to all affected parties.
5) Complete the NEPA planning process. There is no CE category for this action so it must be accomplished in an EA or EIS.

A road stored in ML-1 closed status is restricted from all motorized wheeled vehicle traffic. It may still be used for wheeled non-motorized traffic or motorized over the snow traffic. Note that all motorized over-the-snow traffic will be assessed and regulated in Travel Management planning subpart C.

It is acceptable to have a motorized trail overlay a stored ML-1 closed road. If a motorized trail overlies a ML-1 road then all the motorized use is managed under use and maintenance of the trail. This also stipulates that maintenance of that trail is the responsibility of the recreation department that manages the trail and its use. These trails must be designated as official Forest Service System Trails and maintained in INFRA as such.

FSRs with easements over private lands stored in ML-1 status will preserve the USFS access rights enabling future USFS access to the forest. Storing the road in ML-1 closed condition preserves the public's right to use the right of way granted in the easement for current non-motorized access and future motorized access to National Forest lands.

III. Timber Sale and Forest Restoration Project Temporary Road Management

Acquisition of Temporary Permits to cross private lands should be limited to access for short term management activities where full access is available on alternate routes and where the use of the temporary access will result in savings or more favorable environmental conditions. Permits are inappropriate however for acquiring access over routes that will be needed for future management of NFSL.

Acquisition of temporary permits in Region 6 requires RO review and approval. Early communication with the Lands Zone and detailed travel analysis are critical to determine the viability of proposed access routes. Landowner reluctance to provide full NFS access does not constitute adequate rationale for acquisition of temporary access on routes that will be needed for future access by the United States to implement the Forest Land and Resource Management Plan.

Timber sale temporary road construction, maintenance, and decommissioning is the responsibility of the Timber Sale Administrator (TSA) under the guidance of the Forest Service Representative (FSR). If a TSA needs advice when dealing with the layout, construction, maintenance, or decommissioning of a temporary road, Engineering will make a qualified engineer available to assist. This assistance does not constitute designing a temporary road.

If the District Ranger in discussion with the TSA and FSR determine that the normal construction, operation, or decommissioning of a temporary road presents unacceptable risk of impact to the environment it may be appropriate for Engineering to design the road. This will consist of Engineering laying out the road, developing plans and specifications for the construction, operation, and decommissioning of the road as well as supervising the construction, operation, and decommissioning of the road. This level of Engineering involvement will be expensive, not only the additional cost of engineering time, but the increased level of road construction, operation, and decommissioning. This cost will have to come from the timber sale or other non-engineering funding.

IV. Unauthorized Roads

There are five options to deal with unauthorized roads on NFSL.

1) Convert to a Forest System Road
2) Convert to a non-System Road
3) Convert to a Forest System Trail
4) Use as a temporary road and decommission at the end of the project
5) Decommission

For all of the above described road management activities on unauthorized roads, the USFS must determine if any landowner may be impacted by our action. If USFS actions will likely impact a private landowner's access, consider granting a private road permit or other authorization as a part of the planning analysis.

VI. Reasonable expectations:

1.) Easement holders will rarely vacate easements.
2.) Landowners will usually want motorized access.
3.) If FSRs on private land are decommissioned the Forest Service effectively is vacating our rights to future use of that road forever.
4.) Temporary or Administrative access over private land is rarely appropriate.
5.) We should not be analyzing private roads on private lands. (FACT)
6.) Landowners will not agree to changes in access based solely on USFS's desire for restoration.
7.) Private landowners will generally not support decommissioning of roads that access their private land.
8.) Appropriated funds for road construction and maintenance (CMRD) may not be used for decommissioning without specific legislation authorizing their use. (FACT)

Appendix C - Road Management Activities – Forest Restoration Projects

Table C1. Native Fish Species and Miles of Habitat on the Okanogan-Wenatchee NF

Species	Occupied Habitat (miles)	Critical Habitat (miles)	Historical Habitat (miles)	Special Status
Pacific lamprey	15			
River lamprey	UNK			Sensitive
Western brook lamprey	6			
White Sturgeon	0			
Cutthroat trout (unknown subspecies)	1447			MIS
Westslope Cutthroat trout	185		1447	MIS
Coho	UNK			
Steelhead	470	422	1628	Threatened, MIS
Rainbow trout/redband	864			MIS
Sockeye salmon	58			MIS
Spring chinook salmon	375	197 (upper Columbia ESU only)	769	Endangered (upper Columbia ESU only), MIS
Summer chinook salmon	34			MIS
Pygmy whitefish	22			Sensitive
Mountain whitefish	303			
Bull trout	697	746	1900	Threatened, MIS
Chiselmouth	UNK			
Lake Chub	UNK			
Tui Chub	UNK			
Peamouth	31			
Northern Pikeminnow	43			
Longnose dace	20			
Leopard dace	UNK			
Umatilla Dace	UNK			Sensitive
Speckled dace	29			
Redside shiner	97			
Largescale Sucker	66			
Bridgelip sucker	36			
Longnose sucker	UNK			
Mountain sucker	UNK			
Burbot	62			
Three-spined stickleback	UNK			
Sand roller	6			
Prickly sculpin	UNK			

Mottled sculpin	1			
Paiute sculpin	7			
Slimy sculpin	12			
Torrent sculpin	13			
Sculpin species	404			

Table C2. Non-Native fish species and their miles of habitat on the Okanogan-Wenatchee NF

Species (Status)	Occupied Habitat (miles)
Golden Trout	0.7
Brown Trout	18
Brook Trout	674
Kokanee	122
Lake Trout	38
Yellow Perch	Fish Lake

Appendix D – Sub-watershed Restoration Prioritization: Scoring Distribution and Course Scale Application

	No. of Watersheds
Group 1 (Score Range: 15 - 10)	46
Group 2 (Score Range: 9 - 7)	42
Group 3 (Score Range: 6 - 4)	50
Group 4 (Score Range: 3 - -5)	112
TOTAL	**250**

Group 1: Assume these watersheds have the highest degree of watershed impairment from the road network, which threaten T&E species in the greatest ways (habitat and life history). Highest priority for focused restoration.

Group 2: Assume these watersheds have a high to moderate degree of watershed impairment from the road network, which threaten T&E species (habitat and life history). High priority for focused restoration.

Group 3: Assume these watersheds have a low to moderated degree of watershed impairment from the road network. Watersheds have a low – moderate degree of importance for T&E fishes. Low - Moderate priority for focused restoration.

Group 4: Assume these watersheds have a very low to low degree of watershed impairment from the road network. Watersheds have a very low – low degree of importance for T&E fishes. Low to no priority for focused restoration.

Appendix E – Road Binning Format

RTE_NO	Road Length (mi)	Steelhead Barrier	Chinook Barrier	Bulltrout Barrier	Stream Xings per Catchment	Road Miles within 300 ft.	Road Miles with the Floodplain	Road Encumb	Decom System	Decom NonSystem	Relocate	Hydro Close	Upgrade	Comments	Aquatic Prososed Treatment	IDT Comments	Treatment A	Treatment B

Appendix F – Summary of Whole Watershed Restoration Procedures

<u>Sub-watershed Assessment</u>

1.	Plot Forest HUC 12 layer, NHD stream layer, and system and non-system road layer (include state and county roads).
2.	Delineate the sub-watershed into smaller catchments.
3a.	Perform hydro-geomorphic causal mechanism analysis for: percent increase in drainage area/network, percent of roads within riparian areas, percent of roads within mapped floodplains, and number of road crossings per stream mile.
3b.	Assign catchment values for all individual hydro-geomorphic metric indictors.
3c.	Perform biological condition metric indicator analysis for: focal fish species known distribution (by life history), designated critical habitat, potential habitat, miles of unstable stream banks, width/depth ratio, and entrenchment ratio.
4.	Overlap hydro-geomorphic causal mechanism catchment values with biological condition indicators.

<u>Problem Statement and Purpose and Need</u>

5.	Develop the problem statement, which includes the road related impacts on the following attributes: miles of occupied habitat vs. miles of potential habitat, miles/percent of stream channels entrenched or are in non-functioning conditions, relationship of road crossing to measured width/depth ratio and entrenchment, etc.
6.	Develop the purpose and need that specifically targets restoration of key causal mechanisms directly connected to impairment of indicators.
7.	Integrate the problem statement and purpose and need into the IDT during identification of project area(s).

<u>Identify and Design Initial Proposal</u>

8.	Develop a list of roads which are negatively influencing the catchment ranking criteria (road binning format/spreadsheet – Appendix E). Compare causal mechanisms in the catchments to indicators (Road Binning Matrix).
9.	Acquire any relevant Forest Service road network information from the Roads Planning Specialist, such as various private easements, use agreements, etc. and integrate this information into the road binning format/spreadsheet.
10.	Load GIS catchment, catchment ranking criteria results, and indicator results into Google Earth.
11.	Perform a Google Earth fly-over at appropriate elevations, specifically validating road presence, actual proximity to causal mechanism metrics, and getting an overall feel for restoration treatment options. Include comments from the fly-over in the road binning spreadsheet.
12.	Develop restoration treatment options for each road by using the Priority Restoration Scale Model.
13.	Take the overall analysis with the terrestrial restoration analysis and as an IDT work to identify the project area(s).
14.	Take the final road binning spreadsheet and identify a initial proposal and link it into the IDT process as the overall integrated restoration project is planned and its scope and scale becomes evident.

<u>Field Verification</u>

15.	Perform verification of the initial proposal by utilizing the field verification form in Appendix F.

Proposal Refinement

16.	Where appropriate, refine the initial proposal to reflect needed changes as identified in the field and link into the IDT process for further consideration.
17.	Where appropriate, either conduct additional refinements to the proposal post-NEPA scoping and/or use the road binning spreadsheet to create alternatives to the proposed action, which still meets the purpose and need.

Appendix G – Field Verification Form

Okanogan-Wenatchee National Forest

Field Verification for Whole Watershed Restoration Planning: Road Crossing

Sub-watershed Name:
Catchment Identifier:
Land Ownership:
Road Number:

Project Name:
Tributary Name OR Tributary To:
GPS Coordinates:

Primary equipment needed: depth rod (ft), at least 100 ft measuring tape, GPS, sub-watershed assessment map with road network et al plotted.

Evaluation 1: Approach Lengths

Right Side of Valley (looking downstream) =
Contributing water, sediment or both:
Left Side of Valley (looking downstream) =
Contributing water, sediment or both:

Evaluation 2:   Channel Constriction and Aquatic Organism Passage

Road Crossing Previously Assessed?
If yes, what was the passage determination?
If no, then…..

Crossing Structure Type (circle one):
Circular culvert (CMP)
Horizontal ellipse or "squash pipe"
Box culvert
Bottomless box culvert
Bottomless arch culvert
Pipe arch
Bridge
Ford
Crossing Structure Size (diameter or span) =
Material Characteristics (circle one):   metal, concrete, wood

Channel Constriction (Yes = Crossing Inlet Width $\leq$ Channel Bankfull Width):   Y or N
Outlet Drop (Yes or No; outlet elevation – water surface):   Y or N;   ft
Natural Channel Substrate in the Crossing (Yes or No):   Y   or   N

Barrier Determination (Green = Passable; Red = Impassable; Grey = In-determinant):
circle one below for ONLY one life stage category

- Spring Chinook/Steelhead/Bull Trout/Westslope Cutthroat Trout adult (A) – G R Gr
- Spring Chinook/Steelhead/Bull Trout/Westslope Cutthroat Trout juvenile (J) – G R Gr
- Spring Chinook/Steelhead/Bull Trout/Westslope Cutthroat Trout adult AND juvenile (AJ) – G R Gr

NOTE: If the answers to channel constriction = Y, outlet drop = Y, and natural channel substrate = N, then the barrier determination = Red (impassable) for juveniles and adult/juveniles. If the answers to channel constriction = N, outlet drop = N, and natural channel substrate = N, the barrier determination = Green (passable) for adults and juveniles. If the answers to channel constriction = N, outlet drop = N, and natural channel substrate = N, then the barrier determination = Red (impassable) for juveniles and Green (passable) for adults.

Comments and Recommendation for Restoration (same OR if different than originally identified):

Okanogan-Wenatchee National Forest

Field Verification for Whole Watershed Restoration Planning: Road Length to Valley Length

Sub-watershed Name:
Catchment Identifier:
Land Ownership:
Road Number:

Project Name:
Tributary Name OR Tributary To:
GPS Coordinates:

Evaluation 3: Valley Bottom, Floodplain and Stream Channel

Percentage of road length located within the valley bottom or active floodplain:
Percentage of road length directly interacting with the stream channel:

Stream Channel Adjustment:

W/D Ratio (bankfull width:mean bankfull depth): Observed =
Expected =

Entrenchment Ratio (floodprone area width:bankfull width): Observed =
Expected =

Estimated Stream Type Evolutionary Sequence:
(i.e. B to G)

NOTE: For quick measurements in the channel identification of bankfull is critical. The calculation for W/D Ratio = bankfull width divided by bankfull mean depth. For Entrenchment Ratio = floodprone area width divided by bankfull channel width (note: floodprone area = 2 X max bankfull depth).

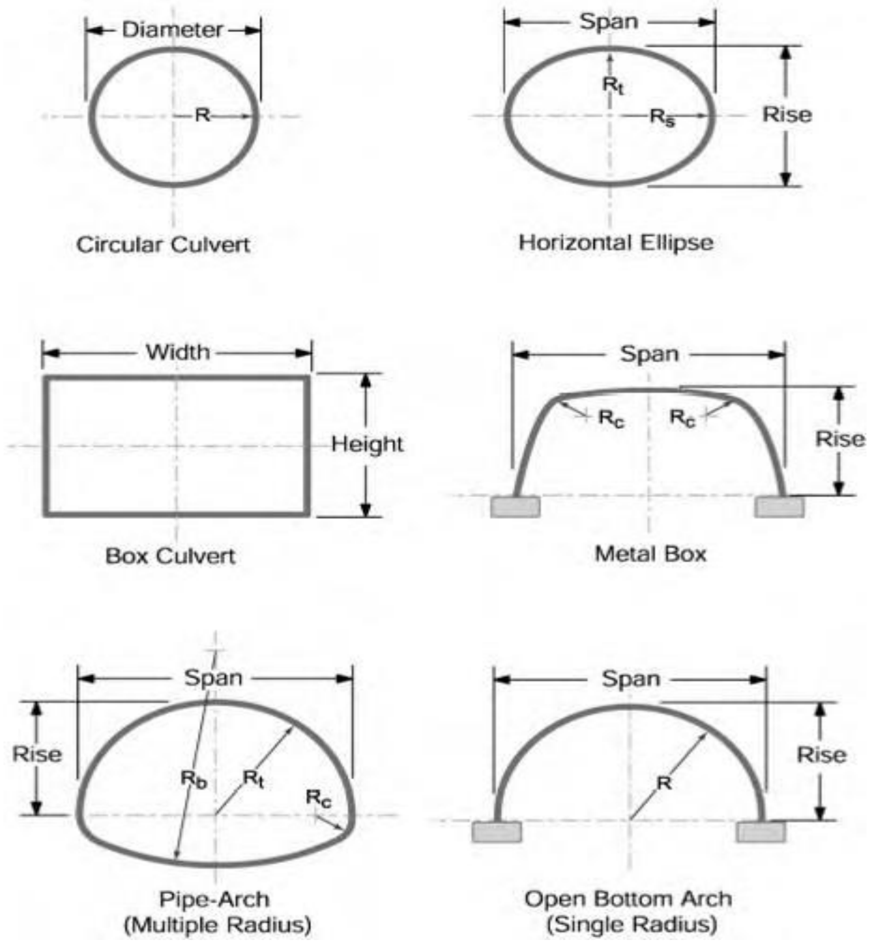
Evaluation 4: Road Surface

Percentage of road surface actively eroding (as evidenced by rutting, rilling, surface movement, etc.):

Number of artificial channels (or gully's) created at crossing drainage features:

Comments and Recommendation for Restoration (same OR if different than originally identified):

Common Stream Crossing Structures and Geometric Measures



Channel Evolution Sequence